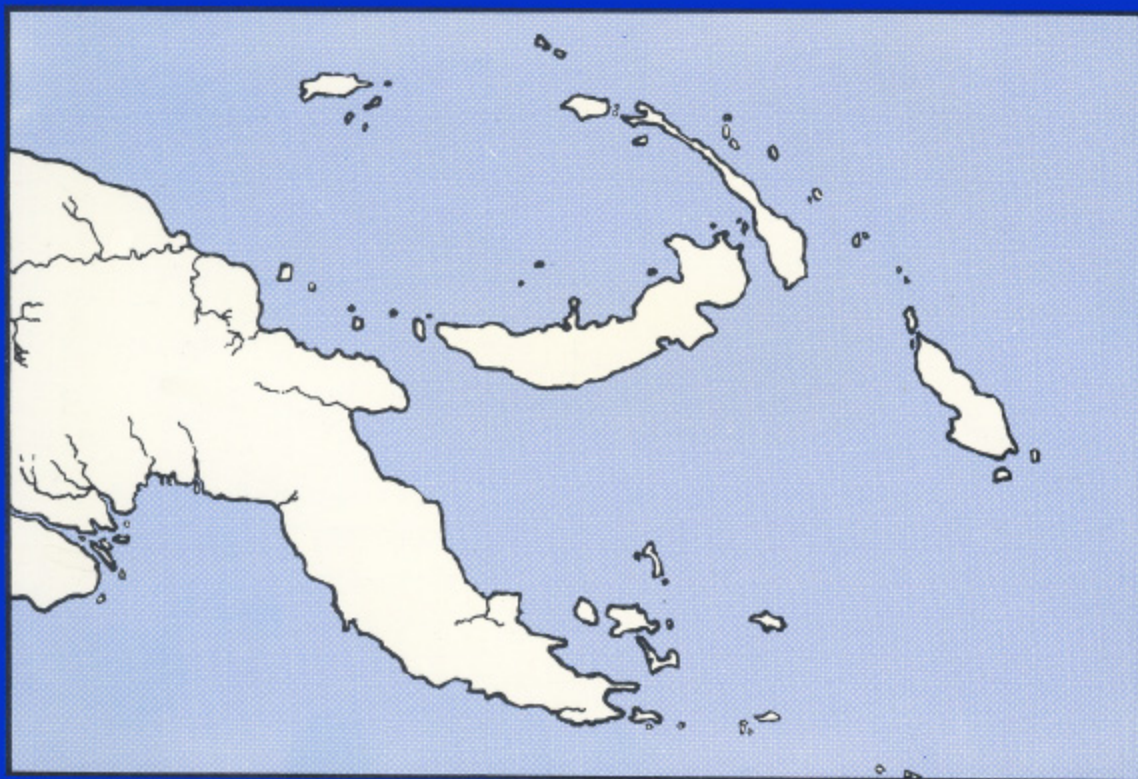


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EDITORIAL

Climate change in Papua New Guinea: impact on disease dynamics

Introduction

Increased temperatures and extreme weather events thought to be attributed to climate change have shown their effects globally, and Papua New Guinea (PNG) is no exception. PNG is prone to a variety of natural hazards, such as volcanic eruptions, earthquakes, tsunamis, tropical cyclones, landslides, flooding, and droughts and frosts in the highland areas. This is largely due to its location in the Western Pacific Region, geology and geologic activity. In the last couple of years, PNG has been affected by volcanic eruption in Rabaul, tropical cyclone Pam, and frost and drought in the highland regions (1-3). While these events on their own are not necessarily a consequence of climate change, the intensity, severity or frequency of some or all of these natural hazards are predicted to be exacerbated by climate change.

Climate change effects include not only the obvious weather changes, but also changes in the patterns and behaviours of infectious and non-infectious diseases within the population, and their severities. It has long been known that climate has an effect on health. Up to 2300 years ago Hippocrates, the 'father of medicine', recognized that disease patterns differed between locations, and that certain maladies were more likely to occur following certain weather events (4,5). Some places will be affected sooner than others; climate change is occurring faster in non-temperate regions such as the tropics. It is likely that climate change will have a more profound effect on populations of developing countries, where current infrastructure and health care systems are unprepared and ill-equipped to meet the changing needs of many rural inhabitants (6-8).

While it is tempting to attribute any extreme weather event today to the effects of climate change, one must be mindful that climate change is a long-term process, and short-term changes in weather patterns may not necessarily reflect or represent climate change. Many factors and driving forces

need to be taken into consideration, making predictions quite complex and definitive impacts rather uncertain.

Climate change in Papua New Guinea

Indicators of climate change have been measured at various sites in PNG since at least 1950. The Pacific Climate Change Science Program (PCCSP) has used previous climate measurements and predictive models to project the impact of climate change on PNG (9,10). These predictions are based on what are called emissions scenarios, which serve to forecast future atmospheric pollution based on global assumptions about a number of driving factors involving human activity and population (such as land usage, economic and population growth, and technological advances and development) (11). The Intergovernmental Panel on Climate Change (IPCC) has defined three such emissions scenarios: Low, Medium and High, for three time periods: 2030, 2055 and 2090, when compared to conditions in 1990. These data are summarized below (9).

Since 1950, the mean annual air temperature in Port Moresby has increased at a rate of 0.11°C per decade, and the sea level has risen approximately 7 cm since 1993. At the very least it is predicted that the average air temperature will have increased by 0.7°C (for both low and high emissions scenarios) by the year 2030. By 2090, the gap between low and high emissions scenarios is predicted to be more marked at 1.6°C and 2.8°C average increases respectively. Sea surface temperatures are also predicted to follow a similar trend with 0.6°C (low) and 0.7°C (high) increases by 2030 and 1.4°C (low) and 2.6°C (high) by 2090. The sea level around PNG is expected to rise 9 cm (low) to 10 cm (high) by 2030 and 31 cm (low) to 41 cm (high) by 2090. Ocean acidification, as measured by aragonite saturation, has occurred over the past century. Aragonite saturation had reduced from 4.5 to 3.9 by the year 2000; aragonite saturations between 3.5 and 4.0 are optimal for coral reef systems. This acidification is expected to continue with

aragonite saturations of 3.5 (low) to 3.4 (high) by 2030 and 3.1 (low) to 2.5 (high) by 2090. In all scenarios average annual rainfall is expected to increase significantly (9).

Overall, both the days and nights are predicted to become warmer. While average annual rainfall is expected to increase, the distribution will likely change. More extreme weather events are expected, resulting in more intense torrential rains during the wet season, but could be followed by intense heat waves and droughts during the dry season (9). The number of tropical cyclones affecting PNG is expected to decrease, but the intensity of these storms is predicted to increase (7,9). El Niño frequency and intensity will likely increase as well (12,13).

Climate change effects on non-infectious disease dynamics

Extreme weather events are already known to cause a host of health problems. With the predicted increase in the severity and incidence of these weather events, it is anticipated that this will lead to a further increase in health problems (14).

According to a 2010 World Health Organization (WHO) global status report, of all the deaths that occurred globally in 2008, almost two-thirds were attributable to non-infectious diseases, in particular cardiovascular diseases, cancer, diabetes and chronic respiratory diseases (15). While non-infectious diseases and their associated risk factors have received little attention and have not been well investigated in PNG, at least one recent report has indicated that non-infectious diseases are on the rise in PNG and are likely to become a real problem in the future (16). Consequently, climate change events may have the greatest impact on these types of health concern. A summary of the potential effects of climate change on non-infectious diseases in PNG can be found in Table 1.

During heat waves the mortality from cardiovascular disease rises, especially in the very young and the elderly. Those with lifestyle cardiovascular problems tend to be concentrated in the more affluent urban areas, so an increased mortality in these populations can be expected (5,8). Prolonged drought can lead to famine and micronutrient deficiencies, especially in those that rely on

subsistence farms for food, as is the case for a large proportion of people in PNG. The decrease in water during droughts will likely affect those that rely on hydropower such as that supplied by the Ramu Dam (5,7,8). As food and water become scarce, conflicts over resources are likely to develop, resulting in injuries and deaths. Greater reliance on 'western' processed foods in urban areas could lead to long-term problems such as diabetes and obesity (8). Drought may lead to bush fires, causing air pollution that will exacerbate chronic respiratory illnesses, damage local infrastructure and displace populations (5-8,23).

Although stratospheric ozone layer depletion due to chlorofluorocarbons (CFCs) appears to have stabilized since 2000, and is predicted to be restored to pre-1980 levels by mid-century, increasing temperatures due to climate change are predicted to increase the amount of tropospheric ozone, which is considered an air pollutant, and may well contribute to increased respiratory and cardiovascular mortalities (14,26).

Flooding due to rises in sea level and increased storms may lead to land erosion, soil and ground water contamination, damage to coastal infrastructure, and migration of people away from coastal areas. The Pacific islands are more likely to be affected by rising sea levels, with noticeable effects in 50 years time; in fact, the atoll of Tuvalu has already been facing these problems (7,8). Increased intensity of tropical cyclones may lead to massive damage to infrastructure, and may result in many more injuries and deaths than currently experienced (7). Displacement and migration of populations may lead to less obvious long-term effects such as mental health problems of those displaced (5,8,23).

Ocean acidification will potentially have the greatest effect on corals and marine species. This could see a complete collapse of some coral ecosystems, resulting in major losses for coastal regions that rely on fishing for food, trade and tourism (8).

Climate change effects on infectious disease dynamics

With climate change the distributions, timing and severity of infectious diseases will also change. As the world warms, the changing environment will enable diseases to

change their geographical locations through the migration of hosts. These changes will occur in both latitude and altitude, and may also allow infectious diseases to persist longer in their current environments and hosts (8,12,18). A summary of the effects of climate change on infectious diseases in PNG can be found in Table 1.

Vector-borne diseases such as dengue, chikungunya, filariasis and malaria may be the most sensitive to these changes as their mosquito hosts are able to spread farther north and south out of the tropics, and to higher altitudes (5,7,12,13,19,20). It is likely that we will begin to see a higher incidence of these diseases in the highlands of PNG over the coming years. This trend is already happening with dengue and malaria at higher altitudes in Africa and Latin America (20). Warmer temperatures (excluding extremes) affect the maturation time of many parasites, including malaria, allowing faster growth and transmission by mosquitoes. For example, at 20°C *Plasmodium falciparum* takes 26 days to mature, but at 25°C it only takes 13 days. As *Anopheles* mosquitoes only live for a few weeks, the *Plasmodium falciparum* parasite does not have enough time to mature and be transmitted at lower temperatures such as those experienced currently in the highlands of PNG. Increasing temperatures in the highlands would allow for maturation and transmission of the parasite (6,18). This is also true for dengue virus; increasing temperatures will allow for faster mosquito development and decreased incubation periods (27). Temperature changes can also influence the behaviour of vectors; for example, increased temperature increases the biting frequency and blood meal digestion time of some mosquitoes, allowing for faster reproduction and further chances to transmit disease (28). Extremely high temperatures during heat waves could have the opposite effect, both resulting in mosquito mortality and reduction in standing water required as breeding grounds for the mosquitoes (18,27). Previously, the vector of dengue and yellow fever, *Aedes aegypti*, was limited to areas below 1000 m above sea level. However, as the world warms, they are now being found at 1100 m in Mexico, and as high as 2200 m in the Colombian Andes (6). In 1999 West Nile virus, carried by *Culex pipiens*, was introduced into New York. With increasingly warmer seasons affecting the vector and birds (the primary host), West Nile virus was able to

take hold and spread across much of North America (6,25). It is feasible that a similar scenario could happen in the highlands of PNG. Existing vectors may occupy new niches in the highlands, and new vectors could be introduced that were previously unknown to PNG. Both *Aedes* and *Anopheles* mosquitoes are present in PNG, along with dengue virus and malaria in the coastal and island regions. It is possible that we could see increased dengue and malaria transmission in the highlands with increased temperatures (29).

Climate change will have a profound effect on zoonoses as the distribution of animals that carry diseases can change drastically (6,18,19,21,22). Rodents are an important vector for many outbreaks during any drastic changes to a region's climate. Rodents are highly sensitive to changes in climate and any movement of rodent populations can potentially result in a change in interaction dynamics between rodent populations and humans, thus resulting in increased disease occurrence. Common pathogens prevalent in many types of rodents are the bacterial species belonging to the genus *Leptospira*. *Leptospira* spp. are common causes of febrile illness (Weil's disease) in tropical climates and PNG is no exception. Currently, no avian influenza has been found in PNG but it has been found in neighbouring Indonesia (30). Change in climate and wind patterns can potentially alter the migration of wild birds that may carry avian influenza or Japanese encephalitis (18,19). Host switching may occur, allowing transmission of diseases from animals that were previously unknown to harbour a disease (18,31). Displacement of populations due to drought or flood may bring humans into closer contact with wild animals, allowing for emergent or re-emergent zoonotic diseases – both animal to human and vice versa (7,13,21,22).

Extreme rainfall and flooding can affect infectious diseases. Diarrhoeal diseases, such as those caused by *Vibrio cholerae* and *Shigella* species, are known to increase after flooding events, which will likely occur in the coastal and estuary regions of PNG (5,13). Higher temperatures and drought, such as we are currently experiencing in PNG due to El Niño, are associated with increased *Campylobacter* and *Salmonella* prevalence. Extreme rainfall events and/or flooding following such a drought facilitate spread of

TABLE 1
SUMMARY OF LIKELY CLIMATE CHANGE OUTCOMES IN PAPUA NEW GUINEA

Pressure from climate change	Outcomes	Possible responses	References
Non-infectious diseases			
Increased UV (ultraviolet) light exposure due to ozone depletion	<ul style="list-style-type: none">• Sunburn• Skin cancer• Cataracts	<ul style="list-style-type: none">• Education on skin and eye UV protection• Availability of skin and eye UV protection• Decrease ozone-depleting substance emissions	(12, 17)
Increased average temperature	<ul style="list-style-type: none">• Changes in distribution of local flora and fauna	<ul style="list-style-type: none">• Biodiversity surveys for future comparison• Increased conservation efforts• Decrease greenhouse gas emissions	(5-7, 12, 13, 18-22)
Increased intensity and duration of heat waves	<ul style="list-style-type: none">• Increase in mortality of elderly (mainly due to cardiovascular disease) and the very young• Heat stroke• Dehydration	<ul style="list-style-type: none">• Education on prevention of heat stroke and dehydration, and management of cardiovascular diseases• Availability of cooling mechanisms (air conditioning, fans) for home use	(5,8)
Increased intensity and duration of droughts	<ul style="list-style-type: none">• Decimation of crops• Famine and malnutrition• Depletion of clean water sources• Increased dependence on 'western' foods leading to obesity and diabetes• Disruption of hydropower• Bush fires• Local infrastructure damage• Displacement of human populations• Exacerbation of chronic respiratory illness due to air pollution caused by fires• Conflict over food, water and land	<ul style="list-style-type: none">• Implementation of irrigation systems for subsistence farms if possible• Disaster response teams distributing food and water to those most affected• Implementation of alternative power sources such as wind and solar• Support for fire response teams and rebuilding of local infrastructure• Strengthening of health care systems• Mental health support of those who have been displaced	(5-8,23)

Flooding due to sea level rise and increased intensity of tropical cyclones	<ul style="list-style-type: none"> • Injury and death during flooding • Land erosion • Soil and groundwater contamination • Damage to coastal infrastructure • Displacement of human populations 	<ul style="list-style-type: none"> • Strengthening of health care systems • Flood preparedness and response programs • Support for rebuilding of damaged local infrastructure • Disaster response teams distributing food and clean water to those most affected • Mental health support of those who have been displaced 	(5,7,8,23)
Ocean acidification	<ul style="list-style-type: none"> • Damage to or collapse of coral ecosystems • Shortage of food for coastal populations that rely on fishing • Decreases in coastal tourism 	<ul style="list-style-type: none"> • Decrease greenhouse gas emissions • Disaster response teams distributing food to those most affected 	(8)

Infectious diseases

Increased average temperature and drought	<ul style="list-style-type: none"> • Vector (mosquito, tick, etc) distribution changes • Vector-borne disease (dengue, chikungunya, filariasis, malaria, etc) location changes as vector moves • Geographical changes in animal distributions • Outbreaks of new zoonoses, and known zoonoses in new places (leptospirosis, plague, etc) • Increase in diarrhoeal diseases caused by <i>Salmonella</i> and <i>Campylobacter</i> species 	<ul style="list-style-type: none"> • Biodiversity surveys to observe vector and animal host population changes in real time • Implementation of vector control programs as vectors move to new areas • Implementation of surveillance of animals for emerging and re-emerging zoonoses • Increased human surveillance of climate-change-sensitive diseases • Education on hygiene and food and water safety • Availability of clean water to those affected, and water decontamination mechanisms • Strengthening of health care systems 	(5-7,12,13,18-22,24)
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Changing climate and wind patterns	<ul style="list-style-type: none"> • Vector (mosquito, tick, etc) distribution changes • Vector-borne disease (dengue, chikungunya, filariasis, malaria, etc) location changes as vector moves • Changes in bird migration bringing disease agents such as avian influenza and Japanese encephalitis viruses to new areas 	<ul style="list-style-type: none"> • Biodiversity surveys to observe vector and animal host population changes in real time • Implementation of vector control programs as vectors move to new areas • Implementation of surveillance of birds for emerging and re-emerging zoonoses • Increased human surveillance of climate-change-sensitive diseases • Strengthening of health care systems 	(5-7,12,13,19,20,25)
Increased extreme rainfall events and flooding	<ul style="list-style-type: none"> • Increase in diarrhoeal diseases caused by <i>Vibrio</i> and <i>Shigella</i> species • Contamination of clean water sources with diarrhoeal agents during flooding • Displacement of rodent populations • Increase in febrile illnesses, such as that caused by <i>Leptospira</i> species, as rodents move to new areas • Displacement of human populations leading to disease outbreaks in crowded shelters (influenza, common cold, diarrhoeal diseases) 	<ul style="list-style-type: none"> • Education on hygiene and food and water safety • Availability of clean water to those affected, and water decontamination mechanisms • Regular surveillance of food and water sources for pathogens causing diarrhoeal and febrile diseases • Increased human surveillance of climate-change-sensitive diseases • Implementation of rodent surveillance for emerging and re-emerging zoonoses • Strengthening of health care systems 	(5,6,8,20,23)

these pathogens through contamination of water sources (24). An increase in febrile illness as a result of flooding is also possible, and has been observed in many developing nations. As rats are displaced from their habitat, they must search for new foraging and nesting areas, leading to contamination of water sources with rat-borne diseases such as leptospirosis. There have been recent outbreaks of leptospirosis in Thailand, Sri Lanka and the Philippines following flooding (32-34). PNG has been fortunate with recent flooding events, with no observed increase in febrile illness. However, the risk is still ever-present due to the large diverse populations of rats in all regions. Flooding can also lead to growth of dangerous fungi and house moulds, leave behind perfect mosquito breeding sites, and trigger toxic algal blooms (6,8,20). Displaced populations after extreme weather events will lead to crowding in health care facilities, unaffected towns and villages, and shelters. This will lead to an increase of disease outbreaks associated with crowding, such as influenza, the common cold and diarrhoeal diseases (5,23).

Bacterial respiratory diseases, such as pneumonia, are also climate sensitive and should not be ignored, especially as childhood pneumonia is still a leading cause of mortality and morbidity in PNG. Factors associated with climate change, such as more intense rainy seasons, malnutrition and air pollution, are likely to have a noticeable impact on the already high burden of pneumonia in PNG (35,36). These same factors may also impact on the burden of tuberculosis (TB) in PNG. Papua New Guinea has high burdens of TB, co-infections of HIV (human immunodeficiency virus) and TB, and multidrug-resistant (MDR)-TB, with an estimated incidence rate of 417 per 100,000 people as of 2014 (37,38). What effect climate change will have on antibiotic-resistant patterns of disease, including MDR-TB, is yet another variable. While environmental temperature shifts may in fact lead to increased transmission rates of antibiotic resistance genes, resistant pathogens, on the other hand, may be less equipped to handle environmental fluctuations and stresses (39-41).

A recent WHO-supported review of climate-sensitive health risks in the Federated States of Micronesia (FSM) identified infectious diseases as the highest priority. Diarrhoeal diseases, vector-borne diseases and

zoonoses (especially leptospirosis) were the infectious diseases predicted to be most affected by climate change in FSM (42). While this prediction is likely to reflect the effects of climate change in coastal and island regions of PNG, it does not address changes in highlands regions as none of the islands of FSM contain rugged highlands similar to PNG. A similar review should be undertaken for PNG.

Current response to climate change in Papua New Guinea

Climate-related public health issues are complicated and will require an integrated approach by medical workers, emergency management personnel, community leaders and other stakeholders. The government of PNG has prioritized climate change in its long-term vision, plans and strategies: Papua New Guinea Vision 2050 (43). The Office of Climate Change and Development (OCCD) has documented the National Climate Compatible Development Management Policy (NCCDMP). This policy is meant to guide decisions on adaptation and mitigation of effects of climate change in PNG. The policy outlines some of the implications of climate change on public health including heat waves, flooding, new infectious diseases, air pollution and the need for emergency services delivery. The policy calls for conducting of health impact assessment (HIA) to evaluate key climate changes that will affect public health in PNG, and the National Department of Health (NDoH) will take the lead in managing and implementing the policies in consultation with the OCCD (44). The National Health Plan (2011-2020) in Key Result Area 8 sets the objective of improved capacity and preparedness of the health sector in order to address the impacts of climate change. The strategies employed to meet this objective will be to increase cross-sectional collaboration to prepare for climate change, and to ensure that every health facility has a disaster preparedness plan which includes issues associated with climate change (45). The OCCD has identified nine priority climate-related risks likely to be prevalent in PNG due to climate change: coastal flooding and sea level rise, inland flooding, food insecurity, cities and climate change, climate-induced migration, damage to coral reefs, malaria and vector-borne diseases, water and sanitation, and landslides – all of which can contribute to public health issues, either directly or indirectly

(46). Working groups have been formed within the OCCD, with the health sector as a major partner in these technical groups. While no actions have yet been taken, discussions are being carried out with the intent to implement policies on climate-change-related public health issues.

The Eastern Highlands Provincial Government has initiated the formation of the Eastern Highlands Provincial Climate Change Committee (EHPCCC). The committee is tasked to initiate plans for action to address adaptation and mitigation measures on climate-change-related issues in the province and report to the provincial executive council (PEC). Stakeholders from the various provincial government departments and institutions and non-government organizations (NGOs) are represented on the committee. The Provincial Health Authority (PHA) and the Papua New Guinea Institute of Medical Research (PNGIMR) both have representatives on the committee. A subcommittee of the EHPCCC is drafting the EHP Climate Change Policy for guiding decisions and actions of the EHP government response on effects of climate change in the province. The health sector is also represented on this subcommittee to contribute to policies for climate-change-related health issues. Several other provinces in PNG have launched similar provincial climate change committees. The provincial government has engaged the Wildlife Conservation Society (WCS) to carry out biodiversity surveys in the province (47). These surveys will allow us to compare the distributions of plant and animal species now and in the future. They can also provide data on animal species that are potential disease vectors in the province. A recent study conducted at IMR looking at rats trapped from local communities showed that many rats harbour *Leptospira* spp. More research is required to collect data on vector biodiversity and the capacity of vectors to amplify or transmit disease-causing pathogens in PNG.

Conclusion

Climate change is a global phenomenon that affects us all. This editorial is meant to highlight some of the climate-change-related issues that PNG may face in the coming years, which are summarized in Table 1. What is evident is that the impact of climate change on health and disease is still very much uncertain and largely unpredictable. Monitoring of climate

change and its impacts is extremely complex and will require a coordinated effort across disciplines. Meteorological data are already being collected in PNG, but there is a need for more surveillance of both infectious and non-infectious diseases throughout the country. The national and provincial governments are beginning to roll out alternative energy initiatives to lower greenhouse gas emissions, encouraging use of solar and wind power. While these changes should be encouraged, PNG is a small country and these efforts alone will not be enough to lessen the impact of climate change in PNG. Biodiversity surveys are being undertaken at least in the EHP, and should be undertaken country-wide, both for the conservation of current flora and fauna and for the measurement of distribution changes. This is important because as the distribution of plants and animals changes, so too will infectious disease dynamics. When hosts and vectors of infectious diseases are displaced or new niches open for them to occupy, the diseases they carry can become endemic in new areas; these movements can also result in new or re-emergent zoonoses, and provide an opportunity for host-switching events. Country-wide disease surveillance will allow us to follow outbreaks and track the spread of disease into new geographical locations, as well as to detect the emergence of new diseases. Surveillance at the human-animal interface will enable us to monitor current zoonoses and detect new ones as they emerge. Reinforcement of vector control programs, as well as tracking of vectors and vector-borne diseases, is also essential. With climate change, an increasing burden on the health care system should be anticipated. Strengthening the health system and upgrading current health care facilities to enable a response to extreme weather events and outbreaks are crucial and should be undertaken, along with programs for the monitoring of food and water quality.

In the current climate of rapid economic growth and urbanization in PNG, synergistic and well-designed climate change, environmental and health policies will go a long way to helping prevent or reduce major health problems and burdens in the future.

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REFERENCES

- 1 **Connors A.** Frost and drought wipes out subsistence crops in Papua New Guinea, Solomon Islands highlands. Australian Broadcasting Commission News, Aug 2015. www.abc.net.au/news/2015-08-19/frost-drought-wipes-out-subsistence-crops-in-png-solomon-islands/6707964
- 2 **Grimm N.** Mount Tavurvur: Rabaul residents describe life alongside active volcano in Papua New Guinea. Australian Broadcasting Commission News, Sep 2014. www.abc.net.au/news/2014-09-18/png-residents-describe-life-in-volcano-prone-rabaul/5753482
- 3 **Kumar N.** Helping remote communities in Papua New Guinea recover after Cyclone Pam. Geneva: International Federation of Red Cross and Red Crescent Societies, Jul 2015. www.ifrc.org/en/news-and-media/news-stories/asia-pacific/papua-new-guinea/helping-remote-communities-in-papua-new-guinea-recover-after-cyclone-pam--69114/
- 4 **Falagas ME, Bliziotis IA, Kosmidis J, Daikos GK.** Unusual climatic conditions and infectious diseases: observations made by Hippocrates. *Enferm Infect Microbiol Clin* 2010;28:716-718.
- 5 **Haines A, Kovats RS, Campbell-Lendrum D, Corvalan C.** Climate change and human health: impacts, vulnerability and public health. *Public Health* 2006;120:585-596.
- 6 **Epstein PR.** Climate change and emerging infectious diseases. *Microbes Infect* 2001;3:747-754.
- 7 **Costello A, Maslin M, Montgomery H, Johnson AM, Ekins P.** Global health and climate change: moving from denial and catastrophic fatalism to positive action. *Philos Trans R Soc A Math Phys Eng Sci* 2011;369:1866-1882.
- 8 **Hess JJ, Malilay JN, Parkinson AJ.** Climate change: the importance of place. *Am J Prev Med* 2008;35:468-478.
- 9 **Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (CSIRO).** Pacific Climate Change Science Program. Climate Change in the Pacific: Scientific Assessment and New Research. Volume 2: Country Reports – Papua New Guinea. Canberra: Australian Government, 2011:169-184.
- 10 **Papua New Guinea National Weather Service, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (CSIRO).** Pacific Climate Change Science Program. Current and future climate of Papua New Guinea. Canberra: Australian Government, 2011:1-8.
- 11 **Nakicenovic N, Swart R, eds.** Emissions Scenarios. Cambridge: Cambridge University Press, 2000.
- 12 **Hales S, Woodward A, Guest C.** Climate change in the South Pacific region: priorities for public health research. *Aust J Public Health* 1995;19:543-545.
- 13 **McMichael AJ.** Extreme weather events and infectious disease outbreaks. *Virulence* 2015;6:543-547.
- 14 **Friel S, Bowen K, Campbell-Lendrum D, Frumkin H, McMichael AJ, Rasanathan K.** Climate change, noncommunicable diseases, and development: the relationships and common policy opportunities. *Annu Rev Public Health* 2011;32:133-147.
- 15 **World Health Organization.** Global status report on noncommunicable diseases 2010. Description of the global burden of NCDs, their risk factors and determinants. Geneva: World Health Organization, 2011.
- 16 **Pulford J, Rarau P, Vengiau G, Gouda H, Phuanukoonnon S; Scientific Advisory Board Members.** Non-communicable diseases and associated risk factors in the Hiri, Karkar and Asaro integrated health and demographic surveillance sites. Goroka: Papua New Guinea Institute of Medical Research, 2015.
- 17 **Andersen LK, Hercogová J, Wollina U, Davis MDP.** Climate change and skin disease: a review of the English-language literature. *Int J Dermatol* 2012;51:656-661.
- 18 **Polley L, Thompson RCA.** Parasite zoonoses and climate change: molecular tools for tracking shifting boundaries. *Trends Parasitol* 2009;25:285-291.
- 19 **Sellers RF.** Weather, host and vector – their interplay in the spread of insect-borne animal virus diseases. *J Hyg (Lond)* 1980;85:65-102.
- 20 **Haines A, McMichael AJ, Epstein PR.** Environment and health: 2. Global climate change and health. *CMAJ* 2000;163:729-734.
- 21 **Mills JN, Gage KL, Khan AS.** Potential influence of climate change on vector-borne and zoonotic diseases: a review and proposed research plan. *Environ Health Perspect* 2010;118:1507-1514.
- 22 **Rosenthal J.** Climate change and the geographic distribution of infectious diseases. *EcoHealth* 2009;6:489-495.
- 23 **McMichael C.** Climate change-related migration and infectious disease. *Virulence* 2015;6:548-553.
- 24 **Semenza JC, Herbst S, Rechenburg A, Suk JE,**

- Höser C, Schreiber C, Kistemann T. Climate change impact assessment of food- and waterborne diseases. *Crit Rev Environ Sci Technol* 2012;42:857-890.
- 25 Soverow JE, Wellenius GA, Fisman DN, Mittleman MA. Infectious disease in a warming world: how weather influenced West Nile virus in the United States (2001-2005). *Environ Health Perspect* 2009;117:1049-1052.
 - 26 World Meteorological Organization. Scientific assessment of ozone depletion: 2014. Global Ozone Research and Monitoring Project – Report No 55. Geneva: World Meteorological Organization, 2014.
 - 27 Naish S, Dale P, Mackenzie JS, McBride J, Mengersen K, Tong S. Climate change and dengue: a critical and systematic review of quantitative modelling approaches. *BMC Infect Dis* 2014;14:167.
 - 28 Afrane YA, Githeko AK, Yan G. The ecology of *Anopheles* mosquitoes under climate change: case studies from the effects of deforestation in East African highlands. *Ann NY Acad Sci* 2012;1249:204-210.
 - 29 Johansen CA, van den Hurk AF, Ritchie SA, Zborowski P, Nisbet DJ, Paru R, Bockarie MJ, Macdonald J, Drew AC, Khromykh TI, Mackenzie JS. Isolation of Japanese encephalitis virus from mosquitoes (Diptera: Culicidae) collected in the Western Province of Papua New Guinea, 1997-1998. *Am J Trop Med Hyg* 2000;62:631-638.
 - 30 Jonduo M, Wong SS, Kapo N, Ominipi P, Abdad M, Siba P, McKenzie P, Webby R, Horwood P. Surveillance of avian influenza viruses in Papua New Guinea poultry, June 2011 to April 2012. *Western Pac Surveill Response J* 2013;4:11-15.
 - 31 Brooks DR, Hoberg EP. How will global climate change affect parasite-host assemblages? *Trends Parasitol* 2007;23:571-574.
 - 32 Mendoza MT, Roxas EA, Ginete JK, Alejandria MM, Roman ADE, Leyritana KT, Penamora MA, Pineda CC. Clinical profile of patients diagnosed with leptospirosis after a typhoon: a multicenter study. *Southeast Asian J Trop Med Public Health* 2013;44:1021-1035.
 - 33 Suwanpakdee S, Kaewkungwal J, White LJ, Asensio N, Ratanakorn P, Singhasivanon P, Day NP, Pan-Ngum W. Spatio-temporal patterns of leptospirosis in Thailand: is flooding a risk factor? *Epidemiol Infect* 2015;143:2106-2115.
 - 34 Agampodi SB, Dahanayaka NJ, Bandaranayaka AK, Perera M, Priyankara S, Weerawansa P, Matthias MA, Vinetz JM. Regional differences of leptospirosis in Sri Lanka: observations from a flood-associated outbreak in 2011. *PLoS Negl Trop Dis* 2014;8:e2626.
 - 35 Paynter S, Ware RS, Weinstein P, Williams G, Sly PD. Childhood pneumonia: a neglected, climate-sensitive disease? *Lancet* 2010;376:1804-1805.
 - 36 Herrera-Lara S, Fernández-Fabrellas E, Cervera-Juan A, Blanquer-Olivas R. Do seasonal changes and climate influence the etiology of community acquired pneumonia? *Arch Bronconeumol* 2013;49:140-145.
 - 37 World Health Organization. Papua New Guinea: tuberculosis profile. Geneva: World Health Organization, 2015.
 - 38 Ley SD, Harino P, Vanuga K, Kamus R, Carter R, Coulter C, Pandey S, Feldmann J, Ballif M, Siba PM, Phuanukoonnon S, Gagneux S, Beck HP. Diversity of *Mycobacterium tuberculosis* and drug resistance in different provinces of Papua New Guinea. *BMC Microbiol* 2014;14:307.
 - 39 Poole K. Bacterial stress responses as determinants of antimicrobial resistance. *J Antimicrob Chemother* 2012;67:2069-2089.
 - 40 Andersson DI, Hughes D. Antibiotic resistance and its cost: is it possible to reverse resistance? *Nat Rev Microbiol* 2010;8:260-271.
 - 41 Davies J, Davies D. Origins and evolution of antibiotic resistance. *Microbiol Mol Biol Rev* 2010;74:417-433.
 - 42 McIver L, Hashizume M, Kim H, Honda Y, Pretrick M, Iddings S, Pavlin B. Assessment of climate-sensitive infectious diseases in the Federated States of Micronesia. *Trop Med Health* 2015;43:29-40.
 - 43 Papua New Guinea National Strategic Plan Taskforce. Papua New Guinea Vision 2050. Port Moresby: National Strategic Plan Taskforce, 2009.
 - 44 Papua New Guinea Office of Climate Change and Development (OCCD). National Climate Compatible Development Management Policy. Port Moresby: OCCD, 2014.
 - 45 Papua New Guinea Department of Health. Papua New Guinea National Health Plan 2011-2020. Port Moresby: Department of Health, 2010.
 - 46 Papua New Guinea Office of Climate Change and Development (OCCD). Office of Climate Change and Development Information Brief 2015. Port Moresby: OCCD, 2015.
 - 47 Geteng B. Wildlife Conservation Society contracted to do biodiversity survey in EHP. Port Moresby: EMTV, Oct 2014. www.emtv.com.pg/article.aspx?slug=Wildlife-Conservation-Society-Contracted-To-Do-Biodiversity-Survey-In-EHP&subcategory=Top-Stories

Assessment of zinc status of women resident in the National Capital District, Papua New Guinea

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SUMMARY

This cross-sectional study assessed the zinc status of non-pregnant and pregnant women resident in the National Capital District (NCD), Papua New Guinea (PNG). Non-fasting morning blood samples were collected by venipuncture from consented women. Flame atomic absorption spectrometry was used to measure the serum zinc concentration in 27 non-pregnant and 100 pregnant women. C-reactive protein (CRP) in serum was measured by enzyme immunoassay and used to interpret the serum Zn data. For all the non-pregnant women, the median serum zinc concentration was 42.7 µg/dl with an interquartile range (IQR) of 27.6 to 91.2 µg/dl. Zinc deficiency was prevalent among 59% in this group of women. For those with normal CRP the median and IQR serum zinc concentrations were 48.9 µg/dl and 30.2 to 98.7 µg/dl, respectively. The median and IQR for all the pregnant women were 63.8 µg/dl and 40.9 to 93.2 µg/dl, respectively. Prevalence of zinc deficiency was 42% using the cut-off point of 56.0 µg/dl. Of the 100 pregnant women, 16 (16%) were in the first trimester, 51 (51%) in the second trimester and 33 (33%) in the third trimester. The median serum zinc concentrations of pregnant women in the first, second and third trimesters were 87.0 µg/dl, 61.6 µg/dl and 60.8 µg/dl, respectively. Using gestational period-specific cut-off points, zinc deficiency was prevalent among 31%, 39% and 36% of the pregnant women in the first, second and third trimesters, respectively. Our results clearly indicate suboptimal zinc status among non-pregnant and pregnant women in the NCD. According to the International Zinc Nutrition Consultative Group (IZiNCG) criteria, this should be considered as a public health problem among these groups of women in the NCD. To effectively address the issue, social mobilization, intensive education and awareness campaigns, with all relevant target groups and policy makers, are urgently required.

Introduction

Zinc (Zn) is one of the essential trace elements in human nutrition. It is a component of over 200 metallo-proteins with a wide range of biochemical functions (1,2). Zn is required for normal cellular growth and differentiation, and for the expression of multiple genes regulating mitosis; it plays a crucial role in the development and maintenance of the immune system; it is also required for the regulation of a family of transcriptional regulators with Zn-finger motif involved in sequence-specific

DNA (deoxyribonucleic acid) recognition and gene expression (1-4). Zinc is also required for the absorption, transport, metabolism, hepatic release and tissue utilization of vitamin A as well as for regulation of blood sugar, acid-base balance, calcium metabolism, and normal functions of the gonads, thyroid and adrenal glands (1-6). Zn is an antioxidant that helps to stabilize and maintain the integrity of cellular membranes (5,6). The consequences of Zn deficiency are manifold (1-12).

Inadequate dietary intake of Zn by women of

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childbearing age can compromise major body functions, including impairment of physical growth, immune competence and reproduction (1,2,12,13). Some scientific reports have indicated that women are at increased risk of Zn deficiency during pregnancy, because of the high fetal requirement for Zn (1,2,13-15). Mild to moderate (subclinical) Zn deficiency has been associated with prolonged gestation, intrauterine growth restriction, pregnancy-induced hypertension, preterm delivery, complications of labour and delivery of neonates with low birthweights (1-3,11-20).

According to the International Zinc Nutrition Consultative Group (IZiNCG), World Health Organization (WHO) and United Nations Children's Fund (UNICEF), serum or plasma Zn concentration is the best available biomarker of the risk of Zn deficiency in target populations, because it is the only biochemical indicator for which some acceptable reference data are available (1,7,21-24).

Flame atomic absorption spectrometry (FAAS) is one of the recommended analytical methods for the assay of Zn in serum. It is a robust technique with high sensitivity, reproducibility, specificity and precision; however, to avoid contamination by ambient sources of Zn, appropriate precautions must be taken during collection, processing and analysis of the serum samples (1,22,24).

Several criteria have been proposed for data interpretation, because serum Zn concentration is affected by recent meals, time of day of sample collection, age, gender, systemic infections, inflammation or trauma (1,22,25,26).

Serum Zn concentration below 66.0 µg/dl (10.1 µmol/l) is the recommended cut-off point that indicates Zn deficiency for non-fasting, non-pregnant women (1,22,25,26).

During the various stages of pregnancy, blood volume expansion and hormonal changes cause variations in the Zn concentration in blood (1,22,25,26). Thus various cut-off points have been used to indicate Zn deficiency in pregnant women (17-19,27,28). However, according to the IZiNCG and others, trimester-specific cut-off points should be used for assessing the Zn status of pregnant women (21,22,25, 26). In the first trimester, serum Zn concentration below 56.0 µg/dl (8.6 µmol/l) indicates Zn deficiency while

in the second and third trimesters of pregnancy, serum Zn concentration below 50.0 µg/dl (7.6 µmol/l) indicates Zn deficiency (2,22,26). To control for infection, inflammation or trauma, the concentration of C-reactive protein (CRP) should be measured in each serum sample (1,2,7) and the results used for appropriate interpretation of the Zn status of the target population (1,2,7,22,26). Zn deficiency in a target population is considered to be of public health significance when the prevalence of Zn deficiency is greater than 20% (1,2,22,26).

Published data on the Zn status of Papua New Guinea (PNG) populations have been focused mainly on children (10,29), with no available data on pregnant women. There are published scientific data indicating a high prevalence of subclinical Zn deficiency status among pregnant women in some resource-limited countries (17,27,28,30,31). These reports are important because of the negative impact of Zn deficiency on maternal and fetal outcomes. Thus the need for continuous monitoring of the Zn status of pregnant women in resource-limited countries like PNG cannot be overemphasized.

Currently there are no published data on the prevalence of zinc deficiency among non-pregnant and pregnant women in PNG. The major objective of this study was to assess the Zn status of non-pregnant and pregnant women resident in the National Capital District (NCD), PNG.

Subjects and Methods

Study site

The primary site was the antenatal clinic in the Obstetrics and Gynaecology (O&G) Department in Port Moresby General Hospital (PMGH), which is the major, general, specialist and referral hospital in the National Capital District and PNG. PMGH is also the Teaching Hospital for the School of Medicine and Health Sciences (SMHS), University of Papua New Guinea (UPNG).

Sample size

Calculation of sample size was based on a design effect of one, relative precision of 10% and confidence level of 95%. As there were no available data on the likely prevalence rate of zinc deficiency among women in NCD, a prevalence rate of 25% was assumed. The

sample size of about 160 was obtained for a predicted non-response rate of 20% (32).

Study design and sampling

This was partly a hospital outpatient-based cross-sectional study, because it is difficult to get pregnant women outside the hospital to donate blood samples for research. All pregnant women who attended the antenatal clinic in PMGH between May and July 2013 were eligible for enrolment in the study. The pregnant women were selected by simple random sampling after their routine examination by the O&G consultants. Non-pregnant, non-lactating women of childbearing age residing in NCD were selected randomly from staff and students in PMGH and SMHS.

Collection of blood samples and questionnaire data

The major aim of the study was explained to each of the women and their accompanying relative before requesting their signed informed consent. A non-fasting morning blood sample was obtained by venipuncture from each consented woman. The blood was transferred into a labelled sterile micronutrient-free polypropylene tube, placed into a cool-box kept at 4-8°C and transported to the Micronutrient Research Laboratory (MRL) in the SMHS, UPNG. The blood samples were centrifuged at 3500 rpm at 4°C for 30 minutes, after which aliquots of each serum were separated into two labelled sterile micronutrient-free Eppendorf vials and kept frozen at -70°C until required for analysis. Special precautions were taken to avoid contamination of the serum by ambient sources of Zn (1,2,22,24). A self-designed pretested questionnaire was used to collect specific information, including time of last meal, type of meal, time of sample collection, age, gestational age and residential location of each participant.

Exclusion criteria

Women with significant illness, those to be admitted in the wards, and women not resident within the NCD were excluded from the study.

Analysis of serum samples

The quantitative assay of Zn in serum was carried out in the PNG National Agricultural

Research Institute (NARI) Chemistry Laboratory, using the Varian AA 240 flame atomic absorption spectrometer. The recommended procedures and precautions for assay of serum Zn were implemented, including the use of four levels of standard serum samples for internal quality control (22,24). The FAAS parameters used were: wavelength 213.9 nm, slit width 1.0 nm, lamp current 4.0 mA, burner height 10.0 mm, acetylene flow 2.0 l/min, air flow 13.5 l/min and aspiration time 5 seconds (33). The assay of C-reactive protein in serum was carried out in the MRL in the SMHS, UPNG. A commercial enzyme immunoassay (EIA) kit for the in vitro diagnostic quantitative determination of CRP in serum was used (34). The controls provided by the manufacturer were used to determine the inter- and intra-assay coefficients of variation (CV), which were 3.0% and 2.4% respectively.

Data analysis and interpretation

The statistical package for social sciences (SPSS) version 20 for Windows and Excel MS data pack software were used for statistical analysis of data. Data distribution was determined by the Shapiro-Wilk test. The Chi-squared test, Fisher's Exact test, Mann-Whitney U test, Wilcoxon rank sum test and one-way analysis of variance (ANOVA) were used as appropriate.

In the present study, the results were interpreted using the recommended criteria proposed by the IZiNCG expert committee (1,22,25,26). Serum Zn concentration below 66.0 µg/dl (10.1 µmol/l) indicates Zn deficiency among non-pregnant women. Two cut-off points were used for the pregnant women, serum Zn concentration below 56.0 µg/dl (8.6 µmol/l) and below 66.0 µg/dl.

The trimester-specific cut-off points indicating Zn deficiency were used as follows: serum Zn below 56.0 µg/dl for pregnant women in the first trimester; serum Zn below 50.0 µg/dl (7.6 µmol/l) for pregnant women in the second and third trimesters. Other cut-off points were used for the purpose of comparing our results with published data in other countries. Risk of a public health problem is indicated when the prevalence of Zn deficiency is between 10 and 20% of the target population; a prevalence of above 20% indicates a public health problem (1,22,26). A serum CRP level below 8.0 µg/ml indicates a

normal CRP level (34).

Ethical clearance

Approval for this study was obtained from the Ethical and Research Grant Committee in the SMHS, UPNG, and the Medical Research Advisory Committee (MRAC), PNG National Department of Health (NDoH). Permission was obtained from the Chief Executive Officer and Director of Medical Services of PMGH. In addition, signed informed consent was obtained from each subject before collecting the blood sample.

Results

The total number of women recruited was 160, but informed consent was obtained from 127 women (response rate 79%). Of the 127 women who participated in the study, 27 (21%) were non-pregnant and 100 (79%) were pregnant. All the women indicated that they had consumed their regular meal before coming to the clinic in the morning. The various foodstuffs they had consumed included bread, rice, sago, sweet potato (kaukau), taro, yam, tapioca, breadfruit, green vegetables, betelnuts, peanuts, coconut, coconut milk, fruits, pork, tinned fish and other seafood.

The mean age of the non-pregnant women was 23.4 ± 2.7 years (mean \pm standard

deviation) and the age range was 19 to 33 years. The Shapiro-Wilk test ($p = 0.03$; $df = 27$) indicated that the serum Zn concentration for the non-pregnant women was not normally distributed. The box-plot of the serum Zn concentration (Figure 1) also indicates that the values were not normally distributed. The median serum Zn concentration for the non-pregnant women was $42.7 \mu\text{g/dl}$ and the interquartile range (IQR) was 27.6 to $91.2 \mu\text{g/dl}$. Zn deficiency was prevalent among 59% of the non-pregnant women (Table 1).

In order to assess the effect of acute infection on serum Zn concentration, the non-pregnant women were separated according to their serum CRP levels.

The serum CRP level was within the normal range in 24 (89%) of the 27 non-pregnant women; their serum Zn data obtained is presented in Table 1. The median and IQR serum Zn concentrations were $48.9 \mu\text{g/dl}$ and 30.2 to $98.7 \mu\text{g/dl}$ respectively. A very weak inverse correlation (Spearman's $\rho = -0.13$, $p = 0.35$) was obtained between the serum Zn concentrations and serum CRP levels for the non-pregnant women.

Using the Mann-Whitney U and Wilcoxon W tests, no significant difference ($p = 0.392$, 2-tailed) was obtained between the serum Zn concentrations for all the non-pregnant women and the non-pregnant women with normal

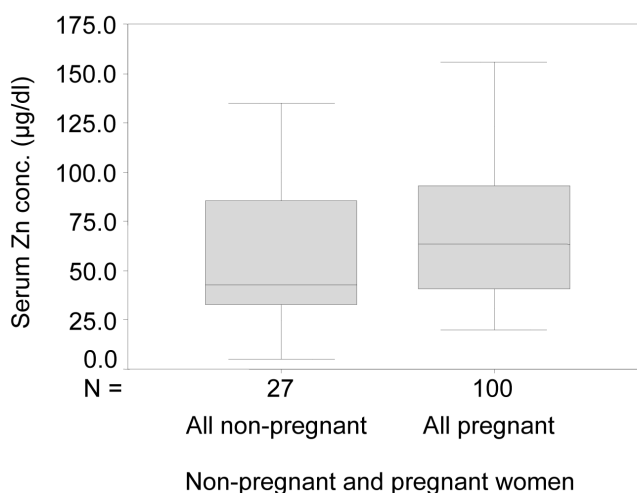


Figure 1. Box-plots of serum Zn concentrations ($\mu\text{g/dl}$) for all the non-pregnant and all the pregnant women.

TABLE 1

SERUM ZINC CONCENTRATION FOR ALL THE NON-PREGNANT WOMEN AND FOR THOSE WITH NORMAL SERUM CRP AND PERCENT BELOW THE CUT-OFF POINT THAT INDICATES ZINC DEFICIENCY

	Non-pregnant women (n = 27)	Non-pregnant women with normal CRP (n = 24)
Median serum Zn (µg/dl)	42.7	48.9
Interquartile range	27.6-91.2	30.2-98.7
Mean serum Zn (µg/dl)	58.3	61.4
Standard deviation	37.5	38.6
95% CI (µg/dl)	43.5-73.1	45.1-77.7
Percent (number) with serum Zn below 66.0 µg/dl	59.3% (16)	54.2% (13)

NB: divide µg/dl by 6.54 to convert to µmol/l

CRP = C-reactive protein

Zn = zinc

CI = confidence interval

serum CRP level. ANOVA also indicated no difference between the two groups ($F = 0.085$, $p = 0.77$). Zn deficiency was prevalent in 54% of the non-pregnant women with normal serum CRP level.

The mean age for the pregnant women was 26.0 ± 5.3 years and the age range was 16 to 42 years. The box-plot for the serum Zn concentrations for all the pregnant women is also presented in Figure 1, which shows that the data were slightly skewed. The Shapiro-Wilk test ($p = 0.001$, $df = 100$) further confirmed that the data were not normally distributed. Table 2 shows the serum Zn data obtained for all the pregnant women and for the pregnant women with normal serum CRP level. A very weak inverse correlation ($\rho = -0.108$, $p = 0.55$) was obtained between the serum Zn concentrations and serum CRP levels for all the pregnant women. No significant difference ($p = 0.095$, 2-tailed) was obtained between the serum Zn concentrations for all the pregnant women and pregnant women with normal serum CRP level. A similar result was obtained using ANOVA ($F = 3.304$, $p = 0.071$).

Using the serum Zn cut-off point of $56.0 \mu\text{g/dl}$, Zn deficiency was prevalent in 42% of all

the pregnant women, compared to 51% of the pregnant women with normal CRP. Analysis of the data for the 30 (30%) pregnant women with elevated serum CRP levels indicated that only 6 (20%) of them had a serum Zn concentration below the cut-off point indicating Zn deficiency.

Of the 100 pregnant women, 16 (16%) were in the first trimester, 51 (51%) in the second trimester and 33 (33%) in the third trimester of pregnancy. The mean ages of the pregnant women in the first, second and third trimesters were 26.1 ± 6.2 years, 26.0 ± 5.0 years and 26.0 ± 5.6 years, respectively. The corresponding age ranges were 23 to 42 years, 16 to 39 years and 17 to 36 years.

The distribution of the serum Zn concentrations for the pregnant women in their first, second and third trimesters are presented in the box-plots in Figure 2. The 3 box-plots are slightly skewed, thus indicating that the data were not normally distributed. The serum Zn data obtained for the pregnant women in the three trimesters of pregnancy are presented in Table 3. The median serum Zn concentrations of the pregnant women in the first, second and third trimesters were $87.0 \mu\text{g/dl}$, $61.6 \mu\text{g/dl}$ and $60.8 \mu\text{g/dl}$, respectively.

TABLE 2

SERUM ZINC CONCENTRATION FOR ALL THE PREGNANT WOMEN AND FOR THOSE WITH NORMAL SERUM CRP AND PERCENT BELOW THE TWO CUT-OFF POINTS THAT INDICATE ZINC DEFICIENCY

	All pregnant women (n = 100)	Pregnant women with normal CRP (n = 70)
Median serum Zn (µg/dl)	63.8	55.1
Interquartile range	40.9-93.2	40.3-68.6
Mean serum Zn (µg/dl)	68.0	58.9
Standard deviation	34.3	28.7
95% CI (µg/dl)	61.2-74.8	52.1-65.7
Percent (number) with serum Zn below 66.0 µg/dl	56.0% (56)	70.0% (49)
Percent (number) with serum Zn below 56.0 µg/dl	42.0% (42)	51.4% (36)

CRP = C-reactive protein

Zn = zinc

CI = confidence interval

No significant differences ($p > 0.05$) were obtained when the serum Zn concentrations in the various trimesters were compared. Table 3 also shows the Zn status of the pregnant women in the three trimesters according to the various cut-off points indicating Zn deficiency. Using the cut-off point of 56.0 µg/dl, zinc deficiency was prevalent in 31% of the pregnant women in the first trimester. Zn deficiency was prevalent in 39% and 36% of pregnant women in the second and third trimesters, respectively, using the cut-off point of 50.0 µg/dl.

The serum CRP level was within the normal range in 56%, 73% and 73% of the pregnant women in the first, second and third trimesters of pregnancy, respectively. The serum Zn data obtained for the three groups of pregnant women with normal serum CRP levels are also presented in Table 3. There were no significant differences ($p > 0.05$, 2-tailed) obtained when their serum Zn concentrations were compared. Using the appropriate cut-off points, Zn deficiency was prevalent in 33% of the pregnant women in the first trimester (cut-off point 56.0 µg/dl). The prevalence was 46% and 46% of the pregnant women in the

second and third trimesters, respectively (cut-off point 50.0 µg/dl).

Discussion

The mean serum Zn concentration (58.3 µg/dl) obtained for the non-pregnant women in the present study was higher than the 53.0 µg/dl reported for rural Malawian women (17), but lower than the values reported for women in Enugu, Nigeria (27), Uruguay, Brazil and Mexico (18). The prevalence (59%) of Zn deficiency was higher than that reported for non-pregnant women in these countries (17,18,23). In the present study, the prevalence (54%) of Zn deficiency among the non-pregnant women with normal CRP was higher than the 36% reported for a similar group of non-pregnant women in rural Malawi (17).

The high prevalence of Zn deficiency among the non-pregnant women in the present study should be of concern to program planners, because it may indicate a prolonged status of Zn depletion in the population. This is because, during short-term Zn depletion, the homeostatic mechanisms in the metabolic

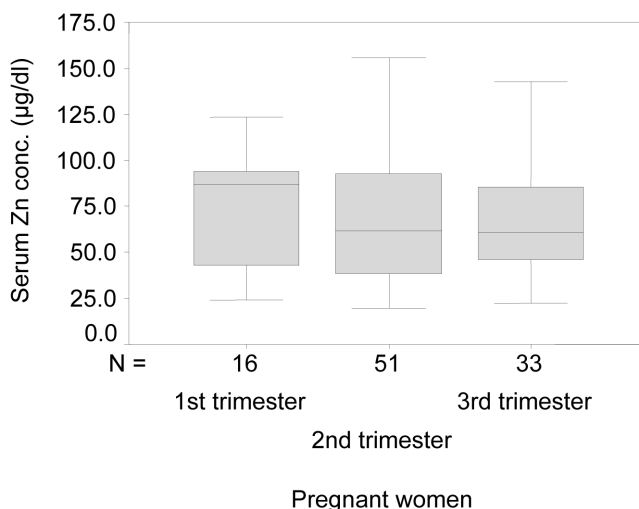


Figure 2. Box-plots of serum Zn concentrations ($\mu\text{g/dl}$) for the pregnant women in the first, second and third trimesters of pregnancy.

system can fairly well maintain serum Zn concentration within a normal range (1,26).

Suboptimal Zn status in non-pregnant women can be one of the major causes of Zn deficiency during pregnancy (1,19,26). Among the pregnant women in the present study, the prevalence of Zn deficiency was 42%. This was lower than the 55.5% in the urban slums of Delhi (35) and the 53% and 76% reported for pregnant women in Southern Ethiopia (9,13,36). In some developing countries (18,19,27,35,37), the cut-off point of 66.0 $\mu\text{g/dl}$ was used to indicate Zn deficiency among pregnant women. Using the same cut-off point, the prevalence among the pregnant women in the present study was 56%. This was higher than the 7 to 14% reported for pregnant women in Uruguay and Argentina (18), the 41% in India, the 54% in Sindh Province Pakistan (19) and the 50% in Pakistan (35,37), but lower than the over 64% prevalence reported for pregnant women in the rural areas in Haryana India and Bangladesh (19).

According to the IZiNCG, since blood volume expansion is not consistent across the three trimesters of pregnancy, changes in serum Zn concentrations are highly variable (1,22). Failure therefore to use trimester-specific cut-off points to indicate serum Zn deficiency may lead to erroneous interpretation of the data

obtained for pregnant women.

In the present study, the prevalence of Zn deficiency of 31% among pregnant women in the first trimester, 39% in the second trimester and 36% in the third trimester was lower than the respective prevalence (46.8%, 48.5% and 58.0%) reported for their counterparts in Southern Ethiopia (13). The 36% prevalence of Zn deficiency among the third trimester pregnant women in our study was lower than the over 70% reported for third trimester pregnant women in the rural areas of Ethiopia (9,36,37), but higher than the 22% reported for India (35).

Our results clearly indicate suboptimal Zn status among the non-pregnant and pregnant women in the NCD. According to the IZiNCG criteria (2,22,26), the extent of Zn deficiency should be considered as a public health problem among non-pregnant and pregnant women in the NCD. This should be of concern, because of the association between Zn deficiency and the potential risk to the fetus and neonate (1,9,12,20,30).

Suboptimal intake of dietary Zn, leading to high prevalence of Zn deficiency in a population group, may be due to several causes, including inadequate dietary intake of absorbable Zn, low bioavailability of Zn caused by anti-nutritional factors in ready-to-

TABLE 3

SERUM ZINC CONCENTRATION FOR ALL THE PREGNANT WOMEN IN THE FIRST, SECOND AND THIRD TRIMESTERS OF PREGNANCY AND FOR THOSE WITH NORMAL SERUM CRP AND PERCENT BELOW THE VARIOUS CUT-OFF POINTS THAT INDICATE ZINC DEFICIENCY

	Pregnant women					
	All first trimester (n = 16)	First trimester with normal CRP (n = 9)	All second trimester (n = 51)	Second trimester with normal CRP (n = 37)	All third trimester (n = 33)	Third trimester with normal CRP (n = 24)
Median serum Zn (µg/dl)	87.0	73.5	61.6	55.1	60.8	53.3
Interquartile range	42.2-94.0	43.0-110.4	37.4-93.0	35.4-67.8	43.6-87.0	40.6-63.6
Mean serum Zn (µg/dl)	79.1	83.5	65.8	55.7	66.0	54.6
Standard deviation	41.0	47.8	34.3	24.8	30.6	21.1
95% CI (µg/dl)	57.3-100.9	46.7-120.3	56.2-75.4	47.4-64.0	55.2-76.8	45.7-63.5
Percent (number) with serum Zn below 66.0 µg/dl	37.5% (6)	44.4% (4)	58.8% (30)	70.3% (26)	60.6% (20)	79.2% (19)
Percent (number) with serum Zn below 56.0 µg/dl	31.3% (5)	33.3% (3)	43.1% (22)	51.4% (19)	45.5% (15)	58.3% (14)
Percent (number) with serum Zn below 50.0 µg/dl			39.2% (20)	45.9% (17)	36.4% (12)	45.8% (11)

CRP = C-reactive protein
Zn = zinc
CI = confidence interval

eat foods, poor food choices and improper food preparation practices. It can also be caused by inadequate knowledge of dietary requirements, poor socioeconomic status, recurrent infections, or religious or cultural practices (1-4,13).

In the present study, the data obtained from the questionnaires indicated popular consumption of foodstuffs such as tubers, root crops, legumes, cereals and leafy vegetables, but lacking in micronutrient-rich foodstuffs like fish, meat, poultry, eggs, dairy products and a variety of fruits. Some of the roots, tubers, nuts and vegetables that are regularly consumed by the non-pregnant and pregnant women contain anti-nutritional factors, such as phytate, oxalate, tannins, saponins and dietary fibre, that chelate Zn, forming complexes that cannot be absorbed in the gastrointestinal tract (1-4,10,29,36-41). Thus the low availability of absorbable Zn may be one of the major contributing factors for the high prevalence of Zn deficiency among the non-pregnant and pregnant women in this study. In addition, haemodilution may potentiate Zn deficiency in pregnant women (1,26). Similar findings have been reported by others in some countries (17,19,27,28,35-37).

In order to achieve optimal Zn status among non-pregnant and pregnant women, an increase in the intake of dietary absorbable Zn is required. Some of the recommended long- and medium-term strategies include supplementation, fortification, dietary diversity (food-based strategies) and nutrition education (41-44). These strategies are usually complementary and not mutually exclusive. In the short term, women should be advised to consume a variety of foodstuffs with high absorbable Zn – foodstuffs such as fresh fruits, meat, poultry, eggs and dairy products – and also to use multivitamins that contain appropriate amounts of Zn and other micronutrients.

Our data also indicated a high prevalence of infection among the pregnant women, with 30% having an elevated serum CRP level. This implies that effective public health and community health policies should be included in all food-based sustainable intervention strategies, because poor sanitation, inadequate disease control measures and high prevalence of infection are often correlated with Zn deficiency (1,22,26). Thus to effectively reduce the current status of Zn

deficiency in the NCD, social mobilization, intensive education and awareness campaigns, including communication with all relevant target groups and the relevant policy makers, are urgently required.

Conclusions

Our results clearly indicate suboptimal Zn status among non-pregnant and pregnant women in the NCD. To achieve optimal Zn status among these women, an increase in the intake of dietary absorbable Zn is required. One of the short-term practical methods is to encourage consumption of foodstuffs with high bioavailability of zinc. In addition, basic nutrition education and aggressive advocacy of appropriate and adequate use of micronutrient-dense foodstuffs for optimal health should be carried out at the antenatal and well-baby clinics in PMGH and at all levels in the various communities in NCD.

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REFERENCES

- 1 **International Zinc Nutrition Consultative Group (IZiNCG), Brown KH, Rivera JA, Bhutta ZA, Gibson RS, King JC, Lönnerdal B, Ruel MT, Sandström B, Wasantwisut E, Hotz C.** International Zinc Nutrition Consultative Group (IZiNCG) Technical Document # 1. Assessment of the risk of zinc deficiency in populations and options for its control. *Food Nutr Bull* 2004;25(1 Suppl 2):S99-S203.
- 2 **Brown KH, Hess SY, eds.** International Zinc Nutrition Consultative Group Technical Document No 2. Systematic reviews of zinc intervention strategies. *Food Nutr Bull* 2009;30(1 Suppl):S1-S186.
- 3 **Gibson RS.** A historical review of progress in the assessment of dietary zinc intake as an indicator of population zinc status. *Adv Nutr* 2012;3:772-782.
- 4 **Temple VJ, Masta A.** Zinc in human health. *PNG Med J* 2004;47:146-158.

- 5 **Konukoglu D, Turhan MS, Ercan M, Serin O.** Relationship between plasma leptin and zinc levels and the effect of insulin and oxidative stress on leptin levels in obese diabetic patients. *J Nutr Biochem* 2004;15:757-760.
- 6 **Ennes Dourado Ferro F, de Sousa Lima VB, Mello Soares NR, Franciscato Cozzolino SM, do Nascimento Marreiro D.** Biomarkers of metabolic syndrome and its relationship with the zinc nutritional status in obese women. *Nutr Hosp* 2011;26:650-654.
- 7 **de Benoist B, Darnton-Hill I, Davidsson L, Fontaine O, Hotz C.** Conclusions of the Joint WHO/UNICEF/IAEA/IzinCG Interagency Meeting on Zinc Status Indicators. *Food Nutr Bull* 2007;28(3 Suppl):S480-S484.
- 8 **King JC.** Determinants of maternal zinc status during pregnancy. *Am J Clin Nutr* 2000;71(5 Suppl):1334S-1343S.
- 9 **Stoecker BJ, Abebe Y, Hubbs-Tait L, Kennedy TS, Gibson RS, Arbide I, Teshome A, Westcott J, Krebs NF, Hambidge KM.** Zinc status and cognitive function of pregnant women in Southern Ethiopia. *Eur J Clin Nutr* 2009;63:916-918.
- 10 **Gibson RS, Heywood A, Yaman C, Sohlström A, Thompson LU, Heywood P.** Growth in children from the Wosera subdistrict, Papua New Guinea, in relation to energy and protein intakes and zinc status. *Am J Clin Nutr* 1991;53:782-789.
- 11 **Gibson RS, Hess SY, Hotz C, Brown KH.** Indicators of zinc status at the population level: a review of the evidence. *Br J Nutr* 2008;99(Suppl 3):S14-S23.
- 12 **Shankar AH, Prasad AS.** Zinc and immune function: the biological basis of altered resistance to infection. *Am J Clin Nutr* 1998;68(2 Suppl):447S-463S.
- 13 **Gebremedhin S, Enquselassie F, Umata M.** Prevalence of prenatal zinc deficiency and its association with socio-demographic, dietary and health care related factors in rural Sidama, Southern Ethiopia: a cross-sectional study. *BMC Public Health* 2011;11:898-908.
- 14 **Caulfield LE, Zavaleta N, Shankar AH, Meriadi M.** Potential contribution of maternal zinc supplementation during pregnancy to maternal and child survival. *Am J Clin Nutr* 1998;68(2 Suppl):499S-508S.
- 15 **Tamura T, Goldenberg RL.** Zinc nutriture and pregnancy outcome. *Nutr Res* 1996;16:139-181.
- 16 **Goldenberg RL, Tamura T, Neggers Y, Copper RL, Johnston KE, DuBard MB, Hauth JC.** The effect of zinc supplementation on pregnancy outcome. *JAMA* 1995;274:463-468.
- 17 **Gibson RS, Huddle JM.** Suboptimal zinc status in pregnant Malawian women: its association with low intakes of poorly available zinc, frequent reproductive cycling, and malaria. *Am J Clin Nutr* 1998;67:702-709.
- 18 **Severi C, Hambidge M, Krebs N, Alonso R, Atalah E.** Zinc in plasma and breast milk in adolescents and adults in pregnancy and postpartum; a cohort study in Uruguay. *Nutr Hosp* 2013;28:223-228.
- 19 **Pathak P, Kapil U, Dwivedi SN, Singh R.** Serum zinc levels amongst pregnant women in a rural block of Haryana State, India. *Asia Pac J Clin Nutr* 2008;17:276-279.
- 20 **Chaffee BW, Kinga JC.** Effect of zinc supplementation on pregnancy and infant outcomes: a systematic review. *Paediatr Perinat Epidemiol* 2012;26(Suppl 1):118-137.
- 21 **de Benoist B, Darnton-Hill I, Davidsson L, Fontaine O, Hotz C.** Recommendations for indicators of population zinc status. Report of WHO/UNICEF/IAEA/IzinCG Interagency Meeting on Zinc Status Indicators. *Food Nutr Bull* 2007;28(3 Suppl):S399-S400.
- 22 **International Zinc Nutrition Consultative Group.** Assessing population zinc status with serum zinc concentration. Technical Brief No 2, 2012, 2nd edition. Davis, California: IZINCG, 2012:1-4. www.izincg.org
- 23 **Gibson RS.** Determining the risk of zinc deficiency: assessment of dietary zinc intake. Technical Brief No 3, 2007. Davis, California: International Zinc Nutrition Consultative Group (IZINCG), 2007:1-4. www.izincg.com
- 24 **International Zinc Nutrition Consultative Group.** Practical tips: Collecting blood in the field for assessment of plasma zinc concentration. Davis, California: IZINCG, 2012. www.izincg.org/publications/practical-tips
- 25 **Brown KH.** Effect of infections on plasma zinc concentration and implications for zinc status assessment in low-income countries. *Am J Clin Nutr* 1998;68(2 Suppl):425S-429S.
- 26 **Hotz C, Pearson JM, Brown KH.** Suggested lower cutoffs of serum zinc concentrations for assessing zinc status: reanalysis of the second National Health and Nutrition Examination Survey data (1976-1980). *Am J Clin Nutr* 2003;78:756-764.
- 27 **Ejezie FE, Nwagha UI.** Zinc concentration during pregnancy and lactation in Enugu, South-East Nigeria. *Ann Med Health Sci Res* 2011;1:69-76.
- 28 **Akhtar S.** Zinc status in South Asian population: an update. *J Health Popul Nutr* 2013;31:139-149.
- 29 **Ross J, Gibson RS, Sabry JH.** A study of seasonal trace element intakes and hair trace element concentrations in selected households from the Wosera, Papua New Guinea. *Trop Geogr Med* 1986;38:246-254.
- 30 **Wessells KR, Brown KH.** Estimating the global prevalence of zinc deficiency: results based on zinc availability in national food supplies and the prevalence of stunting. *PLoS One* 2012;7:e50568.
- 31 **Torheim LE, Ferguson EL, Penrose K, Arimond M.** Women in resource-poor settings are at risk of inadequate intakes of multiple micronutrients. *J Nutr* 2010;140:2051S-2058S.
- 32 **Bartlett JE, Kotlik JW, Higgins CC.** Organizational research: determining appropriate sample size in survey research. *Inform Tech Learn Perform J* 2001;19:43-50.
- 33 **Jian-Xin Q.** Determination of Cu, Zn, Fe, Ca, Mg, Na and K in serum by flame atomic absorption spectroscopy. Varian AA Instruments at Work, No AA-93, 1990:1-2. www.ccservices.ru/lab/res/aa093_3.pdf
- 34 **IBL International GmbH.** CRP (C-reactive protein) ELISA: enzyme immunoassay for the in-vitro-diagnostic quantitative determination of C-reactive protein in human serum and plasma. Hamburg, Germany: IBL International GmbH, 2013. www.IBL-International.com
- 35 **Kapil U, Pathak P, Singh P, Singh C.** Zinc and magnesium nutriture amongst pregnant mothers of urban slum communities in Delhi: a pilot study. *Indian Pediatr* 2002;39:365-368.
- 36 **Abebe Y, Bogale A, Hambidge KM, Stoecker BJ, Arbide I, Teshome A, Krebs NF, Westcott JE, Bailey KB, Gibson RS.** Inadequate intakes of dietary zinc among pregnant women from subsistence households in Sidama, Southern Ethiopia. *Public Health Nutr* 2008;11:379-386.
- 37 **Hambidge M, Abebe Y, Gibson R, Westcott JE,**

- Miller LV, Lei S, Stoecker BJ, Arbide I, Teshome A, Bailey KB, Krebs NF.** Zinc absorption during late pregnancy in rural Southern Ethiopia. *Am J Clin Nutr* 2006;84:1102-1106.
- 38 **Saweri W.** Papua New Guinea nutrition overview. Report of Technical Advisor Nutrition, Family Health Unit, National Department of Health. Port Moresby: Papua New Guinea Department of Health, 2002:1-3.
- 39 **Food and Agricultural Organization of the United Nations.** Nutrition country profiles: Papua New Guinea. Rome: Food and Agricultural Organization of the United Nations, 2003:6-33. <ftp://ftp.fao.org/es/esn/nutrition/ncp/png.pdf>
- 40 **Papua New Guinea Department of Health, United Nations Children's Fund Papua New Guinea, University of Papua New Guinea, Centers for Disease Control and Prevention.** Papua New Guinea National Nutrition Survey, 2005. *Pac J Med Sci* 2011;8:75-80.
- 41 **Temple VJ.** Ending hidden hunger: is there a weak link? *AJFAND* 2012;12(7):1-11.
- 42 **World Health Organization, Food and Agricultural Organization of the United Nations.** The role of food fortification in the control of micronutrient malnutrition. In: Allen L, de Benoist B, Dary O, Hurrell R, eds. Guidelines on Food Fortification with Micronutrients. Geneva: World Health Organization and Food and Agricultural Organization of the United Nations, 2006:3-37.
- 43 **Gibson RS.** Preventing zinc deficiency through diet diversification and modification. Technical Brief No 5, 2007. Davis, California: International Zinc Nutrition Consultative Group (IZiNCG), 2007:1-4. www.izincg.org
- 44 **Thurnham DI.** Multiple micronutrient nutrition: evidence from history to science to effective programs. Workshop Proceedings: Second World Congress of Public Health Nutrition, Porto, Portugal, 23-25 Sep 2010. *Sight and Life* 2012;26:28-42.

Knowledge, attitude and practice of mothers towards breastfeeding in rural Papua New Guinea: a mixed method study

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SUMMARY

Background: Although the World Health Organization (WHO) recommends exclusive breastfeeding in the first 6 months of life as the proven safest feeding practice, recent studies from Papua New Guinea (PNG) showed that the rate of exclusive breastfeeding was well below the world average. There is a paucity of recent studies on breastfeeding in rural PNG, and this study aimed to identify the knowledge of, attitudes towards and practice of breastfeeding by rural mothers. **Methods:** A mixed method study using face-to-face interviews based on semi-structured questionnaires was conducted among rural mothers (n = 40) in 2014. Purposive homogeneous sampling was used to select participants. We included mothers in the child-bearing age of 18-40 years who had a child under the age of three years, and who could speak Tok Pisin. Content analysis for qualitative data and descriptive statistics for quantitative data were applied. **Results:** Despite the fact that most mothers regarded breastfeeding to be a better way of infant feeding than bottle feeding, they did not understand the reasons why. With regard to exclusive breastfeeding for the first 6 months of life our study showed a striking gap between global recommendation and practice. 78% of mothers (n = 31) in our study did not practise exclusive breastfeeding for the first 6 months of their baby's life. Given that the majority of mothers had not completed grade 8, during which formal education on infant feeding practices is supposed to take place, most of the mothers had missed school education on infant feeding. **Conclusion:** Knowledge about the importance of exclusive breastfeeding in the first 6 months of life and its practice was very poor. Because promotion of breastfeeding practices in developing countries has been shown to be one of the most cost-effective health interventions, we suggest the introduction of infant feeding teaching in grade 4 in school curricula and the development of community-based educational programs on infant feeding.

Introduction

The World Health Organization (WHO) strongly recommends exclusive breastfeeding for the first 6 months of life (1). Breast milk provides nutrition for the baby and protects the baby from sickness. In addition, breastfeeding promotes bonding between mother and child (2). Several studies have emphasized that exclusive breastfeeding in early infant life has numerous advantages for growth, immunity and prevention of illness in young infants (3-5). Breastfed infants have a lower rate of malnutrition, reduced risk of infectious diseases such as diarrhoea and pneumonia, and a lower mortality rate than

those who are exposed to commercial feeding formulas (6,7). Breastfeeding also helps to optimize neurological development in infants, and in mothers delays the return of fertility, and lowers the risks of ovarian cancer, premenopausal breast cancer and osteoporosis (4,8-10).

Breastfeeding is a public health issue because it is critical for child health and survival (11,12). It has been estimated that optimal breastfeeding of children under 2 years of age has the potential to prevent 1.4 million deaths annually in the developing world (13). In low- and middle-income countries promotion of exclusive breastfeeding practices in early

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infant life is one of the most cost-effective health interventions for reducing infant morbidity and mortality (14). A systematic review of studies on the cost-effectiveness of breastfeeding interventions shows evidence for the use of women's groups, home-based newborn care using community health workers or traditional birth attendants, providing routine antenatal care, and the promotion of breastfeeding in maternity hospitals (15).

Despite the landmark legislation of 1977 to protect breastfeeding (16), a study 18 years later found that 20% of mothers surveyed had used bottles (17). The studies on infant feeding which have been conducted in PNG have predominantly targeted mothers in urban settings (16-18) while few studies have reported infant feeding practices in rural PNG (19,20).

This study therefore aimed to evaluate the knowledge of, beliefs about and practice of breastfeeding among rural mothers.

Methods

This mixed method study, in which a qualitative study was embedded into a quantitative survey, was carried out in Markham District, Morobe Province and Walium District, Madang Province between August and September, 2014. Open-ended questions were embedded into a semi-structured questionnaire. We adopted purposive homogeneous sampling to select 40 well mothers aged between 18 and 40 years who had a child less than three years of age. The mothers were recruited both in the antenatal clinic and villages during medical patrols. The mothers were interviewed in Tok Pisin by field workers (university students) trained by the senior researcher using a semi-structured questionnaire which included 4 parts relating to the demographic characteristics of the participants and their knowledge, attitude and practice towards infant feeding. Answers to closed questions were recorded manually while answers to open-ended questions were audio-recorded and transcribed. Content analysis for the qualitative data and descriptive statistics for the quantitative data using the mean for continuous and proportions for categorical variables were applied. Some qualitative data were quantified.

Informed consent was obtained from the

participants to carry out the study, which received ethical clearance from the Divine Word University Research Ethics Committee.

Results

Demographic features

We collected data by a semi-structured interview from 40 mothers with an average age of 30 years (range 18-40). Table 1 shows the demographic features of the participants.

Attitudes and behaviours towards breastfeeding

Almost all of the mothers (98%) breastfed their babies; however, only 23% (n = 9) of them reported exclusive breastfeeding for the first 6 months of the baby's life.

The frequencies of various behaviours connected with breastfeeding are displayed in Table 2.

Colostrum was not given by 45% of mothers. The most common reason given by mothers for not giving colostrum was the belief that colostrum contains mother's "dirty from birth" and so is "harmful to child". The majority of the mothers (78%, n = 31) introduced food within 4-6 months for varied reasons. 14 mothers thought that breastfeeding provided inadequate supply for their babies and 2 mothers thought they can give semi-solid food because their babies had developed their first teeth. Some of them started giving supplementary food as early as 2 months. Common supplementary food given to babies under 6 months was mashed pawpaw (papaya), pumpkin, sweet potato, ripe banana and 'kulau' (coconut juice).

70% (n = 28) of the lactating mothers admitted having some food taboos. Interestingly, we noted that elderly multiparous lactating mothers tended to keep food taboos while most of the primiparous mothers did not follow food taboos; however, the difference was not considered significant. Breaking those taboos was believed to cause the child to become sick or crippled, stunted in growth or attain undesirable features of the eaten animal. For instance, one mother said that if she eats fish when breastfeeding, "her baby may develop 'grille' [tinea imbricate] where baby's skin will be scaling like fish scales". Table 3 shows the different types of food

TABLE 1

DEMOGRAPHIC CHARACTERISTICS OF STUDY PARTICIPANTS

Characteristic	Number	%
Age group (years)		
18-25	16	40
26-35	17	43
36-40	7	18
Educational level (grade)		
Illiterate	14	35
<4	3	8
4-8	17	43
9-12	3	8
>12	3	8
Number of children/parity		
Primipara	10	25
Multipara	25	63
Grand multipara	5	13

TABLE 2

BREASTFEEDING BEHAVIOUR OF THE STUDY SAMPLE

Behaviour	Number	%
Colostrum		
Colostrum given	22	55
Not given	18	45
How often breastfed		
3-5 times/day	17	43
6-8 times/day	19	48
Whenever necessary	4	10
Exclusive breastfeeding		
Yes	9	23
No	31	78

restriction imposed on the mothers during the lactation period and their common underlying beliefs.

More than half ($n = 25$, 63%) of mothers stated that breastfeeding promotes healthy growth of babies. A quarter ($n = 10$, 25%) considered breast milk to protect infants against sicknesses common to small children. 13% of the participants considered that among its advantages breastfeeding did not cost money and established a bond between mother and child. 65% ($n = 26$) of husbands were supportive of their wives' breastfeeding practice, while the other 35% did not have any influences. Three-quarters of the mothers had visited antenatal clinics during the course of their pregnancy, although some may have attended only once or twice. Only one mother had used a bottle. A number of participating mothers said they had heard about the effects of bottle feeding, such as diarrhoea, but had not actually used bottle feeding themselves. 58% ($n = 23$) of the participants still had sex while breastfeeding. The remaining mothers who did not practise sex while breastfeeding believed that if they had sex while lactating, the baby may not grow well but will be weak and sickly.

Some of the mothers ($n = 8$) said that they had seen babies who were bottle fed and became ill with diarrhoea and other illnesses. Other conditions observed by participants in bottle-fed babies included enlarged abdomen and small or tiny hands and legs as well as malnutrition. The majority of mothers considered bottle feeding to be not good and not healthy.

Discussion

Practice of breastfeeding

In order to achieve a child's optimal growth, development and health, the WHO recommends exclusive breastfeeding for the first six months of a child's life and continued breastfeeding up to two years of age (1,21). Our study found that only 23% of mothers practised exclusive breastfeeding for the first 6 months. This is lower than the rate recorded in West New Britain (about 50%) (19) but consistent with other studies reporting the prevalence of exclusive breastfeeding at six months, which varied from 9% (22) to 39% (23).

The existing huge gap between

TABLE 3

FOOD TABOOS AND REASONS FOR THEM AMONG LACTATING MOTHERS, PAPUA NEW GUINEA, 2014

Food type	Restricted food	Number of mothers	Reason
Protein	Cuscus (possum)	7	Makes the child crippled or paralyzed
	Fish	2	Child may have 'grille' because of fish scales
	Bandicoot	8	Child will have shortness of breath
	Pork fat ('gris pik')	2	Unhealthy for babies
Plant	Aibika leaf (<i>Hibiscus manihot</i>)	2	Sticky sap from the plant can cause blindness
	Sago	3	Child delays to walk
	Yellow 'marita' (<i>Pandanus conoideus</i>)	4	Believed to remove blood from body so child can have 'sot blut' (anaemia)

breastfeeding practice in low-income countries and global recommendations calls for more initiative in the promotion of exclusive breastfeeding. Breastfeeding promotion interventions in developing countries have resulted in a 6-fold increase in exclusive breastfeeding rates at six months (24). The promotion of breastfeeding has been shown to be one of the most effective public health interventions, reducing under five mortality by 13% (14). Breastfeeding promotion should, therefore, become a health priority in low- and middle-income countries.

Our findings of a very high rate of breastfeeding by rural mothers (98%) were consistent with a previous study in a rural setting of Papua New Guinea (PNG) (20). The prevalence of bottle feeding in our study (2%) differed considerably from findings in an urban situation, where 40% of mothers had experience with bottle feeding (18). Dissimilar employment status of mothers in rural and urban situations might be one factor that accounts for the difference.

Knowledge and attitudes towards breastfeeding

Although almost all the mothers commended breast milk as being the best for their babies, their knowledge about the advantages of breastfeeding and the hazards associated with bottle feeding of babies was very low. Although the advantages were identified and discussed, there was still inadequate knowledge about the advantages of breastfeeding compared with bottle feeding among the mothers.

In the current school curriculum teaching on infant feeding is taught in grade 8. Since more than half of the women were either illiterate or had not progressed further than grade 4, they had not received formal school education on infant feeding.

The majority of husbands were supportive of their wives breastfeeding their babies. However, 27% of husbands had at least some influence on their wives' early cessation of breastfeeding. As indicated by another study, a possible reason was that custom restricted them from having sex when the wife was still breastfeeding (20).

In our study traditional beliefs affected infant feeding practices predominantly in two

areas: blocking mothers from feeding babies with colostrum and imposing various dietary restrictions and food taboos on lactating women. The custom of not giving colostrum is found in other countries, including India (25). Food taboos are known in various cultures and one of the possible explanations sustaining their existence is the belief that they protect mother and child from real or imaginary health hazards (26). Interestingly, food taboos were more frequently reported by older multipara than by young primipara. These findings were consistent with a previous study in rural PNG (20). Food taboos are a significant factor for lactating mothers, who were noted to be one of the most disadvantaged groups with regard to nutrition in PNG (27,28). A better understanding of customary beliefs towards breastfeeding and nutrition of lactating women will allow more effective breastfeeding education and promotion.

Limitations of the study

Because of the small sample, non-probability sampling and limited ethnic representation, the findings may not be representative of the rural population of PNG.

Conclusions and recommendations

Rural mothers' knowledge about good breastfeeding practices, particularly about exclusive breastfeeding in the first six months of life, is very poor. There is a wide gap between global recommendations for exclusive breastfeeding in early infant life and the practice in PNG.

More attention in health planning should be given to the promotion of good breastfeeding practices. In particular, promotion should target the large proportion of women with low education status, who have missed formal school education on infant feeding. All opportunities to educate mothers on the importance of exclusive breastfeeding in the first 6 months of their baby's life, including attendance at antenatal clinics and well-baby clinics, should be taken.

Although the PNG National Health Plan 2011-2020 indicated that "to improve child survival, health workers must emphasize more on breastfeeding", proper planning and implementation and monitoring of breastfeeding interventions at community level are yet to be developed.

REFERENCES

- 1 **World Health Organization.** The optimal duration of exclusive breastfeeding. Report of the expert consultation. Geneva: World Health Organization, 2001. www.who.int/nutrition/publications/infantfeeding/WHO_NHD_01.09/en/
- 2 **Newton N.** Psychologic differences between breast and bottle feeding. *Am J Clin Nutr* 1971;24: 993-1004.
- 3 **Arifeen S, Black RE, Antelman G, Baqui A, Caulfield L, Becker S.** Exclusive breastfeeding reduces acute respiratory infection and diarrhea deaths among infants in Dhaka slums. *Pediatrics* 2001;108:E67.
- 4 **Oddy WH, Sly PD, de Klerk NH, Landau LI, Kendall GE, Holt PG, Stanley FJ.** Breast feeding and respiratory morbidity in infancy: a birth cohort study. *Arch Dis Child* 2003;88:224-228.
- 5 **Kalanda BF, Verhoeff FH, Brabin BJ.** Breast and complementary feeding practices in relation to morbidity and growth in Malawian infants. *Eur J Clin Nutr* 2006;60:401-407.
- 6 **Stuebe AM, Bonuck K.** What predicts intent to breastfeed exclusively? Breastfeeding knowledge, attitudes, and beliefs in a diverse urban population. *Breastfeed Med* 2011;6:413-420.
- 7 **Mohite RV, Mohite VR, Kakade SV.** Knowledge of breast feeding among primigravida mothers. *Bangladesh Journal of Medical Science* 2012;11:312-316.
- 8 **Brown C, McVeigh A.** Keeping abreast. Health Promotion Agency Breastfeeding Conference, London, UK, 2002.
- 9 **Choua G, El Kari K, El Haloui N, Slater C, Aguenauou H, Mokhtar N.** Quantitative assessment of breastfeeding practices and maternal body composition in Moroccan lactating women during six months after birth using stable isotopic dilution technique. *Int J Matern Child Health* 2013;1:45-50.
- 10 **Brown KH, Black RE, Lopez de Romaña G, Creed de Kanashiro H.** Infant-feeding practices and their relationship with diarrheal and other diseases in Huascar (Lima), Peru. *Pediatrics* 1989;83:31-40.
- 11 **Cai X, Wardlaw T, Brown DW.** Global trends in exclusive breastfeeding. *Int Breastfeed J* 2012;7:12.
- 12 **World Health Organization.** Report of the expert consultation on the optimal duration of exclusive breastfeeding. Geneva: World Health Organization, 2002.
- 13 **Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C, Rivera J; Maternal and Child Undernutrition Study Group.** Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* 2008;371:243-260.
- 14 **Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS; Bellagio Child Survival Study Group.** How many child deaths can we prevent this year? *Lancet* 2003;362:65-71.
- 15 **Mangham-Jefferies L, Pitt C, Cousens S, Mills A, Schellenberg J.** Cost-effectiveness of strategies to improve the utilization and provision of maternal and newborn health care in low-income and lower-middle-income countries: a systematic review. *BMC Pregnancy Childbirth* 2014;14:243. www.biomedcentral.com/1471-2393/14/243
- 16 **Benjamin A, Biddulph J.** Port Moresby infant feeding survey, 1979. *PNG Med J* 1980;23:92-96.
- 17 **Friesen H, Vince J, Boas P, Danaya R, Mokela D, Ogle G, Asuo P, Kemiki A, Lagani W, Rongap T, Varughese M, Saweri W.** Infant feeding practices in Papua New Guinea. *Ann Trop Paediatr* 1998;18:209-215.
- 18 **Frank D, Ripa P, Vince JD, Tefuarani N.** Knowledge and attitudes about infant feeding among nulliparous and parous women in Port Moresby: a comparative study. *PNG Med J* 2008;51:5-11.
- 19 **Ayers D.** Infant care and feeding in Kaliai, West New Britain, Papua New Guinea. *Food and Nutrition in History and Anthropology* 1978;3:155-170.
- 20 **Kuzma J.** Knowledge, attitude and practice related to infant feeding among women in rural Papua New Guinea: a descriptive, mixed method study. *Int Breastfeed J* 2013;8:16.
- 21 **World Health Organization.** Infant and young child nutrition. Resolution WHA54.2 of the Fifty-fourth World Health Assembly, Geneva, 14-17 May 2001.
- 22 **Ulak M, Chandyo RK, Mellander L, Shrestha PS, Strand TA.** Infant feeding practices in Bhaktapur, Nepal: a cross-sectional, health facility based survey. *Int Breastfeed J* 2012;7:1.
- 23 **Lauer JA, Betrán AP, Victora CG, de Onís M, Barros AJD.** Breastfeeding patterns and exposure to suboptimal breastfeeding among children in developing countries: review and analysis of nationally representative surveys. *BMC Med* 2004;2:26.
- 24 **Imdad A, Yakoob MY, Bhutta ZA.** Effect of breastfeeding promotion interventions on breastfeeding rates, with special focus on developing countries. *BMC Public Health* 2011;11(Suppl 3):S24.
- 25 **Reddy S.** Breastfeeding: practices, problems and prospects. *J Fam Welfare* 1995;41:43-51.
- 26 **Meyer-Rochow VB.** Food taboos: their origins and purposes. *J Ethnobiol Ethnomed* 2009;5:18.
- 27 **Gillett JE.** The Health of Women in Papua New Guinea. Papua New Guinea Institute of Medical Research Monograph No 9. Goroka: Papua New Guinea Institute of Medical Research, 1990.
- 28 **Saweri W.** The rocky road from roots to rice: a review of the changing food and nutrition situation in Papua New Guinea. *PNG Med J* 2001;44:151-163.

Randomized clinical trial to compare a single dose with 3 doses of prophylactic antibiotic in open reduction and internal fixation of the fractures of long bones

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SUMMARY

To reduce the incidence of surgical site infection (SSI), perioperative antimicrobial prophylaxis has long been advocated for joint replacement and open reduction with internal fixation of long bones. Increasing health care costs have focused hospital interest on more cost-effective procedures. Although current literature indicates that single-dose antibiotic prophylaxis is comparable to a 3-dose regimen, there are no reports from low-income countries. The primary aim of this study was to compare the infection rate following open reduction and internal fixation of long-bone fractures in groups with a single dose and 3 doses of prophylactic antibiotic. The secondary aim was to compare the cost-effectiveness of both antibiotic regimens. This is a prospective randomized clinical trial (RCT) to compare the incidence of surgical site infection between the patients allocated randomly into two groups with different antibiotic prophylactic regimens: single dose or 3 doses 8 hourly of 1g ceftriaxone administered intravenously. 200 consecutive patients who underwent open reduction and internal fixation (ORIF) for closed long-bone fractures were enrolled in this study. The rate of postoperative SSI was 4.1% in the single-dose group and 2.2% in the 3-dose group; the overall SSI rate was 3.2%. The primary endpoint of this study, which is the incidence of SSI, showed no significant difference between the single-dose and 3-dose prophylactic antibiotic groups. Furthermore, there was no difference between groups regarding the length of hospital stay. Our randomized clinical trial affirmed that single-dose antibiotic prophylaxis in orthopaedic clean operations is not only a cost-saving practice but also is effective for SSI prevention, and should be incorporated in the development of clinical practice guidelines in tropical hospitals.

Introduction

Despite the knowledge about preventing infection and the advancement in contemporary surgery, infection is still one of the most feared complications of a surgical procedure. Perioperative antimicrobial prophylaxis has long been advocated in certain types of clean and clean-contaminated surgical procedures to decrease the incidence of surgical site infection (SSI) (1).

The usefulness of antimicrobial prophylaxis

for joint replacement and open reduction with internal fixation of long bones has been confirmed by many studies to reduce the incidence of SSI from 8-12% to 1-3.6% (2-5).

Although Zgonis et al. (6) reported no difference in SSI rate in the foot and ankle surgery in the groups with and without antibiotic prophylaxis, the evidence from a meta-analysis of 22 studies demonstrated that single-dose antibiotic prophylaxis for patients undergoing surgical management of hip and long-bone fractures reduced the incidence

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of superficial and deep wound infections significantly (2).

A few studies indicated that a single dose of antibiotic given before the incision was as effective as 3 doses of antibiotic (1-2). These results have been incorporated in the recently published guidelines for the correct use of prophylactic antibiotics; these guidelines and publications showed that 1-dose prophylaxis was efficacious for most procedures (7,8).

Unfortunately, experience has shown that surgeons' compliance with these recommendations could be hard to obtain (9,10).

Increasing health care costs have forced hospitals and clinics to review procedures aiming at cost reduction. Also, concerns with antimicrobial resistance have pressured infection control specialists to decrease antimicrobial usage (1).

Although current literature indicates that results of an application of single-dose antibiotic prophylaxis are comparable to results of 3 doses, one should notice that authors are not familiar with the studies from low-income countries. In the perspective of a low-income country hospital, we would like to provide evidence that single-dose antibiotic is cost-effective and is applicable in our conditions.

The primary aim of this study was to compare the SSI rate following open reduction and internal fixation of long-bone fractures in groups with a single dose and 3 doses of prophylactic antibiotic. The secondary aim was to compare the cost-effectiveness of both antibiotic regimens.

Methodology

Study design

We performed a prospective randomized clinical trial (RCT) to compare the incidence of surgical site infection between the patients allocated randomly into two groups with different antibiotic prophylactic regimens: single dose or 3 doses 8 hourly of 1 g ceftriaxone administered intravenously (IV). The study was conducted between January 2010 and July 2012 in the orthopaedic units of two teaching hospitals: Port Moresby General Hospital and Modilon General Hospital in

Madang.

Inclusion criteria: All consecutive patients who underwent open reduction and internal fixation (ORIF) by plates or intramedullary devices for closed long-bone fractures were enrolled in this study. The definition of long-bone fracture includes closed fracture of femur, tibia, fibula, humerus, radius and ulna. There were no limits regarding minimal and maximal age for included patients.

Exclusion criteria: Patients who declined to participate or withdrew their consent in the course of the study were excluded. Also patients with open fractures or presence of other infection or severe injury such as burns or severe head, abdominal or chest injury, or who had already been treated with antibiotics were excluded.

After assessing the eligibility criteria and obtaining informed consent, patients were assigned randomly to the groups receiving a single dose or 3 doses of prophylactic antibiotic. Random allocation was performed in a blind manner by hand drawing from a box of sealed opaque envelopes. The selected envelope was opened by the surgical registrar before proceeding with the application of antibiotic prophylaxis and the patient's group allocation was marked on the research form. Blinding of the investigators and patients was not possible owing to the nature of the management protocols.

Patient management

Antibiotic administration protocol: The 1-dose antibiotic protocol defined that 1 g of ceftriaxone was given intravenously at anaesthesia induction (15 minutes before the tourniquet application or skin cutting where a tourniquet was not applied). No doses were given when the operation lasted longer than usual or after the end of surgery. The 3-dose antibiotic protocol followed the same description except that 1 g of ceftriaxone was repeated two times 8 hourly.

All patients received dressing with dry gauze covered with a few layers of sterile orthopaedic wool and compressed with an elastic or crepe bandage ('cocoon dressing').

If required, the patients were shaved just before the operation in the operating theatre. All drains, if applied, were removed within 24

hours.

Outcome measures

In the current study we compared the outcome of two modes of antibiotic prophylaxis in surgical management of long-bone fractures. The primary endpoints of this study are the incidence of surgical site infection in two periods measured by in-hospital surveillance and post-discharge surveillance (at 4 and 6 weeks after operation) and the costs of both modes of antibiotic prophylactic. Incisional SSI, organ SSI and space SSI were checked for daily by an attending surgeon until hospital discharge and checked for again at the postoperative hospital visits.

The secondary endpoints of the study are other postoperative complications and the length of hospital stay. In addition, to compare the demographic features of both groups and analyse the relationship with some known risk factors for postoperative infections, we collected the following data: sex, age, haemoglobin level, smoking habits, body mass index (BMI), thickness of subcutaneous tissue, comorbidities, American Society of Anesthesiologists' (ASA) score, duration from the admission to the operation, type of operative procedure, operative time and number of people in the operating theatre present during the procedure.

Statistical analysis

Our Orthopaedic Department had previously administered antimicrobial prophylaxis for 1-2 days after the operation and the incidence of postoperative SSI after operation of long-bone fractures was about 6%. When the incidence of SSI was predicted to be 6%, the number of cases required to analyse as a non-inferiority test was 89 per group, when the significance level, power and tolerance difference were set to 0.025, 80% and 10%, respectively. Therefore, a sample size of 89 cases per group was deemed as satisfactory to obtain statistically significant results. All analyses were performed as intention-to-treat. To compare frequencies of categorical variables between two groups the Mann-Whitney U test was used. Continuous variables were expressed as means and standard deviation and analysed by two-way t-test for two groups. The association between mode of antibiotic prophylaxis and the SSI rate was analysed by the Chi-squared

test with Yates correction and Fisher's Exact test. Multivariate logistic regression analysis was used to examine the relationship between known risk factors and SSI. A p value of less than 0.05 was considered significant.

Judgement criteria of SSI

The incidence of the surgical site infections after surgery was compared between the two groups. Diagnosis of SSI was made by the attending surgeon or surgical registrar. When postoperative infection was diagnosed during the study, the treatment was changed to therapeutic antimicrobial agents. We used the definitions for SSI described by the Centers for Disease Control and Prevention (11).

Ethical considerations

Written informed consent (Pidgin and English version) was obtained from each participant in the study. The study had been approved by the University of Papua New Guinea (UPNG) Ethics Committee.

Results

Figure 1 shows the flow chart of the trial. The patients' demographic characteristics and some of the known risk factors for surgical site infections are presented in Table 1.

In our study, the rate of postoperative SSI was 4.1% in the single-dose group and 2.2% in the 3-dose group; the overall SSI rate was 3.2%.

The primary endpoint of this study, which is the incidence of SSI, showed no significant difference between the single-dose and 3-dose prophylactic antibiotic groups (Chi-squared with Yates correction, $\chi^2 = 0.122$; $p = 0.7$ or Fisher's Exact test [two-tail], $p = 0.7$).

Furthermore there was no difference between the groups regarding the length of hospital stay ($p = 0.2$; t-test). Comparison of demographic features and risk factors between the two groups showed some differences in bone type profile, number of people in the operating theatre, thickness of subcutaneous tissue, operative time and drain application (Table 1). None of these differences were considered clinically significant. Multivariate logistic regression identified only male sex as an independent risk factor for surgical site

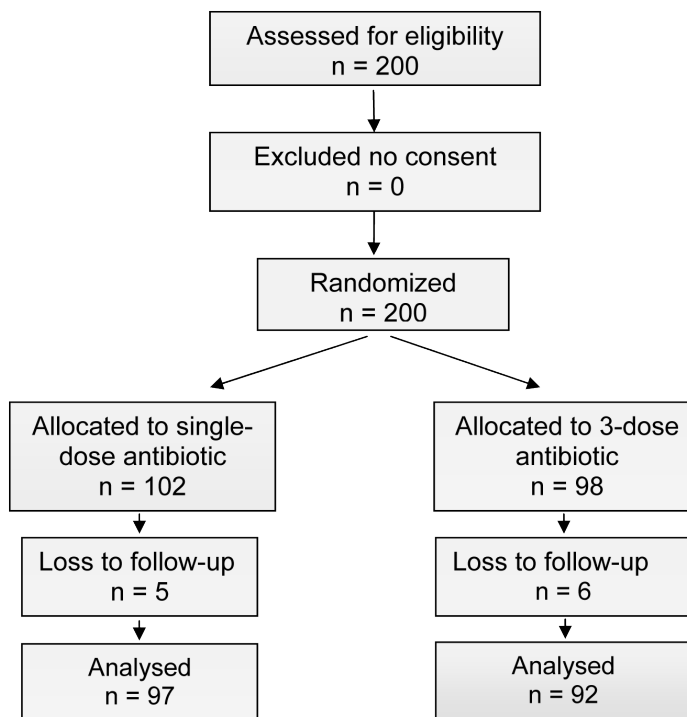


Figure 1. The flow chart of the trial.

infection (odds ratio [OR], 2.44; 95% CI, 0.42-14.06).

Discussion

Antibiotic prophylaxis reducing SSI rate

Postoperative infection is a major cause of morbidity, mortality and health care costs.

Surgical site infections occur in 2-5% of clean extra-abdominal surgeries. Appropriate preoperative administration of antibiotics is effective in preventing infection, and reducing morbidity and mortality.

Our infection rate (3.2%) is comparable to other studies. Boxma et al. (4) randomized 2195 patients with closed fractures to receive either a placebo (no antibiotic) or a single preoperative dose of ceftriaxone. The rate of postoperative infection was 8.3% in the placebo group and 3.6% in the ceftriaxone group ($p < 0.001$). Gillespie and Walenkamp performed a meta-analysis of 20 studies with 8307 patients undergoing surgical management of hip and long-bone fractures and showed that

single-dose antibiotic prophylaxis reduced the incidence of superficial and deep wound infections significantly (relative risk 0.4, 95% CI 0.24-0.67) (2).

No difference between single- and multiple-dose antibiotic prophylaxis

Our findings demonstrated no difference regarding the incidence of SSI between the single-dose and 3-dose prophylactic antibiotic groups in patients after open reduction and internal fixation of long bones. Similarly, a systematic review of RCTs showed that in patients undergoing open reduction and internal fixation for closed fractures, single-dose in comparison to multiple-dose antibiotic prophylaxis had an effect of similar size in reducing deep wound infections (2). Another study by Fonseca et al. (1) reported that in elective surgery one-dose antibiotic prophylaxis with cephazolin did not lead to an increase in rates of surgical site infection. In accord with these findings, a recent meta-analysis of the studies in the setting of closed long-bone fractures failed to demonstrate superiority of multiple-dose prophylaxis over a single-dose strategy (12).

TABLE 1

PATIENTS' CHARACTERISTICS INCLUDING DEMOGRAPHIC FEATURES AND RISK FACTORS

Variable	1-dose antibiotic group	3-dose antibiotic group	Result p value
Sex			No difference, p = 0.4; (mw)
Male	59	61	
Female	38	31	
Age (mean±SD, years)	33.6±12.6	33.3±11.9	No difference, p = 0.9; (t)
Duration from admission to operation (mean±SD, days)	4.6±4.9	5.7±6.6	No difference, p = 0.2; (t)
Bone type			Difference, p = 0.03; (mw)
Tibia	14	19	
Femur	14	24	
Forearm	56	39	
Humerus	4	4	
Others	9	6	
Operation type			No difference, p = 0.5; (mw)
Plate	36	30	
Intramedullary nail	57	57	
Other	4	5	
Haemoglobin	12.0±1.7	11.8±1.8	No difference, p = 0.3; (t)
Number of people in operating theatre	8.3±1.6	8.8±1.6	Difference, p = 0.049; (t)
Thickness of subcutaneous tissue (cm)	0.9±0.6	1.3±0.9	Difference, p <0.001; (t)
Operative time (minutes)	60.5±23.1	69.8±27.7	Difference, p = 0.01; (t)
BMI (body mass index)	24.5±4.3	25.8±8.4	No difference, p = 0.2; (t)
Smoking			No difference, p = 0.1; (mw)
Yes	31	40	
No	66	52	
Comorbidities			No difference, p = 0.3; (mw)
No	90	82	
One	7	10	
ASA score			No difference, p = 0.5; (mw)
Grade 1	89	82	
Grade 2	8	10	
Drain			Difference, p = 0.02; (mw)
Yes	59	68	
No	38	21	

SD = standard deviation

mw = Mann-Whitney U test

t = t-test for mean comparison of two groups (two-way)

ASA = American Society of Anesthesiologists

Regarding antibiotic prophylaxis in a class of contaminated procedures, such as colon surgery, there are conflicting reports regarding single- vs 3-dose antibiotic prophylaxis. On the one hand, Rowe-Jones et al. (13) showed no difference between 1- and 3-dose antibiotic in colon surgery. On the other hand, Fujita et al. (14) indicated that in colorectal surgery three-dose administration of cefmetazole is significantly more effective for prevention of incisional SSI than single-dose antibiotic administration.

Timing of antibiotic prophylaxis

Much of the recent literature emphasizes that one of the approaches for reducing the incidence of surgical site infections is to improve the timing of prophylactic antibiotic administration. In a study of 2847 operated patients, it was found that the lowest incidence of postoperative infection was associated with antibiotic administration during the one hour before surgery (15). The risk of infection increased progressively with greater time intervals between administration and surgical incision. Results of this study showed lowest infection rates (less than 1%) for patients undergoing surgery when an antimicrobial dose was administered within one hour before the incision. Patients who received the antibiotics too soon (more than two hours before the incision) had an infection rate of 3.8%. Likewise, patients who received the antibiotics three hours after the incision had an infection rate of 3.3% (15).

In a recent study of 1922 consecutive hip arthroplasty patients from 11 hospitals, it was found that surgical site infection occurred in 2.6% of cases (16). The highest odds for infection were found in patients who had received prophylaxis after incision, and the authors suggested that intervention programs in search of amendable factors to prevent infection should focus on timely administration of antibiotic prophylaxis (16). A few other authors indicated that antibiotic prophylaxis is most effective when started between 15 and 60 minutes before inflation of the tourniquet and should not continue for more than 24 hours (17-19). Moving along the line, the Johnson study reported that cefuroxime assays of bone and subcutaneous fat from samples collected throughout the operation demonstrated that an interval of 10 minutes was necessary to obtain adequate antibiotic prophylaxis (20).

However, other studies (9,10) have indicated that the adherence to these recommendations is poor. For instance, in Sweden only 53% (CI: 46-61) received antibiotics 15-45 minutes before inflation of a tourniquet as recommended (21). It has also been indicated that excessive duration of antibiotic prophylaxis is one of the most common errors in surgical antibiotic prophylaxis (3,22). Adhering to current recommendations, in our trial we set the antibiotic administration time at 15 minutes before the tourniquet inflation.

Risk factors for SSI

The findings of this study identified only male sex as an independent risk factor for surgical site infection (odds ratio 2.44). Similarly, the study from Nigeria found male sex to be a risk factor for SSI after orthopaedic operations (OR 2.01) (23). However, these findings need further validation because our study was not focused and powered to analyse risk factors. Many studies have demonstrated a positive correlation between the incidence of SSI and various risk factors such as the American Society of Anesthesiologists' (ASA) score (24,25), greater number of persons in the operating room (25), a period of 12 or more hours between shaving and operation (25), duration of operation longer than 120 minutes (23), obesity and inadequate antibiotic prophylaxis (26). There was also a trend toward SSI being associated with use of a surgical drain for longer than 1 day (27).

Cost of the antibiotic prophylaxis

The expenditure for prophylactic antibiotics per single surgery was 2.40 Kina in the single-dose group and 7.20 Kina in the 3-doses group. With 230 major orthopaedic operations at Modilon General Hospital in 2011 the annual savings from use of single-dose prophylaxis for one provincial hospital is estimated to be 1104 Kina.

Antibiotic choice for prophylaxis in orthopaedic surgery

Controlled clinical trials have shown that antibiotic prophylaxis in long-bone operations has lowered the incidence of superficial and deep infection, and thus reduced morbidity, hospital stay and antibiotic usage, and subsequently lowered the risk of developing bacterial resistance connected with prolonged antibiotic therapy (28). Cephalosporins

are considered to be the drug of choice in antibiotic prophylaxis because they rarely cause allergic reactions. Although some authors recommend 1st- or 2nd-generation cephalosporins, ceftriaxone (a 3rd-generation cephalosporin) in particular is far exceeding the sales of any other drug for prophylaxis (28). There are no published data on bacterial profile and the antimicrobial susceptibility pattern for orthopaedic infection in Papua New Guinea. The study from Nigeria recorded that in infections after elective long-bone operations *Staphylococcus aureus* and Gram-negative bacilli were each responsible for about half of postoperative infections (23). In the light of the increasing role of methicillin-resistant *Staphylococcus aureus* and Gram-negative bacilli in surgical infection, it has become more important to use antibiotics acting effectively against such microorganisms. Ceftriaxone not only covers this wide spectrum, but also shows favourable pharmacodynamic features, such as a high concentration in the bones and keeping a therapeutic level in tissues after 8 hours (29). Therefore ceftriaxone has been commonly used in prophylaxis in surgical treatment of bones (4,30,31). Furthermore, in favour of ceftriaxone could be the study indicating that after use of a 2nd-generation cephalosporin development of beta-lactamase-producing bacteria was higher than after a 3rd-generation cephalosporin (32). Finally, cost-benefit analysis of administering ceftriaxone as a single preoperative injection in orthopaedic surgery led to a dramatic savings in terms of nursing effort, time and cost of prophylaxis per patient. It is concluded that the clinical results and economic implications justify the use of ceftriaxone as a routine prophylactic antibiotic for patients undergoing orthopaedic surgery (33).

Limitations of the study and conclusions

One of the potential weaknesses of this study is the relatively short follow-up knowing that the recommended post-discharge period of follow-up for orthopaedic procedures is 1 year. While our study was powered to assess a correlation between the mode of antibiotic prophylaxis and SSI the authors of a recent meta-analysis pointed out that SSIs are relatively rare events and that any potential difference in infection rates between prophylaxis strategies is likely to be quite small (12). Furthermore, the authors indicated that the expected difference in SSI incidence

between single and multiple doses or different antibiotic prophylactic regimens has to be very large to demonstrate a significant difference (2).

Although future research is required to ensure our prophylaxis decisions continue to be evidence based and cost-effective, it is unlikely that a single clinical trial will be able to provide the answer. The use of other quantitative methods, such as cost-effectiveness analysis, may be helpful in modelling an optimal prophylaxis strategy (15).

We hope that this randomized clinical trial showing the effectiveness of ceftriaxone used as a single-dose antibiotic prophylaxis in orthopaedic clean operations has provided good evidence for the development of clinical practice guidelines which may reduce the incidence of surgical site infections.

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REFERENCES

- 1 **Fonseca SNS, Kunzle SRM, Junqueira MJ, Nascimento RT, de Andrade JI, Levin AS.** Implementing 1-dose antibiotic prophylaxis for prevention of surgical site infection. *Arch Surg* 2006;141:1109-1113.
- 2 **Gillespie WJ, Walenkamp G.** Antibiotic prophylaxis for surgery for proximal femoral and other closed long bone fractures. *Cochrane Database Syst Rev* 2000;(2):CD000244.
- 3 **AlBuhairan B, Hind D, Hutchinson A.** Antibiotic prophylaxis for wound infections in total joint arthroplasty: a systematic review. *J Bone Joint Surg Br* 2008;90:915-919.
- 4 **Boxma H, Broekhuizen T, Patka P, Oosting H.** Randomised controlled trial of single-dose antibiotic prophylaxis in surgical treatment of closed fractures: the Dutch Trauma Trial. *Lancet* 1996;347:1133-1137.
- 5 **Pollard JP, Hughes SP, Scott JE, Evans MJ, Benson MK.** Antibiotic prophylaxis in total hip replacement. *Br Med J* 1979;1:707-709.
- 6 **Zgonis T, Jolly GP, Garbalosa JC.** The efficacy of prophylactic intravenous antibiotics in elective foot and ankle surgery. *J Foot Ankle Surg* 2004;43:97-103.
- 7 **Scottish Intercollegiate Guidelines Network.** Antimicrobial prophylaxis in surgery. SIGN No 104. Edinburgh, Scotland: Scottish Intercollegiate Guidelines Network, Jul 2008. www.sign.ac.uk/guidelines/fulltext/104/index.html
- 8 **Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR.** Guidelines for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol*

- 1999;20:250-278.
- 9 **Bailly P, Lallemand S, Thouverez M, Talon D.** Multicentre study on the appropriateness of surgical antibiotic prophylaxis. *J Hosp Infect* 2001;49:135-138.
 - 10 **Hosoglu S, Sunbul M, Erol S, Altindis M, Caylan R, Demirdag K, Ucmak H, Mendes H, Geyik MF, Turgut H, Gundes S, Doyuk EK, Aldemir M, Dokucu AI.** A national survey of surgical antibiotic prophylaxis in Turkey. *Infect Control Hosp Epidemiol* 2003;24:758-761.
 - 11 **Centers for Disease Control and Prevention.** National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 to June 2002. Atlanta, Georgia: Centers for Disease Control and Prevention, 2002.
 - 12 **Slobogean GP, Kennedy SA, Davidson D, O'Brien PJ.** Single- versus multiple-dose antibiotic prophylaxis in the surgical treatment of closed fractures: a meta-analysis. *J Orthop Trauma* 2008;22:264-269.
 - 13 **Rowe-Jones DC, Peel AL, Kingston RD, Shaw JF, Teasdale C, Cole DS.** Single dose cefotaxime plus metronidazole versus three dose cefuroxime plus metronidazole as prophylaxis against wound infection in colorectal surgery: multicentre prospective randomized study. *Br Med J* 1990;300:18-22.
 - 14 **Fujita S, Saito N, Yamada T, Takii Y, Kondo K, Ohue M, Ikeda E, Moriya Y.** Randomized, multicenter trial of antibiotic prophylaxis in elective colorectal surgery: single dose vs 3 doses of a second-generation cephalosporin without metronidazole and oral antibiotics. *Arch Surg* 2007;142:657-661.
 - 15 **Burke JP.** Maximizing appropriate antibiotic prophylaxis for surgical patients: an update from LDS Hospital, Salt Lake City. *Clin Infect Dis* 2001;33(Suppl 2):S78-S83.
 - 16 **van Kasteren MEE, Manniën J, Ott A, Kullberg BJ, de Boer AS, Gyssens IC.** Antibiotic prophylaxis and the risk of surgical site infections following total hip arthroplasty: timely administration is the most important factor. *Clin Infect Dis* 2007;44:921-927.
 - 17 **Dellinger EP, Gross PA, Barrett TL, Krause PJ, Martone WJ, McGowan JE Jr, Sweet RL, Wenzel RP.** Quality standard for antimicrobial prophylaxis in surgical procedures. Infectious Diseases Society of America. *Clin Infect Dis* 1994;18:422-427.
 - 18 **Holtom PD.** Antibiotic prophylaxis: current recommendations. *J Am Acad Orthop Surg* 2006;14(10 Spec No):S98-S100.
 - 19 **Polk HC Jr, Christmas AB.** Prophylactic antibiotics in surgery and surgical wound infections. *Am Surg* 2000;66:105-111.
 - 20 **Johnson DP.** Antibiotic prophylaxis with cefuroxime in arthroplasty of the knee. *J Bone Joint Surg Br* 1987;69:787-789.
 - 21 **Stefánsdóttir A, Robertsson O, W-Dahl A, Kiernan S, Gustafson P, Lidgren L.** Inadequate timing of prophylactic antibiotics in orthopedic surgery. We can do better. *Acta Orthop* 2009;80:633-638.
 - 22 **Gorecki P, Schein M, Rucinski JC, Wise L.** Antibiotic administration in patients undergoing common surgical procedures in a community teaching hospital: the chaos continues. *World J Surg* 1999;23:429-432.
 - 23 **Thanni LOA, Aigoro NO.** Surgical site infection complicating internal fixation of fractures: incidence and risk factors. *J Natl Med Assoc* 2004;96:1070-1072.
 - 24 **Soletto L, Pirard M, Boelaert M, Peredo R, Vargas R, Gianella A, Van der Stuyft P.** Incidence of surgical-site infections and the validity of the National Nosocomial Infections Surveillance System risk index in a general surgical ward in Santa Cruz, Bolivia. *Infect Control Hosp Epidemiol* 2003;24:26-30.
 - 25 **Maksimović J, Marković-Denić L, Bumbaširević M, Marinković J, Vlajinac H.** Surgical site infections in orthopedic patients: prospective cohort study. *Croat Med J* 2008;49:58-65.
 - 26 **Fernández AH, Monge V, Garcinuño MA.** Surgical antibiotic prophylaxis: effect in postoperative infections. *Eur J Epidemiol* 2001;17:369-374.
 - 27 **Manian FA, Meyer PL, Setzer J, Senkel D.** Surgical site infections associated with methicillin-resistant *Staphylococcus aureus*: do postoperative factors play a role? *Clin Infect Dis* 2003;36:863-868.
 - 28 **Geroulanos S, Marathias K, Kriaras J, Kadas B.** Cephalosporins in surgical prophylaxis. *J Chemother* 2001;13:23-26.
 - 29 **Lovering AM, Walsh TR, Bannister GC, MacGowan AP.** The penetration of ceftriaxone and cefamandole into bone, fat and haematoma and relevance of serum protein binding to their penetration into bone. *J Antimicrob Chemother* 2001;47:483-486.
 - 30 **Karachalios T, Lyritis GP, Hatzopoulos E.** Antibiotic prophylaxis in the surgical treatment of peritrochanteric fractures: a comparative trial between two cephalosporins. *Chemotherapy* 1990;36:448-453.
 - 31 **Lüthje P, Nurmi I, Aho H, Honkanen P, Jokipii P, Kataja M, Kytömaa J, Nirhamo J, Pekkanen A, Rimpiläinen J, Sihvonen R, Sinisaari I, Tulikoura I, Valtonen V.** Single-dose antibiotic prophylaxis in osteosynthesis for hip fractures. A clinical multicentre study in Finland. *Ann Chi Gynaecol* 2000;89:125-130.
 - 32 **Colodner R, Rock W, Chazan B, Keller N, Guy N, Sakran W, Raz R.** Risk factors for the development of extended-spectrum beta-lactamase-producing bacteria in nonhospitalized patients. *Eur J Clin Microbiol Infect Dis* 2004;23:163-167.
 - 33 **Mazza A.** Ceftriaxone as short-term antibiotic prophylaxis in orthopedic surgery: a cost-benefit analysis involving 808 patients. *J Chemother* 2000;12(Suppl 3):29-33.

History of surgery at Tari Hospital

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SUMMARY

The Southern Highlands were first discovered and explored by Europeans in the 1930s. The first patrols led by Lloyd Yelland, a medical assistant, assessed the health of the population in the early 1950s. Thereafter, Tari Hospital was built in 1954 and first staffed by medical assistants. The first medical officer, Roger Rodrigue, was not stationed there until 1959. He performed minor operations with local or general anaesthetic using ether. The first surgeon to operate there – Bill Ramsey (1967-1968) – did so under the auspices of the Leprosy Mission. The first nurse was Judith Wilson posted in 1970. By 1972, the hospital had 100 inpatients, saw 50 outpatients a day and had a staff complement of 9 trained nurses and a matron. A research station was set up in the Tari Basin, which eventually came under the Papua New Guinea Institute of Medical Research (PNGIMR) in Goroka. In the 1970s Ian Riley (later a Professor of Public Health) and his wife, an anaesthetist, were based in Tari, studying pneumonia and pneumococcal vaccines, and managed emergency cases including trauma and caesarean sections. Stephen Flew, now a general practitioner in Northern Victoria, was superintendent of the hospital from 1989 to 1993, whilst Tim Dyke FRCS Edin was based at the PNGIMR in Tari. They offered a significant surgical service, again largely based on emergency presentations. Their tenure resulted in a number of publications and conference presentations on surgical topics, largely related to trauma. After Dyke, the hospital had no surgeon until 2007, largely due to political reasons. Médecins Sans Frontières (MSF) were invited to provide surgical services in 2009, and even in 2013 there was still no government-funded surgeon at Tari Hospital. The MSF surgical audit data in 2010-2011 showed that more than 90% of surgical cases seen at Tari Hospital required emergency surgery, most of which resulted from trauma. More than half of the trauma procedures were classified as major.

Early European explorers

The Tari Basin was one of the last few places in Papua New Guinea (PNG) to be explored by Europeans. In 1934, Jack and Tom Fox (1), identical twin brothers from Australia who were prospecting for gold, set out from Mt Hagen with the goal of reaching the Dutch border. Instead, they somehow ended up at the Tari Basin. In the course of their travel, they used firearms for intimidation purposes and killed at least 45 Huli tribesmen. In 1935 (1), the Strickland-Purari Patrol, led by Jack Hides, 'officially' discovered the Tari Basin and met a mixed reception from the awestruck Huli people. Hides ordered the police to fire when

the patrols were attacked. Several Hulis died. In 1936 (1), Ivan Champion and Adamson established a base camp at Lake Kutubu so as to patrol into the Tari Basin. Reportedly no hostilities occurred and no shots were fired.

Before the Second World War the Southern Highlands was part of the Territory of Papua and was, as described above, unexplored and without much official interaction with the colonial administration. Following the War, the Territory of Papua and New Guinea was formed with a united health service that covered both former Territories. In 1952, Smith and Clancy (1) walked from Lake Kutubu to Tari Basin, where they began construction of the airstrip

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at Lumulumu. When the airstrip was finished, Tari station was officially opened.

Health services in Tari

Health services were introduced into Tari first by missionaries, then patrol officers. The native people had little contact with civilization and consequently had no prior knowledge or trust in health services. They regarded the removal of arrows and suturing of wounds as white man's magic. But soon their attitude changed because, as Sister Joyce Walker (2) stated, 'seeing is believing'. A village leader had to walk 6 hours to seek treatment for an arrow in his jaw. He was not only immensely interested in his own treatment but absolutely fascinated to see an orphaned baby fed from a bottle. He went home widely recommending the medical work.

This paper briefly reviews the pioneer surgeons and their early work at Tari Hospital. It also draws on data from health service and surgical audits, including those by Médecins Sans Frontières (MSF). The methods of study in this paper include literature review, interviews and review of surgical audit data. Today just over 300,000 people live in the new Hela Province and it will be important for their future that they have access to an efficient referral system and surgical service, albeit with complex cases able to be transferred to Mendi and Mt Hagen.

Tari Hospital in the 1950s

The health service was established in 1951 when the colonial (Australian) patrol officers first opened a patrol post. Some of the early medical assistants who were involved in building the Tari Hospital include Albert Speer and Lloyd Yelland (Lloyd Yelland, personal communication). They started building the hospital in 1954. Yelland was a European Medical Assistant (EMA) who did medical patrols to Tari in 1954. In his patrol report, published in the first issue of the *Papua and New Guinea Medical Journal* in 1955 (3), he recognized that only a small percentage of the population, about 4186 in total, presented to the camps for medical inspection. Many of those who attended were males who had had no previous contact with Europeans. The men were shy and did not bring their women for medical examination as they considered it to be culturally inappropriate. The people who were seen appeared to be generally healthy

and most were well-nourished.

Table 1 gives an estimate of the burden of disease in the population at Tari Basin in 1954.

Most of the health services at that time were provided by missionaries. After the establishment of a patrol post, the Methodist church was the first to set up a mission in Hoyabia, and Sister Joyce Walker was sent from Mendi to look after the new mission in 1954. Most of her early work involved child and maternal health. The Methodist church later collaborated with the Leprosy Mission to form the Hoyabia Leprosy Mission (2).

Dr Roger Rodrigue was appointed to be the first doctor stationed in Tari in 1959 (Roger Rodrigue, personal communication). He vividly recalled the Tari Basin as the 'Land of the Wigmen', famous for their head wigs made from human hair of living or deceased relatives interwoven into their own hair. He was assisted by Papuan staff that he regarded as well trained. These Papuan staff managed many aspects of the work in the new hospital including administration records, security, privacy for patients, medical therapy, follow-up and dietary and even basic surgical procedures. Tari at that time was a 'newly controlled station', meaning that fighting between various groups was common and there were many bow and arrow injuries.

Dr Rodrigue as the only medical officer tended to remain at the hospital most of the time to supervise the care given. After the wounds were reviewed by the Papuan 'dokta bois', he would debride and suture wounds in a minor treatment room or take them to an operating room if major surgery was required. The autoclave was powered by a primus stove. A local Papuan staff member would be the surgical scrub assisting whilst another Papuan administered the general anaesthetic with ether after an induction with ethyl chloride. The suction apparatus was a pump, which was foot-operated to produce negative pressure. The system was functional and not dependent on electric power from generators. The lights were powered from a charged six-volt battery which could be recharged. Overall the system worked without failure and permitted procedures like small bowel repair and anastomosis, removal of abdominal cysts, setting of limb fractures and placement of chest tubes after removal of arrows.

TABLE 1

BURDEN OF DISEASE AT TARI BASIN IN 1954 (3)

Diagnosis	Population seen (%)
Abrasions/lacerations/small sores	9.5
Eye cases (conjunctivitis, cataracts, corneal ulcers, strabismus, blindness)	3
Tinea imbricata	2.3
Abscesses and boils	1.8
Deformities and abnormalities	1.1
Gingivitis	1.8
Hansen's disease (leprosy)	0.52
Osteomyelitis	0.5
Pneumonia	0.2
Dysentery	0.5
Yaws	0.07
Malnutrition	0.05
Pulmonary tuberculosis	Nil

Recovery took place in a relatively clean area under the supervision of an attendant who charted the progress and complications if they developed. The system worked and the outcomes, considering all the risks, were good. Dr Rodrigue and his team also had to resuscitate and stabilize patients for air transport to other hospitals if the conditions were more than they could manage, with cases flown to Mendi or Goroka, approximately two hours flight at the most. Radio communication alerted the next hospital of the transfer and the plane was met on arrival. Roger Rodrigue left Tari in 1961 and was followed by Dr Ian Welsh (4).

Leprosy reconstructive surgery

In 1965, the Leprosy Mission was established at Hoyabia about 3 km east of Tari town and Dr Bill Ramsay was invited to work there in 1967 (Bill Ramsay, personal communication). He was also responsible for leprosy services to Balimo Hospital in the Western Province, Aitape in West Sepik and Togoba Hospital in the Western Highlands. He was particularly involved with leprosy reconstructive surgery, as this was the main surgical procedure carried out at that time.

The Hoyabia Leprosy Hospital was built with a theatre, sterilizer and wards attached. Electrical power from the mission station was reliable and later derived from hydroelectricity. The sterilizer was brand new and surgical instruments included special tendon and fascia strippers and tunnelling items which were sourced from India. Anaesthetics for leprosy were administered regionally; lower limb surgery was conducted under spinal and upper limb using a Bier's or regional block. Ketamine became available a little later.

Head and neck leprosy procedures included correcting lagophthalmus due to facial palsy. Upper limb problems included repairing ulna and median nerve paralysis singly or together with tendon transfers as pioneered by Dr Paul Brand. Lower limb surgery included transfers for lateral popliteal nerve palsy which results in foot drop. Early but established foot drop was corrected by transfer of the tibialis posterior tendon to the front of the foot and was a very effective procedure.

Dr Ramsay recalled that the government hospital buildings in Tari consisted of few permanent materials as most wards were constructed from bush materials, mainly kunai

and pitpit (small bamboo). The hospital was staffed by an Asian doctor when he arrived, though he soon left and was not replaced. Dr Ramsay was invited by the hospital to visit and consult, and his surgical cases included a large parotid tumour removed under local anaesthetic. Tragically, during the ward round the following morning he found the patient lying dead in the corner of the pitpit ward. Later he appreciated that postoperative nursing care had only been provided by one of the patient's uneducated bush relatives. This taught him to be more restrained in what he attempted, and he tried to avoid general anaesthesia. Injuries were common and there were lacerations to any part of the body that often needed delayed primary closure or secondary repair. Once Bill Ramsay left in 1968, Dr Fitzgerald was posted to work at Tari Hospital in 1969.

Surgical practice at Tari in the 1970s

It was during the 1970s that major surgical procedures including emergency caesarian sections were performed at Tari Hospital. The first European nurse posted to Tari was Judith Wilson in 1970 (2). Doctors Ian Riley and Rae Howard (anaesthetist) lived in Tari from 1972 to 1974 (Ian Riley and Rae Howard-Riley, personal communication). Their primary purpose for being in Tari was for Dr Riley to establish health and demographic surveillance, investigate pneumonia and conduct a field trial of a pneumococcal vaccine, which in the late 1970s came under the auspices of the Papua New Guinea Institute of Medical Research (PNGIMR) in Goroka. In addition to their primary research role, they had to look after medical, surgical and obstetric patients. They had received some basic surgical and anaesthetic training as junior doctors in NSW which helped them cope. Ian recalled that on his first arrival at Tari airstrip, he was greeted by a nurse who asked him if he could review a mother with obstructed labour. He then had to perform an emergency caesarian section with open ether anaesthetics.

Dr Riley recalled that most of the surgical cases were emergency procedures such as caesarian sections, obstructed labour, laparotomies for bowel perforation and peritonitis, appendectomies with complications, liver abscess with bile and pus leak and lower limb amputations for gangrene. It was difficult for them to carry out elective surgery because of limited

resources including a lack of well-trained staff or infrastructure. Rae was confident at giving anaesthetics using the EMO (Epstein Macintosh Oxford) inhaler. Unfortunately there was no ventilator available at that time. Oxygen was in short supply so Rae had to sparingly utilize the contents of the three oxygen cylinders available; thus oxygen was used only when absolutely necessary and usually for sick infants.

Surgical practice in the 1980s

Tari was connected to Mendi and the rest of the highlands provinces, and on down to Lae, in 1981 after completion of the Highlands Highway. The Tari Research Unit (TRU) was by then well established, and there were about 30 expatriates including some doctors sent by the Institute of Medical Research from Goroka (5). In 1985, Tari Hospital was upgraded from a major health centre to district hospital status by the Southern Highlands Provincial government (6). By June 1986, Tari had a fully functioning microbiology laboratory, initially for research purposes but later also for haematology and microbiology tests on hospital patients. Tari Hospital had grown to 130 beds, and offered 24 hours a day nursing care, X-ray and basic laboratory facilities, a pharmacy and operating theatres (5).

Table 2 shows the mortality rates from injuries and other leading causes in the Tari Basin in the period 1977-1983 (7). The mortality rate from injuries was still high in the 1970s and early 1980s. In a report, Lehmann (7) found injuries, both intentional and unintentional, to be the fourth cause of mortality in Tari from 1977 to 1983. Intentional and unintentional injuries (eg, homicide, road traffic accidents, drowning, burns and, in the case of young adult females, suicide) accounted for 20% of all deaths in the 15-44 year age group and was the commonest cause of death in this age group.

Surgical practice in the 1990s

The first author's father was a health extension officer (HEO) at Tari Hospital in 1990-1991 (Philip Pakalu, personal communication). He recalls that during his time at Tari Hospital there were volunteer expatriate surgical doctors from the United States, Britain and Canada who spent 6-12 months at the hospital. At that time, trauma was the main reason that surgery was

TABLE 2

MORTALITY RATES FROM INJURIES AND OTHER LEADING CAUSES, TARI BASIN, PNG, 1977-1983 (7)

Diagnosis	Actual figures	Rate/100,000/year
Acute lower respiratory infection	461	290
Chronic lung disease	318	200
Gastroenteritis and dysentery	175	110
Injuries (intentional and unintentional)	143	90
Malaria, meningitis, encephalitis	95	60
Measles	48	30
Pigbel	48	30
Neonatal and congenital	48	30
Other known causes	497	310
Unknown causes	528	330

performed. He remembered being woken up by one of the expatriate surgeons to assist him with an emergency laparotomy after a patient presented with multiple stab wounds to the abdomen. On exploration, there was a bowel perforation, which was repaired, but no major damage to other organs. The patient made a full recovery. There were times when there was no surgeon available so they transferred patients to Mt Hagen or Mendi. The most serious ones were transferred though there were some who died due to haemorrhagic shock or sepsis before they could be sent. Sometimes relatives of the deceased retaliated and attacked the hospital staff, blaming them for the patient's death. This has proved one of the hindrances to doctors being willing to work in Tari.

The audit of the month of October 1992 conducted by Tim Dyke FRCS Edin, who was based in Tari, reported that there were 90 minor procedures not requiring a doctor which were performed by an HEO or nurse and 98 major operations that needed to be done by the medical staff (8). 40% of the major cases were trauma related. Many involved drainage of large abscesses which required general anaesthesia. Much of the work load was done by the technical staff and their efforts must be acknowledged as Tari was a small district hospital with one or two doctors working. The procedures for the month included seven tubal ligations and one caesarean section.

Clearly there was an uncounted burden of elective surgery that was not performed but in 1992 more than half the operative procedures were for trauma. Table 3 shows the results of an audit of operative procedures related to trauma at Tari Hospital in October 1992 (8).

Dr Stephen Flew, the medical superintendent of Tari Hospital from 1989 to 1993, reported in a paper of surgical practice that deaths resulting from trauma and accidents were the major causes of morbidity and mortality (9). Trauma from clan warfare or small arguments originated from disputes over land, women or pigs. Pigs are still a highly prized currency in most highlands cultures in PNG, including the Huli. From their study on arrow wound management in Tari and Mendi Hospitals (10), van Gurp et al. recorded a significant mortality from arrow wound injuries. They reported cases with an arrow tip lodged in the posterior wall of the occipital fossa and metallic arrow tips in collapsed lungs. One patient presented with an arrow in the left posterior flank but was clinically stable. Not until day 4 when the patient deteriorated was an urgent laparotomy performed revealing a retroperitoneal injury to the descending colon. The patient survived but spent three months in hospital.

Tari Hospital in the 21st century

The 1997 general election brought a resurgence in violence and civil unrest as a result

TABLE 3

AUDIT OF OPERATIVE PROCEDURES RELATED TO TRAUMA AT TARI HOSPITAL IN OCTOBER 1992 (8)

Surgical diagnosis/procedure	Major theatre	Minor theatre
Lacerations	15 (3 tendon repair)	-
Fractures	8	4
Internal fixation	1 (medial malleolus)	-
Amputation of leg	1	-
Amputation	6 (fingers)	11
Foreign body	3	7
Enucleation of eye	1	-
Split skin grafts	1	-

of political tensions between the Nipa and the Huli people (11). The Nipa people live on the fringe of the Highlands Highway that passes through to Tari and they made it difficult or impossible for vehicles to pass through at the height of the tension. By September 2000, communications in Tari were not functioning, the road to Mendi was impassable except to police-escorted convoys, the bank and post office were closed, and the town power supply out of order. There was again no doctor at Tari Hospital, and several health centres and many rural aid posts were closed. Immunization patrols had all but ceased. Several community schools had been destroyed or were closed, and most others were short of teachers. Few public servants were at their posts in Tari town. Almost no aspect of the administration was functioning properly. The Hela people suffered for just over a decade before surgical services were resumed back at Tari Hospital in 2009 thanks to Médecins Sans Frontières.

Médecins Sans Frontières, an international, independent, medical humanitarian organization that delivers emergency aid to people affected by natural or man-made disasters, based a team in Tari to provide emergency surgical services and an integrated medical and psychosocial service to survivors of sexual and family violence (12). This team consisted of a general surgeon, an anaesthetist and 5-6 assisting staff such as a team leader, nurses, physiotherapists and psychologists.

In 2010 there was only one government-funded doctor, a national doctor, Dr Hamia Hewali (Hamia Hewali, personal communication), who has been Chief Executive Officer since 2010 and has also looked after the medical ward. All the surgical patients are managed by the MSF team in the surgical wards. There are currently 50 beds in the hospital, 26 of which are surgical beds with the remainder for medical and obstetric patients. The Paediatric Ward is non-operational. Dr Hewali stated that before his arrival in 2010 hardly any health services were provided at Tari Hospital. He confirmed that the presence of MSF had improved surgical service delivery at Tari Hospital. In 2011, Tari Hospital was promised government funding of 25 million Kina (AUD\$10 million). Unfortunately the hospital did not receive the funding as it was diverted elsewhere.

Surgical records at Tari have been lost or destroyed so the only surgical data available for the years 2010 and 2011 have been obtained from MSF (Médecins Sans Frontières statistician, personal communication). Figure 1 shows the different surgical interventions at Tari Hospital in 2010 and 2011. The total number of surgical interventions carried out by MSF at Tari Hospital in 2010 was 1064 cases compared to 1147 cases in 2011, an increase of 7.8%. The top four surgical interventions done during 2010-2011 were under the categories of other surgical interventions, incision and drainage, orthopaedic and soft tissue injuries

(Figure 1). There were fewer cases of burns, hernia repairs and gynaecological procedures such as hysterectomies. Table 4 shows a list of interesting surgical cases dealt with by the MSF team.

Table 5 shows that of the 1147 cases seen in 2011, 597 (52%) of them were major cases and needed major surgical interventions. Of all the major cases, more than half (64%) were major emergency interventions compared to 32% of surgery due to infections and neglect. Only 4% were elective cases.

Of the 64% that had major emergency surgery, only 4 lives were lost in 2011. A study done on trauma in PNG shows that trauma is the leading cause of emergency surgical interventions and the number one cause of death, not only in Tari but also in the rest of PNG (13). In Tari, the main forms of trauma are arrow and machete wounds. The Huli people are well known for their extraordinary, violent ways of solving conflicts. An example is a woman coming in to the hospital with an almost amputated left hand chopped with a machete without warning by her brother after an argument over money (Rijk Willemz, MSF trauma and vascular surgeon, personal communication). The MSF records show that

more than 90% of surgical cases seen at Tari Hospital required emergency surgery, most of which resulted from trauma, with over half being major.

Conclusion

It is more than 50 years since Tari Hospital was first established but there is hardly any evidence of surgical services currently being provided by the PNG government. The service to Huli people is provided by MSF, and their team has saved many lives. Today the new Hela Province is home to the big liquefied natural gas (LNG) project worth billions of dollars but still a basic health service that includes essential and emergency surgery does not exist. There is a need for the government of PNG to establish a bigger hospital in Tari with more beds and a surgical service that includes qualified surgeons, of whom PNG has now trained more than 70.

Tari town is now the capital of the new Hela Province, which was established in 2010 by an Act of Parliament. It is no longer part of Southern Highlands Province. Tari Hospital will be the major referral hospital serving the more than 300,000 people of Hela. It needs surgical services.

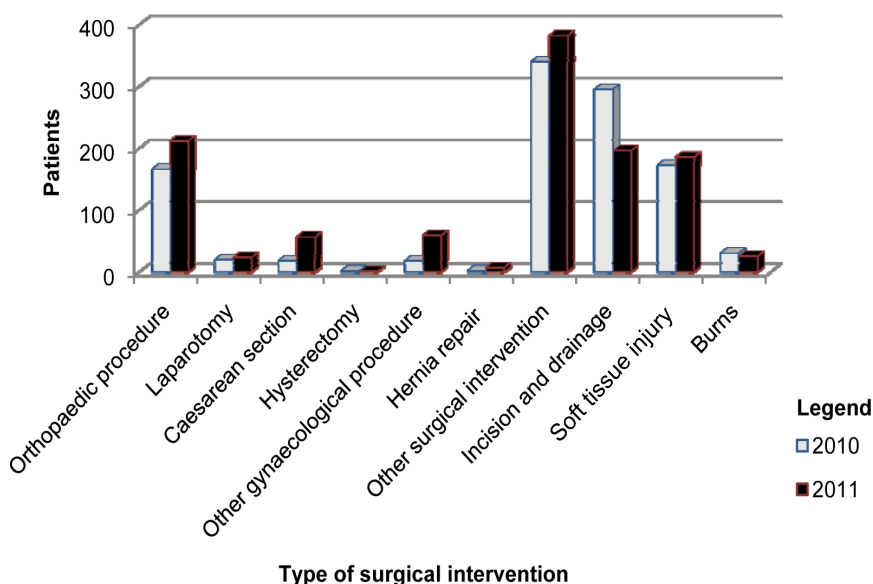


Figure 1. Surgical cases, both major and minor, in Tari Hospital from 2010 to 2011.

TABLE 4

EXAMPLES OF INTERESTING CASES REQUIRING SURGICAL INTERVENTION BY THE MSF
TEAM, TARI HOSPITAL, 2010-2011

Cases

- Axe wound to left lung
- Stab wound by wife
- Penile injury bitten by wife
- Gunshot wound (pellets) for exploration
- Chopped right hand, open fracture and tendon rupture
- Human bite ring finger debridement
- Appendicectomy in pregnancy
- Chopped tendons
- Gunshot – soft tissue injury
- Spear wound on left side of face
- Osteomyelitis left leg
- Penetrated vaginal/rectal injury
- MVA – head injury and internal bleeding
- Spear wound on mid chest
- Chopped left shoulder and shoulder bone fracture
- Deep head laceration and skull fracture
- Both ear lobes bitten by pig – suturing
- Bitten by pig on right cheek
- MVA – spinal injury
- Stab wound right lower abdomen
- Scrotum wound after fall on stick
- Gunshot wound X3 to both legs
- Laceration to nostril from knife wound
- Deep posterior neck laceration
- Blunt head trauma
- Multiple lacerations on head and left forearm
- Second and third degree burns to scalp and left arm
- Stab wound back with haemopneumothorax
- Chopped wound left leg with partial open fracture of tibia
- Amputation of left hand from chopping wounds
- Pneumothorax from stab wound to right chest
- Chopped wound to face – closure

MSF = Médecins Sans Frontières
MVA = motor vehicle accident

TABLE 5

MAJOR SURGICAL INTERVENTIONS IN TARI HOSPITAL IN 2011

Surgical intervention	Emergency intervention		Surgery of infections and neglect		Elective intervention		Total		Intervention type (%)
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	
Orthopaedic procedure	113	0	27	0	5	0	145	0	24
Laparotomy	23	2	0	0	0	0	23	2	4
Caesarian section	56	0	1	0	0	0	57	0	10
Hysterectomy	1	0	0	0	0	0	1	0	1
Other gynaecological procedure	35	0	2	0	1	0	38	0	6
Hernia repair	3	0	1	0	1	0	5	0	1
Other surgical intervention	81	1	56	0	15	0	152	1	25
Incision and drainage	20	0	87	0	0	0	107	0	18
Soft tissue injury	43	0	13	0	0	0	56	0	9
Burns	10	1	2	0	1	0	13	1	2
Total	385	4	189	0	23	0	597	4	
% (of those data in relevant fields)	64	100	32	0	4	0			

REFERENCES

- 1 **Biersack A, ed.** Papuan Borderlands: Huli, Duna and Ipili Perspectives on the Papua New Guinea Highlands. Ann Arbor: University of Michigan Press, 1995.
- 2 **Kettle ES.** That They Might Live. Sydney: FP Leonard, 1979.
- 3 **Yelland LC.** Tari Sub-district patrols: Numbers 1, 2 and 3 from January to June, 1954. *PNG Med J* 1955;1:29-32.
- 4 **Watters D, Koestenbauer A.** Stitches in Time: Two Centuries of Surgery in Papua New Guinea. Bloomington, Indiana: Xlibris Corporation, 2012.
- 5 **Rose G.** The Pacific way. *NZ J Med Lab Technol* 1987;41:119-120.
- 6 **Lehmann D.** Demography and causes of death among the Huli in the Tari Basin. *PNG Med J* 2002;45:51-62.
- 7 **Lehmann D.** Tari Research Unit. Final Report for the Southern Highlands Rural Development Project. Mendi, PNG: Media Unit, 1984.
- 8 **Dyke T, ed.** A review of services for trauma in Papua New Guinea. Port Moresby: Faculty of Medicine, University of Papua New Guinea, 1995.
- 9 **Flew S.** District health care at Tari until 1991. *PNG Med J* 2002;45:106-112.
- 10 **van Gurp G, Hutchison TJ, Alto WA.** Arrow wound management in Papua New Guinea. *J Trauma* 1990;30:183-188.
- 11 **Vail J.** Community-based development in Tari – present and prospects. In: Haley N, May RJ, eds. Conflict and Resource Development in the Southern Highlands of Papua New Guinea. State, Society and Governance in Melanesia Program: Studies in State and Society in the Pacific, No 3. Canberra: ANU E Press, 2007:107-121.
- 12 **Médecins Sans Frontières/Doctors Without Borders.** Hidden and neglected: the medical and emotional needs of survivors of family and sexual violence in Papua New Guinea. Port Moresby: Médecins Sans Frontières, Jun 2011. www.msf.org.uk/article/papua-new-guinea-hidden-and-neglected
- 13 **Watters D, Dyke T.** Trauma in Papua New Guinea: what do we do and where do we go? *PNG Med J* 1996;39:121-125.

***Trichinella papuae*: a zoonotic nematode present in Papua New Guinea**

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SUMMARY

The zoonotic nematode, *Trichinella papuae*, was first discovered in wild and domestic pigs in the Bensbach area, Morehead District, Western Province of Papua New Guinea (PNG) in 1988. 15 years later, *T. papuae* was found in wild pigs and captive crocodiles (*Crocodylus porosus*) in the Kikori area, Gulf Province of PNG. An overall prevalence of anti-*Trichinella* IgG was detected in 10% (0.0%-36.7%) of 1536 villagers living in Morehead District by using an ELISA as screening test and a Western blot as confirmatory test. No anti-*Trichinella* IgG antibodies were detected in 313 villagers living in the Kikori District in spite of the fact that *T. papuae* was circulating in wild pigs in the district. These results may reflect the different methods of cooking in the two districts. Specific symptoms typical of trichinellosis were not reported by serologically positive persons living in Morehead District, although some non-pathognomonic symptoms, common to trichinellosis and other ailments, were noted. In Thailand, trichinellosis caused by *T. papuae* was attributed to the custom of eating large quantities of raw pig meat, a food behaviour not found in people living in Morehead and Kikori Districts. This fact probably accounts for the lack of pathognomonic symptoms of trichinellosis in serologically positive people of Morehead District, although they, as well as the Kikori people, occasionally eat tidbits of raw pork sufficient, in the case of the Morehead people, to develop an immune response. The importance of consumer education to eat only thoroughly cooked meat in the localities where *T. papuae* is circulating is emphasized.

Introduction

For well over 100 years (1835 to 1972) the scientific world assumed that the nematode genus *Trichinella* contained only one species, *Trichinella spiralis* (1). The parasite can infect a range of mammals but only humans become clinically affected with the disease, trichinellosis (2). Humans become infected by eating uncooked or partly cooked infected meat, usually pig meat. A distinctive character of this worm is that each larva is enclosed in a collagen capsule within the host's muscle fibres (Figure 1). Over the last few decades, with the aid of molecular tools, eight other encapsulated species have been described. Like *T. spiralis*, all are infective to

mammals only. *Trichinella spiralis* is the most widespread species, in part due to its passive dissemination in the domestic pig through European colonization activity, as well as by synanthropic rats (3). It does not occur, however, in Papua New Guinea (PNG).

In 1972 another species, *Trichinella pseudospiralis*, was described that differs from *T. spiralis* and other encapsulated species in that the larval stage within a muscle fibre of the host is not enclosed in a collagen capsule (4). It is infective to mammals and birds. Later, in 1988, another non-encapsulated species was discovered in PNG and named *Trichinella papuae* (5) (Figure 2). *Trichinella papuae*, together with a third non-encapsulated

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Figure 1. An encapsulated larva of *Trichinella spiralis* in the diaphragm muscle of a pig.

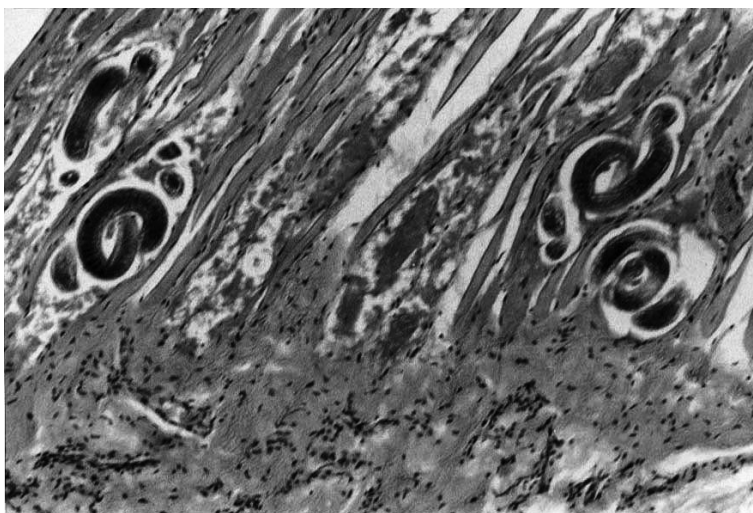


Figure 2. Stained histological section of striated muscle of a pig containing *Trichinella papuae* larvae, each within a muscle fibre (x100).

species, *T. zimbabwensis* (6), is infective to mammals and reptiles.

The genus *Trichinella* forms a monophyletic lineage in the family Trichinellidae, which is related to the family Trichuridae (that includes the genera *Capillaria* and *Trichuris*). *Trichinella* spp. are all very small (a maximum length of 3 mm) and are characterized by a series of glandular cells (stichocytes) in the anterior oesophageal region. Morphologically, adult *Trichinella* species are virtually indistinguishable; separation of the species is only possible by the use of molecular analysis aided, in a few cases, by the geographical location and the type of animal they infect. *Trichinella* is a unique nematode as both adult and larval stages occur in the same host – the adults in intestinal epithelial cells and the larvae in well-oxygenated striated muscle fibres.

Mating of male and female worms takes place in the intestinal epithelium of the host and the larvae, measuring about 100 µm, migrate via the lymphatic system into the blood stream and are carried around the body. Larvae can complete their development only in striated skeletal muscles. On entering a muscle fibre, a larva induces a series of changes in the host cell, which becomes transformed into a nurse cell. A network of capillaries develops around the nurse cell and, in the encapsulated species, a capsule of collagen is formed. Larvae can remain viable for many years in the host, but unless the infected muscle is eaten by a suitable animal, the cycle cannot continue, and the larvae eventually become calcified.

The non-encapsulated *T. papuae* larvae can retain their infectivity in the decaying carcass of a pig for up to 9 days under conditions when the temperature within the carcass reaches 35°C (7). This ability enhances continuity of the cycle in the tropical environment of PNG by improving the chances for scavengers becoming infected. *Trichinella papuae* larvae have no resistance to freezing (2).

Detection of infection

Adult worms of encapsulated species remain in the gut of their mammalian hosts for only a few weeks, but possibly for longer periods if the immune system is compromised (8), before being expelled. This fact, together with their small size, means they are seldom

encountered post mortem in infected hosts. On the other hand, live adults of non-encapsulated species were reported present in some reptiles 60 days after infection (9).

Trichinella larvae show a predilection for muscle sites; in the case of *T. papuae* in pigs, diaphragm, tongue, neck, jaw and upper foreleg muscles, with jaw, foreleg, rib and tail muscles in crocodiles. Several methods are used to detect larvae in muscle: 1) visually checking compressed muscle tissue under a dissecting microscope (trichinoscopy); 2) histology; 3) artificial digestion; and 4) finding specific circulating antibodies in serum.

Trichinoscopy is commonly used to find encapsulated species, but it is an unsuitable method for use with non-encapsulated species like *T. papuae* as the lack of a capsule makes detection of larvae difficult. Instead, fresh muscle tissue is subjected to pepsin/HCl (hydrochloric acid) digestion (10) and the digest deposit scanned for larvae under a dissecting microscope. However, isolation of larvae from muscle cannot be carried out using digestion before 17 to 21 days of infection as larvae are not yet resistant to the digestion process (8).

Histology has the advantage of being able to detect characteristic basophilic changes in infected muscle cells induced by larvae, even if actual larvae are not seen, but the disadvantage is the necessity of examining large numbers of sections (11).

Serology to detect anti-*Trichinella* IgG in serum samples is useful for the diagnosis of trichinellosis in humans, surveillance and epidemiological investigations. The enzyme-linked immunosorbent assay (ELISA) is the most commonly used, having high repeatability and sensitivity in detecting anti-*Trichinella* IgG, but with a limited specificity (12) due to nonspecific reactivity of the ELISA in sera from people with a range of helminthic, protozoan and other infections. Gómez Morales et al. found that the use of the Western blot technique provides greater specificity, distinguishing immune responses to specific *Trichinella* antigens from cross-reactive antigens and is, therefore, a valuable confirmatory test (13). Seroconversion usually occurs between the third and fifth week of infection (but up to two months in light infections) and serum remains positive up to one year or more after clinical symptoms

disappear (8).

Trichinella infection in naturally infected animals is asymptomatic (2). Clinical symptoms in humans depend on factors such as the number of infected larvae ingested, the species of *Trichinella* involved, and the immune status of the host (2,8,11). Diagnosis of infection is relatively straightforward in epizootic outbreaks, but differential diagnosis of human infection is difficult in low-level or occasional infections because some of the clinical signs are common to many other diseases, such as typhoid fever, influenza, chronic fatigue syndrome, polyarteritis nodosa, myositis during HIV infection, malaria, dengue fever, filariasis and eosinophilic leukaemia (8). Attention needs to be paid to what was eaten during the weeks preceding the onset of symptoms. A history of eating raw or undercooked meat, accompanied by the presence

of gastroenteritis, myalgia, symmetrical facial oedema, or subungual or conjunctival haemorrhages and an increase in eosinophil levels should suggest trichinellosis (8).

Trichinella papuae in Papua New Guinea

Infection in animals

Trichinella papuae was first detected in domestic pigs reared in a village of the Bensbach River area, Morehead District, Western Province, which had been fed with wild pig scraps. Subsequently, this parasite was discovered in 11.5% of wild pigs in the adjacent Bula Plain (Figure 3). Experimentally, *T. papuae* was found to be infective to mice, rats and cats (14) but no animals other than pigs have been found infected in Morehead District.

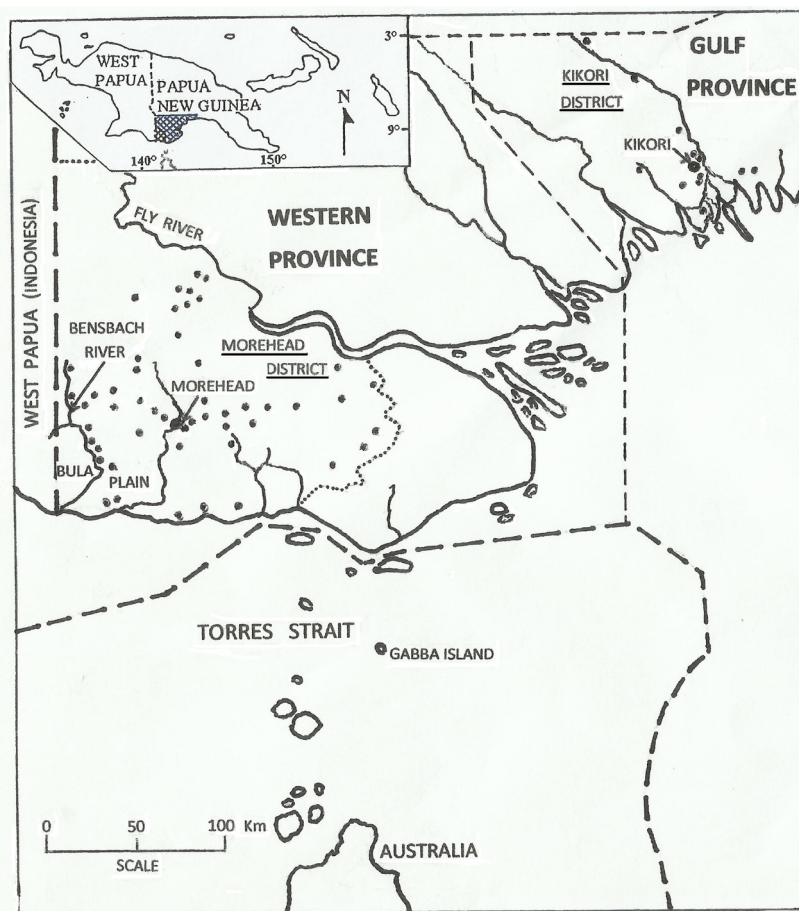


Figure 3. Map to show localities mentioned in the text.

● = location of villages in Morehead and Kikori Districts in which people participated in the surveys

Wild pigs are very common in the lowlands, present but less common in highland fringes and abundant in grassland habitats above 3000 metres (15). Morehead and Kikori (Gulf Province) are the only districts in PNG where wild pigs have been checked for the presence of *Trichinella*. Random checks of a few wild pigs from other localities have proved negative as have examinations of many domestic pigs from slaughter houses (14). The absence of wild pigs in the densely populated central highland valleys of PNG, together with the type of domestic pig husbandry practised, suggests that almost certainly *Trichinella* is absent from the region. 29 pigs from eight different villages in Eastern Highlands Province, as well as 33 rats collected in villages, were negative for *T. papuae* larvae (unpublished data). However, due to the small sample size, further investigations are required to confirm that the worm is absent from this highland region.

In 2003, saltwater crocodiles (*Crocodylus porosus*) purchased from Kikori District by a commercial crocodile farm were discovered to be infected with *T. papuae* (16). Subsequent investigation in 2004 found that wild pigs in the vicinity of Kikori were infected and that captured young crocodiles, while penned at Kikori, were fed with wild pig meat, together with fish. Molecular analysis showed that the Kikori worms were distinguishable from the Morehead worms (17). In the meantime, *T. papuae* was found in overseas studies to be infective experimentally to other reptiles (goannas, caimans, pythons and turtles) (9). Freshwater carnivorous fish were found not to be susceptible to infection with *T. papuae* (18).

Although natural infection of wild animals is not known to cause trichinellosis, under experimental conditions two young cats, infected with *T. papuae*, displayed morbidity; one (with 800 larvae per g of muscle) died within a few weeks, probably as a result of the infection, and the other (with 66 larvae per g of muscle) showed little body growth over a 7-month period when compared with an uninfected sibling given the same diet (14).

Infection of humans

As *Trichinella spiralis* is the cause of trichinellosis, a survey was conducted of people living in six villages located near Bula Plain to determine if villagers of the area

were infected with *T. papuae*. The people are traditionally gardeners, hunters and fishermen. Almost 29% of the 97 participants were seropositive (19). Later, a wider survey was carried out in Morehead District, involving 1536 people from 51 villages. It showed an overall seroprevalence of 10% (range from 0.0% to 36.7%) by ELISA and Western blot (20).

Participants in the latter survey were asked in semi-structured interviews if they had experienced any clinical symptoms associated with *Trichinella* infection. As most symptoms, as mentioned above, are not pathognomonic, the queries were limited to the presence of myalgia and facial or periorbital oedema, ie, the clinical features most frequently reported in human trichinellosis (11), as well as limb and joint pain. Bruschi and Murrell state that periorbital oedema is peculiar to trichinellosis, occurring in 17% to 100% of patients (8). As might be expected in a rural setting, where physical work is routine, muscle pain was a common complaint, more in men than in women. Although those reporting pain in limbs and joints were more likely to be seropositive than those not reporting such pain, the difference was not considered significant on statistical analysis. It is impossible to say how much, if any, of the pain experienced was induced by *Trichinella*, rather than other diseases, or caused by hard work. No one reported facial, eyelid or periorbital oedema.

A check for eosinophilia carried out in the first survey showed a higher prevalence in *Trichinella*-positive people than in *Trichinella*-negative people but, because of the low sample number, the difference was not found to be significant (19).

People were also asked about their eating habits. Well over 80% of both men and women said they 'sometimes' ate raw or under-cooked wild pig meat; men ate tidbits while in the bush after a hunt and women while preparing meat for cooking. Of these, 10.5% of the men and 7.3% of the women were positive for *Trichinella* antibodies (20). There is the likelihood that the method of cooking also exposes people to infection (21), but there is no tradition of eating raw meat, and no one indicated a preference for it.

A serological survey was carried out in 2008 on 313 people living in 11 villages in the Kikori District (Figure 3), following the discovery

that wild pigs (and penned crocodiles) in the vicinity of Kikori were infected with *T. papuae* (17). No people tested positive by both ELISA and Western blot, but 11.5% had false positive ELISA reactions (unpublished data). Without information on the parasite infections of the enrolled people, one can only speculate that the false positive results were due to cross-reactions with antibodies against other parasites. Roach et al., using ELISA, reported cross-reactivity between whipworms (*Trichuris* spp.) and *Trichinella spiralis* muscle larvae (22). Faecal egg count surveys carried out on people in the Kikori/Purari delta in the late 1970s showed that *Ascaris*, hookworm and *Trichuris* were the predominant helminths in the area (23,24). Filariasis (*Wuchereria bancrofti*) and malaria are also known to be present.

Information obtained during the unpublished 2008 survey indicates that the meat-eating habits of people living in Kikori District resemble those recorded in Morehead District (20), with 60% saying they 'sometimes' ate tidbits of raw or under-cooked wild pig meat. Their methods of cooking, however, differ. In Morehead the most common method used is the earth-oven ('mumu'). Round river stones are used in a 'mumu' elsewhere in PNG, but these are lacking in the Morehead area. Instead, people use materials such as sun-dried clay balls, pieces of termite mounds and small, rough lateritic stones, which do not retain heat as well as river stones (21). It means meat may not always be sufficiently cooked – as confirmed by some participants – to kill any larvae present, especially if it is not cut into small pieces. The International Commission on Trichinellosis strongly advises consumers to cook meat to an internal temperature of 71°C (10). In Kikori, cooking is done using a pot, or by roasting, or in a bamboo tube or wrapped in nipa palm leaves (known as 'biri'), methods that require cutting meat into small pieces, thereby being more likely to ensure that the meat is thoroughly cooked. Temperatures between 85° and 97° C were recorded in the centre of two traditionally cooked 'biri' that contained pig meat and sago (unpublished data). In only two villages, where river stones can be collected, is a 'mumu' regularly used.

***Trichinella papuae* infection in other countries**

The first reported case of human infection with *T. papuae* outside PNG occurred in

Thailand in 2006 (25), followed by a second report of further cases from the same locality (26). In both instances, the infected people lived in rural villages and consumed raw pig meat, sometimes as part of traditional dishes. Many villagers that had eaten meat of wild pigs became sick, displaying classical symptoms of trichinellosis, namely, fever, diarrhoea and abdominal pain within a few days of eating the meat, followed by eosinophilia, leukocytosis, myalgia, weakness, trunk/limb swelling, headache, and facial and/or periorbital oedema. Molecular analysis of worms obtained from biopsies confirmed the identification of *T. papuae*, identical to the genotype found in Kikori.

The treatment of infected people with mebendazole over a period of 10 days, together with a corticosteroid (prednisolone) for those individuals who had severe symptoms, led to a rapid improvement.

Intapan et al. (27) reported that an earlier case of trichinellosis (28) of a Thai worker returning from Malaysia was misdiagnosed as being caused by *T. spiralis*; they found the worm in question to be *T. papuae*. The patient showed generalized muscular hypertrophy of the body and weakness, with high white cell count, elevated creatine kinase level and eosinophilia. Gradual improvement followed treatment with albendazole over several weeks.

Lo et al. described an instance of trichinellosis, possibly due to *T. papuae*, in two groups of people in urban Taiwan who were suspected of developing typical symptoms after eating raw meat of soft-shelled turtles (*Pelodiscus sinensis*) in a restaurant; a few were hospitalized (29). The authors deduced that the outbreak was caused by *T. papuae* but were unable to discover how the turtles, bred on a farm and fed fish and shellfish, became infected.

In 2011, *T. papuae* was found for the first time in a wild pig on an uninhabited Australian island (Gabba Island) in the Torres Strait (30) (Figure 3). It is not known how long pigs have been on the island and for how long the infection has been present. Sequence analysis of the worms recovered matched that of the Kikori strain. The distance of the island from Kikori is much greater than from the Bula Plain area of Morehead District, which poses the question of how the infection arrived there.

Discussion

With the evidence from Thailand that *T. papuae* is capable of producing trichinellosis in humans, the question arises why the disease has not been seen in humans living in PNG areas where this parasite is circulating in wildlife. An important difference between circumstances in the two countries is that in Thailand the affected people traditionally ate raw meat, a practice not seen in Morehead or Kikori. It means that the Thai villagers may consume large quantities of raw pig meat in a short period of time, potentially allowing infection with large numbers of larvae. This is the standard way that trichinellosis occurs. In contrast, both the Morehead and Kikori people only occasionally eat raw or under-cooked meat and only as very small portions.

The level of infection of wild pigs in Thailand is not known, but the highest rate of infection recorded for pigs on Bula Plain is 8.9 larvae per g of meat (2.3 larvae per g in rib muscle – the preferred tissue eaten raw or under-cooked by men while hunting). These are considered to be low levels of infection (20) and, when only small pieces of meat are consumed, may not be sufficient to induce a noticeable reaction in the human host. Such small numbers of larvae, however, could trigger an immune response that would be maintained by the occasional intake of a few infective larvae, and reflected in the continuous presence of antibodies. Dupouy-Camet et al. mention that it has been estimated that an infecting dose of between 70 and 150 larvae is required to cause symptomatic trichinellosis (31). It was not possible to obtain biopsies of any Morehead participants to ascertain the worm burden in serologically positive people.

Why no Kikori participants had *Trichinella* antibodies remains unresolved. It may indicate that the cooking methods practised by Kikori people are more effective in cooking meat thoroughly than is the 'mumu' method used in Morehead, and/or that *Trichinella* infection is not prevalent in wild pigs in the locality. Wild pigs in the vicinity of only one village near Kikori are known to be infected. Rib muscle samples from two pigs from there yielded, respectively, 10.6 and 115 larvae per g (unpublished data), which indicates a higher level of infection than in Bula Plain pigs, but it is not known how widespread the infection of wild pigs is in the Kikori area.

Explanation for the false positive results, as mentioned earlier, probably lies with cross-reactions to antibodies of other parasitic infections.

Conclusions

The geographical limits of *T. papuae* infection in PNG have yet to be defined, but awareness of its potential to produce trichinellosis under suitable conditions is important.

Prevention of infection involves educating people that meat should be thoroughly cooked, not only pig meat, but meat of crocodiles and other carnivores and omnivores – information that has been conveyed, wherever possible, to the participants.

Diagnosis of infection is relatively easy in epizootic or outbreak form but difficult in low-level or sporadic infections, especially in countries, such as PNG, that are unfamiliar with the disease, making it necessary to carry out a careful differential diagnosis.

Treatment of trichinellosis, at least when caused by encapsulated species, is wholly effective only if drugs are administered within a short time after infection, that is, during the enteral (gut) phase and before larvae become enclosed in collagen capsules (32). Unfamiliarity with the disease often leads to a delay in diagnosis, with encapsulated larvae developing resistance to drugs. With non-encapsulated *T. papuae*, evidence from the cases in Thailand indicates that drugs given early in infection effect a rapid improvement in clinical symptoms. It is uncertain if appropriate drugs will kill larvae with the absence of collagen capsules, once they are fully established in muscle fibres. Bruschi and Murrell consider that asymptomatic, light infections (as found in Morehead) do not require treatment (8).

Wherever possible, participants in the surveys have been advised of the results but, unfortunately, it was not possible to revisit some villages owing to transport problems and roads becoming unusable.

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REFERENCES

- Owen R. Description of a microscopic entozoon infesting the muscles of the human body. *Trans Zool Soc London* 1835;1:315-324.
- Gottstein B, Pozio E, Nöckler K. Epidemiology, diagnosis, treatment, and control of trichinellosis. *Clin Microbiol Rev* 2009;22:127-145.
- Pozio E. The broad spectrum of *Trichinella* hosts: from cold- to warm-blooded animals. *Vet Parasitol* 2005;132:3-11.
- Garkavi BL. The species of *Trichinella* isolated from wild carnivores. [Rus] *Veterinariia* 1972;10:90-91.
- Pozio E, Owen IL, La Rosa G, Sacchi L, Rossi P, Corona S. *Trichinella papuae* n.sp. (Nematoda), a new non-encapsulated species from domestic and sylvatic swine of Papua New Guinea. *Int J Parasitol* 1999;29:1825-1839.
- Pozio E, Foggini CM, Marucci G, La Rosa G, Sacchi L, Corona S, Rossi P, Mukaratirwa S. *Trichinella zimbabwensis* n.sp. (Nematoda), a new non-encapsulated species from crocodiles (*Crocodylus niloticus*) in Zimbabwe also infecting mammals. *Int J Parasitol* 2002;32:1787-1799.
- Owen IL, Reid SA. Survival of *Trichinella papuae* muscle larvae in a pig carcass maintained under simulated natural conditions in Papua New Guinea. *J Helminthol* 2007;81:429-432.
- Bruschi F, Murrell KD. New aspects of human trichinellosis: the impact of new *Trichinella* species. *Postgrad Med J* 2002;78:15-22.
- Pozio E, Marucci G, Casulli A, Sacchi L, Mukaratirwa S, Foggini CM, La Rosa G. *Trichinella papuae* and *Trichinella zimbabwensis* induce infection in experimentally infected varans, caimans, pythons and turtles. *Parasitology* 2004;128:333-342.
- Gamble HR, Bessonov AS, Cuperlovic K, Gajadhar AA, van Knapen F, Noeckler K, Schenone H, Zhu X. International Commission on Trichinellosis: Recommendations on methods for the control of *Trichinella* in domestic and wild animals intended for human consumption. *Vet Parasitol* 2000;93:393-408.
- Pozio E, Gómez Morales MA, Dupouy-Camet J. Clinical aspects, diagnosis and treatment of trichinellosis. *Expert Rev Anti Infect Ther* 2003;1:471-482.
- Gómez Morales MA, Ludovisi A, Amati M, Cherchi S, Pezzotti P, Pozio E. Validation of an enzyme-linked immunosorbent assay for diagnosis of human trichinellosis. *Clin Vaccine Immunol* 2008;15:1723-1729.
- Gómez Morales MA, Ludovisi A, Amati M, Blaga R, Zivojinovic M, Ribicich M, Pozio E. A distinctive Western blot pattern to recognize *Trichinella* infections in humans and pigs. *Int J Parasitol* 2012;42:1017-1023.
- Owen IL, Sims LD, Wigglesworth MC, Puana I. Trichinellosis in Papua New Guinea. *Aust Vet J* 2000;78:698-701.
- Flannery TF. Mammals of New Guinea. Revised and updated edition. Ithaca, New York: Cornell University Press, 1995.
- Pozio E, Owen IL, Marucci G, La Rosa G. *Trichinella papuae* in saltwater crocodiles (*Crocodylus porosus*) of Papua New Guinea. *Emerg Infect Dis* 2004;10:1507-1509.
- Pozio E, Owen IL, Marucci G, La Rosa G. Inappropriate feeding practice favors the transmission of *Trichinella papuae* from wild pigs to saltwater crocodiles in Papua New Guinea. *Vet Parasitol* 2005;127:245-251.
- Pozio E, La Rosa G. Evaluation of the infectivity of *Trichinella papuae* and *Trichinella zimbabwensis* for equatorial freshwater fishes. *Vet Parasitol* 2005;132:113-114.
- Owen IL, Pozio E, Tamburrini A, Danaya RT, Bruschi F, Gómez Morales MA. Focus of human trichinellosis in Papua New Guinea. *Am J Trop Med Hyg* 2001;65:553-557.
- Owen IL, Gómez Morales MA, Pezzotti P, Pozio E. *Trichinella* infection in a hunting population of Papua New Guinea suggests an ancient relationship between *Trichinella* and human beings. *Trans R Soc Trop Med Hyg* 2005;99:618-624.
- Owen IL, Muke L, Davies HL. Trichinellosis: a possible link between human infection and the traditional earth-oven or 'mumu' method of cooking in Morehead District, Western Province, Papua New Guinea. *Anthrop Med* 2008;15:189-197.
- Roach TIA, Wakelin D, Else KJ, Bundy DAP. Antigenic cross-reactivity between the human whipworm, *Trichuris trichiura*, and the mouse trichuroids *Trichuris muris* and *Trichinella spiralis*. *Parasit Immunol* 1988;10:279-291.
- Ashford RW, Babona D. The parasites of the Purari people of Gulf Province, Papua New Guinea. *PNG Med J* 1980;23:165-168.
- Ashford RW, Hall AJ, Babona D. Distribution and abundance of intestinal helminths in man in western Papua New Guinea with special reference to *Strongyloides*. *Ann Trop Med Parasitol* 1981;75:269-279.
- Khumjui C, Choomkasien P, Dekumyoy P, Kusolsuk T, Kongkaew W, Chalamaat M, Jones JL. Outbreak of trichinellosis caused by *Trichinella papuae*, Thailand, 2006. *Emerg Infect Dis* 2008;14:1913-1915.
- Kusolsuk T, Kamonrattanakun S, Wesanonthawech A, Dekumyoy P, Thaenkham U, Yoonuan T, Nuamtanong S, Sa-nguankiat S, Pubampen S, Maipanich W, Panitchakit J, Marucci

- G, Pozio E, Waikagul J.** The second outbreak of trichinellosis caused by *Trichinella papuae* in Thailand. *Trans R Soc Trop Med Hyg* 2010;104:433-437.
- 27 **Intapan PM, Chotmongkol V, Tantrawatpan C, Sanpool O, Morakote N, Maleewong W.** Molecular identification of *Trichinella papuae* from a Thai patient with imported trichinellosis. *Am J Trop Med Hyg* 2011;84:994-997.
- 28 **Chotmongkol V, Intapan PM, Koonmee S, Kularbkaew C, Aungaree T.** Case report: acquired progressive muscular hypertrophy and trichinosis. *Am J Trop Med Hyg* 2005;72:649-650.
- 29 **Lo YC, Hung CC, Lai CS, Wu Z, Nagano I, Maeda T, Takahashi Y, Chiu CH, Jiang DDS.** Human trichinosis after consumption of soft-shelled turtles, Taiwan. *Emerg Infect Dis* 2009;15:2056-2058.
- 30 **Cuttell L, Cookson B, Jackson LA, Gray C, Traub RJ.** First report of a *Trichinella papuae* infection in a wild pig (*Sus scrofa*) from an Australian island in the Torres Strait region. *Vet Parasitol* 2012;185:343-345.
- 31 **Dupouy-Camet J, Kociecka W, Bruschi F, Bolas-Fernandez F, Pozio E.** Opinion on the diagnosis and treatment of human trichinellosis. *Expert Opin Pharmacother* 2002;3:1117-1130.
- 32 **Pozio E, Sacchini D, Sacchi L, Tamburrini A, Alberici F.** Failure of mebendazole in the treatment of humans with *Trichinella spiralis* infection at the stage of encapsulating larvae. *Clin Infect Dis* 2001;32:638-642.

Knowledge of physiotherapy services among hospital-based health care professionals in Papua New Guinea

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SUMMARY

It is not clear to what extent the health care professionals in Papua New Guinean hospitals are aware of the physiotherapy and rehabilitation services available to them. A study was conducted aimed at assessing the level of knowledge and perception of physiotherapy by hospital-based health professionals using a simple self-administered closed and open-ended questionnaire. 200 questionnaires were sent to each of five major hospitals but only 145 responses (15%) were received from different cadres of health professionals. Responses from nursing officers accounted for 46% (n = 67) while those from medical officers accounted for only 10% (n = 14). The respondents generally showed a lack of knowledge about physiotherapy services. It is suggested that inter-professional training and communication should be given greater attention during medical and health professional training to ensure that all health professionals are aware of the role and importance of physiotherapy services.

Introduction

Physiotherapy in Papua New Guinea (PNG) was first documented in 1955. There was only one physiotherapist for the population of 19,000 people (15,000 native population and 4000 expatriates) in Port Moresby (1). By the early 1980s, the National Health Department (NDoH) had created 11 physiotherapy positions within the department and in the same year 3 students were sent to New Zealand to undertake a three-year diploma program (2). By the beginning of the 1990s, there were only two Papua New Guinean physiotherapists working in hospitals, with a number of overseas volunteers (3). A need for physiotherapy training was identified and a three-year diploma program was initiated at Divine Word University (DWU) in 2003 (4,5) with the first batch of Papua New Guinean physiotherapists graduating in 2006. In 2008, the physiotherapy program was upgraded to a degree (Bachelor's level), requiring four years of undergraduate studies (5). At present most of the provincial hospitals have a physiotherapy department and are staffed by nationally trained physiotherapists. Whilst

some physiotherapists are in the public sector, some are employed in the private sector, including private health facilities and sporting institutions.

Physiotherapy is an established and regulated profession, but its training and practice differ in different countries, depending on the health needs, economic, health care and educational systems and demographic characteristics of the country (6). The current global paradigm for health care systems is towards the prevention of illness, rather than curing of individuals (6). Given physiotherapy's role in the prevention and minimization of disability, physiotherapists have a major role to play in rehabilitation and promotion of health awareness in communities. The World Health Organization (WHO) in its report on disability in 2004 was not able to provide the prevalence of disability in PNG, but in 2011 the indicator of 'years of health lost due to disability' was reported to be 9.4 per 100 persons (7). In 2003, Ramu in Madang Province and Wosera in East Sepik Province reported that 3.2% of their populations were living with some kind of disability (8). Therefore physiotherapy

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should be an important part of rehabilitation to prevent and manage the people with disabilities. Literature from the United States of America (USA) suggests that when health care professionals, including doctors, are well informed on the role of physiotherapy there is better utilization of physiotherapy services (9). Information on PNG health care professionals' knowledge of physiotherapy and its roles has been lacking. The aim of this study was to assess the level of knowledge and perception of physiotherapy by health care professionals in selected major hospitals.

Materials and Methods

Study design and sampling

A descriptive cross-sectional observational study was conducted using a self-administered survey questionnaire focussing on the perception of physiotherapy among health care professionals in PNG. Five hospitals were purposely selected (Figure 1) as they are the major hospitals with the highest number of referrals from rural health facilities. All cadres of health care professionals, including doctors, health extension officers, nursing officers and community health workers (CHWs), and the residents from the respective above-mentioned professions were invited to participate in this study.

Questionnaire development

The questionnaire was developed based

on similar studies conducted in the USA and Australia (10-13). The questions were adapted to suit the PNG context. The questionnaire consisted of closed and open-ended questions that included demographic information, current knowledge of physiotherapy, referral patterns, communication between health professionals and the need for and methods to increase knowledge of physiotherapy. The questionnaire was initially piloted among health care professionals during the 48th Annual Medical Symposium held in September 2012 in Port Moresby. Data obtained from the pilot study allowed researchers to make changes to improve the clarity of questions, hence improving content and face validity (14).

Data collection and analysis

A total of 1000 questionnaires (a pack of 200 questionnaires for each selected hospital) were dispatched to the physiotherapy officer-in-charge (OIC) of each hospital. Each pack was numbered and colour-coded to define respondents by region and hospital. Data were collected over an eight-week period under the supervision of the OIC. The completed questionnaires were collected and placed in a sealed envelope, maintaining anonymity, and returned to the researchers from the hospitals via mail. When the questionnaires were received, the data were checked for completeness and then entered into Microsoft Excel spreadsheet and subsequently exported to IBM-SPSS version 21 for analysis. Quantitative data were used

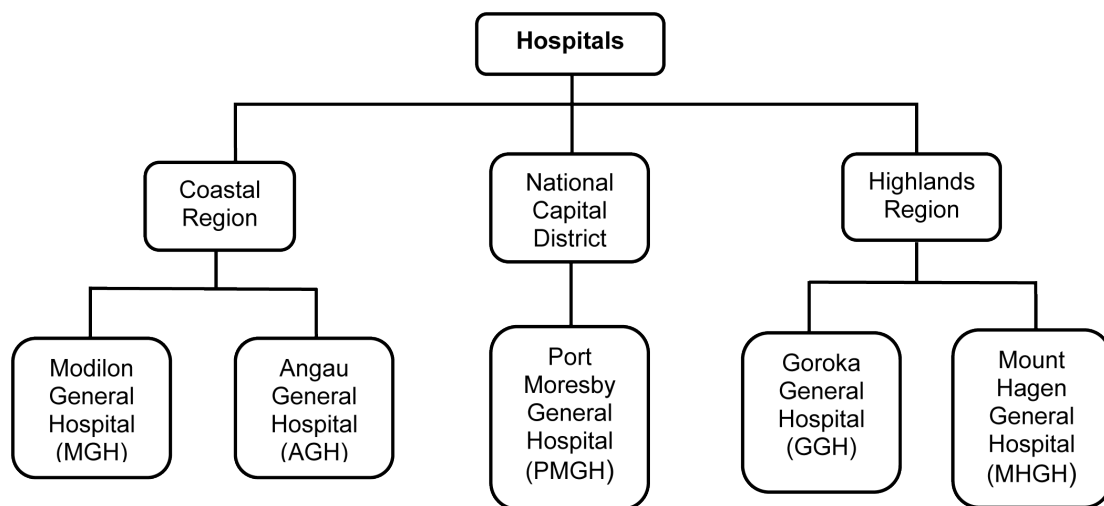


Figure 1. The five hospitals used for the survey.

for descriptive statistics while qualitative data were reviewed for content analysis and the frequency of responses reported.

Ethical approval for this study was obtained from DWU Research Ethics Committee and the Human Research Ethics Committee of James Cook University. The return of a completed questionnaire was considered as an implied consent from participants.

Results

Of the 1000 questionnaires dispatched, 170 questionnaires (17%) were returned in sealed and secured envelopes but only 145 (15%) were analysable, the remaining 25 being incomplete. 46 responses were

received from the Port Moresby General Hospital (PMGH), 41 from Angau Memorial Hospital, 38 from Modilon General Hospital (Madang) and 20 from Goroka General Hospital. 67 (46%) of the responses were from nursing officers, including midwives and specialty nurses, 41 (28%) from CHWs, 20 (14%) from hospital resident trainees and 14 (10%) from doctors, including specialists. Overall, despite a general lack of knowledge and awareness of the role of physiotherapy services in the hospitals, a good number of respondents were aware of the existence of rehabilitation services within their respective hospitals (Table 1). There was a lack of clear understanding of the relationship between rehabilitation services and physiotherapy services. Partly this may be due to lack of

TABLE 1

KNOWLEDGE AND AWARENESS OF PHYSIOTHERAPY

Description	Yes (n) %	Not applicable (n) %
Do you have a rehabilitation team in your hospital?	120 82.7%	-
Have you worked with a rehabilitation team?	40 27.6%	-
Are there any rehabilitation services for people with disabilities in PNG?	122 84.1%	-
Do you know how to refer patients for physiotherapy?	76 52.4%	35 24.1%
Have you referred any patients for physiotherapy?	55 37.9%	-
Have you discussed the need for physiotherapy intervention with your colleagues?	55 37.9%	-
Do the physiotherapists communicate regarding the patients that you referred for physiotherapy?	52 35.9%	40 27.6%
Do you agree with physiotherapists' suggestions?	58 40.0%	48 33.1%
Do you think physiotherapy professionals create awareness of physiotherapy?	64 44.1%	-
Do you have enough information about physiotherapy?	46 31.7%	-
Would you like to know about physiotherapy?	140 96.6%	-
Do you think you need training to understand physiotherapy?	139 95.9%	-

awareness or lack of appropriate information during training. Figure 2 outlines themes generated from open-ended enquiry. Lack of education and lack of reinforcement for a multidisciplinary approach to health care services in hospital are some of the key factors contributing to lack of knowledge and awareness of physiotherapy services in hospitals.

Discussion

The very disappointing response rate is a major limitation to the study. Nevertheless the results show that there is a general lack of knowledge on the role of physiotherapy and rehabilitation services, despite these services being available within the hospitals. Whilst 83% of respondents indicated that they are aware of rehabilitation services available in the hospital in which they work only about a third (28%) indicated interacting with these services. These findings are likely to have practical implications in terms of utility of these services at the hospitals. It is recognized that lack of knowledge of physiotherapy and rehabilitation services leads to underutilization of these services (15,16). Physiotherapy is an essential and well-utilized part of the health

care system in most developed countries. In developing countries, such as PNG and countries in Africa, Asia and the Western Pacific, the role of physiotherapy is less developed (6) and physiotherapy services are underutilized (15). Understanding why underutilization occurs in PNG is important. Our research is the first of its kind and more research in this area is needed.

The results of our study show that although physiotherapy and rehabilitation services were available, knowledge of the function and scope of physiotherapy among those surveyed was poor. An earlier PNG study in 1982 found that simple physiotherapy techniques, demonstrations and lectures were provided to trainee nurses at PMGH (2). In the current study only one-third of respondents felt that they had enough information about physiotherapy and almost all indicated that they required training to understand physiotherapy and its role. Doctor's lack of knowledge of the rehabilitation process leads to underutilization of services provided by rehabilitation medicine (17). Respondents in this study stated that including teaching about physiotherapy in their undergraduate training or during clinical opportunities would help to provide a better

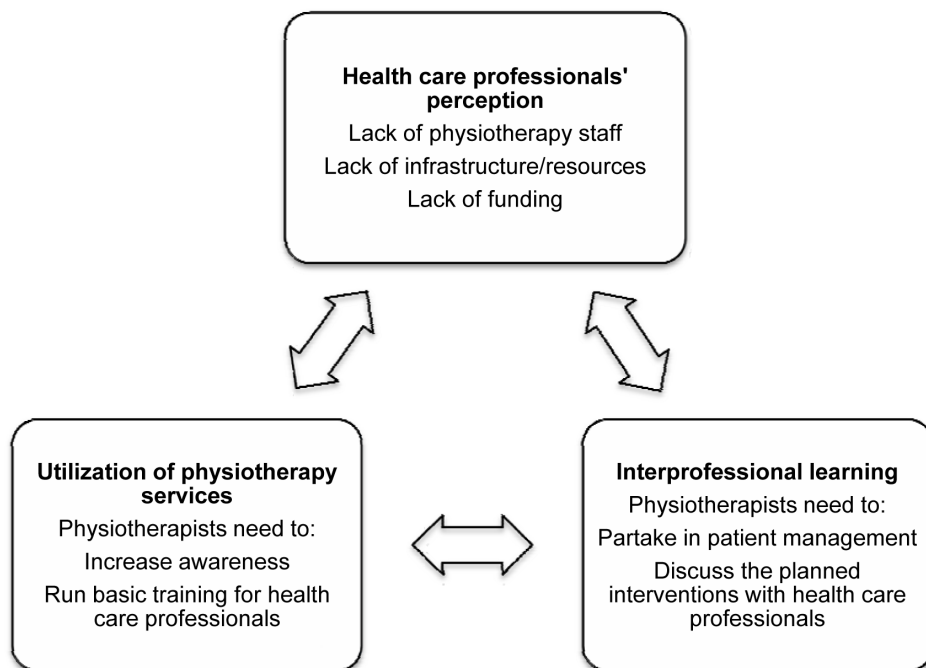


Figure 2. Themes developed from content analysis of qualitative data.

understanding of physiotherapy and its role in PNG, a finding similar to that in a study amongst Australian medical undergraduates (13). Lack of knowledge about the role of physiotherapy among health professionals may lead to lack of interest in creating physiotherapy positions in hospitals (18). Doctors and other health professionals who do not have enough information about the service and the profession of physiotherapy cannot make appropriate referrals (13).

Our study found that 97% of health care professionals would like more information regarding physiotherapy. Physiotherapists have to take the lead in this area. It is the responsibility of physiotherapists, physiotherapy educational programs and the physiotherapy associations to promote the profession and its status among other health professions and the general public (12). Developing countries such as Afghanistan (19), Vietnam (20), Kenya, Uganda, Malawi and Tanzania are facing similar challenges regarding the lack of awareness of the physiotherapy profession (21).

Communication is the key factor in improving collaboration between physiotherapists and other health professionals for the benefit of the community (16) and to improve the referral process (11). Reported ways to improve doctors' interactions with physiotherapists are by attending medical rounds, giving presentations and involvement in research projects (9). Respondents in our study also suggested similar ways of increasing health professional knowledge, including ward rounds, communicating plans for treatment, and in-service and basic training. Only 36% of the health care professionals in our study stated that they communicate with physiotherapists. Similar findings were reported in a recent study of general practitioners' perspectives of education and collaboration with physiotherapists in primary health care (16). To improve the knowledge of physiotherapy and its role (and subsequent increased and improved utilization in clinical practice) it would be appropriate to include some physiotherapy training in the undergraduate curricula of all health professionals – the concept of inter-professional education (16). Physiotherapy placements in training programs have been shown to be valuable in general practice and in undergraduate medical training (13,22).

Conclusion

Our study has identified a lack of knowledge of physiotherapy and its role among the health professionals surveyed which is likely to reflect the situation in the wider health professional community. There is therefore an urgent need to improve education regarding physiotherapy and rehabilitation services for all cadres of health workers. Physiotherapists need to be proactive in this area and need the support of health service and training institutions and government.

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REFERENCES

- 1 **Davies P.** Physiotherapy at Port Moresby. *Aust J Physiother* 1955;1:157-159.
- 2 **Brogan J.** The physiotherapist in Papua New Guinea. *PNG Med J* 1982;25:186-188.
- 3 **Powell N.** Physiotherapy in Mount Hagen General Hospital: an audit of activity over a six-month period. *PNG Med J* 2001;44:24-35.
- 4 **Pronk F, Thornton P.** Physical disabilities in Papua New Guinea: how can professional physiotherapy training fit best? *Contemporary PNG Studies: DWU Research Journal* 2009;11:73-89.
- 5 **Ramalingam K, Karthikeyan P, Akiro C.** Educating to combat disability: a profile of physiotherapy training in Papua New Guinea. *Physiotherapy* 2011;97(Suppl 1):eS1577-eS1578.
- 6 **Higgs J, Refshauge K, Ellis E.** Portrait of the physiotherapy profession. *J Interprof Care* 2001;15:79-89.
- 7 **World Health Organization, World Bank.** World report on disability. Geneva: World Health Organization, 2011. www.who.int/disabilities/world_report/2011/en/index.html
- 8 **Byford J, Veenstra N, Gi S.** Towards a method for informing the planning of community-based rehabilitation in Papua New Guinea. *PNG Med J* 2003;46:63-80.
- 9 **Ritchey FJ, Pinkston D, Goldbaum JE, Heerten ME.** Perceptual correlates of physician referral to physical therapists: implications for role expansion. *Soc Sci Med* 1989;28:69-80.
- 10 **Uili RM, Shepard KF, Savinar E.** Physician knowledge and utilization of physical therapy procedures. *Phys Ther* 1984;64:1523-1530.
- 11 **Stanton PE, Fox FK, Frangos KM, Hoover DH, Spilecki GM.** Assessment of resident physicians' knowledge of physical therapy. *Phys Ther* 1985;65:27-30.
- 12 **Silva DM, Clark SD, Raymond G.** California

- physicians' professional image of therapists. *Phys Ther* 1981;61:1152-1157.
- 13 **Lee K, Sheppard L.** An investigation into medical students' knowledge and perception of physiotherapy services. *Aust J Physiother* 1998;44:239-245.
 - 14 **Polgar S, Thomas SA.** Introduction to Research in the Health Sciences. Fifth edition. Edinburgh: Churchill Livingstone Elsevier, 2008.
 - 15 **Kay E, Kilonzo C, Harris MJ.** Improving rehabilitation services in developing nations: the proposed role of physiotherapists. *Physiotherapy* 1994;80:77-82.
 - 16 **Paz-Lourido B, Kuisma RME.** General practitioners' perspectives of education and collaboration with physiotherapists in primary health care: a discourse analysis. *J Interprof Care* 2013;27:254-260.
 - 17 **Anderson TP, Fenderson DA, Kottke FJ.** Strategies for recruiting medical students to physical medicine and rehabilitation. *Arch Phys Med Rehabil* 1983;64:85-87.
 - 18 **van Lieshout J.** Physiotherapy in Papua New Guinea: assessment of employment opportunities. *Contemporary PNG Studies: DWU Research Journal* 2010;12:81-91.
 - 19 **Armstrong J, Ager A.** Physiotherapy in Afghanistan: an analysis of current challenges. *Disabil Rehabil* 2006;28:315-322.
 - 20 **Kay E, Huong NT, Chau NTM.** Upgrading physical therapy education in Vietnam. In: Leavitt RL, ed. *Cross-Cultural Rehabilitation: An International Perspective*. First edition. Philadelphia: WB Saunders, 1999.
 - 21 **World Confederation for Physical Therapy.** WCPT Newsletter. *Physiotherapy* 1994;80:231-232.
 - 22 **Crotty M, Finucane P, Ahern MJ.** Teaching medical students about disability and rehabilitation: methods and student feedback. *Med Educ* 2000;34:659-664.

The Medical Society and the Medical Journal, with comments on pigbel, swollen belly syndrome, kuru and other Papua New Guinean medical icons

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SUMMARY

The Fiftieth Annual Medical Symposium of the Medical Society of Papua New Guinea held in Goroka from 31 August to 3 September 2014 celebrated the success of the Medical Society and the *Papua New Guinea Medical Journal*. This paper was presented as an address at the meeting and praised the work of medical doctors, allied health staff, medical scientists and research staff engaged in the field and laboratory for their many achievements over these 50 years. It describes the major Papua New Guinean medical icons of kuru, pigbel and swollen belly syndrome and draws out lessons learned from them and the research that elucidated them. Other medical icons that are briefly described include neonatal tetanus, Burkitt lymphoma, standard treatment books, respiratory bacteriology, insecticide-treated bednets, pneumococcal polysaccharide vaccine, a blood-stage malaria vaccine, snakebite, conservative management of ruptured spleen, radial paralysis in leprosy, the response to BCG and the BCG leprosy trial, bottle-feeding legislation, betelnut chewing and oral cancer, hyperreactive malarious splenomegaly, genetic polymorphisms associated with malaria, subacute sclerosing panencephalitis, donovanosis, endemic goitre and endemic cretinism, lymphatic filariasis, adult asthma and sago haemolytic disease. Attention is also drawn to likely future challenges – from infectious diseases and their unpredictability, outbreaks of disease on a global scale, climate change, the difficulty of establishing effective community engagement in the pursuit of greater equity in health and well-being, and the need to ensure that the mineral wealth of the nation is used for everybody's benefit. A Health Think-Tank is proposed as a means of developing innovative and efficient ways of improving the health of all Papua New Guineans.

The Papua New Guinean medical icons

The Medical Society of Papua New Guinea and the *Papua New Guinea Medical Journal* are inextricably entwined. The Journal is 9 years older than the Society, but it did not flourish until it was taken over by the Medical Society. The objectives of the new Society were set out by one of its founders, Dr Ian Maddocks, in the March 1965 issue of the Journal (1). The first objective was to promote the advance of medical knowledge and to assist in the dissemination of such knowledge amongst its members. Conducting an annual Medical Symposium and publishing the Medical Journal are clearly relevant to fulfilling this objective. That both activities are still flourishing is a tribute to the Society and to the many people responsible for it and the Journal

over the past 50 years.

The first Symposium of the Society held in Goroka in 1965 established the tradition of having a theme or main topic, which on this occasion was **pigbel**. Tim Murrell had done the pioneering work on pigbel from Goroka and had established the primary role of the beta-toxin of *Clostridium perfringens* type C in the pathogenesis of the disease; in this work he had collaborated with veterinary scientists and bypassed the medical establishment. He was not invited to the meeting. However, when the papers were published in the first focus issue of the Journal, on the theme of pigbel, in July 1966, Tim contributed two papers (2,3) and a letter replying to the comments made by the Australian professors who had been invited to the Goroka meeting to deliver their expert

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opinion (4). They had expressed scepticism about the role of pig-feasting in the aetiology of the disease and, in a contradictory way, predicted that as the importance of pig-wealth to highland societies declined the disease would disappear. They also commented that no progress in understanding the disease would be made until proper epidemiological and anthropological studies had been carried out. In the outcome, Greg Lawrence, who took over the reins of pigbel research from Tim Murrell, proved the value of the pigbel toxoid vaccine in preventing the disease by undertaking a hospital-based trial without detailed epidemiological or anthropological studies (5).

Swollen belly syndrome is a remarkable disease that was found in young infants in several locations in Papua New Guinea. The concentration of cases at Kanabea in Gulf Province led to clinical, epidemiological and aetiological studies by John Vince, Dick Ashford, Mike Gratten and Joe Bana-Koiri that solved the problem, established curative treatment and led to the elimination of the disease. The two papers reporting this considerable achievement were published in the Journal in June 1979 (6,7). The causative organism, found in enormous numbers in affected infants, was *Strongyloides fuelleborni*-like, which had previously been discovered by Alan Kelly in small numbers in adult surveys in Western Province. Subsequent work by the Liverpool School of Tropical Medicine and the Papua New Guinea Institute of Medical Research confirmed the taxonomy of the parasite, which is now named *Strongyloides fuelleborni kellyi* (8). Its fascinating life cycle, like that of some other helminths, appears to show only a few worms in adults, an expanding population in pregnant females and vertical transmission to cause massive infection in young offspring. Because the disease was sporadic and rare when the subsequent studies were done it was not possible to formally prove vertical transmission, through placenta or milk, but evidence from elsewhere supports it, as clearly stated by the original investigators; this question is critically discussed by Guy Barnish (9).

Kuru is a fatal neurodegenerative disease that was found only in a remote region of the Eastern Highlands. The epidemic began in the early 1900s, reached a peak in the 1950s with 200 deaths a year and died out in

the early 2000s; the most recent cases had incubation periods greater than 50 years. The causative agent is a prion (protein-only agent) that spontaneously changed to an infectious form in one person's brain and was transmitted to create an expanding epidemic through the local mortuary practice of transumption, in which the bodies of the dead were consumed by grieving relatives (10). The solution of the puzzle of kuru and subsequent studies led to a paradigm shift in our knowledge of human infections and achieved international recognition. It became the global model for 'mad cow disease' and other epidemic neurodegenerative diseases. An important early paper on kuru was published in the Journal in 1959 (11), but because the location of kuru was so remote few members of the Society have had direct experience of the disease. However, the Fore people who suffered from it were deeply engaged in kuru research, and it was their presentations that made the only session of a Medical Symposium devoted to kuru, in Goroka in 2005, such a moving occasion.

Pigbel, swollen belly syndrome and kuru are iconic Papua New Guinean diseases. They are characteristic of Papua New Guinea, where they were first identified and described, though their causative agents may be found throughout the world. From them we can draw various lessons relevant to human medicine and infectious disease and also to possible future challenges here in Papua New Guinea. Furthermore, they are only the most famous in the list of Papua New Guinean medical icons from which we and the rest of the world have learned: there are many more.

Frank Schofield and colleagues investigated **neonatal tetanus** in the Maprik area and showed that it could be prevented by maternal immunization with tetanus toxoid (12). This has become standard practice around the world. Unfortunately, the intervention is not always practised and neonatal tetanus is still a significant cause of death, especially in Sub-Saharan Africa.

Papua New Guinea has the second major focus of **Burkitt lymphoma** outside of Africa. This tumour can grow to a massive size in children but responds well to cyclophosphamide. Its pathogenesis is based on the combined effects of malaria and Epstein-Barr virus (EBV) infection. It was first described by Denis Burkitt in Africa in 1958,

but in fact the description of this unusual lymphoma in children in Papua New Guinea by Jan Saave (13) predates Burkitt's report by 3 years, so it really should be called the Saave lymphoma.

Professor John Biddulph and the Paediatric Society of Papua New Guinea were pioneers in the creation of **standard treatment books**. This concept was adopted by other clinical disciplines in Papua New Guinea and also, most importantly, by the World Health Organization (WHO). Standard treatment enabled the best available clinical care to be given across all levels of the health services and provided a rational list of affordable drugs that could be procured by the Department of Health for distribution throughout the country.

Research studies in Papua New Guinea have pioneered several significant aspects of **respiratory bacteriology**. The aetiology of pneumonia in children in the tropics was established by a series of studies conducted by the paediatricians at Goroka Hospital and the bacteriologists at the Papua New Guinea Institute of Medical Research, beginning with Frank Shann and Mike Gratten (14,15). *Streptococcus pneumoniae* (the pneumococcus) and *Haemophilus influenzae* were found to be the principal aetiological organisms. The significant pathogens included many serotypes of *S. pneumoniae* and, with *H. influenzae*, non-typeable strains as well as type b. In order to study the ecosystem of these infecting bacteria, innovative nasopharyngeal carriage studies, including the acquisition of colonizing bacteria from birth (16), were undertaken, which became the model approach subsequently adopted by investigators elsewhere. The methodology used was also innovative, and Mike Gratten was commissioned to write the manual for respiratory bacteriology that was adopted by WHO. Susceptibility to penicillin was initially a defining characteristic of the pneumococcus, and then, in the Land of the Unexpected, penicillin-resistant strains were discovered: no-one else was prepared to believe it. These results were reviewed in the Journal by David Hansman in 1973 (17). Eventually, after similar strains appeared elsewhere, the rest of the world had to accept that these unexpected findings from Papua New Guinea were real.

When the Papua New Guinea Institute of Medical Research began its work on

permethrin-impregnated mosquito nets in 1983 most of the pundits determining global policy for malaria control thought that the idea was a joke. Following an initial study by Bruce Millen, a trial by Patricia Graves and others demonstrated the value of these nets in preventing malaria in children (18). Subsequently the use of **insecticide-treated bednets** became a key element in the control strategy promoted by WHO. The widespread implementation of this intervention has not been easy to achieve but where it has been done successfully the effect on malaria has been dramatic (19). As a consequence the mosquito vectors of malaria have responded by changing their behaviour, and so we now need to develop another set of innovative ideas in order to maintain or expand current levels of malaria control.

As part of the research on pneumonia, which had been initiated in adults by Robert Douglas and Ian Riley in 1970, a trial of **pneumococcal polysaccharide vaccine** in children was undertaken in Tari and in the Asaro Valley near Goroka, even though the accepted dogma was that this vaccine was not immunogenic in children under the age of 2 years. The outcome of the trial, published in 1986, showed significant efficacy of the vaccine against both mortality from pneumonia and all-cause mortality in children aged from 6 months to 5 years and, indeed, also in the subset of children in the trial aged from 6 months to 2 years (20). Studies to replicate this result in other countries were planned but ultimately not undertaken because it was believed that a pneumococcal conjugate vaccine that would be more immunogenic in children was 'just around the corner'. It has taken more than two decades for the conjugate vaccine to become available to children in tropical countries, and in these settings the polysaccharide vaccine has been shown to have a continuing important role as a booster (21). However, even this has been controversial and thus the Papua New Guinean experience with this vaccine remains at the forefront of global debate.

As part of research on malaria, a **blood-stage malaria vaccine** was tested in Papua New Guinea. Unlike other malaria vaccines that have been developed around the world, this vaccine was designed not to protect against infection but to prevent severe malaria and death in children. Its purpose was not to prevent tourists or military personnel from

getting malaria but to enable children growing up in a malaria-endemic area to survive attacks of malaria, develop their own immunity and reach healthy adulthood. After the completion of detailed population-based preparatory studies (22), the vaccine was shown in a trial in children in the Wosera area of East Sepik Province to reduce parasite density, a surrogate for malarial disease severity, which thus proved the principle of this vaccine (23). Despite such a promising beginning further studies were unfortunately not possible because the company that made the vaccine ceased operating. Nevertheless, this was a landmark trial in Papua New Guinea – even if the rest of the world has yet to acknowledge and fully understand the implications of these studies.

One of the serious health problems that is exceptionally common in Papua New Guinea and makes the country famous in medical circles is **snakebite**. It is like a Goliath that attracts aspiring Davids to come and do battle with it: we had David Warrell, David Theakston and David Laloo, and now we have David Williams. They have been engaged in clinical studies and have helped develop new antivenoms, as in the study reported at this symposium (24). Although some have suffered from snakebite themselves while collecting venom, all are fascinated by the powerful beauty of Papua New Guinean snakes and passionate about preventing deaths from snakebite.

Surgeons in Papua New Guinea have also been innovative and the demonstration of the value and safety of **conservative management of ruptured spleen** by Ken Clezy, David Hamilton and others has been a world-leading change in surgical practice (25). This is not always possible, but because the spleen is important in providing protection against malaria and also against infection by encapsulated bacteria such as the pneumococcus and *Haemophilus influenzae*, the major causes of pneumonia, there is a strong incentive to preserve it. Severe and fatal malaria and pneumonia are both common in the tropics, as is an enlarged and vulnerable spleen from malaria, and therefore the knowledge that non-operative management of ruptured spleen is safe led to an advance in practice that has saved many lives.

In the past leprosy was much more

common in Papua New Guinea than it is today. Though tuberculosis – the other well-known mycobacterial disease – was not present in highland populations in early colonial times, leprosy had entered the highlands by transmission along traditional trade routes from the coast. For example, there was a particular focus in Karimui, from where the prevalence progressively diminished as this trade route dissipated into the central highlands. Patients suffering from leprosy were cared for and treated in various leprosaria scattered throughout the country. Ken Clezy was widely renowned for his work on surgical rehabilitation in leprosy patients and in Papua New Guinea he identified a much higher frequency of **radial paralysis in leprosy** than had been reported elsewhere (26).

BCG given at birth is a useful vaccine for modulating the immune system in a helpful way and for protecting children from miliary and extrapulmonary tuberculosis. It was once believed that BCG would also protect against pulmonary tuberculosis and therefore all labourers recruited from the tuberculosis-free highlands to work on coastal plantations in a government-sponsored scheme were given BCG by the health authorities before they were taken to the coast. Remarkably, very few of them converted to become Mantoux positive after their inoculation. This peculiarity of Papua New Guinean highlanders in their **response to BCG**, possibly due to prior infection with other mycobacteria, did no harm to them but presented annoying difficulties to the Australian health authorities who were anxious to do the right thing for the people under their care. Though BCG does not protect against pulmonary tuberculosis, it does provide protection against leprosy, as was shown by the **BCG leprosy trial** undertaken in Karimui. However, the global impact of this study was somewhat diminished by the length of time it took to write up and publish the results (27).

John Biddulph and the paediatricians were involved in another distinctly Papua New Guinean innovation: **bottle-feeding legislation**. Diarrhoeal disease and malnutrition associated with the improper use of bottle feeding was a major concern to paediatricians and, in response to their eloquent persuasion, the government agreed to pass legislation requiring bottle-feeding equipment and infant formula to be available

only on a doctor's prescription.

Betelnut chewing is a common practice in Papua New Guinea and is an important part of social interaction in coastal cultures. Unfortunately **betelnut chewing and oral cancer** are strongly associated, even when tobacco smoking or chewing is not involved. This association has been identified by several groups in different disciplines, but the careful epidemiological studies by Robert MacLennan and his team have produced the most rigorous evidence to support it (28).

When the endemicity of malaria is unstable and mesoendemic the response of the host can lead to very large spleens and the immunologically deleterious condition of **hyperreactive malarious splenomegaly**. In the Watut area of Morobe Province the people suffered from a severe form of this condition. Extremely large spleens were common and, moreover, functioned poorly, which led to premature death from bacterial infection, most likely pneumococcal. The disease was studied by Greg Crane (29) and attracted other medical scientists from around the world with an interest in this unusual host response to malaria. Their studies demonstrated a complex genetic basis to the condition and showed that the disease could be prevented by regular antimalarial prophylaxis.

Infections commonly lead to adaptations by both the infecting microorganism and the host through evolutionary mechanisms that can cause demonstrable genetic change even after a few generations. In the case of malaria, which has been associated with humans for millennia, the human host has adapted genetically in many different ways to reduce mortality from malaria, and Papua New Guinea is famous for the number of human **genetic polymorphisms associated with malaria** (30). These include alpha- and beta-thalassaemia, Southeast Asian ovalocytosis (SAO), glucose-6-phosphate dehydrogenase (G6PD) deficiency and Gerbich blood group negativity.

In the past measles was a surprisingly minor problem for children and paediatricians in Papua New Guinea. However, at about the time that measles vaccine became available this situation changed dramatically. Measles epidemics became common and were characterized by severe morbidity and many deaths, with unusually high frequency

in young infants. Sadly, Papua New Guinea experienced a disturbingly high incidence in older children of **subacute sclerosing panencephalitis** (SSPE), a delayed, normally rare, complication of measles infection that affects the brain and has a distressing subacute and fatal course (31,32). Because maternally derived immunity was commonly lost early, leaving many young infants vulnerable to measles, and because unusual, early measles infections may predispose to SSPE, Papua New Guinea independently adopted the policy of vaccinating infants against measles at 6 months of age as well as giving the standard vaccinating dose at 9 months.

Papua New Guineans have suffered from the whole gamut of sexually transmitted infections (STIs), including some that are uncommon elsewhere. In the past **donovanosis** was a well-recognized ulcerative STI that was frequently seen here, though it never reached the high prevalence found in the south-west coastal communities of West Papua just over the border (33). This once famous disease is now rarely seen, which is a blessing. Another STI, chancroid, which was never noticeably common, is now also rare; however, the organism, *Haemophilus ducreyi*, has surprisingly persisted as a cause of ulcers similar to yaws that are not transmitted sexually. With the introduction of the human immunodeficiency virus (HIV) and, much earlier, gonorrhoea and syphilis, Papua New Guinea has its full share of STIs. Because the immunity due to yaws protects against both forms of *Treponema* infection syphilis took a while to become established, but once it did so it expanded predictably along well-known routes of transmission, such as the Highlands Highway, and then more widely, so that congenital syphilis is today another preventable disease with a disturbingly high incidence in Papua New Guinea (34).

The global program to prevent iodine deficiency diseases was established through a high-profile, successful campaign led by Basil Hetzel that was based on his own research studies with P. O. D. Pharoah and others, following the earlier work of S. F. McCullagh, on **endemic goitre and endemic cretinism** in Papua New Guinea. These studies showed that severe iodine deficiency was present in certain populations and could be corrected by iodized oil injections; in particular, endemic cretinism was prevented by giving iodized

oil injections to women of reproductive age (35). In the long term iodine deficiency can be countered by the use of iodized salt by all members of the community and it is essential that the public health regulations for the iodination of salt in Papua New Guinea are strictly adhered to and the adherence is carefully monitored.

The prevalence rates of **lymphatic filariasis** in some communities in the Dreikikir area of East Sepik Province were the highest reported in the world. If the disease could be eliminated there it should be possible to eliminate it everywhere. Studies of mass drug administration (36) and vector control (37) conducted in Dreikikir by the Papua New Guinea Institute of Medical Research and international colleagues over many years have shown that elimination can be achieved but needs to be followed by careful surveillance. These studies have been prominent internationally and have helped to drive the WHO program for the global elimination of lymphatic filariasis. Thus Papua New Guinea is well-known for lymphatic filariasis; unfortunately it has also achieved notoriety for being the worst performer in the Pacific region in its national elimination program.

As Papua New Guinea has made its transition into the modern world diseases such as asthma have newly appeared, and in urban children the incidence of asthma is now much the same as in other cities and towns throughout the world. However, in the Eastern Highlands there occurred an epidemic of **adult asthma** that was unique to Papua New Guinea (38). Despite considerable research effort the basis of this disease is not fully understood, though it clearly is an allergic response to house dust mite, as occurs in asthma world-wide. It began with the common use of blankets to keep warm at night in a cold highland area of high humidity; these blankets proved to be an ideal environment for the growth of house dust mite. Other areas in the highlands that were more open and with less local humidity did not have the same problem. The asthma responded to the same drugs as asthma elsewhere and could be prevented by reducing the load of house dust mite in the blankets. Surprisingly, the disease did not appear in children living in the same environment. Though still present, the epidemic has subsided, with a high mortality among asthmatic patients and a reduced incidence of new cases, though exact data

are not available after the termination of the research program in the 1990s.

Sago is an important staple for many communities in Papua New Guinea. The consumption of stored sago has led to **sago haemolytic disease** in outbreaks among diverse communities of sago-eaters. It was described by Tukutau Taufa in the Journal in 1974 (39) and has been investigated in a number of studies since then. It is likely to be caused by a toxin elaborated by fungal or bacterial contamination of the sago, and several such possibilities have been investigated. There is still much to learn about the disease but ways to prevent it have been determined and their use should reduce its incidence in the future (40).

Lessons learned and future challenges

Lessons learned

There are lessons to be learned from the diseases that have been discussed and I will allude to some of them here without any attempt at elaboration.

In research, follow your passion and build your team.

In his early work on pigbel Tim Murrell followed up every lead that he could on his own and then quickly looked for assistance from colleagues with the relevant specialized knowledge. Since veterinary microbiologists had experience with diseases like pigbel he sought their advice and technical help and bypassed the medical establishment. The initial research work on kuru was all done by individuals who went out on their own, engaged with the local people and formed their own partnerships and collaborations in the field, while the established research institutions stayed away and did nothing. Swollen belly syndrome was solved by a pair of clinicians, a microbiologist and a parasitologist all working together as a team, both in the hospital and in the field.

Embrace the concept of One Health: that human and veterinary medicine form one domain.

Many diseases cross between animals and humans and, even where they do not, medical and veterinary practitioners have much to learn from each other. In pigbel not only were

there model diseases in lambs and piglets but there was a veterinary vaccine that could be adapted for use in humans. The veterinary connection was vital both to understanding the pathogenesis of pigbel and to establishing a way of preventing the human disease. Without it, there would have been no chance at all of getting a vaccine against the disease. In kuru an essential clue – its similarity to scrapie, an unusual disease of sheep – came from veterinary medicine and provided a way forward for the research that was ultimately successful. Then, later, veterinary doctors struggling to understand the new disease bovine spongiform encephalopathy ('mad cow disease') were able to do so by using kuru as a model.

To understand a human disease one must study human behaviour as well as the disease.

In pigbel the association of the disease with pig feasting was an important initial observation. Kuru is the classic example of the salience of this 'lesson'. Clinical and neuropathological observations in kuru led to the scrapie connection, which eventually led to the experimental demonstration of the transmissibility of kuru, but full understanding of its mode of transmission required knowledge of specific human behaviours, by sex and age, among participants in the mortuary feasts when the bodies of those who had died were consumed by their relatives. Putting these details of human behaviour into the model enabled all the epidemiological features of kuru to be explained.

Listen to nurses and other health workers.

Swollen belly syndrome as a sporadic disease would not have attracted much attention, but it was the clustering of cases at Kanabea that was striking. Even so, it was only the insistence of the nursing sisters at the Kanabea hospital that this disease was unusual and needed investigation that stimulated the formation of the research team. In his early work on pigbel Tim Murrell worked in a hospital, where patients suffering from pigbel were brought for surgery, but he also worked in aid posts and their surrounding communities, and it was from aid post orderlies that he first heard the name 'pikbel' given to the disease: they had noted the association of the disease with pig feasts before anybody else. Kuru was a new disease

and conventional medical opinion was not much help in describing it, but the people affected by it had had 50 years' experience of kuru when the outside world first became aware of it. The Fore gave their own name to the disease: 'kuru', which means 'shaking', as in shivering with cold or when grass waves in a gusty breeze, and this makes it a very appropriate name. Furthermore, the people from the Fore and other groups affected by kuru made essential contributions to the research on kuru in a number of different ways, through their knowledge of the disease and their willingness to assist inquisitive doctors, scientists and anthropologists in getting answers to a multitude of questions, and by employment as field research assistants, throughout the 50-year period in which the research was conducted.

Some future challenges

Infectious diseases are unpredictable.

*They emerge and re-emerge from the environment.

We can be sure that *Strongyloides fülleborni kellyi* and *Clostridium perfringens* type C have not disappeared and will emerge at unexpected times and places to cause sporadic cases or new outbreaks of swollen belly syndrome or pigbel. This is also true of the organisms that cause diseases such as leptospirosis and cholera. The first outbreak of typhoid fever in Papua New Guinea occurred in a high school in the highlands when in a time of drought the school authorities filled their water tanks with water from the local river that had long been used as a safe water supply by local communities. The bacteria must have been present in low numbers in the water, insufficient to cause disease, but in the static warm environment of the school tanks had multiplied to an infectious level. The disease then spread into these susceptible communities to cause a major epidemic. Now it has become endemic in many communities, which thus have high levels of established immunity, while in others it may have disappeared, thereby setting them up for another epidemic in the future.

*They emerge from elsewhere.

Human immunodeficiency virus (HIV) emerged as a human pathogen in Africa and it did not take long for it to spread all over

the world. In Papua New Guinea in 1990 we had a handful of cases of HIV infection, which quickly expanded to become a serious epidemic. Murray Valley encephalitis virus is endemic to our region and Japanese encephalitis virus (JEV) is its counterpart on the other side of Wallace's Line – or was, until JEV unexpectedly appeared on this side of the Line, in Papua New Guinea and northern Australia. In the recent outbreak of Ebola in West Africa Papua New Guinea was spared any cases but nevertheless had to be vigilant about the possibility of its introduction. This vigilance is likely to be required during many global outbreaks in the future.

*They emerge from within.

One of the prototype strains of dengue virus is the New Guinea strain isolated during World War 2, yet dengue has not been recognized as a major disease problem here. That may change. We need to have the technical tools to understand the epidemiology of dengue in Papua New Guinea and to investigate possible outbreaks as soon as they occur. Drug-resistant organisms across the spectrum from viruses to parasites may come from outside but may also arise from within. It is essential to maintain national monitoring of drug resistance in HIV, *Mycobacterium tuberculosis*, *Streptococcus pneumoniae*, *Neisseria gonorrhoeae*, *Salmonella enterica* serovar Typhi, *Plasmodium falciparum*, *Plasmodium vivax* and other major infecting organisms.

A national outbreak response capability is obligatory.

This is a good example of the need to 'think globally, act locally'. Novel or more virulent infectious agents can emerge anywhere, and the International Health Regulations (IHR) oblige signatory nations, of which Papua New Guinea is one, to investigate possible outbreaks and report them immediately to global health authorities. The World Health Organization has established an independent collaborative Global Outbreak Alert and Response Network (GOARN) to ensure timely and effective responses to disease outbreaks anywhere in the world. When as a good global citizen we participate in these activities we are also acting in the national interest, so it is important to have a trained national outbreak team ready for action anywhere in the country.

In all policy decisions for health the effects of climate change need to be taken into account.

There may be some health benefits from the effects of climate change though most effects will be deleterious. The possible outcomes, globally and nationally, need to be discussed and anticipated. There will also be health benefits from various actions taken by society to mitigate the effects of global warming and other components of climate change, such as extreme weather events, and these benefits need to be promoted in support of such actions.

Community engagement is essential to the provision of good health for all members of society.

In the provision of health services there is a supply side and a demand side. The supply side is provided by the health system and the staff at all levels within it. The demand side should come from the community, but all too often the community is regarded, by both the health services staff and the community members themselves, as merely passive recipients of health care. The provision of health care should be regarded as a right and one that is achieved through collaboration between health staff and members of the community. The community needs to take some responsibility for individual and collective health and well-being, and health staff need to engage with community leaders and extended family groups to explain what services are available and how they can be most effectively used to maximize the benefit for everybody. The Healthy Islands concept needs to be more widely promoted, put into effect and made sustainable. Service deficiencies should not simply be tolerated but lead to local political action demanding the necessary resources to correct them.

The mineral wealth of the nation should be used for the benefit of its people.

This is accepted as valid across the political spectrum and promises are therefore frequently made that a significant proportion of the government revenue from the resources sector will be used for health and education. Unfortunately too much of the revenue ends up being siphoned off before it can be spent on the public good. Once it is gone little can be done, so it is important for civil society to

be proactive and for members of the health sector, through organizations such as the Medical Society of Papua New Guinea, to lobby ministers, to advocate for social equity, to use the media effectively and to keep the pressure up with constant reminders to the government of the political promises that have been made.

A Health Think-Tank of creative and well-informed individuals should be established to develop innovative and efficient ways of improving the nation's health.

The Health Think-Tank should have status within the Ministry of Health and be funded through the Health budget but be an independent body. It should comprise individuals chosen for their personal qualities, and not by virtue of their office, from health policy, academic medicine, clinical medicine, public health, health economics, medical science and research. It should not be too large nor aim to be fully representative; the quality of its individual members must be paramount. It should be proactive and generate its own ideas and questions as well as responding to ideas and questions raised by others: from the Ministry, the Department, the research community, health professionals at all levels and the community at large. It should ensure the rapid implementation of research findings into policy and health care delivery and the identification of research questions that require urgent investigation.

Reflections on the Medical Society of Papua New Guinea

Keep the Medical Society for everybody.

The Society's outstanding achievement of conducting 50 successive annual symposia without a break deserves to be celebrated. Each symposium has allowed health policy-makers, clinicians, teachers, students, research scientists and professional health workers of all kinds and at all levels to meet and discuss health issues and research findings and this has provided a powerful benefit both for the cohesion of the health sector and for the health of the nation. This is unusual in the fragmented and exclusive nature of health disciplines today, and we should ensure that the connected and inclusive approach so long maintained in Papua New Guinea continues.

Keep the Specialist Societies special.

The Specialist Societies also have a long

history and new ones are springing up all the time. These meetings attached to the main Symposium enable members to get the best of both worlds. They build the knowledge base of each professional discipline and enhance respect and collaboration between its practitioners across the nation.

Let the young run and the elders advise.

It is important for the vitality of the Society that younger members are willing to stand for office, prepared to challenge the establishment and ready to work hard for the common good. In that way the Society will be vigorously run and can take a running leap into the future. The elders should be happy to take a back seat and yet always be ready with sympathetic advice and wise counsel when consulted.

Listen to our women.

The strong voice of the women of the Society must be heard. This can be achieved through electing women to office but also by ensuring that individual members and women's lobby groups are encouraged and given every opportunity to express their views.

Write for the Journal.

The Journal publishes scientific papers, reviews, clinical articles, case reports, letters, historical articles, obituaries, biographies and autobiographies. It is a journal of medicine, a journal of science and a journal of record. We should not omit to comment on important medical events in Papua New Guinea or to record the lives and achievements of our colleagues – or, indeed, of ourselves. The lives of Papua New Guinean health professionals are intensely interesting, as that of Wilfred Moi in the early days (41) and the more recent series on women in health and medicine (42) have abundantly shown. Each one of us can contribute to this by writing about a friend and colleague or about our own life. Students' research projects can be turned into short papers, reviews or letters with the help of their supervisors and submitted to the Journal. The peer review process has then to be dealt with and this in itself will provide help in learning about writing for a journal and how to get one's work published. Immediately an article is published in the Journal it is on the international stage, by being in open access and by being listed, with its abstract, on

PubMed. If you need help with your analysis or writing, ask someone on the editorial board of the Journal, who may be able to help directly or assist by finding somebody who can. If all else fails you can try turning to the Emeritus Editor for assistance!

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REFERENCES

- Maddocks I. The search for a national character. *PNG Med J* 1965;8:1-2.
- Murrell TGC. Some epidemiological features of pig-bel. *PNG Med J* 1966;9:39-50.
- Murrell TGC. Pig-bel – case reports. *PNG Med J* 1966;9:68-71.
- Murrell TGC. Pig-bel – final comment. *PNG Med J* 1966;9:74.
- Lawrence G, Shann F, Freestone DS, Walker PD. Prevention of necrotising enteritis in Papua New Guinea by active immunisation. *Lancet* 1979;1:227-230.
- Vince JD, Ashford RW, Gratten MJ, Bana-Koiri J. *Strongyloides* species infestation in young infants of Papua New Guinea: association with generalized oedema. *PNG Med J* 1979;22:120-127.
- Ashford RW, Vince JD, Gratten MJ, Bana-Koiri J. *Strongyloides* infection in a mid-mountain Papua New Guinea community: results of an epidemiological survey. *PNG Med J* 1979;22:128-135.
- Ashford RW, Barnish G, Viney ME. *Strongyloides fuelleborni kellyi*: infection and disease in Papua New Guinea. *Parasitol Today* 1992;8:314-318.
- Barnish G. The epidemiology of intestinal parasites in Papua New Guinea. In: Attenborough RD, Alpers MP, eds. *Human Biology in Papua New Guinea: The Small Cosmos*. Oxford: Clarendon Press, 1992:345-354.
- Alpers MP. A history of kuru. *PNG Med J* 2007;50:10-19.
- Zigas V, Gajdusek DC. Kuru: clinical, pathological and epidemiological study of a recently discovered acute progressive degenerative disease of the central nervous system reaching 'epidemic' proportions among natives of the Eastern Highlands of New Guinea. *PNG Med J* 1959;3:1-24.
- Schofield FD, Tucker VM, Westbrook GR. Neonatal tetanus in New Guinea. Effects of active immunization in pregnancy. *Br Med J* 1961;2:785-789.
- Saave JJ. Lymphadenosis amongst New Guinea natives. *Med J Aust* 1955;1:358-360.
- Shann F, Gratten M, Germer S, Linnemann V, Hazlett D, Payne R. Aetiology of pneumonia in children in Goroka Hospital, Papua New Guinea. *Lancet* 1984;2:537-541.
- Barker J, Gratten M, Riley I, Lehmann D, Montgomery J, Kajoi M, Gratten H, Smith D, Marshall TFdeC, Alpers MP. Pneumonia in children in the Eastern Highlands of Papua New Guinea: a bacteriologic study of patients selected by standard clinical criteria. *J Infect Dis* 1989;159:348-352.
- Gratten M, Gratten H, Poli A, Carrad E, Raymer M, Koki G. Colonisation of *Haemophilus influenzae* and *Streptococcus pneumoniae* in the upper respiratory tract of neonates in Papua New Guinea: primary acquisition, duration of carriage, and relationship to carriage in mothers. *Biol Neonate* 1986;50:114-120.
- Hansman D. The development of antibiotic resistance in pneumococcus and its relevance to the treatment of pneumonia in tropical countries. *PNG Med J* 1973;16:15-19.
- Graves PM, Brabin BJ, Charlwood JD, Burkot TR, Cattani JA, Ginny M, Paino J, Gibson FD, Alpers MP. Reduction in incidence and prevalence of *Plasmodium falciparum* in under-5-year-old children by permethrin impregnation of mosquito nets. *Bull World Health Organ* 1987;65:869-878.
- Hetzel MW, Choudhury AAK, Pulford J, Ura Y, Whittaker M, Siba PM, Mueller I. Progress in mosquito net coverage in Papua New Guinea. *Malar J* 2014;13:242.
- Riley ID, Lehmann D, Alpers MP, Marshall TFdeC, Gratten H, Smith D. Pneumococcal vaccine prevents death from acute lower-respiratory-tract infections in Papua New Guinean children. *Lancet* 1986;2:877-881.
- Pomat WS, van den Biggelaar AHJ, Phuanukoonnon S, Francis J, Jacoby P, Siba PM, Alpers MP, Reeder JC, Holt PG, Richmond PC, Lehmann D; Neonatal Pneumococcal Conjugate Vaccine Trial Study Team. Safety and immunogenicity of neonatal pneumococcal conjugate vaccination in Papua New Guinean children: a randomised controlled trial. *PLoS One* 2013;8(2):e56698.
- Alpers MP, Al-Yaman F, Beck HP, Bhatia KK, Hii J, Lewis DJ, Paru R, Smith TA. The Malaria Vaccine Epidemiology and Evaluation Project of Papua New Guinea: rationale and baseline studies. *PNG Med J* 1992;35:285-297.
- Genton B, Betuela I, Felger I, Al-Yaman F, Anders RF, Saul A, Rare L, Baisor M, Lorry K, Brown GV, Pye D, Irving DO, Smith TA, Beck HP, Alpers MP. A recombinant blood-stage malaria vaccine reduces *Plasmodium falciparum* density and exerts selective pressure on parasite populations in a phase 1-2b trial in Papua New Guinea. *J Infect Dis* 2002;185:820-827.
- Williams DJ, Oge R, Power R, Paiva OK, Bande B, Yockopua S, Paiva M, Müller R, Matainaho T, Winkel KD, Gutiérrez JM, Warrell DA, Jensen SD. Phase 1 dose-finding and safety study of a new equine whole IgG monovalent antivenom for the treatment of Papuan taipan (*Oxyuranus scutellatus*) envenoming in Papua New Guinea. Abstract A32 in Achievements of the Past 50 Years and Future Challenges, Program and Abstracts of the Fiftieth Annual Symposium of the Medical Society of Papua New Guinea, Goroka, 31 Aug-3 Sep 2014:38-39.
- Hamilton D, Pikacha D. Ruptured spleen in a malarious area: with emphasis on conservative management in both adults and children. *Aust NZ J*

- Surg* 1982;52:310-313.
- 26 **Clezy JKA.** Patterns of radial paralysis in leprosy in Papua New Guinea. *Int J Lepr* 1967;35:345-347.
 - 27 **Bagshawe A, Scott GC, Russell DA, Wigley SC, Merianos A, Berry G.** BCG vaccination in leprosy: final results of the trial in Karimui, Papua New Guinea, 1963-79. *Bull World Health Organ* 1989;67:389-399.
 - 28 **Thomas SJ, Bain CJ, Battistutta D, Ness AR, Paissat D, MacLennan R.** Betel quid not containing tobacco and oral cancer: a report on a case-control study in Papua New Guinea and a meta-analysis of current evidence. *Int J Cancer* 2007;120:1318-1323.
 - 29 **Crane G.** The genetic basis of hyperreactive malarious splenomegaly. *PNG Med J* 1989;32:269-276.
 - 30 **Serjeantson SW, Board PG, Bhatia KK.** Population genetics in Papua New Guinea: a perspective on human evolution. In: Attenborough RD, Alpers MP, eds. *Human Biology in Papua New Guinea: The Small Cosmos*. Oxford: Clarendon Press, 1992:198-233.
 - 31 **Lucas KM, Sanders RC, Rongap A, Rongap T, Pinai S, Alpers MP.** Subacute sclerosing panencephalitis (SSPE) in Papua New Guinea: a high incidence in young children. *Epidemiol Infect* 1992;108:547-553.
 - 32 **Manning L, Laman M, Edoni H, Mueller I, Karunajeewa HA, Smith D, Hwaihwanje I, Siba PM, Davis TME.** Subacute sclerosing panencephalitis in Papua New Guinean children: the cost of continuing inadequate measles vaccine coverage. *PLoS Negl Trop Dis* 2011;5:e932.
 - 33 **Vogel LC, Richens J.** Donovanosis in Dutch South New Guinea: history, evolution of the epidemic and control. *PNG Med J* 1989;32:203-218.
 - 34 **Frank D, Duke T.** Congenital syphilis at Goroka Base Hospital: incidence, clinical features and risk factors for mortality. *PNG Med J* 2000;43:121-126.
 - 35 **Hetzel BS, Pharoah POD, eds.** Endemic Cretinism. Papua New Guinea Institute of Medical Research Monograph No 2. Goroka: Papua New Guinea Institute of Medical Research, 1971.
 - 36 **Bockarie MJ, Tisch DJ, Kastens W, Alexander NDE, Dimber Z, Bockarie F, Ibam E, Alpers MP, Kazura JW.** Mass treatment to eliminate filariasis in Papua New Guinea. *N Engl J Med* 2002;347:1841-1848.
 - 37 **Reimer LJ, Thomsen EK, Tisch DJ, Henry-Halldin CN, Zimmerman PA, Baea ME, Dagoro H, Susapu M, Hetzel MW, Bockarie MJ, Michael E, Siba PM, Kazura JW.** Insecticidal bed nets and filariasis transmission in Papua New Guinea. *N Engl J Med* 2013;369:745-753.
 - 38 **Dowse GK, Turner KJ, Woolcock AJ, Alpers MP.** Emerging asthma in the Okapa District of Eastern Highlands Province of Papua New Guinea: the problem and its implications. *PNG Med J* 1983;26:33-41.
 - 39 **Taufa T.** Sago haemolytic disease. *PNG Med J* 1974;17:227-228.
 - 40 **Shipton WA, Greenhill AR, Warner JM.** Sago haemolytic disease: towards understanding a novel food-borne toxicosis. *PNG Med J* 2013;56:166-177.
 - 41 **Moi W.** Growing up in Ambasi. *PNG Med J* 1976;19:14-18.
 - 42 **Laumaea A, Spark C, eds.** Women in Health and Medicine in Papua New Guinea. *PNG Med J* 2013;56:32-78.

The Medical Society of Papua New Guinea: achievements, challenges and the way forward

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The celebration of 50 years of the Medical Society of Papua New Guinea provides an opportunity to look back, to assess progress and the role of the Society in the year 2014, and to reflect on the challenges that lie ahead and how the Society can meet these challenges.

The Medical Society was formed in 1964 and the following year saw the first Society Symposium held in Goroka. The stated Objectives of the Society were:

- To promote the advance of medical knowledge and to assist in the dissemination of such knowledge amongst its members;
- To promote such ethical rules, conduct and practice as will best maintain the honour of the profession; and
- To represent the corporate interest of all Medical Practitioners in the Territory.

Dissatisfaction among the national doctors with the perceived inefficiency of the Society in fulfilling the third objective in relation to terms and conditions led to the formation of the National Medical Officers' Union, later superseded by the National Doctors' Association, and in effect removed this objective as a function of the Medical Society.

The Society is registered as a professional body comprised not only of medical doctors, but also of dentists, medical researchers and allied health workers.

The spirit of the first two objectives has been maintained and expanded in several reviews of the Society's constitution over the years, the last in 2007. The stated purposes

of the Society remain as promotion of health care in Papua New Guinea (PNG) through education and dissemination of knowledge. Papua New Guinea has been a world leader in the development of Standard Treatment Manuals, and I hope that these manuals, now the responsibility of the Specialist Societies, will continue to be updated and remain pivotal to health care provision at all levels.

The Society also has a responsibility in representing its members in matters of public interest.

The roles of the Society can, then, be summarized as Professional, Collegiate and Educational. The professional role includes ensuring that the Code of Ethics which should govern our practice is appropriate, providing advice to the National Department of Health (NDoH) and ensuring that NDoH policies are in the best interests of the people of PNG.

Two of the Society's major achievements are holding of the Annual Symposia and Medical Society Meetings continuously over the fifty years through varying economic conditions and times of political uncertainty, and the continuation of the Papua New Guinea Medical Journal. These achievements have required strong leadership from the Society's presidents and their committees, commitment and enthusiasm from Symposia Organizing Committees and the persistence and enthusiasm of the Journal editors and their editorial teams.

The first president of the Society (then the Medical Society of Papua and New Guinea) in 1964 was Dr Charles Haszler, originally a surgeon from Budapest, one of the 35 original New Australian Doctors from Eastern Europe who were posted to PNG in 1950. Dr Haszler

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retired 18 years later from the position of First Assistant Director of Public Health. In the 1960s there were only a few Fijian-trained PNG national doctors and the Medical Society consisted very largely of expatriates, but with the graduation of doctors from the Papuan Medical College and then the Faculty of Medicine, membership and leadership changed. Leadership of the Society (Table 1) has been provided by Papua New Guinean doctors from the University of Papua New Guinea, the Papua New Guinea Institute of Medical Research, the National Department of Health and provincial hospitals, and private

practitioners.

The record of 50 consecutive Medical Symposia is certainly commendable and, given the uncertainties of politics and financial support and the challenges of hosting the event for increasing numbers of members and participants, is remarkable. From the small beginning in Goroka, when membership of the Society was 10 shillings, number of participants in the low 10s and accommodation in the homes of colleagues, the Symposium developed to the stage at which, with hundreds of participants from all parts of the country and

TABLE 1

PRESIDENTS OF THE MEDICAL SOCIETY OF PAPUA NEW GUINEA

Name	Period in office
Dr Charles Haszler	1964-1966
Dr Peter Booth	1966-1968
Dr Peter Pangkatana	1968-1969
Father Frank Flynn	1969-1971
Dr Reuben Taureka	1971-1972
Dr Kila Wari	1972-1973
Dr Morris Wainetti	1973-1974
Dr Solo Tongia	
Dr Sugaho	1974-1975
Dr Lapu Bussim	
Dr Lapu Bussim	1975-1976
Prof. Hortense Gandy	1976-1977
Dr Solo Tongia	1977-1978
Dr Chris Marjen	1978-1979
Prof. John Biddulph	1979-1980
Dr Peter Pangkatana	1980-1982
Prof. Joseph Igo	1982-1983
Assoc. Prof. Isi Kevau	1984-1987
Dr Edward Talwat	1987-1989
Dr Paul Mondia	1989-1997
Prof. Isi Kevau	1997-1999
Prof. Mathias Sapuri	1999-2010
Prof. Nakapi Tefuarani	2011-2014

from abroad, the Medical Society Symposium was listed as a National Event in 2005. One of the features of the symposia has been the differing locations, with the underlying aim of rotating venues through the four Regions of the country (Table 2). The challenges of hosting such a large event both in the larger and the relatively small centres have been admirably met as a result of the hard work of the organizing committees and Society executives.

The first symposium in 1965 was on the topic of pigbel, and the majority of symposia

since have had a theme, although the theme has not been exclusive (Tables 3 and 4). Perhaps not surprisingly a significant proportion of the themes have been related to infectious diseases, but a very wide variety of topics have been highlighted. There are perhaps some omissions which might be included in the near future, including pneumonia and respiratory diseases other than tuberculosis (TB), neurology and neurosurgery, cardiovascular disease and ophthalmology. In recent years a section of the symposium has been designated for student research presentations. This has

TABLE 2

SYMPOSIUM VENUES

Venues	Number of years held
Port Moresby	18
Goroka	9
Lae	7
Madang	5
Rabaul	4
Mt Hagen	3
Arawa, Alotau, Wewak, Kimbe	1 each

TABLE 3

SYMPOSIUM MAJOR THEMES

Major themes	Number of occasions
Infectious diseases	9
Community/rural health	4
Medical education	4
Accidents/epidemics/disasters	4
Emerging diseases/changes/future	3
Cancer and non-communicable diseases	3

TABLE 4

OTHER THEMES COVERED IN THE MEDICAL SYMPOSIA

Specialties	Other
Obstetrics	Public health and clinical medicine
Paediatrics	Chronic illness and disability
Maternal and child health	National Health Plan
Family health	Antibiotics
Surgery/medicine	Immunology
Mental health	Pain relief
Trauma	Peace in Papua New Guinea
Emergency medicine	Health planning
Oral/head and neck	Public/private partnerships
Occupational health and rehabilitation	

proved very popular.

The symposia booklets provide a valuable document of topics presented and discussed and some of the covers illustrate unique facets of PNG medicine and health.

In the process of preparing this address I have had the pleasure of browsing through early issues of the PNG Medical Journal. The first issue of what was then the Papua and New Guinea Medical Journal was published in 1955, by the Department of Public Health of the Territory of Papua and New Guinea. The editor of this first edition was Prof. Roy Scragg. Dr Eric Wright took over editorship in 1959. The establishment of the Medical Society was an opportunity for the Journal to become the organ of the Society, under the editorship of Prof. Ian Maddocks, and an editorial committee of 10 people who are now 'household' names in the history of medicine in PNG. These early editions of the journal provide an irreplaceable source of information on a wide range of topics, including kuru, pigbel, sago haemolysis and other fascinating and important topics, and they set the high standard which has been maintained to the present time under the continuum of devoted and inspired editors and their teams (Table 5). A detailed review of the journal and the people

involved in its production by Prof. Alpers was published in the Golden Jubilee edition (1). The PNG Medical Journal has been internationally recognized as one of the best journals in the area of Tropical Medicine. The 31-year continuous and continuing editorship of Prof. Michael Alpers is a quite extraordinary contribution to medical knowledge and continuing education. Without his leadership and support the PNG Medical Journal may well have become a historical document rather than a historical and contemporary publication. The Society owes Prof. Alpers an enormous debt of gratitude. The outstanding support over many years of the Journal's current assistant editor, Cynthea Leahy, is also gratefully acknowledged.

To return to the original objectives of the Medical Society, the gathering at this symposium of a large number of highly skilled Papua New Guinea doctors – both specialists and generalists – and the fact that the Society has been led for many years by Papua New Guinea nationals is undoubtedly a source of considerable satisfaction for those who set the Society on a somewhat uncertain road 50 years ago. The fact that the symposium includes eminent colleagues from abroad, and that many of these colleagues are members, indicates that the Society, whilst being a PNG

TABLE 5

PAPUA NEW GUINEA MEDICAL JOURNAL EDITORS

Editors	Period
Prof. Roy Scragg	1955
Dr Eric Wright	1959-1964
Prof. Ian Maddocks	1965-1971
Dr DG Woodfield	1972-1975
Dr Dom Amato	1976-1977
Prof. Sirus Naraq	1978-1979
Prof. Ken Clezy	1979-1980
Dr Euan Scrimgeour	1980-1982
Prof. John Lourie, Prof. Isi Kevau, Dr Mohamed Patel	1983-1984
Prof. Michael Alpers	1984-1999*
Prof. Charles Mgone, Prof. Peter Siba	2000
Prof. Charles Mgone	2001
Prof. Charles Mgone, Prof. Peter Siba	2002
Prof. Peter Siba, Prof. Nakapi Tefuarani	2003
Prof. Peter Siba, Prof. John Reeder, Prof. Nakapi Tefuarani	2004-2005
Prof. Peter Siba, Prof. Nakapi Tefuarani	2006-2007
Prof. Peter Siba, Prof. Nakapi Tefuarani, Prof. Francis Hombhanje	2008-2014

*Prof. Michael Alpers has remained as Emeritus Editor from 2000 to 2014

The current Assistant Editor Mrs Cynthia Leahy has assisted in the production and publication of 45 issues of the Journal

Society, has an international perspective. The Society has clearly filled and continues to fill the role of a professional organization for its members, providing leadership in the areas of medical education and research. The annual general meeting of the Society, once the domain of the resolute few, is now that of the equally resolute many. The Society's role as a collegiate as well as an educational body is evidenced by the number of members who each year make the effort required to participate in the symposium. Its role as an independent advisory body to the Department of Health has been exemplified by its involvement in the drafting of health legislation, particularly in legislation regulating tobacco sales and consumption.

While we celebrate these achievements,

we should also focus on the challenges faced by the Society.

PNG continues to move through an astonishing period of rapid change. Smart phones, the internet, availability of cinemas and mass media affect individuals' understanding of the world and of what is right and wrong. There is a need to review and update the Society's Code of Ethics in the light of changing attitudes towards issues such as gender, individual rights and new technology.

One of the challenges emanates from the very success of the Society and the symposia. In my opinion, one of the great strengths of the symposia is that they have covered a wide variety of topics. The increasing numbers of specialists, and the increasing

push for the presentation of research papers, has raised the issue of whether or not a 'General' Symposium is still important. In my view it is, and I would hope that it will remain a forum where paediatricians can learn important issues relating to surgery, public health, malaria research, diabetes, sexually transmitted disease and HIV (human immunodeficiency virus). In 1998 as one of two symposium guest speakers on the topic of "Public Health and Clinical Medicine – where do they meet?" I wrote in my abstract, "One of the strengths of Papua New Guinea Medicine has been the active involvement in Public Health by its clinicians. Far from being mutually exclusive, Clinical Medicine and Public Health are complementary." Sixteen years later I remain convinced that doctors in PNG must have a broad view of health. The general appeal of the Medical Symposium helps to ensure and maintain this broad view.

Internet technology now offers ways of communication – both individually and communally – which were difficult or impossible previously. How the Society embraces this technology to enhance its various roles is a matter for the current and future generations. There must surely be a limit to the numbers of members who can afford or who are sponsored to attend. Perhaps in the near future, members who are unable to attend can participate actively in the virtual world.

Large amounts of money are raised to host the symposia. The Society is a professional organization and financial accountability to its members and to the organizations that support it is mandatory.

In recent weeks the Society, together with other concerned organizations including Transparency International, has raised concern about the awarding of pharmaceutical contracts. This is surely an important issue and in commending the current Society leadership for its stand on the issue, I would hope that the Society continues to rise to the challenge of fulfilling the role of independent but informed observer and, where necessary, commentator on issues related to the health of Papua New Guineans.

Like it or not, the general Papua New

Guinea population looks up to members of the medical profession. We all, therefore, have personal as well as corporate responsibility for maintaining the image of the profession. In the Symposium of 2005 the Goroka committee organized an alcohol-free dinner. This as I remember it was certainly no less enjoyable than other occasions in which too much alcohol was consumed by a small proportion of the gathering. We have set the standard in relation to tobacco-related disease – very few doctors smoke. But in relation to non-communicable disease more generally we as a profession should also set standards in terms of life-style.

In conclusion, we can look back and take pride in the birth, infancy and adulthood of the Medical Society of Papua New Guinea, the Medical Symposia and the PNG Medical Journal. The leadership of the Society is assured by the quality of the Society's members. There will be challenges ahead but challenges when met will strengthen the Society. There is a need for younger members to take on new responsibilities within the Society and to take on roles in the continuation of the Journal.

We should acknowledge those who went before us in establishing and maintaining the Society and the Journal, we should enjoy the moment and we should look forward to the continued involvement of the Society and Journal in our individual and corporate development.

I thank the Medical Society, the Medical Journal and the Medical Symposia for providing information and professional stimulation over my time in Papua New Guinea.

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REFERENCE

- 1 **Alpers MP.** The first 50 years of the Papua New Guinea Medical Journal: a celebration of its Golden Jubilee. *PNG Med J* 2005;48:2-26.

A case of accidental cardiac perforation during chest drain insertion

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Introduction

This is a case report of a rare complication of a chest drain inserted for postoperative pneumothorax, which resulted in cardiac perforation in a child with congenital heart disease. Ethical clearance for this report was received from the Port Moresby General Hospital management in the absence of a hospital-appointed Ethics Committee.

Case Report

The patient was a 15-month-old girl diagnosed with congenital heart disease. She initially presented to the paediatricians with recurrent respiratory tract infection and had been treated with antibiotics and anti-heart failure medications. Over the preceding 8 months she was on amoxycillin and Septrin for chest infection as well as digoxin and furosemide for heart failure.

She was found to have patent ductus arteriosus (PDA), a congenital heart disease, and was scheduled for duct ligation surgery. Her vital signs preoperatively were within normal limits and her anti-failure medication was continued right up until day of operation. Haemoglobin, urea and electrolytes were within normal limits and 2 units of blood were cross-matched as routine. Preoperative chest X-ray showed cardiomegaly and small areas of consolidation.

General anaesthesia was induced with oxygen/halothane and maintained with oxygen/halothane and morphine. The patient was cannulated, airway secured via endotracheal tube following paralysis and positive pressure ventilation applied. Following insertion of an oesophageal stethoscope, the patient was

positioned on the right lateral side for the duct ligation through a left thoracotomy approach. The anaesthesia and surgery were otherwise uneventful.

Surgery took about 45 minutes. The vital signs monitor showed no issues of concern with all parameters within normal limits except for high ETCO₂ (end tidal carbon dioxide) of 45-55 mmHg, likely to be related to lung retraction by the surgeons. At the end of the case significant positive end expiratory pressure (PEEP) was applied to re-expand the lung and help prevent residual pneumothorax, and the pleura was closed.

At the end of the surgery, neostigmine/atropine mixture was given for reversal of neuromuscular blockade and the patient was extubated when she was awake with good spontaneous respiratory efforts. Some continuous positive airway pressure (CPAP) was applied post extubation to augment respiratory effort and maintain oxygenation.

About 10-20 minutes after extubation, the patient started to de-saturate, with oxygen saturation dropping down to 50% despite 100% oxygen via facemask with CPAP. On auscultation there was diminished air entry on the left chest plus hyperresonance on percussion on the same side. Other vital signs showed normal blood pressure (BP), tachycardia and normal ETCO₂. In view of these clinical signs, a diagnosis of left pneumothorax was made and a decision for chest drain (CD) insertion reached.

Within 10 minutes of clinical diagnosis of left pneumothorax, a CD was inserted at the left mid-axillary line 5th intercostal space, without imaging guidance, using a 12 Fr trocar tube

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(Figure 1). The procedure was done under 100% oxygen with facemask.

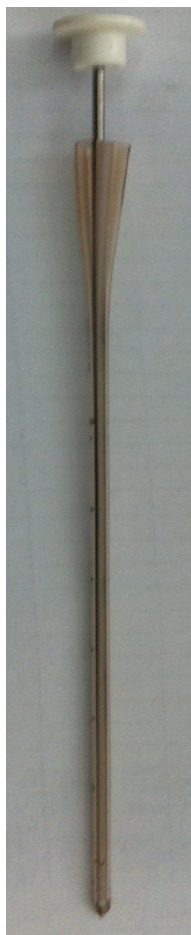


Figure 1. Chest drain kit, with a trocar similar to the one used in this patient.

After insertion of the CD and withdrawal of the trocar, a small amount of bright red blood was noted in the CD tube, but the tube was quickly clamped and then secured to the skin with silk sutures. Once the CD was secured, the clamp was released and almost immediately frank blood was noted to be draining in a pulsatile manner and about 250-300 ml filled the drain bag in a few minutes. This raised the suspicion that the CD had entered into one of the heart chambers. Haemodynamically the vital signs became worse, with loss of blood pressure recording and tachycardia. The

patient then developed irregular nonspecific arrhythmias, then ventricular fibrillation (VF) and finally asystole within about 5-10 minutes. The oxygen saturation trace was lost as well as the ETCO₂ and the patient was pulseless.

The CD tube was clamped while cardiopulmonary resuscitation was commenced immediately with re-intubation, blood transfusion and adrenaline boluses followed by an infusion. A central line via the right internal jugular vein was inserted (with a 5.5 Fr catheter), as well as an arterial line via the left axillary artery. Other drugs given during resuscitation included sodium bicarbonate, calcium chloride and atropine. At the same time the surgeon proceeded with re-exploration via the thoracotomy site.

On re-exploration the CD trocar was found to have perforated the left ventricle. The chest drain was removed and the myocardium sutured primarily with silk 1/0. Resuscitation with the transfusion of 2 units of whole blood (total of 600 ml) was continued while the myocardium was being repaired.

Following approximately 20 minutes of cardiac arrest and active resuscitation, the patient regained sinus rhythm and a cardiac output, but was still unresponsive and there was no neurological response to painful stimulation. The patient was admitted to the intensive care unit for inotropic support and mechanical ventilator support.

Over the following 16 days in intensive care, the patient was maintained on mechanical ventilation, dexamethasone, antibiotics, digoxin and intravenous fluids, with no sedation, but the patient remained unresponsive. There was no spontaneous respiratory effort and the haemodynamic status was supported with inotropic support. Chest X-ray showed no haemopneumothorax and the chest drain was removed. Subsequent CT (computerized tomography) scan of the brain showed gross cerebral oedema and swelling indicating brainstem death and, therefore, a very poor prognosis.

Eventually, after explanation to and discussion with the parents and extended family, the decision was made to discontinue life support.

The autopsy results were not available at the time of writing this case report.

Discussion

Many complications of chest drains have been reported, including lung perforation, intercostal artery laceration, pulmonary infarction, arteriovenous fistula, and laceration of liver, diaphragm, stomach, spleen and subclavian vein (1-3).

Cardiac injury following chest drain insertion is a rare but often fatal complication of management of patients with pneumothorax, pleural effusion, haemothorax or empyema (4). In cardiothoracic surgery chest drain insertion is used routinely whenever the pleura has been opened and there is a risk of air or fluid (blood) collection postoperatively, which might compromise patient recovery. Since 1986 there have been about 10 cases reported of cardiac perforation (5).

In the treatment of PDAs, surgical ligation via left thoracotomy is performed in many places where there are no facilities or expertise for interventional cardiology procedures such as device closure or coil embolization for PDAs.

In our hospital, the left thoracotomy approach is commonly taken with full lung expansion before the chest is closed following the surgery. There is always the risk of developing haemopneumothorax following a left thoracotomy, hence the need for chest drainage following a left thoracotomy and therefore CD insertion.

Several case reports have indicated anatomical distortion and extreme kyphoscoliosis as possible risk factors for cardiac perforation with chest drain insertion. Cardiomegaly has also been reported as increasing the likelihood of cardiac perforation, which appears to be a contributing factor in this case (3,6-8). Anatomical orientation, tube insertion site and location have been identified as very crucial factors, especially in susceptible patients such as these, in order to avoid fatal complications of chest tube insertion (7). The use of trocars has been shown to cause internal organ perforation and avoiding their use has been shown to reduce complications (3,9).

There are a number of case reports of patients surviving after removal of chest tubes from cardiac chambers but not so in this case.

This may have been due to the fact that our patient bled nearly all her blood volume in a short time, and that prolonged resuscitation was required contributing to brain and major organ dysfunction.

In conclusion, this case as well as the many case reports demonstrate that while thoracostomy and CD insertion is a life-saving procedure, it can also have fatal complications, especially with the use of trocars. Some cases such as this one will require immediate thoracotomy and direct cardiac repair as well as emergency resuscitation with no time for confirmatory imaging studies. To avoid further such incidents we now insert chest drains without trocars under direct vision in all our PDA ligation patients.

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REFERENCES

- 1 Kerger H, Blaettner T, Froehlich C, Ernst J, Frietsch T, Isselhorst C, Nguyen AK, Volz A, Fiedler F, Genzwuerker HV. Perforation of the left atrium by a chest tube in a patient with cardiomegaly: management of a rare, but life-threatening complication. *Resuscitation* 2007;74:178-182.
- 2 Schley M, Rössler M, Konrad CJ, Schüpfer G. Damage of the subclavian vein with a thorax drainage. [Ger] *Anaesthesist* 2009;58:387-390.
- 3 Meisel S, Ram Z, Priel I, Nass D, Lieberman P. Another complication of thoracostomy – perforation of the right atrium. *Chest* 1990;98:772-773.
- 4 Collop NA, Kim S, Sahn SA. Analysis of tube thoracostomy performed by pulmonologists at a teaching hospital. *Chest* 1997;112:709-713.
- 5 Kim D, Lim SH, Seo PW. Iatrogenic perforation of left ventricle during insertion of a chest drain. *Korean J Thorac Cardiovasc Surg* 2013;46:223-225.
- 6 Asopa S, Iyenger S, Lloyd CT, Brown I, Barlow CW. Accidental perforation of the left ventricle with a Bonanno catheter. *J Thorac Cardiovasc Surg* 2009;137:1023-1024.
- 7 Goltz JP, Gorski A, Böhler J, Kickuth R, Hahn D, Ritter CO. Iatrogenic perforation of the left heart during placement of a chest drain. *Diagn Interv Radiol* 2011;17:229-231.
- 8 Kopec SE, Conlan AA, Irwin RS. Perforation of the right ventricle: a complication of blind placement of a chest tube into the postpneumonectomy space. *Chest* 1998;114:1213-1215.
- 9 Millikan JS, Moore EE, Steiner E, Aragon GE, Van Way CW 3rd. Complications of tube thoracostomy for acute trauma. *Am J Surg* 1980;140:738-741.

Hirschsprung's disease in a 21-year-old female: a challenge in diagnosis

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SUMMARY

Hirschsprung's disease (HD) is a disease entity synonymous with infants and newborns. We present a case of HD in a 21-year-old female that was never diagnosed in her infancy. This case highlights the diagnosis of HD in adults and enlightens us that this congenital disease may rarely be diagnosed in adults.

Case Report

A young female of 21 years old, from Central Province of Papua New Guinea (PNG), presented to Alotau Provincial Hospital in 2014 with a chronic history of constipation since birth. At the age of 2 weeks, her maternal grandmother adopted her as her parents divorced. Her grandmother noted that she was having difficulty passing stool and therefore took her to Alotau Hospital. The health workers at that time did a rectal washout with saline and reportedly told the grandmother that there was nothing much to be done and therefore no proper diagnosis was made. Over the years she has lived with chronic bouts of constipation and consistently passed small hard stools. Because of persistent abdominal discomfort she has not been able to maintain a good appetite. On most occasions she used her hand to assist defecation. In 2009 she was married after completing high school and had her first pregnancy in 2012, which culminated in a fetal death in utero at 31 weeks of gestation. In 2014 she presented to the Surgical Clinic at Alotau Provincial Hospital because of 2-3 months of a lower abdominal mass and to seek advice on her 'lifelong' problem. On clinical examination, she was haemodynamically stable. There was no obvious abdominal distension; however, a soft, huge mobile mass was palpable around the umbilical area to the left iliac fossa. Per rectal examination revealed a normal anal sphincter tone with

impacted faeces. Based on her long history, a provisional diagnosis of Hirschsprung's disease (HD) was made with an exploratory laparotomy undertaken a few days later.

Intraoperatively the upper two-thirds of her sigmoid colon was markedly distended with faeces and the lower third to the rectum was collapsed (Figure 1). Bowel decompression was done before a double barrel colostomy, and three bowel tissue biopsy specimens, one proximal, one distal and one rectal, were taken and sent for histological analysis. Histological results came back a few days later showing that all three specimens had no ganglionic cells present. A diagnosis of HD was confirmed. She made an uneventful recovery and gained 8 kg in a space of 1 month. She was discharged home with a pull-through procedure planned for an appropriate time.

Discussion

Hirschsprung's disease or aganglionic megacolon is the result of an absence of ganglionic cells in a distal segment of the colon. Neuroenteric ganglionic cells normally originate in the neural crest, enter the cranial end of the oesophagus, and then follow vagus nerve fibres caudally until the entire gut is innervated. Why the migrating cells stop short of the rectum and at times the distal sigmoid colon is unknown. About 70% of HD affects the rectum and sigmoid colon. The disease

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Figure 1. The distal collapsed sigmoid colon with proximal distended normal segment.

was first described by Harald Hirschsprung in 1886. The incidence is about 1 in 5000 live births. Due to its congenital origin, the three classical signs of HD are 1) delay in the passage of meconium (ie, beyond 24 hours after birth); 2) vomitus containing bile; and 3) abdominal distension. Failure to thrive with a protein-losing enteropathy is now a less common presentation as HD is now recognized early. The radiographic diagnosis of HD is based on the presence of a transition zone between normal dilated proximal colon and a smaller-caliber obstructed distal colon caused by nonrelaxation of the aganglionic bowel. The transition zone is not present before 1-2 weeks of age and on a radiograph is a funnel-shaped area of intestine between the proximal dilated colon and the constricted distal bowel. Radiographic evaluation should be performed without preparation to prevent transient dilatation of the aganglionic segment. Twenty-four hour films are helpful. If significant barium is present in the colon, it increases the suspicion of HD even if a transition zone is not identified. Barium enema examination is useful in determining the extent of aganglionosis before surgery and in evaluating other diseases that present as lower bowel obstruction in neonates (1). The introduction of histochemical staining techniques for the detection of acetylcholinesterase activity in suction rectal biopsy has resulted in a reliable and simple method for the diagnosis of HD (2). Adult

cases of HD present with a lifelong history of constipation, requiring frequent laxatives and enemas. The first case of adult HD was reported by Tan et al. in 2006 (3) and later by Ghaemi et al. in 2010 (4). We believe our case is the first reported case in Papua New Guinea. What makes it more intriguing is the failure to make a proper diagnosis and appropriate referral during infancy or childhood. HD can easily be overlooked in adults, which makes it much more challenging. The aim of this paper is to educate all health colleagues who may be faced with a similar case in the future and to urge them to make appropriate referrals if a similar case is encountered.

REFERENCES

- 1 **Wyllie R.** Congenital aganglionic megacolon (Hirschsprung disease). In: Behrman RE, Kliegman RM, Jenson HB, eds. *Nelson Textbook of Paediatrics*. Seventeenth edition. Philadelphia: Saunders, 2004:1239-1240.
- 2 **Hutson JM, O'Brien M, Woodward AA, Beasley SW, eds.** *Jones' Clinical Paediatric Surgery: Diagnosis and Management*. Sixth edition. Oxford: Blackwell Publishing, 2008:37.
- 3 **Tan FL, Tan YM, Heah SM, Seow-Choen F.** Adult Hirschsprung's disease presenting as sigmoid volvulus: a case report and review of literature. *Tech Coloproctol* 2006;10:245-248.
- 4 **Ghaemi M, Bahar MM, Motie MR, Hiraifar M, Soltani E, Saremi E.** Late presentation of Hirschsprung's disease as sigmoid colon volvulus: report of four cases and review of the literature. *Colorectal Dis* 2010;12:704-705.

Gastroschisis management without a neonatal intensive care unit and total parenteral nutritional support

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Introduction

In the absence of a neonatal intensive care unit (NICU) and total parenteral nutrition (TPN) gastroschisis management is challenging (1). If surgical closure is not done within the first 6 hours post partum, impending complications intervene, which then prevent a good outcome in such infants. The defect near the right side of the umbilicus provides the avenue for the intra-abdominal contents to protrude into the amniotic cavity in intra-uterine life and visceral exposure to the external environment increases the morbidity after delivery. The tight 2.5-5 cm bottleneck diameter provides further complications if not surgically corrected immediately. The prognosis has improved over the years and in well-set-up hospitals more than 95% have survived. Appropriate antenatal diagnosis (2) and early neonatal surgical intervention have improved the survival of these neonates. Blood investigation to assist with the antenatal diagnosis, such as amniotic fluid beta-endorphin analysis (3) and alpha-fetoprotein, assists in anticipating severe complications. Prevention of complications such as mesenteric infarct, fluid and electrolyte imbalance, necrotizing enterocolitis (NEC) and raised intra-abdominal compartment syndrome (RIACS) (2) and providing nutritional support have resulted in the good outcome of these cases. In the absence of accurate radiological diagnosis and back-up support services such as NICU and TPN, it is challenging to manage such infants. In a country where subspecialties are lacking it is very difficult to reassure the

parents of a gastroschisis patient. Most of them do not make it. The following two case reports highlight some of these limitations and the alternative measures that can be taken to address the issues.

Verbal consent was obtained respectively from both parents to publish these case reports.

Case one

Baby of CP was a female infant from Kairiku in Central Province, and was delivered in the village around 9 am on 12/10/2013 weighing 2.8 kg at 38 weeks gestation. The infant was seen at the nearest rural health subcentre 2 hours after delivery and she was referred and transported in an ambulance to Port Moresby General Hospital (PMGH) for further management. She was admitted to the Special Care Nursery (SCN) late in the evening and the paediatric surgical team was called to review the patient the following day. She had clinical features of gastroschisis, which was then 24 hours post partum. She was clinically well hydrated with protruding small intestines and was also covered with meconium. There were no associated anomalies detected and the two heart sounds were normal. Figure 1 shows the patient prior to first aid being given by the PMGH SCN and the surgical team – the child is distressed because the contents were not well secured centrally so that the bowel mesentery was pulled taut.

Preoperatively she was covered with triple

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Figure 1. Prior to first aid by the Port Moresby General Hospital Special Care Nursery and the surgical team the child was in distress because the contents were not well secured centrally so that the bowel mesentery was being pulled taut.

antibiotics (metronidazole, gentamicin and ampicillin) and resuscitated with intravenous fluid – mostly Hartman's and 10% dextrose solutions. The herniating contents were wrapped around with transparent plastic and then reinforced; a normal-saline-soaked gauze bandage was applied to prevent heat loss.

The patient was then taken to the operating theatre around 26 hours post partum. The first stage of corrective surgery was done under general anaesthesia. Dissection was performed between the skin and the umbilical cord. Stitch ligation of the umbilical vessels (umbilical vein and 2 arteries) and the urachus was done separately with vicryl 3/0. The skin was undermined from the rectus sheath and a transverse cut was made to divide the rectus sheath to increase the abdominal cavity space. A thorough bowel decompression was done via nasogastric tube and a Witzel's proximal jejunostomy feeding tube (1,2,4). Tenacious meconium was aspirated through this tube before burying the tube over the serosa, and then bringing it out percutaneously. The herniated contents (mostly small and large bowel) were reduced into the abdominal

cavity, while care was taken to avoid any undue tension on the mesentery. A sterile blood-collecting transfusion bag was used as a silo and a tight occlusive stitched tie was applied through the silo on to the skin with 4/0 nylon. A compressive dressing was applied from the base to reduce the content further and secondly to prevent the stitch from giving way and exposing the peritoneal cavity.

A size 5 feeding tube was inserted into the urinary bladder to measure the intra-abdominal pressure just after suturing the silo on to the skin. The catheter was then filled with normal saline and was lifted vertically up to measure the level of the water. The contents were reduced until the pressure was not more than 10 cm of water vertically. The symphysis pubis was taken as the benchmark. Then a compressive pressure dressing was applied when the pressure range was about 7-12 cm of water (5).

Postoperatively the baby was continued on triple antibiotics (metronidazole, gentamicin and ampicillin). The silo was then compressed on a daily basis. Nasogastric tube lavage was done with 2 ml warm normal saline 2-hourly.

Through the jejunostomy feeding tube, 2 ml of warm saline was given 3-hourly beginning 6 hours postoperatively and then breast milk was commenced via the jejunostomy tube 24 hours postoperatively. On the third postoperative day there was no bile aspirated via the nasogastric tube (only clear fluids), and there was meconium passed through the anus, as demonstrated in Figure 2.

The infant was now allowed to take oral fluids, which she tolerated well, while maintaining milk feeds through the jejunostomy tube. On the fourth postoperative

day she was tolerating fluids well so she was allowed to breastfeed with supplement via the jejunostomy tube. The intravenous intake was then reduced to half the dose. On the seventh postoperative day the silo stitch gave way exposing the bowel and the peritoneum. There was viable bowel under the silo so the second stage of the surgical repair was done on the seventh postoperative day. By this time all the bowel contents were reduced well but the skin could not be closed (Figure 3) so another flat silo was left in place. Another bowel decompression was also done via the jejunostomy tube.



Figure 2. On the third postoperative day there was meconium being passed and the child was crying not in pain, but because of hunger.



Figure 3. On the second stage of the surgical repair all the bowels were reduced but the skin could not yet be closed.

The baby became septic a few days later and had a septic work-up: blood culture and pus swab both grew *Klebsiella pneumoniae* susceptible to ceftriaxone, with which she was treated. Cimetidine was commenced to prevent any stress-related gastritis. The jejunostomy tube was removed on the fifth postoperative day of the second stage. On the seventh day after the second stage repair the skin closure was done and her recovery was then unremarkable. She passed stool 6 hours postoperatively so she was commenced on breast milk the following day.

She was discharged home after a month of hospitalization. Upon review three months later, the child had gained a lot of weight, weighing 4 kg. There was obvious scarring over the wound site but ventral hernia was not prominent. After the 6 months review this child had no ventral hernia and hence did not require further surgery.

Case two

Baby of MT, a female infant, was delivered in the Port Moresby General Hospital Labour Ward and was transferred straight to the Special Care Nursery on 12/01/2014 as a case of gastroschisis. This was the third child from a mother without any previous medical or surgical problems. Upon examination the defect was 4 cm in diameter but the herniated contents extended from the proximal jejunum to the transverse colon. There was no sign of bowel atresia or other significant congenital associated pathologies. As there had been no alerting clinical signs antenatally, an ultrasound scan had not been done to pick up this pathology.

A first stage repair procedure was done within 6 hours post partum. In this case the silo was stitched to the sheath and not to skin. A jejunostomy feeding tube was not inserted. The herniated contents, mostly small bowels, were well reduced into the abdominal cavity. The skin in this case should have been primarily closed but due to the absence of a support service a silo was applied.

Postoperatively the bowels were opened on the third postoperative day, and hence the patient was commenced on feeds, which she tolerated well. Triple antibiotics were continued for a five-day course. Second stage with skin closure was done seven days later without any tension.

Postoperatively the skin closure wound healed up well. She had no sign of bowel obstruction and she fed immediately. This child recovered progressively well over the first two stages. During the second stage a pus swab was taken from the sloughed silo; it grew two organisms, *Pseudomonas aeruginosa* and *Streptococcus mirabilis*, both of which were susceptible to ciprofloxacin, with which she was treated. She was discharged 1 week later after the second stage surgery. Upon review in the surgical clinic 4 months later, the child's wound had healed and there was no ventral hernia defect.

Discussion

These two cases have survived where there is no NICU and TPN with various back-up support services. These are the first two recent survivors recorded apart from the one survivor in 2002 (4). The only medical officers who took care of these children were the general paediatric surgeons, the general paediatricians and the anaesthetists. Establishing a diagnosis antenatally is important because once gastroschisis is diagnosed the mother is advised to go to the nearest hospital where there are appropriate tertiary medical facilities so that the gastroschisis can be surgically corrected immediately. The mode of delivery does not determine the outcome but the initiation of surgical management is crucial. Early surgical intervention provides good outcome as illustrated in the above two cases. The first case had three surgical procedures and the second one had two procedures. The first case required a jejunostomy feeding tube whereas the second case did not. Antenatal clinical features such as polyhydramnios indicate the need for ultrasound scan of the pregnancy to establish the diagnosis (6). Prognostic indicators for morbidities such as AFBE (amniotic fluid beta-endorphin) are essential to determine the outcome (3) in an antenatal diagnosis of gastroschisis. In a scenario where antenatal diagnosis is not possible, where there is no trained radiologist, where necessary blood investigations are not available and there are no back-up support services with trained qualified staff and an NICU, surgical management of gastroschisis is challenging.

In any hospital where immediate surgical intervention is not possible, stabilization of such patients is crucial before transporting

them to where there is a skilled surgeon. Adequate fluid and electrolyte replacement should be maintained so that hydration and urine output are within the acceptable limits. Broad spectrum antibiotic cover is needed to prevent infection and for these patients triple antibiotics are indicated. The herniated contents are centrally placed over the abdomen with a plastic sheet covering the viscera, which are then secured with a saline-soaked gauze bandage. The aim of this is to prevent mesenteric infarct. A nasogastric tube is inserted to drain the stomach. Once the medical anticipated morbidities have been considered and addressed, the infant is taken to the operating theatre for surgical management.

The above two cases illustrate the essence of these principles. Increase in the intra-abdominal cavity space is done by total bowel lavage and stretching of the rectus sheath, as mentioned by Stoke in 1953 (7).

The measurement of intra-abdominal pressure (IAP) is essential in all gastroschisis patients because the consequences of failure to rectify this lead to intra-abdominal compartment syndrome (IACS) (3,7). There are ways to measure the IAP such as the urinary bladder pressure measurement, intragastric pressure measurement via a nasogastric tube and inferior vena cava pressure monitoring via a central venous line, as well as intra-abdominal pressure monitoring via a peripherally inserted central (PIC) line through the femoral vein or the saphenous vein. Inserting a nasogastric tube is fine but in our case it was not done because the nasogastric tube was used for lavage and feeding. For the PIC line there was no device available, hence it was not carried out. The normal range of 7 to 12 cm of water is adequate (5); but going beyond that will result in a cascade of events related to the pressure effect, and lead to IACS. In our case, a urinary catheter was used to measure the intra-abdominal pressure.

Ideally the child should be on a paediatric ventilator in a neonatal intensive care unit to prevent hypoxia or assisted ventilation is used. If that is not possible then the nasotracheal tube should be left alone until such time as the child's postoperative oxygen saturation is maintained at 96% or above and the heart rate is within the normal range of 120 to 160 beats per minute in a neonate. This demands extra

manpower and resources and was impossible in our setting. Hence alternative ways were used to manage this serious aspect of care.

Postoperatively the contents are reduced into the abdominal cavity on a regular basis. Gentle compression was applied against the silo and a tie at the top of the silo was made to prevent the content herniating back. By gravity the contents were compressed into the abdominal cavity. If there was insufficient intra-abdominal space then one positioned the silo centrally and the vertical position was maintained so that gravity could assist in the reduction of the bowel content. Oxygen saturation and the heart rate were observed to make sure that they were not compromised and bowel loops were examined to assess their viability.

Continual nasogastric lavage and Witzel's jejunostomy feeding was done not only for prevention of aspiration pneumonia and for nutrition, respectively, but also to stimulate the gastric and intestinal phases of intestinal motility. These peristalses also assist in the reduction of the contents from the silo into the abdominal cavity. The regular irrigation of these tubes is essential to maintain their patency. Ideally it is advisable for this to be done on an hourly basis but where nursing staff are limited it should be done as often as possible. The jejunostomy feeding tube is cleansed or irrigated with normal saline on a regular basis to maintain its patency for the first 24 hours. Pure water is avoided because it can slough the intestinal mucosa and thus predispose to NEC. There is no better substitute for breast milk for the initiation of the feeds into the lumen of a virgin gastrointestinal tract where TPN is unavailable. Early feeding has been advocated and commenced once the physiological manifestation of bowel recovery and function has occurred. Colostrum is the best initial food that should be given to any neonate as it contains the nutrition as well as the secretory IgAs that provide immunity along the virgin gastrointestinal tract of the newborn. Avoid feeding with formula milk as its osmolality may predispose to NEC. The time to remove the nasogastric tube is when there is no more bile drainage, meaning that the pylorus has prevented any backflow of duodenal content into the stomach (3,7). Early enteral feeding stimulates peristalsis, mucosal growth, gastrointestinal tract lengthening and gallbladder contraction, thus preventing cholestatic jaundice and

stimulating pancreatic secretion (8).

Postoperatively all blood parameters are checked and corrected accordingly. The most important parameters include full blood investigation, liver function tests, the coagulation profile, urea and electrolytes, phosphate, magnesium, blood sugar and C-reactive protein to assess if there is any source of an active inflammatory process. After the required period is over the silo is removed and the skin is mobilized and closed after reducing the content into the peritoneal cavity. During the second stage, further bowel decompression is wise and the skin should be closed as soon as possible. It is advisable not to do any further dissection or adhesiolysis of the bowel if the infant has tolerated feed well because further adhesiolysis can predispose the infant to significant adhesive bowel obstructions in the years to come. The time to remove the jejunostomy tube is when the child is able to breastfeed without any vomiting and the infant starts to gain weight, even after completing the second stage or skin cover. The removal of the tube is progressive and is determined by the surgeon who manages the patient. The ventral hernia can be corrected later as an elective procedure.

Ideally TPN is continued for 9 days and assisted ventilation for 14 days (9). This was impossible for these infants. The nasogastric tube remained to drain the gastric content and feeding was commenced via the percutaneous jejunostomy feeding tube. The first case had undergone three stage procedures while the other case had two stage procedures. The difference was that one was managed after 24 hours and the other within 4 hours post partum. On top of that, the first case was a village delivery and the second a hospital delivery. The reports demonstrate why it is mandatory to transfer such patients to the nearest place where the appropriate resources and manpower are available (8). Importantly it has been reported that such patients can spend more than 100 days (104 days) in hospital (9) but these two cases spent only about a month in hospital.

Complications must be diagnosed early and managed expeditiously. In places where there is no NICU and resources are limited, certain necessary steps need to be

considered. Safe transport and prevention of hypothermia, prevention of mesenteric infarct, and maintaining fluids and electrolyte balance are vital to achieve a good outcome. Early surgical correction after adequate resuscitation, commencing early feeding and preventing infections are important. Prevention of IACS (10,11) is crucial to prevent the compression of diaphragm and renal vessels that then respectively compromise the lung and lead to renal failure. Ventral hernia surgical correction is not a major issue and can be done as an elective case after 6 months' time.

REFERENCES

- 1 **Ameah EA, Bickler SW, Lakhoo K, Nwomeh BC, Poenaru D, eds.** Paediatric Surgery: A Comprehensive Text for Africa. Seattle, Washington: Global HELP Organization, 2010. www.global-help.org/products/paediatric_surgery_a_comprehensive_text_for_africa/
- 2 **Moore TC.** Gastroschisis with antenatal evisceration of intestines and urinary bladder. *Ann Surg* 1963;158:263-269.
- 3 **Mahieu-Caputo D, Muller F, Jouvet P, Thalabard JC, Jouannic JM, Nihoul-Fekété C, Dumez Y, Dommergues M.** Amniotic fluid beta-endorphin: a prognostic marker for gastroschisis? *J Pediatr Surg* 2002;37:1602-1606.
- 4 **Poki HO, Shun A, Cooper MG, Paiva H.** Gastroschisis management: an experience in Angau Memorial Hospital. *PNG Med J* 2003;46:41-45.
- 5 **Rino Y, Yukawa N, Murakami H, Sato T, Takata K, Hayashi T, Oshima T, Wada N, Masuda M, Imada T.** Primary placement technique of jejunostomy using the entriStar™ skin-level gastrostomy tube in patients with esophageal cancer. *BMC Gastroenterol* 2011;11:8.
- 6 **Marcucci L, ed.** Jejunostomy feeding tube – open (Witzel procedure). Inside Surgery 2009. <http://insidesurgery.com/2009/03/jejunostomy-feeding-tube-open-witzel-procedure/>
- 7 **Chabra S.** Gastroschisis: brief early history. *J Perinat Med* 2007;35:455.
- 8 **Insinga V, Lo Verso C, Antona V, Cimador M, Ortolano R, Carta M, La Placa S, Giuffrè M, Corsello G.** Perinatal management of gastroschisis. *Journal of Pediatric and Neonatal Individualized Medicine* 2014;3:e030113.
- 9 **Grosfeld JL, O'Neill JA Jr, Fonkalsrud EW, Coran AG.** Pediatric Surgery. Sixth edition. Philadelphia, Pennsylvania: Mosby Elsevier, 2006.
- 10 **Newcombe J, Mathur M, Ejike JC.** Abdominal compartment syndrome in children. *Crit Care Nurse* 2012;32:51-61.
- 11 **Royal Children's Hospital Melbourne.** Clinical Guidelines (Nursing): Intra-abdominal Pressure Monitoring. Melbourne: Royal Children's Hospital, 2011:1-6. www.rch.org.au/rchcpg/hospital_clinical_guideline_index/Intraabdominal_Pressure_Monitoring/

BOOK REVIEW

Singsings, Sutures and Sorcery – A 50 Year Experience in Papua New Guinea. A Dokta at Large in the Land of the Unexpected

BY ANTHONY J. RADFORD

Adelaide: Open Book, Howden Press, Reprinted 2015: 371 pages. Soft cover, illustrated with photos

“As the twig is bent, so grows the tree” – or so the saying goes. For so many of us, it is those early experiences that go on to shape our lives, both professionally and personally, in profound ways.

Such thoughts come to mind in reading (the now Emeritus Professor) Tony Radford's book on his life and work in Papua New Guinea (PNG) across the years 1959-2011.

It's an interesting observation that although after leaving PNG in 1972 Radford went on to hold distinguished academic posts in the United Kingdom (UK) and Australia, and consulted in over 42 countries of the world – yet he speaks so little of these in this book. Quite clearly, despite many and varied career twists and turns, his deepest affections seem to still lie here with us.

Arriving here on a cadetship rotation after completing his 4th year of medical school, those 7 weeks spent in Eastern Highlands and Simbu left an indelible mark (nearly a quarter of the book is spent in recounting his medical student sojourn).

‘Training’ goes on to become almost the subplot of this book. Returning soon after graduating, the young Dr Radford is plunged, early (as so many people were in the PNG administration of the time), into a senior teaching role at the nascent Papuan Medical College. The teachers are new, the students are new – everything is embryonic, and so too are the ideas. ‘What sort of medical school does PNG need in 1963?’ Indeed it is a question that today in 2015 we are still wrestling with in this country. Back then, the bold decisions were made, with Radford actively agitating along the way that the focus should be for the training of doctors at the

rural level, to first understand, then to live along side, and then to educate and treat the populations among which they lived and shared a common future.

The account chronicles the setting up of the early undergraduate programs at Kainantu and later at Saiho. The schools were pioneering programs unlike anything else in the world at the time and one of the seminal achievements of Radford's career. Clearly, he had strong support from key administrators without which backing these achievements could never have risen above the level of frustrated hopes. Nevertheless, Radford was at the cutting edge, doing the teaching, leading the patrols – taking a ‘do as I do’ approach to teaching the next generation.

From the vantage point of ‘modern’ times, and looking at the road forward for rural health in PNG, I found myself gleaning many insights out of this book.

The boldness to take risky and very unorthodox approaches to medical training; what is right for us as a nation may well be something totally different to what was right for Australia, England or the United States. Indeed, was it even right for them? Can we see their mistakes, not just their successes? The boldness to ask such questions is part of what it means to be not only a mature medical fraternity, but also a mature nation.

Improvisation and flexibility – these have always been bedrock requirements for anyone who wishes to succeed or even survive in rural PNG environments. They are clearly highlighted, even in the ‘taim bilong masta’ setting of Radford's sojourn in PNG.

And yet there is not the sense of eulogizing

about 'taim bipo' that one might expect from this book. Although he highlights the changes, often negative, that have ensued in health administration since his departure, and one can't help but feel his pain at seeing Saiho now returning to the jungle, nevertheless, his narrative of the colonial times in which he was present (1959-1975) is stark and sometimes very unflattering. For those of us who never knew that time, and have only grown up hearing the wistful reveries for PNG's 'golden age', this book is a helpful antidote. Each age will have its own failings. Although we can never gloss over or minimize the shortcomings of our own times, it never helps to have a distorted view of another.

Perhaps finally, but not improperly so, I took away from this book something that perhaps gets less mention than it should – partnership. No man is an island, and Anthony Radford was most surely blessed in having an intelligent, thought provoking, committed and loving wife. Robyn's own published thesis, on the real story of first contact with the PNG highlands, is a fascinating and important piece of history. Is it more so in this country than in so many others, that men and women

with vision, ability and determination, have their ambitions, sometimes noble, sometimes ignoble, fall short, because their family life becomes unsustainable? Perhaps not, but the foresight and achievements of Emeritus Professor Anthony Radford, in helping forge a unique and bold path for rural health in Papua New Guinea, clearly bears Robyn's marks and is a lesson for all who dream large.

'Singsings, Sutures and Sorcery – A 50 Year Experience in Papua New Guinea' should be read by all medical students, and everyone with an interest in understanding our 'branch' of service in this country we love.

You cannot understand the branch without first understanding the twig.

David Mills

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List of Medical Research Projects in Papua New Guinea

Approved or Noted

By the Medical Research Advisory Committee in 2014

An observational study of women and health workers on the uptake, acceptability and continuation of contraceptive implant in Milne Bay and Madang Provinces

Prof. Glen Mola (Obstetrics and Gynaecology Department, School of Medicine and Health Sciences, University of Papua New Guinea, PO Box 5623, Boroko, National Capital District, Papua New Guinea)

Improving the prevention, control and treatment of lymphatic filariasis and soil transmitted helminths in PNG

Dr Patricia Graves (James Cook University, Centre for Lymphatic Filariasis and other NTDs, Cairns and Townsville, Australia)

Teenagers' experiences of pregnancies in two sites, Madang and Goroka of Papua New Guinea

Ms Rebecca Emori (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Supplementary protocol of cellular immunity to *Plasmodium vivax* and *P. falciparum* in early childhood, (*P. vivax*) vaccine baseline and immuno-epidemiology cohort study and effect of liver and blood-stage treatment on subsequent *Plasmodium* re-infection and morbidity

Dr Inoni Betuela, Dr William Pomat, Dr Leanne Robinson, Dr Ivo Mueller and Dr Louis Schofield (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

Generating national political priority for global surgery in low and middle income countries (LMICs)

Dr Osborne Liko (Chief Surgeon, Port Moresby General Hospital, Private Mail Bag 1, Boroko, National Capital District, Papua New Guinea)

A study of National Health Plan (NHP)

implementation planning in the decentralized health system in Madang Province of Papua New Guinea

Mr Tabian Ambang (Divine Word University, PO Box 483, Madang, Madang Province, Papua New Guinea)

Functional analysis of band 3 protein role in *P. vivax* invasion

Dr Eline Kattenberg, Dr Leanne Robinson and Dr Anna Rosanas-Urgell (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

Village Birth Attendant Programme Review, Milne Bay Province

Ms Lisa Vallyely, Mr Billy Naidi, Sr Rebecca Paul and Ms Rebecca Emori (Papua New Guinea Institute of Medical Research, PO Box 235, Alotau, Milne Bay Province, Papua New Guinea)

Plasmodium transcriptome studies to improve understanding of malaria transmission

Dr Cristian Koepfli, Dr Leanne Robinson, Dr Eline Kattenberg, Dr Cyrille Czeher, Ms Dulcie Lautu, Dr Ingrid Felger and Prof. Ivo Mueller (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

Intermittent preventive treatment with azithromycin-containing regimens for the prevention of malarial infections and anaemia and the control of sexually transmitted infections in pregnant women in Papua New Guinea (MRAC 08.01). Supplementary protocol on laboratory studies on the causes of low birth weight, infections, and anaemia

Dr Stephen Rogerson, Dr Ivo Mueller, Dr Inoni Betuela, Prof. Peter Siba, Dr James Beeson, Dr William Pomat, Dr Christopher King and Dr Ruth Karron (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

Immunology studies related to malaria

Dr Christopher King and Prof. Peter Siba (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

A study in increasing vasectomy uptake: understanding and acceptability of vasectomy uptake amongst men in three regions of Papua New Guinea

Mr Seta Menu (Marie Stopes PNG, PO Box 972, Waigani, National Capital District, Papua New Guinea)

A qualitative study of the *Marasin Stoa Kipa* program: evaluating the acceptability, accessibility, and sustainability of a community-based malaria treatment and social franchise business model

Dr Kevin Miles (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

A retrospective study of invasive *Streptococcus pneumoniae* serotype 2 infections causing meningitis in Bangladesh

Prof. Samir Saha, Prof. Derrick Crook, Dr Catrin Moore and Dr William Pomat (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Health facility efficiency study in PNG with a focus on secondary care

Dr Justin Pulford and Dr M. Mahmud Khan (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Healthy mothers, healthy babies Study 1, Cohort Study

Dr James Beeson, Dr Christopher Morgan, Prof. Peter Siba, Dr William Pomat and Dr Michelle Hendel (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Pilot intervention study to investigate the acceptability, operational feasibility and public health impact of point of care HPV-DNA testing as a screening tool for the early detection and treatment of cervical cancer in PNG

Dr Andrew Vallely (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Optimisation of antimicrobial therapy for severe bacterial infections in neonates and young children in Papua New Guinea

Dr Laurens Manning (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Evaluation of G6PD deficiency testing strategies prior to conducting mass drug administration with primaquine in Lihir Island, Papua New Guinea

Dr Ivo Mueller, Dr Celine Barnadas, Dr Oriol Mitja, Dr Leanne Robinson, Dr Quique Bassat and Prof. Pedro L. Alonso (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Randomized control trial comparing efficacy of a single dose of treatment of yaws with 20 mg/kg versus 30 mg/kg of azithromycin

Prof. David Mabey (Clinical Research Department, London School of Hygiene and Tropical Medicine, Keppel Street, WC1E 7HT, London, United Kingdom)

Nutritional status of children 0-5 years in Kanabea, Papua New Guinea

Mrs Janny Martine Goris (14 Main Western Road, North Tamborine, Queensland 4272, Australia)

Evaluating the medical-circumcision-integrated male initiation ceremonies in Yangoru-Sausia, Papua New Guinea

Dr Clement Manineng (c/- Divine Word University, PO Box 483, Madang, Madang Province, Papua New Guinea)

Treatment of hyperreactive malarial splenomegaly in Papua New Guinea

Prof. Laurens Manning (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Note:

These projects have been examined and cleared by the MRAC but they have not all started, nor is there any guarantee that they all will, since in many cases this still depends on funding. It should be noted that the project funds for the MRAC were deleted from the Health Budget from 1997 to 2014.

Information about these projects may

be obtained from the investigators or from the Chairperson of the Medical Research Advisory Committee (Director of Research

and Monitoring, Department of Health, PO Box 807, Waigani, National Capital District, Papua New Guinea).

MEDLARS BIBLIOGRAPHY

PUBLICATIONS OF RELEVANCE TO PAPUA NEW GUINEA AND MELANESIA

Bibliographic Citation List generated from MEDLARS

- 1 **Aipit J, Laman M, Hwaihanje I, Bona C, Pomat N, Siba P, Davis TME, Manning L.**
Accuracy of initial clinical diagnosis of acute bacterial meningitis in children from a malaria-endemic area of Papua New Guinea.
Trans R Soc Trop Med Hyg 2014 Jul;108(7):444-448. doi: 10.1093/trstmh/tru067. Epub 2014 May 3.
BACKGROUND: The diagnosis of acute bacterial meningitis (ABM) is challenging in resource-limited settings where cerebral malaria and viral encephalitis are also common. METHODS: To assess the accuracy of an initial clinical diagnosis of ABM in a malaria-endemic area of Papua New Guinea (PNG), a retrospective chart review of hospitalized children aged 2 months to 10 years was conducted. RESULTS: Of the 481 eligible children, 240 had an initial clinical diagnosis of ABM that was confirmed independently by trained research staff under standardized conditions, with laboratory support in only 84 (17.5%; 84/481). When compared with the final laboratory-confirmed diagnosis, an initial diagnosis of ABM had a sensitivity, specificity, positive predictive value and negative predictive value of 76% (95% CI 66-85%), 56% (95% CI 51-61%), 27% (95% CI 21-33%) and 92% (95% CI 87-95%), respectively. There was discordance between initial and final diagnosis of ABM in 196 children; 176 initially considered to have ABM had an alternative diagnosis, while 20 without an initial diagnosis of ABM were confirmed to have ABM. CONCLUSION: These data show that initial misdiagnosis of ABM is common in a malaria-endemic area of PNG. A diagnostic algorithm using standardized assessment for meningeal irritation, coma and malaria parasitological testing needs further evaluation in this setting.
- 2 **Aipit S, Aipit J, Laman M.**
Malnutrition: a neglected but leading cause of child deaths in Papua New Guinea.
Lancet Glob Health 2014 Oct;2(10):e568. doi: 10.1016/S2214-109X(14)70302-X.
- 3 **Ambrose L, Cooper RD, Russell TL, Burkot TR, Lobo NF, Collins FH, Hii J, Beebe NW.**
Microsatellite and mitochondrial markers reveal strong gene flow barriers for *Anopheles farauti* in the Solomon Archipelago: implications for malaria vector control.
Int J Parasitol 2014 Mar;44(3-4):225-233. doi: 10.1016/j.ijpara.2013.12.001. Epub 2014 Jan 16.
Anopheles farauti is the primary malaria vector throughout the coastal regions of the Southwest Pacific. A shift in peak biting time from late to early in the night occurred following widespread indoor residue spraying of dichlorodiphenyltrichloro-ethane (DDT) and has persisted in some island populations despite the intervention ending decades ago. We used mitochondrial cytochrome oxidase I (COI) sequence data and 12 newly developed microsatellite markers to assess the population genetic structure of this malaria vector in the Solomon Archipelago. With geographically distinct differences in peak *A. farauti* night biting time observed in the Solomon Archipelago, we tested the hypothesis that strong barriers to gene flow exist in this region. Significant and often large fixation index (FST) values were found between different island populations for the mitochondrial and nuclear markers, suggesting highly restricted gene flow between islands. Some discordance in the location and strength of genetic breaks was observed between the mitochondrial and microsatellite markers. Since early night biting *A. farauti* individuals occur naturally in all populations, the strong gene flow barriers that we have identified in the Solomon Archipelago lend weight to the hypothesis that the shifts in peak biting time from late to early night have appeared independently in these disconnected island populations. For this reason, we suggest that insecticide impregnated bed nets and indoor residue spraying are unlikely to be effective as control tools against *A. farauti* occurring elsewhere, and if used, will probably result in peak biting time behavioural shifts similar to that observed in the Solomon Islands.
- 4 **Andrew EV, Pell C, Angwin A, Auwun A, Daniels J, Mueller I, Phuanukoonnon S, Pool R.**
Factors affecting attendance at and timing of formal antenatal care: results from a qualitative study in Madang, Papua New Guinea.
PLoS One 2014 May 19;9(5):e93025. doi: 10.1371/journal.pone.0093025. eCollection 2014.
BACKGROUND: Appropriate antenatal care (ANC) is key for the health of mother and child. However, in Papua New Guinea (PNG), only a third of women receive any ANC during pregnancy. Drawing on qualitative research, this paper explores the influences on ANC attendance and timing of first visit in the Madang region of Papua New Guinea. METHODS: Data were collected in three sites utilizing several qualitative methods: free-listing and sorting of terms and definitions, focus group discussions, in-depth interviews, observation in health care facilities and case studies of pregnant women. Respondents included pregnant women, their relatives, biomedical and traditional health providers, opinion leaders and community members. RESULTS: Although generally reported to be important, respondents' understanding of the procedures involved in ANC was limited. Factors influencing attendance fell into three main categories: accessibility, attitudes to ANC, and interpersonal issues. Although women saw accessibility (distance and cost) as a barrier, those who lived close to health facilities and could easily afford ANC also demonstrated poor attendance. Attitudes were shaped by previous experiences of ANC, such as waiting times, quality of care, and perceptions of preventative care and medical interventions during pregnancy. Interpersonal factors included relationships with healthcare providers, pregnancy disclosure, and family conflict. A desire to

avoid repeat clinic visits, ideas about the strength of the fetus and parity were particularly relevant to the timing of first ANC visit. **CONCLUSIONS:** This long-term in-depth study (the first of its kind in Madang, PNG) shows how socio-cultural and economic factors influence ANC attendance. These factors must be addressed to encourage timely ANC visits: interventions could focus on ANC delivery in health facilities, for example, by addressing healthcare staff's attitudes towards pregnant women.

5 Ang MJ, Li Z, Lim HA, Ng FM, Then SW, Wee JL, Joy J, Hill J, Chia CS.

A P2 and P3 substrate specificity comparison between the Murray Valley encephalitis and West Nile virus NS2B/NS3 protease using C-terminal agmatine dipeptides.

Peptides 2014 Feb;52:49-52. doi: 10.1016/j.peptides.2013.12.002. Epub 2013 Dec 9.

The Murray Valley encephalitis virus (MVEV) and the West Nile virus (WNV) are mosquito-borne single-stranded RNA Flaviviruses responsible for many cases of viral encephalitis and deaths worldwide. The former is endemic in north Australia and Papua New Guinea while the latter has spread to different parts of the world and was responsible for a recent North American outbreak in 2012, resulting in 243 fatalities. There are currently no approved vaccines or drugs against MVEV and WNV viral infections. A plausible drug target is the viral non-structural NS2B/NS3 protease due to its role in viral replication. This trypsin-like serine protease recognizes and cleaves viral polyproteins at the C-terminal end of an arginine residue, opening an avenue for the development of peptide-based antivirals. This communication compares the P2 and P3 residue preferences of the MVEV and WNV NS2B/NS3 proteases using a series of C-terminal agmatine dipeptides. Our results revealed that both viral enzymes were highly specific toward lysines at the P2 and P3 positions, suggesting that a peptidomimetic viral protease inhibitor developed against one virus should also be active against the other.

6 Arnott A, Wapling J, Mueller I, Ramsland PA, Siba PM, Reeder JC, Barry AE.

Distinct patterns of diversity, population structure and evolution in the AMA1 genes of sympatric *Plasmodium falciparum* and *Plasmodium vivax* populations of Papua New Guinea from an area of similarly high transmission.

Malar J 2014 Jun 14;13:233. doi: 10.1186/1475-2875-13-233.

BACKGROUND: As *Plasmodium falciparum* and *Plasmodium vivax* co-exist in most malaria-endemic regions outside sub-Saharan Africa, malaria control strategies in these areas must target both species in order to succeed. Population genetic analyses can predict the effectiveness of interventions including vaccines, by providing insight into patterns of diversity and evolution. The aim of this study was to investigate the population genetics of leading malaria vaccine candidate AMA1 in sympatric *P. falciparum* and *P. vivax* populations of Papua New Guinea (PNG), an area of similarly high prevalence (Pf=22.3 to 38.8%, Pv=15.3 to 31.8%). **METHODS:** A total of 72 *Pfama1* and 102 *Pvama1* sequences were collected from two distinct areas, Madang and Wosera, on the highly endemic PNG north coast. **RESULTS:** Despite a greater number of polymorphic sites in the AMA1 genes of

P. falciparum (Madang=52; Wosera=56) compared to *P. vivax* (Madang=36, Wosera=34), the number of AMA1 haplotypes, haplotype diversity (Hd) and recombination (R) was far lower for *P. falciparum* (Madang=12, Wosera=20; Hd \leq 0.92, R \leq 45.8) than for *P. vivax* (Madang=50, Wosera=38; Hd=0.99, R \leq 70.9). Balancing selection was detected only within domain I of AMA1 for *P. vivax*, and in both domains I and III for *P. falciparum*. **CONCLUSIONS:** Higher diversity in the genes encoding *P. vivax* AMA1 than in *P. falciparum* AMA1 in this highly endemic area has important implications for development of AMA1-based vaccines in PNG and beyond. These results also suggest a smaller effective population size of *P. falciparum* compared to *P. vivax*, a finding that warrants further investigation. Differing patterns of selection on the AMA1 genes indicate that critical antigenic sites may differ between the species, highlighting the need for independent investigations of these two leading vaccine candidates.

7 Asnet MJ, Rubia AG, Ramya G, Nagalakshmi RN, Shenbagarathai R.

DENVirDB: a web portal of dengue virus sequence information on Asian isolates.

J Vector Borne Dis 2014 Jun;51(2):82-85.

DENVirDB is a web portal that provides the sequence information and computationally curated information of dengue viral proteins. The advent of genomic technology has increased the sequences available in the public databases. In order to create relevant concise information on Dengue Virus (DENV), the genomic sequences were collected, analysed with the bioinformatics tools and presented as DENVirDB. It provides the comprehensive information of complete genome sequences of dengue virus isolates of Southeast Asia, viz. India, Bangladesh, Sri Lanka, East Timor, Philippines, Malaysia, Papua New Guinea, Brunei and China. DENVirDB also includes the structural and non-structural protein sequences of DENV. It intends to provide the integrated information on the physicochemical properties, topology, secondary structure, domain and structural properties for each protein sequence. It contains over 99 entries in complete genome sequences and 990 entries in protein sequences. Therefore, DENVirDB could serve as a user friendly database for researchers in acquiring sequences and proteomic information in one platform.

8 Ayove T, Houniei W, Wangnapi R, Bieb SV, Kazadi W, Luke LN, Manineng C, Moses P, Paru R, Esfandiari J, Alonso PL, de Lazzari E, Bassat Q, Mabey D, Mitjà O.

Sensitivity and specificity of a rapid point-of-care test for active yaws: a comparative study.

Lancet Glob Health 2014 Jul;2(7):e415-21. doi: 10.1016/S2214-109X(14)70231-1. Epub 2014 May 31.

BACKGROUND: To eradicate yaws, national control programmes use the Morges strategy (initial mass treatment and biannual resurveys). The resurvey component is designed to actively detect and treat remaining yaws cases and is initiated on the basis of laboratory-supported reactive non-treponemal serology (using the rapid plasma reagin [RPR] test). Unfortunately, the RPR test is available rarely in yaws-endemic areas. We sought to assess a new point-of-care assay – the Dual Path Platform (DPP) syphilis assay, which is based on

simultaneous detection of antibodies to treponemal and non-treponemal antigens – for guiding use of antibiotics for yaws eradication. A secondary goal was to ascertain at what timepoint the DPP assay line reverted to negative after treatment. **METHODS:** 703 children (aged 1-18 years) with suspected clinical yaws living in two remote, yaws-endemic villages in Papua New Guinea were enrolled. Clinical suspicion of yaws was established according to a WHO pictorial guide. We obtained blood samples from all patients. We calculated the sensitivity and specificity of the DPP assay for detection of antibodies to treponemal (T1) and non-treponemal (T2) antigens and compared values against those obtained with standard laboratory tests (the *Treponema pallidum* haemagglutination assay [TPHA] and the RPR test). We followed up a subsample of children with dually positive serology (T1 and T2) to monitor changes in DPP optical density (using an automatic reader) at 3 and 6 months. This trial is registered with ClinicalTrials.gov, number NCT01841203. **FINDINGS:** Of 703 participants, 389 (55%) were reactive for TPHA, 305 (43%) for the RPR test, and 287 (41%) for both TPHA and the RPR test. The DPP T1 (treponemal) assay had a sensitivity of 88.4% (95% CI 84.8-91.4) and specificity of 95.2% (92.2-97.3). The DPP T2 (non-treponemal) assay had a sensitivity of 87.9% (83.7-91.3) and specificity of 92.5% (89.4-94.9). In subgroup analyses, sensitivities and specificities did not differ according to type of specimen (plasma vs whole blood). For specimens with an RPR titre of 8 or greater, the sensitivity of the DPP T2 assay was 94.1% (95% CI 89.9-96.9). Serological cure (including seroreversion or a fourfold reduction in optical density value) was attained at 6 months in 173 (95%) of 182 children with dual-positive serology. **INTERPRETATION:** The DPP assay is accurate for identification of antibodies to treponemal and non-treponemal antigens in patients with yaws and avoids the need for laboratory support. A change of diagnostic procedure from the currently implemented RPR test to the simpler DPP assay could ease the implementation of yaws eradication activities. **FUNDING:** Chembio Diagnostic Systems, Newcrest Mining, and the Papua New Guinea National Department of Health.

- 9 **Baker ML, Painter G, Hewitt AW, Islam FM, Sztetu J, Qalo M, Keffe J.**

Profile of ocular trauma in the Solomon Islands. *Clin Experiment Ophthalmol* 2014 Jul;42(5):440-446.

BACKGROUND: The objective of this study was to characterize the causes of ocular trauma and determine the risk factors for infection and vision loss following ocular trauma in the Solomon Islands. **DESIGN:** A prospective clinic-based study. **PARTICIPANTS:** A total of 507 patients with ocular trauma who were reviewed at the National Referral Hospital in Honiara or one of five provincial eye clinics were included. **METHODS:** An interview-based questionnaire to determine the circumstances of ocular trauma, and an ocular examination to elicit the trauma sustained, infectious sequelae and the visual outcome. **MAIN OUTCOME MEASURE:** Visual acuity. **RESULTS:** Males were significantly more likely to have ocular trauma than females ($p = 0.01$). The major cause of ocular trauma in young boys and girls was being poked by a stick, followed by lime burns in young boys. For both genders,

physical violence resulted in most injuries across all adult age groups. Microbial keratitis complicated 4.4% of ocular trauma. Monocular vision impairment (<6/18) occurred in 5.5% of participants and was more likely to occur if female ($p = 0.02$). **CONCLUSIONS:** Ocular trauma is a significant cause of visual morbidity in the Solomon Islands. The results from this prospective study provide a basis for planning blindness prevention programmes in the Western Pacific.

- 10 **Barnadas C, Senn N, Iga J, Timinao L, Javati S, Malau E, Rarau P, Reeder JC, Siba P, Karunajeewa H, Zimmerman PA, Davis TME, Mueller I.**

Plasmodium falciparum and *Plasmodium vivax* genotypes and efficacy of intermittent preventive treatment in Papua New Guinea.

Antimicrob Agents Chemother 2014 Nov;58(11):6958-6961. doi: 10.1128/AAC.03323-14. Epub 2014 Aug 25.

Intermittent preventive treatment of infants (IPTi) reduces early childhood malaria-related morbidity. While genotypic drug resistance markers have proven useful in predicting the efficacy of antimalarial drugs in case management, there are few equivalent data relating to their protective efficacy when used as IPTi. The present data from an IPTi trial in Papua New Guinea demonstrate how these markers can predict protective efficacy of IPTi for both *Plasmodium falciparum* and *Plasmodium vivax*.

- 11 **Beekman AM, Barrow RA.**

Syntheses of the fungal metabolites boletopsins 7, 11, and 12 from the Papua New Guinea medicinal mushroom *Boletopsis* sp. *J Org Chem* 2014 Feb 7;79(3):1017-1024. doi: 10.1021/jo402492d. Epub 2014 Jan 17.

Boletopsins 7 (1), 11 (2), and 12 (3) are p-terphenyl dibenzofuran compounds, isolated from the Papua New Guinean medicinal mushroom *Boletopsis* sp. The first syntheses of these fungal metabolites are reported, allowing for an investigation of their antibiotic activity. The key steps include sequential Suzuki-Miyaura couplings to rapidly form the p-terphenyl backbone and an Ullmann ether synthesis on a formate ester to create the dibenzofuran moiety. Biological evaluation of the synthetic compounds and intermediates against a panel of bacterial nosocomial pathogens was performed.

- 12 **Benny E, Mesere K, Pavlin BI, Yakam L, Ford R, Yoannes M, Kisa D, Abdad MY, Menda L, Greenhill AR, Horwood PF.**

A large outbreak of shigellosis commencing in an internally displaced population, Papua New Guinea, 2013.

Western Pac Surveill Response J 2014 Sep 15;5(3):18-21. doi: 10.5365/WPSAR.2014.5.2.003.

OBJECTIVE: The objective of this study was to investigate a large outbreak of shigellosis in Papua New Guinea that began in a camp for internally displaced persons before spreading throughout the general community. **METHODS:** Outbreak mitigation strategies were implemented in the affected area to curtail the spread of the disease. Data were collected from the surveillance system and analysed by time, place and person. Rectal swab samples were tested by standard culture methods and real-time polymerase chain reaction to determine the

etiology of the outbreak. **RESULTS:** Laboratory analysis at two independent institutions established that the outbreak was caused by *Shigella* sp., with one strain further characterized as *Shigella flexneri* serotype 2. Approximately 1200 suspected cases of shigellosis were reported in a two-month period from two townships in Morobe Province, Papua New Guinea. The outbreak resulted in at least five deaths, all in young children. **DISCUSSION:** This outbreak of shigellosis highlights the threat of enteric diseases to vulnerable populations such as internally displaced persons in Papua New Guinea, as has been observed in other global settings.

13 Bilve A, Nogareda F, Joshua C, Ross L, Betcha C, Durski K, Fleischl J, Nilles E.

Establishing an early warning alert and response network following the Solomon Islands tsunami in 2013.

Bull World Health Organ 2014 Nov 1;92(11):844-848. doi: 10.2471/BLT.13.133512. Epub 2014 Aug 15.

PROBLEM: On 6 February 2013, an 8.0 magnitude earthquake generated a tsunami that struck the Santa Cruz Islands, Solomon Islands, killing 10 people and displacing over 4700. **APPROACH:** A post-disaster assessment of the risk of epidemic disease transmission recommended the implementation of an early warning alert and response network (EWARN) to rapidly detect, assess and respond to potential outbreaks in the aftermath of the tsunami. **LOCAL SETTING:** Almost 40% of the Santa Cruz Islands' population were displaced by the disaster, and living in cramped temporary camps with poor or absent sanitation facilities and insufficient access to clean water. There was no early warning disease surveillance system. **RELEVANT CHANGES:** By 25 February, an EWARN was operational in five health facilities that served 90% of the displaced population. Eight priority diseases or syndromes were reported weekly; unexpected health events were reported immediately. Between 25 February and 19 May, 1177 target diseases or syndrome cases were reported. Seven alerts were investigated. No sustained transmission or epidemics were identified. Reporting compliance was 85%. The EWARN was then transitioned to the routine four-syndrome early warning disease surveillance system. **LESSON LEARNT:** It was necessary to conduct a detailed assessment to evaluate the risk and potential impact of serious infectious disease outbreaks, to assess whether and how enhanced early warning disease surveillance should be implemented. Local capacities and available resources should be considered in planning EWARN implementation. An EWARN can be an opportunity to establish or strengthen early warning disease surveillance capabilities.

14 Bolinga JW, Hamura NN, Umbers AJ, Rogerson SJ, Unger HW.

Insights into maternal mortality in Madang Province, Papua New Guinea.

Int J Gynaecol Obstet 2014 Feb;124(2):123-127. doi: 10.1016/j.ijgo.2013.08.012. Epub 2013 Nov 6.

OBJECTIVE: To assess the frequency, causes, and reporting of maternal deaths at a provincial referral hospital in coastal Papua New Guinea (PNG), and to describe delays in care. **METHODS:** In a structured retrospective review of maternal deaths at Modilon General Hospital, Madang, PNG,

registers and case notes for the period January 2008 to July 2012 were analyzed to determine causes, characteristics, and management of maternal death cases. Public databases were assessed for underreporting. **RESULTS:** During the review period, there were 64 maternal deaths (institutional maternal mortality ratio, 588 deaths per 100 000 live births). Fifty-two cases were analyzed in detail: 71.2% (n = 37) were direct maternal deaths, and hemorrhage (n = 24, 46.2%) and infection (n = 16, 30.8%) were the leading causes of mortality overall. Women frequently did not attend prenatal clinics (n = 34, 65.4%), resided in rural areas (n = 45, 86.5%), and experienced delays in care (n = 45, 86.5%). Maternal deaths were underreported in public databases. **CONCLUSION:** The burden of maternal mortality was found to be high at a provincial hospital in PNG. Most women died of direct causes and experienced delays in care. Strategies to complement current hospital and national policy to reduce maternal mortality and to improve reporting of deaths are needed.

15 Bordbar B, Tuikue Ndam N, Renard E, Jafari-Guemouri S, Tavul L, Jennison C, Gnidehou S, Tahar R, Gamboa D, Bendezu J, Menard D, Barry AE, Deloron P, Sabbagh A.

Genetic diversity of VAR2CSA ID1-DBL2Xb in worldwide *Plasmodium falciparum* populations: impact on vaccine design for placental malaria.

Infect Genet Evol 2014 Jul;25:81-92. doi: 10.1016/j.meegid.2014.04.010. Epub 2014 Apr 21.

In placental malaria (PM), sequestration of infected erythrocytes in the placenta is mediated by an interaction between VAR2CSA, a *Plasmodium falciparum* protein expressed on erythrocytes, and chondroitin sulfate A (CSA) on syncytiotrophoblasts. Recent works have identified ID1-DBL2Xb as the minimal CSA-binding region within VAR2CSA able to induce strong protective immunity, making it the leading candidate for the development of a vaccine against PM. Assessing the existence of population differences in the distribution of ID1-DBL2Xb polymorphisms is of paramount importance to determine whether geographic diversity must be considered when designing a candidate vaccine based on this fragment. In this study, we examined patterns of sequence variation of ID1-DBL2Xb in a large collection of *P. falciparum* field isolates (n = 247) from different malaria-endemic areas, including Africa (Benin, Senegal, Cameroon and Madagascar), Asia (Cambodia), Oceania (Papua New Guinea), and Latin America (Peru). Detection of variants and estimation of their allele frequencies were performed using next-generation sequencing of DNA pools. A considerable amount of variation was detected along the whole gene segment, suggesting that several allelic variants may need to be included in a candidate vaccine to achieve broad population coverage. However, most sequence variants were common and extensively shared among worldwide parasite populations, demonstrating long term persistence of those polymorphisms, probably maintained through balancing selection. Therefore, a vaccine mixture including such stable antigen variants will be putatively applicable and efficacious in all world regions where malaria occurs. Despite similarity in ID1-DBL2Xb allele repertoire across geographic areas, several peaks of strong population differentiation were observed at specific polymorphic loci, pointing out putative targets of humoral immunity

subject to positive immune selection.

16 **Brown AN, McCormack C.**

Twenty cultural and learning principles to guide the development of pharmacy curriculum in Pacific Island countries.

Rural Remote Health 2014;14(4):2581. Epub 2014 Oct 6.

INTRODUCTION: A lack of education capacity to support the development of medical supply management competency is a major issue affecting Pacific Island countries (PICs). Limited human resources and underdeveloped medicines supply management competency are two significant impediments to reaching the health-related Millennium Development Goals in many countries in this rural and remote region. Two recent review publications have provided relevant background documenting factors affecting learning and teaching. These articles have presented available information regarding competency and training requirements for health personnel involved in essential medicine supply management in the region. This background research has provided a platform from which tangible principles can be developed to aid educators and professionals in PICs in the development and delivery of appropriate pharmacy curriculum. Specifically the aim of the present article is to identify culturally meaningful learning and teaching principles to guide the development and delivery of pharmaceutical curriculum in PICs. Subsequently, this information will be applied to develop and trial new pedagogical approaches to the training of health personnel involved in essential medicines supply management, to improve medicine availability for patients in their own environment. This article forms part of a wider research project involving the United Nations Population Fund Suva subregional office, the University of Canberra, Ministry of Health officials and health personnel within identified PICs. **METHODS:** Two previous reviews, investigating Pacific culture, learning approaches, and training requirements affecting pharmaceutical personnel, were synthesised into a set of principles that could be applied to the development of pharmaceutical curriculum. These principles were validated through focus groups of health personnel using action research methods. **RESULTS:** An initial set of 16 principles was developed from the synthesis of the two reviews. These principles were reviewed by two focus groups held in Fiji and the Solomon Islands to produce a set of 20 validated principles. These validated principles can be grouped under the headings of learning theory, structure and design, and learning and teaching methods. **CONCLUSIONS:** The 20 principles outlined in this article will be used to develop and trial culturally relevant training approaches for the development of medicine management competencies for various cadres of health personnel in PICs. These principles provide a practical framework for educators and health professionals to apply to health-based education and training in the Pacific, with potential application to other rural and remote environments.

17 **Brown AN, Gilbert B.**

The Papua New Guinea medical supply system – documenting opportunities and challenges to meet the Millennium Development Goals.

J Pharm Policy Pract 2014 May 19;7:5. doi: 10.1186/2052-3211-7-5. eCollection 2014.

OBJECTIVES: Limited human resources are widely recognised as an impediment to achieving the health-related Millennium Development Goals in Pacific Island Countries, with the availability of medical supplies and suitably trained health personnel crucial to ensuring a well-functioning medical supply chain. This paper presents our findings as we seek to answer the research question 'What factors influence the availability of medical supplies within the health facilities of Papua New Guinea?' **METHODS:** We used a qualitative, triangulated strategy using semi-structured interviews, workplace observation and semi-structured focus groups. The parallel use of the interview tool and workplace observation tool allowed identification of 'know-do' gaps between what the interviewee said they did in their work practices, and the actual evidence of these practices. Focus groups provided further opportunities for raising and elaborating issues. **RESULTS:** During 2 weeks of data collection we conducted 17 interviews and 15 observational workplace surveys in 15 facilities. Sixteen health personnel participated in 3 focus groups across 2 provinces and one district. An array of medical supply issues across all levels of the medical supply chain were revealed, including standard operating procedures, facilities, transport, emergency medical kits, the cold chain and record keeping. The influence of health worker training and competency was found to be common across all of these issues. **CONCLUSION:** The factors influencing the availability of medical supplies in PNG consist of a range of interrelating issues, consisting of both simple and complex problems involving the different levels and cadres of workers within the medical supply chain. Health systems sustainability theory suggests that a coordinated approach which addresses the inter-related nature of these issues, led by the PNG government and supported by suitable development partners, will be required for sustainable health systems change to occur. These changes are necessary for PNG to meet the health-related Millennium Development Goals.

18 **Brown H, Spickett J, Katscherian D.**

A health impact assessment framework for assessing vulnerability and adaptation planning for climate change.

Int J Environ Res Public Health 2014 Dec 12;11(12):12896-12914. doi: 10.3390/ijerph111212896.

This paper presents a detailed description of an approach designed to investigate the application of the Health Impact Assessment (HIA) framework to assess the potential health impacts of climate change. A HIA framework has been combined with key climate change terminology and concepts. The fundamental premise of this framework is an understanding of the interactions between people, the environment and climate. The diversity and complexity of these interactions can hinder much needed action on the critical health issue of climate change. The objectives of the framework are to improve the methodology for understanding and assessing the risks associated with potential health impacts of climate change, and to provide decision-makers with information that can facilitate the development of effective adaptation plans. While the process presented here provides guidance with respect to this task it is not intended to be prescriptive. As such, aspects of the process can be

amended to suit the scope and available resources of each project. A series of working tables has been developed to assist in the collation of evidence throughout the process. The framework has been tested in a number of locations including Western Australia, Solomon Islands, Vanuatu and Nauru.

- 19 **Brown IS, Bettington A, Bettington M, Rosty C.** Tropical sprue: revisiting an underrecognized disease.

Am J Surg Pathol 2014 May;38(5):666-672. doi: 10.1097/PAS.0000000000000153.

Tropical sprue is an acquired chronic diarrheal disorder of unclear etiology affecting residents of and visitors to tropical regions. Patients usually present with profuse diarrhea, weight loss, and malabsorption, notably of vitamin B12 and folate. The histologic changes typically resemble that of gluten-sensitive enteropathy. Reports of tropical sprue have become infrequent in the literature, and the diagnosis is often not considered either clinically or pathologically. This disease may, however, cause significant morbidity, although it is eminently treatable with broad-spectrum antibiotics. In this study, we report the clinical presentation of 12 tropical sprue patients along with the histologic changes of the intestinal mucosa and compare it with those of a series of 150 cases of gluten-sensitive enteropathy, the condition with which it is most frequently misdiagnosed. The cohort comprised 6 men and 6 women with a median age of 59 years (range, 38 to 78 y) with a history of residence or visitation in South Asia or Papua New Guinea. Partial villous blunting in the duodenal mucosa was present in 75% of cases, and a marked intraepithelial lymphocytosis was observed in all cases (mean per 100 epithelial cells 77.3; range, 42 to 124). A villous tip accentuation of intraepithelial lymphocytosis was not appreciable in most cases. No case of complete villous blunting (Marsh stage 3c) was identified in tropical sprue, contrasting with 25% in gluten-sensitive enteropathy cases. A duodenal mucosa eosinophil infiltrate was present in all cases with significantly higher counts compared with untreated gluten-sensitive enteropathy patients (26.6/HPF vs. 14.6/HPF; $p = 0.009$). The ileal mucosa displayed more severe villous blunting with higher Marsh stages than in the corresponding duodenum from 5 patients. There was a mild intraepithelial lymphocytosis and eosinophil infiltrate in the colonic mucosa of half of the cases. Follow-up biopsies in 6 patients demonstrated a histologic response after oral folates and doxycycline treatment. In summary, tropical sprue is a pan-enteric inflammatory process often mistaken for gluten-sensitive enteropathy. Histologic findings suggesting tropical sprue in the appropriate clinical context include incomplete duodenal villous blunting without development of flat mucosa, frequent involvement of the terminal ileum with more marked inflammation and villous blunting than in the duodenum, and a conspicuous eosinophil infiltrate in the lamina propria. With the expansion of tourism and increasing employment opportunities in tropical regions, pathologists in the West are increasingly likely to encounter cases of tropical sprue and should be aware of this diagnosis.

- 20 **Bugoro H, Hii JL, Butafa C, Iro'ofa C, Apairamo A, Cooper RD, Chen CC, Russell TL.**

The bionomics of the malaria vector *Anopheles farauti* in Northern Guadalcanal, Solomon Islands:

issues for successful vector control.

Malar J 2014 Feb 15;13:56. doi: 10.1186/1475-2875-13-56.

BACKGROUND: The north coast of Guadalcanal has some of the most intense malaria transmission in the Solomon Islands. And, there is a push for intensified vector control in Guadalcanal, to improve the livelihood of residents and to minimize the number of cases, which are regularly exported to the rest of the country. Therefore, the bionomics of the target vector, *Anopheles farauti*, was profiled in 2007-2008, which was after 20 years of limited surveillance during which time treated bed nets (ITNs) were distributed in the area. **METHODS:** In three villages on northern Guadalcanal, blood-seeking female mosquitoes were caught using hourly human landing catches by four collectors, two working indoors and two outdoors, from 18.00-06.00 for at least two nights per month from July 2007 to June 2008. The mosquitoes were counted, identified using morphological and molecular markers and dissected to determine parity. **RESULTS:** Seasonality in vector densities was similar in the three villages, with a peak at the end of the drier months (October to December) and a trough at the end of the wetter months (March to May). There was some variability in endophagy (indoor biting) and nocturnal biting (activity during sleeping hours) both spatially and temporally across the longitudinal dataset. The general biting pattern was consistent throughout all sample collections, with the majority of biting occurring outdoors (64%) and outside of sleeping hours (65%). Peak biting was 19.00-20.00. The proportion parous across each village ranged between 0.54-0.58. Parity showed little seasonal trend despite fluctuations in vector densities over the year. **CONCLUSION:** The early, outdoor biting behaviour of *An. farauti* documented 20 years previously on north Guadalcanal was still exhibited. It is possible that bed net use may have maintained this biting profile though this could not be determined unequivocally. The longevity of these populations has not changed despite long-term ITN use. This early, outdoor biting behaviour led to the failure of the eradication programme and is likely responsible for the continued transmission in Guadalcanal following the introduction of ITNs. Other vector control strategies which do not rely on the vector entering houses are needed if elimination or intensified control is to be achieved.

- 21 **Byrne A, Hodge A, Jimenez-Soto E, Morgan A.**

What works? Strategies to increase reproductive, maternal and child health in difficult-to-access mountainous locations: a systematic literature review.

PLoS One 2014 Feb 3;9(2):e87683. doi: 10.1371/journal.pone.0087683. eCollection 2014.

BACKGROUND: Geography poses serious challenges to delivery of health services and is a well documented marker of inequity. Maternal, newborn and child health (MNCH) outcomes are poorer in mountainous regions of low and lower-middle income countries due to geographical inaccessibility combined with other barriers: poorer quality services, persistent cultural and traditional practices and lower socioeconomic and educational status. Reaching universal coverage goals will require attention for remote mountain settings. This study aims to identify strategies to address barriers to reproductive MNCH (RMNCH) service utilization in difficult-to-reach mountainous regions in low and lower-

middle income settings worldwide. **METHODS:** A systematic literature review drawing from MEDLINE, Web of Science, Scopus, Google Scholar, and Eldis. Inclusion was based on: testing an intervention for utilisation of RMNCH services; remote mountain settings of low and lower-middle income countries; selected study designs. Studies were assessed for quality and analysed to present a narrative review of the key themes. **FINDINGS:** From 4,130 articles 34 studies were included, from Afghanistan, Bolivia, Ethiopia, Guatemala, Indonesia, Kenya, Kyrgyzstan, Nepal, Pakistan, Papua New Guinea and Tajikistan. Strategies fall into four broad categories: improving service delivery through selected, trained and supported community health workers (CHWs) to act alongside formal health workers and the distribution of critical medicines to the home; improving the desirability of existing services by addressing the quality of care, innovative training and supervision of health workers; generating demand by engaging communities; and improving health knowledge for timely care-seeking. Task shifting, strengthened roles of CHWs and volunteers, mobile teams, and inclusive structured planning forums have proved effective. **CONCLUSIONS:** The review highlights where known evidence-based strategies have increased the utilisation of RMNCH services in low income mountainous areas. While these are known strategies in public health, in such disadvantaged settings additional supports are required to address both supply and demand barriers.

- 22 **Cao-Lormeau VM, Roche C, Musso D, Mallet HP, Dalipanda T, Dofai A, Nogareda F, Nilles EJ, Aaskov J.** Dengue virus type 3, South Pacific Islands, 2013. *Emerg Infect Dis* 2014 Jun;20(6):1034-1036. doi: 10.3201/eid2006.131413.

After an 18-year absence, dengue virus serotype 3 reemerged in the South Pacific Islands in 2013. Outbreaks in western (Solomon Islands) and eastern (French Polynesia) regions were caused by different genotypes. This finding suggested that immunity against dengue virus serotype, rather than virus genotype, was the principal determinant of reemergence.

- 23 **Carmone A, Bomai K, Bongi W, Frank TD, Dalepa H, Loifa B, Kiromat M, Das S, Franke MF.** Partner testing, linkage to care, and HIV-free survival in a program to prevent parent-to-child transmission of HIV in the Highlands of Papua New Guinea. *Glob Health Action* 2014 Aug 27;7:24995. doi: 10.3402/gha.v7.24995. eCollection 2014.

BACKGROUND: To eliminate new pediatric HIV infections, interventions that facilitate adherence, including those that minimize stigma, enhance social support, and mitigate the influence of poverty, will likely be required in addition to combination antiretroviral therapy (ART). We examined the relationship between partner testing and infant outcome in a prevention of parent-to-child transmission of HIV program, which included a family-centered case management approach and a supportive environment for partner disclosure and testing. **DESIGN:** We analyzed routinely collected data for women and infants who enrolled in the parent-to-child transmission of HIV program at Goroka Family Clinic, Eastern Highlands Provincial Hospital, Papua New Guinea, from 2007 through 2011. **RESULTS:** Two hundred and sixty-five women

were included for analysis. Of these, 226 (85%) had a partner, 127 (56%) of whom had a documented HIV test. Of the 102 HIV-infected partners, 81 (79%) had been linked to care. In adjusted analyses, we found a significantly higher risk of infant death, infant HIV infection, or loss to follow-up among mother-infant pairs in which the mother reported having no partner or a partner who was not tested or had an unknown testing status. In a second multivariable analysis, infants born to women with more time on ART or who enrolled in the program in later years experienced greater HIV-free survival. **CONCLUSIONS:** In a program with a patient-oriented and family-centered approach to prevent vertical HIV transmission, the majority of women's partners had a documented HIV test and, if positive, linkage to care. Having a tested partner was associated with program retention and HIV-free survival for infants. Programs aiming to facilitate diagnosis disclosure, partner testing, and linkage to care may contribute importantly to the elimination of pediatric HIV.

- 24 **Chiu CY, Healer J, Thompson JK, Chen L, Kaul A, Saverigave L, Raghuvanshi A, Li Wai Suen CS, Siba PM, Schofield L, Mueller I, Cowman AF, Hansen DS.**

Association of antibodies to *Plasmodium falciparum* reticulocyte binding protein homolog 5 with protection from clinical malaria.

Front Microbiol 2014 Jun 30;5:314. doi: 10.3389/fmicb.2014.00314. eCollection 2014.

Emerging evidence suggests that antibodies against merozoite proteins involved in *Plasmodium falciparum* invasion into the red blood cell (RBC) play an important role in clinical immunity to malaria. The protein family of parasite antigens known as *P. falciparum* reticulocyte binding protein-like homolog (PfRh) is required for RBC invasion. PfRh5 is the only member within the PfRh family that cannot be genetically deleted, suggesting it plays an essential role in parasite survival. This antigen forms a complex with the cysteine-rich *P. falciparum* Rh5 interacting protein (PfRipr) on the merozoite surface during RBC invasion. The PfRh5 ectodomain sequence and a C-terminal fragment of PfRipr were cloned and expressed in *Escherichia coli* and baculovirus-infected cells, respectively. Immunization of rabbits with these recombinant proteins induced antibodies able to inhibit growth of various *P. falciparum* strains. Antibody responses to these proteins were investigated in a treatment-re-infection study conducted in an endemic area of Papua New Guinea (PNG) to determine their contribution to naturally acquired immunity. Antibody titers to PfRh5 but not PfRipr showed strong association with protection against *P. falciparum* clinical episodes. When associations with time-to-first infection were analyzed, high antibody levels against PfRh5 were also found to be associated with protection from high-density infections but not from re-infection. Together these results indicate that PfRh5 is an important target of protective immunity and constitutes a promising vaccine candidate.

- 25 **Cross GB, Coles K, Nikpour M, Moore OA, Denholm J, McBryde ES, Eisen DP, Warigi B, Carter R, Pandey S, Harino P, Siba P, Coulter C, Mueller I, Phuanukoonnon S, Pellegrini M.**

TB incidence and characteristics in the remote Gulf Province of Papua New Guinea: a prospective study. *BMC Infect Dis* 2014 Feb 20;14:93. doi:

10.1186/1471-2334-14-93.

BACKGROUND: The incidence and characteristics of tuberculosis (TB) in remote areas of Papua New Guinea (PNG) are largely unknown. The purpose of our study was to determine the incidence of TB in the Gulf Province of PNG and describe disease characteristics, co-morbidities and drug resistance profiles that could impact on disease outcomes and transmission. **METHODS:** Between March 2012 and June 2012, we prospectively collected data on 274 patients presenting to Kikori Hospital with a presumptive diagnosis of TB, and on hospital inpatients receiving TB treatment during the study period. Sputum was collected for microscopy, GeneXpert analysis, culture and genotyping of isolates. **RESULTS:** We estimate the incidence of TB in Kikori to be 1290 per 100,000 people (95% CI 1140 to 1460) in 2012. The proportion of TB patients co-infected with HIV was 1.9%. Three of 32 TB cases tested were rifampicin resistant. Typing of nine isolates demonstrated allelic diversity and most were related to Beijing strains. **CONCLUSIONS:** The incidence of TB in Kikori is one of the highest in the world and it is not driven by HIV co-infection. The high incidence and the presence of rifampicin resistance warrant urgent attention to mitigate substantial morbidity in the region.

- 26 **Céspedes N, Jiménez E, Lopez-Perez M, Rubiano K, Felger I, Alonso P, Arévalo-Herrera M, Corradin G, Herrera S.**

Antigenicity and immunogenicity of a novel *Plasmodium vivax* circumsporozoite derived synthetic vaccine construct.

Vaccine 2014 May 30;32(26):3179-3186. doi: 10.1016/j.vaccine.2014.04.007. Epub 2014 Apr 13.

BACKGROUND: The circumsporozoite (CS) protein is a major malaria sporozoite surface antigen currently being considered as a vaccine candidate. *Plasmodium vivax* CS (PvCS) protein comprises a dimorphic central repeat fragment flanked by conserved regions that contain functional domains involved in parasite invasion of host cells. The protein amino (N-terminal) flank has a cleavage region (region I), essential for proteolytic processing prior to parasite invasion of liver cells. **METHODS:** We have developed a 131-mer long synthetic polypeptide (LSP) named PvNR1R2 that includes the N-terminal flank and the two natural repeat variant regions known as VK210 and VK247. We studied the natural immune response to this region in human sera from different malaria-endemic areas and its immunogenicity in mice. **RESULTS:** PvNR1R2 was more frequently recognized by sera from Papua New Guinea (PNG) (83%) than by samples from Colombia (24%) when tested by ELISA. The polypeptide formulated in Montanide ISA51 adjuvant elicited strong antibody responses in both C3H and CB6F1 mice strains. Antibodies from immunized mice as well as affinity-purified human IgG reacted with native protein by IFA test. Moreover, mouse immune sera induced strong (90%) *in vitro* inhibition of sporozoite invasion (ISI) of hepatoma cell lines. **CONCLUSIONS:** These results encourage further studies in non-human primates to confirm the elicitation of sporozoite invasion blocking antibodies, to assess cell mediated immune responses and the protective efficacy of this polypeptide.

- 27 **Céspedes N, Habel C, Lopez-Perez M, Castellanos A, Kajava AV, Servis C, Felger I, Moret R, Arévalo-**

Herrera M, Corradin G, Herrera S.

Plasmodium vivax antigen discovery based on alpha-helical coiled coil protein motif.

PLoS One 2014 Jun 24;9(6):e100440. doi: 10.1371/journal.pone.0100440. eCollection 2014.

Protein α -helical coiled coil structures that elicit antibody responses which block critical functions of medically important microorganisms represent a means for vaccine development. By using bioinformatics algorithms, a total of 50 antigens with α -helical coiled coil motifs orthologous to *Plasmodium falciparum* were identified in the *P. vivax* genome. The peptides identified *in silico* were chemically synthesized; circular dichroism studies indicated partial or high α -helical content. Antigenicity was evaluated using human sera samples from malaria-endemic areas of Colombia and Papua New Guinea. Eight of these fragments were selected and used to assess immunogenicity in BALB/c mice. ELISA assays indicated strong reactivity of serum samples from individuals residing in malaria-endemic regions and sera of immunized mice with the α -helical coiled coil structures. In addition, *ex vivo* production of IFN- γ by murine mononuclear cells confirmed the immunogenicity of these structures and the presence of T-cell epitopes in the peptide sequences. Moreover, sera of mice immunized with four of the eight antigens recognized native proteins on blood-stage *P. vivax* parasites, and antigenic cross-reactivity with three of the peptides was observed when reacted with both the *P. falciparum* orthologous fragments and whole parasites. Results here point to the α -helical coiled coil peptides as possible *P. vivax* malaria vaccine candidates as were observed for *P. falciparum*. Fragments selected here warrant further study in humans and non-human primate models to assess their protective efficacy as single components or assembled as hybrid linear epitopes.

- 28 **Das S, Carmone A, Franke MF, Frank D, Kiromat H, Kaima P, Kiromat M.**

Retention among ART patients in the Highlands of Papua New Guinea: evaluating the PAPUA model. *J Acquir Immune Defic Syndr* 2014 Feb 1;65(2):e67-73. doi: 10.1097/QAI.0b013e3182a14f7e.

BACKGROUND: Despite more than 10,000 patients on antiretroviral therapy (ART), there remains a dearth of operational research in Papua New Guinea related to HIV service delivery. This study examined the effectiveness of a locally developed model of HIV service delivery called PAPUA (Patient and Provider Unified Approach) in the Highlands of Papua New Guinea. The model emphasizes coordinated patient and provider support along with decentralized services to rural districts in the Highlands. **METHODS:** We conducted a chart review among HIV-infected adults on ART at clinics in Eastern Highlands Province, where the PAPUA model was implemented in addition to the standard of care, and in Western Highlands Province, where the standard of care was implemented. We calculated yearly retention rates and used multivariable Cox proportional hazards regression analyses to compare retention rates across the provinces. **RESULTS:** Data for 2457 patients from the 2 provinces were analyzed. Among patients receiving ART under the PAPUA model in Eastern Highlands, the 12-, 24-, 36-, and 48-month retention proportions were 0.79, 0.73, 0.68, and 0.63, respectively. When we compared retention probabilities across

the 2 provinces, patients receiving care under the PAPUA model had a 15% lower rate of attrition from care during the first 4 years of ART (hazard ratio, 0.85; 95% confidence interval: 0.74 to 0.99; $p = 0.03$), after adjusting for age, gender, and year of enrollment. **CONCLUSIONS:** The PAPUA model seems to be a promising intervention although it is inextricably linked to the limitations posed by a resource-constrained health system.

- 29 **Douglas NM, Pontororing GJ, Lampah DA, Yeo TW, Kenangalem E, Poespoprodjo JR, Ralph AP, Bangs MJ, Sugiarto P, Anstey NM, Price RN.**

Mortality attributable to *Plasmodium vivax* malaria: a clinical audit from Papua, Indonesia. *BMC Med* 2014 Nov 18;12:217. doi: 10.1186/s12916-014-0217-z.

BACKGROUND: *Plasmodium vivax* causes almost half of all malaria cases in Asia and is recognised as a significant cause of morbidity. In recent years it has been associated with severe and fatal disease. The extent to which *P. vivax* contributes to death is not known. **METHODS:** To define the epidemiology of mortality attributable to vivax malaria in southern Papua, Indonesia, a retrospective clinical records-based audit was conducted of all deaths in patients with vivax malaria at a tertiary referral hospital. **RESULTS:** Between January 2004 and September 2009, hospital surveillance identified 3,495 inpatients with *P. vivax* mono-infection and 65 (1.9%) patients who subsequently died. Charts for 54 of these 65 patients could be reviewed, 40 (74%) of whom had pure *P. vivax* infections on cross-checking. Using pre-defined conservative criteria, vivax malaria was the primary cause of death in 6 cases, a major contributor in 17 cases and a minor contributor in a further 13 cases. Extreme anaemia was the most common primary cause of death. Malnutrition, sepsis with respiratory and gastrointestinal manifestations, and chronic diseases were the commonest attributed causes of death for patients in the latter two categories. There were an estimated 293,763 cases of pure *P. vivax* infection in the community during the study period giving an overall minimum case fatality of 0.12 per 1,000 infections. The corresponding case fatality in hospitalized patients was 10.3 per 1,000 infections. **CONCLUSIONS:** Although uncommonly directly fatal, vivax malaria is an important indirect cause of death in southern Papua in patients with malnutrition, sepsis syndrome and chronic diseases, including HIV infection.

- 30 **Duggan AT, Evans B, Friedlaender FR, Friedlaender JS, Koki G, Merriwether DA, Kayser M, Stoneking M.**

Maternal history of Oceania from complete mtDNA genomes: contrasting ancient diversity with recent homogenization due to the Austronesian expansion. *Am J Hum Genet* 2014 May 1;94(5):721-733. doi: 10.1016/j.ajhg.2014.03.014. Epub 2014 Apr 10.

Archaeology, linguistics, and existing genetic studies indicate that Oceania was settled by two major waves of migration. The first migration took place approximately 40 thousand years ago and these migrants, Papuans, colonized much of Near Oceania. Approximately 3.5 thousand years ago, a second expansion of Austronesian-speakers arrived in Near Oceania and the descendants of these people spread to the far corners of the Pacific, colonizing Remote Oceania. To assess the female

contribution of these two human expansions to modern populations and to investigate the potential impact of other migrations, we obtained 1,331 whole mitochondrial genome sequences from 34 populations spanning both Near and Remote Oceania. Our results quantify the magnitude of the Austronesian expansion and demonstrate the homogenizing effect of this expansion on almost all studied populations. With regards to Papuan influence, autochthonous haplogroups support the hypothesis of a long history in Near Oceania, with some lineages suggesting a time depth of 60 thousand years, and offer insight into historical interpopulation dynamics. Santa Cruz, a population located in Remote Oceania, is an anomaly with extreme frequencies of autochthonous haplogroups of Near Oceanian origin; simulations to investigate whether this might reflect a pre-Austronesian versus Austronesian settlement of the island failed to provide unequivocal support for either scenario.

- 31 **Duke T; World Health Organization.**

Pneumonia and bronchiolitis in developing countries. *Arch Dis Child* 2014 Oct;99(10):892-893. doi: 10.1136/archdischild-2014-306838. Epub 2014 Jul 22.

- 32 **Dutta SN, Amon J, Iata H, Cooper RD, Russell TL.**

Long-term insecticidal activity and physical integrity of Olyset nets in Tafea Province, Vanuatu. *J Med Entomol* 2014 Jan;51(1):164-169.

The long-term efficacy of long-lasting insecticidal nets (LLINs) depends on both the physical condition of the net and the residual activity of the insecticide. This study focused on monitoring these parameters in Olyset nets (Sumitomo Chemical Co., Osaka, Japan) ($n = 101$) that had been used for 1-3 years in Tafea Province, Vanuatu. Net usage and frequency of washing was ascertained by questionnaire; the nets were assessed with regards to cleanliness and damage owing to holes. Insecticide efficacy was determined with cone bioassays using *Anopheles farauti* Laveran. Net usage was high and 86.1% (87 of 101) of villagers stated that they used the net every night. Washing of nets was low (11.9%, 12 of 101), and most nets (79.2%, 80 of 101) were considered dirty. Most nets were damaged (73.4% had holes), and 22.8% (23 of 101) had large holes ($>200 \text{ cm}^2$). The 24-hour mortality of *An. farauti* exposed to nets aged 1-2 years was 79.4%, while the mortality for nets 3 years of age was significantly lower at 73.7%. There was no difference in the insecticidal activity of clean compared with dirty nets (mean 24-hour mortality: Clean = 76.7%, Dirty = 77.1%). Although the majority of nets had holes, the physical condition of 8.9-22.8% of nets was altered so severely to potentially affect efficacy. Although the 3-year-old nets would still be providing significant levels of insecticidal and personal protection, consideration should be given to replacing nets >3 years old.

- 33 **Ekeroma AJ, Kenealy T, Shulruf B, McCowan LM, Hill A.**

Building reproductive health research and audit capacity and activity in the Pacific Islands (BRRACAP) study: methods, rationale and baseline results. *BMC Med Educ* 2014 Jun 19;14:121. doi: 10.1186/1472-6920-14-121.

BACKGROUND: Clinical research and audit in reproductive health is essential to improve

reproductive health outcomes and to address the Millennium Development Goals 4 and 5. Research training, mentoring and a supportive participatory research environment have been shown to increase research activity and capacity in low to middle income countries (LMIC). This paper details the methods, rationale and baseline findings of a research program aimed at increasing clinical research activity and audit in the six Pacific Islands of Fiji, Samoa, Tonga, Vanuatu, Cook Islands and the Solomon Islands. **METHOD:** Twenty-eight clinician participants were selected by the five Ministries of Health and the Fiji National University to undergo a research capacity building program which includes a research workshop and mentoring support to perform research and audit as teams in their country. Data on the participants' characteristics, knowledge and experiences were collected from structured interviews, questionnaires, focus groups, and an online survey. The interviews and the two focus groups were audio-recorded and all replies were analysed in a thematic framework. **RESULTS:** The 28 participants included 9 nurses/midwives, 17 medical doctors of whom 8 were specialists in reproductive health and 2 other health workers. Most (24, 86%) were required to perform research as part of their employment and yet 17 (61%) were not confident in writing a research proposal, 13 (46%) could not use an electronic spreadsheet and the same number had not analysed quantitative data. The limited environmental enablers contributed to poor capacity with only 11 (46%) having access to a library, 10 (42%) receiving management support and 6 (25%) having access to an experienced researcher. Barriers to research that affected more than 70% of the participants were time constraints, poor coordination, no funding and a lack of skills. **CONCLUSION:** Building a research capacity program appropriate for the diversity of Pacific clinicians required research evidence and collaborative effort of key stakeholders in the Pacific Islands and the region. The participants had limited research knowledge, skills and experience and would require individualized training and continuous intensive mentorship to realize their potential as clinician researchers for their services in the Pacific.

34 **Farrell PC, Negin J, Houasia P, Munamua AB, Leon DP, Rimon M, Martiniuk AL.**

Hospital visits due to domestic violence from 1994 to 2011 in the Solomon Islands: a descriptive case series. *Hawaii J Med Public Health* 2014 Sep;73(9):276-282.

The Solomon Islands has one of the highest rates of domestic violence in the world. This paper is a descriptive case series of all cases of domestic violence presenting to the Solomon Islands National Referral Hospital (NRH) over 18 years. Data were routinely collected from a database of all patients who were treated by NRH general surgery and orthopedic clinicians between 1994 and 2011, inclusive. The total number of cases in the injury database as a result of domestic violence was 387. The average number of cases in the database per year from 1994 to 2011 was 20. There were 6% more female patients (205 of 387; 53%) than male (182 of 387; 47%). Of the cases in which the perpetrator of the violence against a female patient was specified (111 of 205 female cases), 74% (82 of 111) were the patient's husband. Only 5% (5 of 111) of cases in females were inflicted by another female.

This analysis provides the best available information on domestic violence cases requiring a visit to a tertiary hospital in a Pacific Island in the specified time period and is undoubtedly an under-estimate of the total cases of domestic violence. Preventing and treating domestic violence in the Solomon Islands and in the Pacific is an important challenge and there is a significant role for secondary and tertiary health services in screening for and preventing domestic violence.

35 **Finney OC, Danziger SA, Molina DM, Vignali M, Takagi A, Ji M, Stanisic DI, Siba PM, Liang X, Aitchison JD, Mueller I, Gardner MJ, Wang R.**

Predicting antidiarrhoeal immunity using proteome arrays and sera from children naturally exposed to malaria.

Mol Cell Proteomics 2014 Oct;13(10):2646-2660. doi: 10.1074/mcp.M113.036632. Epub 2014 Jul 14.

Malaria remains one of the most prevalent and lethal human infectious diseases worldwide. A comprehensive characterization of antibody responses to blood stage malaria is essential to support the development of future vaccines, sero-diagnostic tests, and sero-surveillance methods. We constructed a proteome array containing 4441 recombinant proteins expressed by the blood stages of the two most common human malaria parasites, *P. falciparum* (Pf) and *P. vivax* (Pv), and used this array to screen sera of Papua New Guinea children infected with Pf, Pv, or both (Pf/Pv) that were either symptomatic (febrile), or asymptomatic but had parasitemia detectable via microscopy or PCR. We hypothesized that asymptomatic children would develop antigen-specific antibody profiles associated with antidiarrhoeal immunity, as compared with symptomatic children. The sera from these children recognized hundreds of the arrayed recombinant Pf and Pv proteins. In general, responses in asymptomatic children were highest in those with high parasitemia, suggesting that antibody levels are associated with parasite burden. In contrast, symptomatic children carried fewer antibodies than asymptomatic children with infections detectable by microscopy, particularly in Pv and Pf/Pv groups, suggesting that antibody production may be impaired during symptomatic infections. We used machine-learning algorithms to investigate the relationship between antibody responses and symptoms, and we identified antibody responses to sets of *Plasmodium* proteins that could predict clinical status of the donors. Several of these antibody responses were identified by multiple comparisons, including those against members of the serine enriched repeat antigen family and merozoite protein 4. Interestingly, both *P. falciparum* serine enriched repeat antigen-5 and merozoite protein 4 have been previously investigated for use in vaccines. This machine learning approach, never previously applied to proteome arrays, can be used to generate a list of potential seroprotective and/or diagnostic antigen candidates that can be further evaluated in longitudinal studies.

36 **Flores A, Marrero JA.**

Emerging trends in hepatocellular carcinoma: focus on diagnosis and therapeutics.

Clin Med Insights Oncol 2014 May 19;8:71-76. doi: 10.4137/CMO.S9926. eCollection 2014.

Hepatocellular carcinoma (HCC) is one of the most common tumors worldwide and one of

the deadliest. Patients with chronic liver disease are at the highest risk for developing this tumor. This link provides an opportunity for developing preventive strategies and surveillance that aims at early detection of this tumor and possibly improving outcomes. In this review, we will discuss the latest developments in surveillance strategies, diagnosis, and treatment of this tumor. HCC is the sixth most common cancer in the world, with 782,000 new cases occurring in 2012 worldwide. In 2012, there were 746,000 deaths from liver cancer. HCC is the third most fatal cancer in the world. The distribution of HCC, which varies geographically, is related to the prevalence of hepatotropic virus. The burden of the disease is the highest in Eastern Asia, sub-Saharan Africa, and Melanesia where hepatitis B (HBV) infection is endemic. Meanwhile, in Japan, United States, and Europe, hepatitis C (HCV) infection is prevalent, and subsequently is the major risk factor for acquiring HCC in these regions. It is estimated that the incidence of HCC in Europe and United States will peak at 2020 – there will be 78,000 new HCC cases in Europe and 27,000 in the United States – and decline thereafter. Indeed, in Japan, the incidence of HCC had already plateaued and started to slowly fall. Cirrhosis is the most important risk factor for HCC regardless of etiology and may be caused by chronic viral hepatitis (mainly HBV and HCV), alcoholic liver disease, autoimmune disease, Stage 4 primary biliary cirrhosis, and metabolic diseases such as hereditary hemochromatosis, alpha-1 antitrypsin deficiency, and non-alcoholic fatty liver disease. In the Western hemisphere, HCC occurs in a background of cirrhosis in 90% of the cases. Before concentrating on diagnosis and therapeutics, it is important to discuss surveillance for this tumor.

- 37 **Gare J, Ryan CE, David M, Timbi D, Kaima P, Kombati Z, Imara U, Kelly-Hanku A, Siba PM, Crowe SM, Hearps AC.**

Presence of HIV drug resistance in antiretroviral therapy-naïve and -experienced patients from Papua New Guinea.

J Antimicrob Chemother 2014 Aug;69(8):2183-2186. doi: 10.1093/jac/dku089. Epub 2014 Apr 9.

OBJECTIVES: The optimal benefits of antiretroviral therapy (ART) can be compromised by the emergence of HIV drug resistance (HIVDR) resulting in treatment failure. ART was introduced in Papua New Guinea (PNG) in 2004, yet biological data on HIVDR are lacking. The aim of the study was to investigate levels of HIVDR in ART-naïve and -experienced patients in PNG. **METHODS:** We recruited, interviewed and collected blood from 108 ART-naïve and 102 ART-experienced patients from two Highlands provinces of PNG. Dried blood spots were tested for HIVDR from all patients with detectable plasma viral load of ≥ 200 copies/mL using established in-house assays. **RESULTS:** The PCR amplification success was 90.6% ($n = 96$) and 66.7% ($n = 12$) using dried blood spots from ART-naïve and -experienced patients, respectively. Transmitted drug resistance was detected in 2.1% ($n = 2$) of samples from ART-naïve patients; acquired drug resistance was detected in 50% ($n = 6$) of samples from ART-experienced individuals. **CONCLUSIONS:** Our data showed that transmitted drug resistance in PNG is low and acquired drug resistance is higher with 12.7% of the ART-experienced patients failing treatment. As ART access is rapidly expanding in

PNG, monitoring of drug resistance is paramount for early detection of treatment failure.

- 38 **Gray RT, Vallely A, Wilson DP, Kaldor J, MacLaren D, Kelly-Hanku A, Siba P, Murray JM; Male Circumcision Acceptability and Impact Study (MCAIS) team.**

Impact of male circumcision on the HIV epidemic in Papua New Guinea: a country with extensive foreskin cutting practices.

PLoS One 2014 Aug 11;9(8):e104531. doi: 10.1371/journal.pone.0104531. eCollection 2014.

The degree to which adult medical male circumcision (MC) programs can reduce new HIV infections in a moderate HIV prevalence country like Papua New Guinea (PNG) is uncertain especially given the widespread prevalence of longitudinal foreskin cuts among adult males. We estimated the likely impact of a medical MC intervention in PNG using a mathematical model of HIV transmission. The model was age-structured and incorporated separate components for sex, rural/urban, men who have sex with men and female sex workers. Country-specific data of the prevalence of foreskin cuts, sexually transmitted infections, condom usage, and the acceptability of MC were obtained by our group through related studies. If longitudinal foreskin cutting has a protective efficacy of 20% compared to 60% for MC, then providing MC to 20% of uncut males from 2012 would require 376,000 procedures, avert 7,900 HIV infections by 2032, and require 143 MC per averted infection. Targeting uncut urban youths would achieve the most cost effective returns of 54 MC per HIV infection averted. These numbers of MC required to avert an HIV infection change little even with coverage up to 80% of men. The greater the protective efficacy of longitudinal foreskin cuts against HIV acquisition, the less impact MC interventions will have. Dependent on this efficacy, increasing condom use could have a much greater impact with a 10 percentage point increase averting 18,400 infections over this same period. MC programs could be effective in reducing HIV infections in PNG, particularly in high prevalence populations. However, the overall impact is highly dependent on the protective efficacy of existing longitudinal foreskin cutting in preventing HIV.

- 39 **Greenhill AR, Guwada C, Siba V, Michael A, Yoannes M, Wawarie Y, Ford R, Siba PM, Horwood PF.**

Antibiotic resistant *Shigella* is a major cause of diarrhoea in the Highlands of Papua New Guinea.

J Infect Dev Ctries 2014 Nov 13;8(11):1391-1397. doi: 10.3855/jidc.4396.

INTRODUCTION: Diarrhoea remains a major cause of illness in Papua New Guinea (PNG); however, little is known about its aetiology. As a result of the cholera outbreak that spread throughout PNG in 2009-2011, we conducted diarrhoeal surveillance in Eastern Highlands Province. **METHODOLOGY:** Following informed consent and a brief questionnaire, participants provided a stool sample or duplicate rectal swabs. Samples were tested for common bacterial pathogens *Salmonella* spp., *Shigella* spp., *Vibrio* spp., *Campylobacter* spp. and *Yersinia enterocolitica* using established culture methods. Enteric parasites were detected using microscopy. **RESULTS:** A total of 216 participants were enrolled; where age was recorded, 42% were under 5 years of age, 6.7% were 5 to 17 years of

age and 51.3% ≥ 18 years of age. One or more pathogens were detected in 68 (31.5%) participants, with *Shigella* (primarily *S. flexneri*) being the most commonly isolated (47 of 216 participants). Enteric parasites were detected in 23 of the 216 participants, occurring as a co-infection with another pathogen in 12 of 23 cases. No *Vibrio cholerae* was detected. *Shigella* isolates were commonly resistant to ampicillin, tetracycline, co-trimoxazole and chloramphenicol. **CONCLUSIONS:** *Shigellae*, specifically *S. flexneri*, are important pathogens in the highlands of PNG. While most studies in low-income settings focus on childhood aetiology, we have demonstrated the importance of *Shigella* in both children and adults. Enteric parasites remain present and presumably contribute to the burden of gastrointestinal illness. While improvements in sanitation and hygiene would help lower the burden of all aetiologies of infectious diarrhoea, additional control strategies targeting *Shigella* may also be warranted.

40 **Gresty KJ, Gray KA, Bobogare A, Taleo G, Hii J, Wini L, Cheng Q, Waters NC.**

Genetic mutations in *pfprt* and *pfmdr1* at the time of artemisinin combination therapy introduction in South Pacific islands of Vanuatu and Solomon Islands.

Malar J 2014 Oct 15;13:406. doi: 10.1186/1475-2875-13-406.

BACKGROUND: Chloroquine (CQ), alone or in combination with sulphadoxine-pyrimethamine, was widely used for the treatment of *Plasmodium falciparum* and *Plasmodium vivax* for several decades in both Vanuatu and Solomon Islands prior to the introduction of artemether-lumefantrine (AL) in 2008. However, the effect of chloroquine selection on parasite populations, which may affect the efficacy of lumefantrine or other partner drugs of artemisinin, has not been well assessed. This study aims to provide baseline data on molecular markers (*pfprt* and *pfmdr1*), along with the origins of *pfprt*, prior to the introduction of AL. **METHODS:** Blood spots were obtained from epidemiological surveys conducted on Tanna Island, Tafea Province, Vanuatu and Temotu Province, Solomon Islands in 2008. Additional samples from Malaita Province, Solomon Islands were collected as part of an artemether-lumefantrine efficacy study in 2008. *Plasmodium falciparum* *pfprt* and *pfmdr1* genes were examined for polymorphisms. Microsatellite markers flanking *pfprt* were also examined to ascertain origins of CQ resistance. **RESULTS:** *Pfprt* analysis revealed 100% of parasites from Tafea Province, Vanuatu and Malaita Province, Solomon Islands and 98% of parasites from Temotu Province, Solomon Islands carried the K76T polymorphism that confers CQ resistance. Comparison of *pfprt* allelic patterns and microsatellite markers flanking *pfprt* revealed six haplotypes with more than 70% of isolates possessing haplotypes very similar to those observed in Papua New Guinea. The dominant (98.5%) *pfmdr1* allele across all island groups was YYCND. **CONCLUSIONS:** Prior to the introduction of AL in the Solomon Islands and Vanuatu, *P. falciparum* isolates possessed point mutations known to confer CQ resistance and possibly associated with a decreased susceptibility to quinine and halofantrine, but an increased susceptibility to artemisinin and lumefantrine. Overall, *pfprt* allelic types and the flanking microsatellite markers exhibited similarities

to those of Papua New Guinea, suggesting these parasites share a common ancestry. The current use of AL for both *P. falciparum* and *P. vivax* infections will enable changes in these markers, in the absence of CQ pressure, to be monitored.

41 **Gresty KJ, Gray KA, Bobogare A, Wini L, Taleo G, Hii J, Cheng Q, Waters NC.**

Genetic mutations in *Plasmodium falciparum* and *Plasmodium vivax* dihydrofolate reductase (DHFR) and dihydropteroate synthase (DHPS) in Vanuatu and Solomon Islands prior to the introduction of artemisinin combination therapy.

Malar J 2014 Oct 14;13:402. doi: 10.1186/1475-2875-13-402.

BACKGROUND: *Plasmodium falciparum* and *Plasmodium vivax* are endemic in Vanuatu and the Solomon Islands. While both countries have introduced artemether-lumefantrine (AL) as first-line therapy for both *P. falciparum* and *P. vivax* since 2008, chloroquine and sulphadoxine-pyrimethamine (SP) were used as first-line therapy for many years prior to the introduction of AL. Limited data are available on the extent of SP resistance at the time of policy change. **METHODS:** Blood spots were obtained from epidemiological surveys conducted on Tanna Island, Tafea Province, Vanuatu and Temotu Province, Solomon Islands in 2008. Samples from Malaita Province, Solomon Islands were collected as part of an AL therapeutic efficacy study conducted in 2008. *Plasmodium vivax* and *P. falciparum* *dhfr* and *dhps* genes were sequenced to detect nucleotide polymorphisms. **RESULTS:** All *P. falciparum* samples analysed ($n = 114$) possessed a double mutant *pfdhfr* allele (C59R/S108N). Additionally, mutation A437G in *pfdhps* was detected in a small number of samples 2/13, 1/17 and 3/26 from Tanna Island, Vanuatu and Temotu and Malaita Provinces, Solomon Islands respectively. Mutations were also common in *pvdhfr* from Tanna Island, Vanuatu, where 33/51 parasites carried the double amino acid substitution S58R/S117N, while in Temotu and Malaita Provinces, Solomon Islands 32/40 and 39/46 isolates carried the quadruple amino acid substitution F57L/S58R/T61M/S117T in DHFR respectively. No mutations in *pvdhps* ($n = 108$) were detected in these three island groups. **CONCLUSION:** Prior to the introduction of AL, there was a moderate level of SP resistance in the *P. falciparum* population that may cause SP treatment failure in young children. Of the *P. vivax* isolates, a majority of Solomon Islands isolates carried quadruple mutant *pvdhfr* alleles while a majority of Vanuatu isolates carried double mutant *pvdhfr* alleles. This suggests a higher level of SP resistance in the *P. vivax* population in Solomon Islands compared to the sympatric *P. falciparum* population and there is a higher level of SP resistance in *P. vivax* parasites from Solomon Islands than Vanuatu. This study demonstrates that the change of treatment policy in these countries from SP to ACT was timely. The information also provides a baseline for future monitoring.

42 **Grogan AD.**

Sudden onset Oculo-cardiac Reflex post-traumatic eye injury in PNG: a case study and discussion.

Australas Emerg Nurs J 2014 Aug;17(3):135-137. doi: 10.1016/j.aenj.2014.04.002. Epub 2014 Jul 4.

This case study examines the onset of traumatic OCR – Oculo-cardiac Reflex – in the remote southern highlands of PNG. The spontaneous occurrence

of OCR post-trauma in the clinical setting leads to sudden onset bradycardia, nausea and hypotension, resulting in cardiovascular compromise and deteriorating clinical conditions. Initial recognition of the characteristics of OCR will prepare the clinician to deal with the sequence of events that arise post the reflex initiation.

- 43 **Gunasekera H, Tefuarani N, Kilalang C, Amini J, Sobi K, Vuvu J, Duke T.**
A day on the paediatric wards in Port Moresby, Papua New Guinea.
J Paediatr Child Health 2014 Jun;50(6):494-495. doi: 10.1111/jpc.12594.

- 44 **Gupta S, Wong EG, Kushner AL.**
Scarcity of protective items against HIV and other bloodborne infections in 13 low- and middle-income countries.
Trop Med Int Health 2014 Nov;19(11):1384-1390. doi: 10.1111/tmi.12371. Epub 2014 Aug 8.

OBJECTIVE: To assess protection of surgical healthcare workers against HIV and other bloodborne infections in low- and middle-income countries (LMICs). **METHODS:** Literature review based on recent studies assessing baseline surgical capacity in LMICs using the WHO Situational Analysis of Access to Emergency and Essential Surgical Care, the Surgeons Overseas (SOS) Personnel, Infrastructure, Procedures, Equipment and Supplies (PIPES) survey and the Harvard Humanitarian Initiative survey tools. The availability of protective eyewear, sterile gloves and sterilisers was assessed. **RESULTS:** Thirteen individual country studies with relevant data were identified documenting items from 399 hospitals. The countries included Afghanistan, Bolivia, Gambia, Ghana, Liberia, Mongolia, Nigeria, Sierra Leone, Solomon Islands, Somalia, Sri Lanka, Tanzania and Zambia. Overall, only 29% (79/270) of hospitals always had eye protection. Sterilisers were only available at 64% (244/383) of facilities. Sterile gloves were the most available item, available at 75% of facilities (256/340). **CONCLUSION:** Surgical healthcare worker protection for bloodborne infections continues to be deficient in LMICs. Improved documentation of these items should be incorporated into future surgical capacity studies. Policy makers and clinicians should work together to secure resources and interventions that will protect this vital workforce.

- 45 **Halliday JS, Harrison GL, Brown A, Hunter JG, Bendall R, Penny D, Toatu T, Abdad MY, Klenerman P, Barnes E, Dalton HR.**
Hepatitis E virus infection, Papua New Guinea, Fiji, and Kiribati, 2003-2005.
Emerg Infect Dis 2014 Jun;20(6):1057-1058. doi: 10.3201/eid2006.130562.

- 46 **Han M, Littlejohn M, Yuen L, Edwards R, Devi U, Bowden S, Ning Q, Locarnini S, Jackson K.**
Molecular epidemiology of hepatitis delta virus in the Western Pacific region.
J Clin Virol 2014 Sep;61(1):34-39. doi: 10.1016/j.jcv.2014.05.021. Epub 2014 Jun 5.

BACKGROUND: Hepatitis delta virus (HDV) is a defective RNA virus requiring the presence of the hepatitis B virus (HBV) for the completion of its life cycle. Active replication of HDV can lead to severe hepatitis, and although present worldwide it has an irregular geographical distribution, especially in

the Asian Pacific region. **OBJECTIVES:** The aim of this study was to determine the prevalence and molecular epidemiology of HDV isolates in Oceania following the 1998 evaluation of the hepatitis B vaccine program. **STUDY DESIGN:** Sera collected from 184 hepatitis B surface antigen (HBsAg) positive Pacific Islanders living in Micronesia, Polynesia and Melanesia were tested for HDV RNA. **RESULTS:** Twenty of 54 patients with chronic hepatitis B (CHB) from Kiribati were positive for serum HDV RNA (37%), whilst sera from patients with CHB from Tonga (59), Fiji (42) and Vanuatu (29) were negative. The mean HDV RNA load for the 20 samples was 7.00log10copies/mL. Phylogenetic analysis revealed that the Kiribati HDV isolates were of genotype 1 and clustered with a previously published isolate from Nauru forming a distinct clade of Pacific HDV. All Micronesian isolates contained a serine at codon 202 of large hepatitis delta antigen (L-HDAg) demonstrating possible relatedness to strains of HDV-1 of African origin. **CONCLUSIONS:** This study has confirmed endemic HDV infection in Micronesia and identified Kiribati as having amongst the highest prevalence for HDV viraemia in patients with CHB. Further investigations are ongoing into the origins of this unique HDV Pacific strain, and its inter-relationship with HBV.

- 47 **Herrera M, Paiva OK, Pagotto AH, Segura A, Serrano SM, Vargas M, Villalta M, Jensen SD, León G, Williams DJ, Gutiérrez JM.**

Antivenomic characterization of two antivenoms against the venom of the taipan, *Oxyuranus scutellatus*, from Papua New Guinea and Australia.
Am J Trop Med Hyg 2014 Nov;91(5):887-894. doi: 10.4269/ajtmh.14-0333. Epub 2014 Aug 25.

Antivenoms manufactured by bioCSL Limited (Australia) and Instituto Clodomiro Picado (Costa Rica) against the venom of the taipan snakes (*Oxyuranus scutellatus*) from Australia and Papua New Guinea (PNG), respectively, were compared using antivenomics, an analytical approach that combines proteomics with immunoaffinity chromatography. Both antivenoms recognized all venom proteins present in venom from PNG *O. scutellatus*, although a pattern of partial recognition was observed for some components. In the case of the Australian *O. scutellatus* venom, both antivenoms immunorecognized the majority of the components, but the CSL antivenom showed a stronger pattern of immunoreactivity, which was revealed by the percentage of retained proteins in the immunoaffinity column. Antivenoms interacted with taipoxin in surface plasmon resonance. These observations on antivenomics agree with previous neutralization studies.

- 48 **Hetzel MW, Choudhury AA, Pulford J, Ura Y, Whittaker M, Siba PM, Mueller I.**

Progress in mosquito net coverage in Papua New Guinea.
Malar J 2014 Jun 24;13:242. doi: 10.1186/1475-2875-13-242.

BACKGROUND: Since 2004, the Global Fund-supported National Malaria Control Programme of Papua New Guinea (PNG) has been implementing country-wide free long-lasting insecticidal net (LLIN) distribution campaigns. In 2009, after the first distribution, only 32.5% of the population used a LLIN, mainly due to an insufficient number of nets available. This study investigated changes in mosquito net

ownership and use following the continued free distribution of LLINs across PNG. **METHODS:** Five villages from each province and 30 households from each village were randomly sampled in a country-wide household survey in 2010/11. A structured questionnaire administered to household heads recorded information on mosquito net ownership and use alongside household characteristics. Revised ownership and access indicators were applied in the analysis to reveal coverage gaps. **RESULTS:** The survey covered 1,996 households in 77 villages. Ownership of at least one LLIN was reported by 81.8% of households, compared to 64.6% in 2009 ($p=0.002$). Sufficient LLINs to cover all household members (one net per two people) were found in 41.3% of the households (21.4% in 2009, $p<0.001$). Of all household members, 61.4% had access to a LLIN within their household (44.3% in 2009 $p=0.002$), and 48.3% slept under a LLIN (32.5% in 2009, $p=0.001$). LLIN use in children under five years amounted to 58.2%, compared to 39.5% in 2009 ($p<0.001$). Significant regional differences in coverage and changes over time were observed. A recent LLIN distribution was a key determinant of LLIN ownership (adj. OR=3.46) while families in high quality houses would frequently not own a LLIN (adj. OR=0.09). Residents were more likely to use LLINs than household guests (OR=2.04). **CONCLUSIONS:** Repeated LLIN distribution has led to significant increases in mosquito net ownership and use with a few regional exceptions. Additional nets are required in areas where access is low, while major efforts are required to encourage the use of existing nets in regions where access is high but use remains low. Complementary vector control approaches should also be considered in such settings.

- 49 **Hetzel MW, Page-Sharp M, Bala N, Pulford J, Betuela I, Davis TME, Lavu EK.**

Quality of antimalarial drugs and antibiotics in Papua New Guinea: a survey of the health facility supply chain.

PLoS One 2014 May 14;9(5):e96810. doi: 10.1371/journal.pone.0096810. eCollection 2014.

BACKGROUND: Poor-quality life-saving medicines are a major public health threat, particularly in settings with a weak regulatory environment. Insufficient amounts of active pharmaceutical ingredients (API) endanger patient safety and may contribute to the development of drug resistance. In the case of malaria, concerns relate to implications for the efficacy of artemisinin-based combination therapies (ACT). In Papua New Guinea (PNG), *Plasmodium falciparum* and *P. vivax* are both endemic and health facilities are the main source of treatment. ACT has been introduced as first-line treatment but other drugs, such as primaquine for the treatment of *P. vivax* hypnozoites, are widely available. This study investigated the quality of antimalarial drugs and selected antibiotics at all levels of the health facility supply chain in PNG. **METHODS AND FINDINGS:** Medicines were obtained from randomly sampled health facilities and selected warehouses and hospitals across PNG and analysed for API content using validated high performance liquid chromatography (HPLC). Of 360 tablet/capsule samples from 60 providers, 9.7% (95% CI 6.9-13.3) contained less, and 0.6% more, API than pharmacopoeial reference ranges, including 29/37 (78.4%) primaquine, 3/70 (4.3%)

amodiaquine, and one sample each of quinine, artemether, sulphadoxine-pyrimethamine and amoxicillin. According to the package label, 86.5% of poor-quality samples originated from India. Poor-quality medicines were found in 48.3% of providers at all levels of the supply chain. Drug quality was unrelated to storage conditions. **CONCLUSIONS:** This study documents the presence of poor-quality medicines, particularly primaquine, throughout PNG. Primaquine is the only available transmission-blocking antimalarial, likely to become important to prevent the spread of artemisinin-resistant *P. falciparum* and eliminating *P. vivax* hypnozoites. The availability of poor-quality medicines reflects the lack of adequate quality control and regulatory mechanisms. Measures to stop the availability of poor-quality medicines should include limiting procurement to WHO prequalified products and implementing routine quality testing.

- 50 **Ho MF, Baker J, Lee N, Luchavez J, Arie F, Nhem S, Oyibo W, Bell D, González I, Chiodini P, Gatton ML, Cheng Q, McCarthy JS.**

Circulating antibodies against *Plasmodium falciparum* histidine-rich proteins 2 interfere with antigen detection by rapid diagnostic tests.

Malar J 2014 Dec 6;13:480. doi: 10.1186/1475-2875-13-480.

BACKGROUND: Rapid diagnostic tests (RDTs) for detection of *Plasmodium falciparum* infection that target *P. falciparum* histidine-rich protein 2 (PfHRP2), a protein that circulates in the blood of patients infected with this species of malaria, are widely used to guide case management. Understanding determinants of PfHRP2 availability in circulation is therefore essential to understanding the performance of PfHRP2-detecting RDTs. **METHODS:** The possibility that pre-formed host anti-PfHRP2 antibodies may block target antigen detection, thereby causing false negative test results was investigated in this study. **RESULTS:** Anti-PfHRP2 antibodies were detected in 19/75 (25%) of plasma samples collected from patients with acute malaria from Cambodia, Nigeria and the Philippines, as well as in 3/28 (10.7%) asymptomatic Solomon Islands residents. Pre-incubation of plasma samples from subjects with high-titre anti-PfHRP2 antibodies with soluble PfHRP2 blocked the detection of the target antigen on two of the three brands of RDTs tested, leading to false negative results. Pre-incubation of the plasma with intact parasitized erythrocytes resulted in a reduction of band intensity at the highest parasite density, and a reduction of lower detection threshold by ten-fold on all three brands of RDTs tested. **CONCLUSIONS:** These observations indicate possible reduced sensitivity for diagnosis of *P. falciparum* malaria using PfHRP2-detecting RDTs among people with high levels of specific antibodies and low density infection, as well as possible interference with tests configured to detect soluble PfHRP2 in saliva or urine samples. Further investigations are required to assess the impact of pre-formed anti-PfHRP2 antibodies on RDT performance in different transmission settings.

- 51 **Horwood PF, Karl S, Mueller I, Jonduo MH, Pavlin BI, Dagina R, Ropa B, Bieb S, Rosewell A, Umezaki M, Siba PM, Greenhill AR.**

Spatio-temporal epidemiology of the cholera outbreak in Papua New Guinea, 2009-2011.

BMC Infect Dis 2014 Aug 20;14:449. doi:

10.1186/1471-2334-14-449.

BACKGROUND: Cholera continues to be a devastating disease in many developing countries where inadequate safe water supply and poor sanitation facilitate spread. From July 2009 until late 2011 Papua New Guinea experienced the first outbreak of cholera recorded in the country, resulting in >15,500 cases and >500 deaths. **METHODS:** Using the national cholera database, we analysed the spatio-temporal distribution and clustering of the Papua New Guinea cholera outbreak. The Kulldorff space-time permutation scan statistic, contained in the software package SatScan v9.2, was used to describe the first 8 weeks of the outbreak in Morobe Province before cholera cases spread throughout other regions of the country. Data were aggregated at the provincial level to describe the spread of the disease to other affected provinces. **RESULTS:** Spatio-temporal and cluster analyses revealed that the outbreak was characterized by three distinct phases punctuated by explosive propagation of cases when the outbreak spread to a new region. The lack of road networks across most of Papua New Guinea is likely to have had a major influence on the slow spread of the disease during this outbreak. **CONCLUSIONS:** Identification of high risk areas and the likely mode of spread can guide government health authorities to formulate public health strategies to mitigate the spread of the disease through education campaigns, vaccination, increased surveillance in targeted areas and interventions to improve water, sanitation and hygiene.

- 52 **Hurly DS, Buhrer-Skinner M, Badman SG, Bulu S, Tabrizi SN, Tariyonda L, Muller R.**

Field evaluation of the CRT and ACON chlamydia point-of-care tests in a tropical, low-resource setting. *Sex Transm Infect* 2014 May;90(3):179-184. doi: 10.1136/sextrans-2013-051246. Epub 2013 Dec 13.

OBJECTIVE: To evaluate the clinical performance of two chlamydia point-of-care (POC) tests compared with a gold standard nucleic acid amplification test (NAAT). **METHODS:** Tests evaluated were the Chlamydia Rapid Test (CRT), Diagnostics for the Real World and the ACON Chlamydia Rapid Test Device, ACON Laboratories (ACON). Overall 226 men and 225 women in Port Vila, Vanuatu, participated in this prospective study in 2010. NAAT and POC testing was performed on samples of male urine and female vaginal swabs for 156 men and 223 women (CRT), and 133 men and 75 women (ACON). **RESULTS:** The sensitivity and specificity of the CRT in men were 41.4% (95% CI 23.5% to 61.1%) and 89.0% (95% CI 82.2% to 93.8%), respectively, and in women 74.2% (95% CI 61.5% to 84.5%) and 95.7% (95% CI 91.3% to 98.2%), respectively; for ACON, they were 43.8% (95% CI 19.8% to 70.1%) and 98.3% (95% CI 93.9% to 99.8%) in men, and in women 66.7% (95% CI 22.3% to 95.7%) and 91.3% (95% CI 82.0% to 96.7%), respectively. Both tests were (absolutely) insensitive at organism loads less than 1000 (log = 3) per mL or per swab; the CRT sensitivity was significantly lower at loads less than, compared with those greater than, 100 000 (log = 5) per mL or per swab. **CONCLUSIONS:** The performance of both CRT and ACON is well below the levels stated by the manufacturers. The evaluated tests are unlikely to be helpful in clinical settings due to the high proportion of false-negatives that will go untreated

and false-positives that will result in overtreatment and potential adverse social consequences.

- 53 **Ingram RJ, Crenna-Darusallam C, Soebianto S, Noviyanti R, Baird JK.**

The clinical and public health problem of relapse despite primaquine therapy: case review of repeated relapses of *Plasmodium vivax* acquired in Papua New Guinea.

Malar J 2014 Dec 12;13:488. doi: 10.1186/1475-2875-13-488.

BACKGROUND: Primaquine is the only drug available for preventing relapse following a primary attack by *Plasmodium vivax* malaria. This drug imposes several important problems: daily dosing over two weeks; toxicity in patients with glucose-6-phosphate dehydrogenase (G6PD) deficiency; partner blood schizontocides possibly impacting primaquine safety and efficacy; cytochrome P-450 abnormalities impairing metabolism and therapeutic activity; and some strains of parasite may be tolerant or resistant to primaquine. There are many possible causes of repeated relapses in a patient treated with primaquine. **CASE DESCRIPTION:** A 56-year-old Caucasian woman from New Zealand traveled to New Ireland, Papua New Guinea for two months in 2012. One month after returning home she stopped daily doxycycline prophylaxis against malaria, and one week later she became acutely ill and hospitalized with a diagnosis of *Plasmodium vivax* malaria. Over the ensuing year she suffered four more attacks of vivax malaria at approximately two-month intervals despite consuming primaquine daily for 14 days after each of those attacks, except the last. Genotype of the patient's cytochrome P-450 2D6 alleles (*5/*41) corresponded with an intermediate metabolizer phenotype of predicted low activity. **DISCUSSION:** Multiple relapses in patients taking primaquine as prescribed present a serious clinical problem, and understanding the basis of repeated therapeutic failure is a challenging technical problem. This case highlights these issues in a single traveler, but these problems will also arise as endemic nations approach elimination of malaria transmission.

- 54 **Jackson KJ, Wang Y, Collins AM.**

Human immunoglobulin classes and subclasses show variability in VDJ gene mutation levels.

Immunol Cell Biol 2014 Sep;92(8):729-733. doi: 10.1038/icb.2014.44. Epub 2014 Jun 10.

Somatic point mutations provide glimpses into B-cell histories, and mutation numbers generally correlate with antibody affinity. We recently proposed a model of human isotype function, based in part on mutation analysis, in which the dominant pathway of isotype switching involves B cells moving sequentially through the four immunoglobulin (Ig) G subclasses. This should result in predictable differences in affinity between isotypes, and this helps explain how different isotypes work together. The model was built on analysis of rearranged immunoglobulin heavy chain sequences amplified from Papua New Guinean villagers, which showed highly significant differences in the mean number of V-REGION mutations in sequences, associated with the different IgG subclasses. To determine whether this relationship between mutation levels and isotypes is a more general phenomenon, the present study was conducted in healthy, urban residents of Sydney, Australia. VDJ sequences were generated

from eight individuals, using 454 pyrosequencing, from cells expressing all isotypes except IgD and IgE. This resulted in 35 118 unique, productive VDJ sequences for the study. The data confirm that VDJ genes associated with progressively more 3' Ig heavy chain gamma (IGHG) constant region genes show increasing levels of point mutation. Mean V-REGION mutations in IgA1 and IgA2 sequences were similar. Patterns of mutations also differed between isotypes. Despite their association with T-independent responses, IgG2 sequences showed significantly more mutational evidence of antigen selection than other IgG isotypes. Antigen selection was also significantly higher in IgA2 than in IgA1 sequences, raising the possibility of a preferential switch pathway from IGHG2 to IGHG2.

- 55 **Jadulco RC, Koch M, Kakule TB, Schmidt EW, Orendt A, He H, Janso JE, Carter GT, Larson EC, Pond C, Matainaho TK, Barrows LR.**

Isolation of pyrrolocins A-C: cis- and trans-decalin tetramic acid antibiotics from an endophytic fungal-derived pathway.

J Nat Prod 2014 Nov 26;77(11):2537-2544. doi: 10.1021/np500617u. Epub 2014 Oct 29.

Three new decalin-type tetramic acid analogues, pyrrolocins A (1), B (2), and C (3), were defined as products of a metabolic pathway from a fern endophyte, NRRL 50135, from Papua New Guinea. NRRL 50135 initially produced 1 but ceased its production before chemical or biological evaluation could be completed. Upon transfer of the biosynthetic pathway to a model host, 1-3 were produced. All three compounds are structurally related to equisetin-type compounds, with 1 and 3 having a trans-decalin ring system, while 2 has a cis-fused decalin. All were active against *Mycobacterium tuberculosis*, with the trans-decalin analogues 1 and 3 exhibiting lower MICs than the cis-decalin analogue 2. Here we report the isolation, structure elucidation, and antimycobacterial activities of 1-3 from the recombinant expression as well as the isolation of 1 from the wild-type fungus NRRL 50135.

- 56 **Jadulco RC, Pond CD, Van Wagoner RM, Koch M, Gideon OG, Matainaho TK, Piskaut P, Barrows LR.**

4-Quinolone alkaloids from *Melochia odorata*.

J Nat Prod 2014 Jan 24;77(1):183-187. doi: 10.1021/np400847t. Epub 2014 Jan 7.

The methanol extract of *Melochia odorata* yielded three 4-quinolone alkaloids including waltherione A (1) and two new alkaloids, waltherione C (2) and waltherione D (3). Waltheriones A and C showed significant activities in an in vitro anti-HIV cytoprotection assay at concentrations of 56.2 and 0.84 μ M and inhibition of HIV P24 formation of more than 50% at 1.7 and 0.95 μ M, respectively. The structures of the alkaloids were established by spectroscopic data interpretation.

- 57 **Jayasuriya R, Jayasinghe UW, Wang Q.**

Health worker performance in rural health organizations in low- and middle-income countries: do organizational factors predict non-task performance?

Soc Sci Med 2014 Jul;113:1-4. doi: 10.1016/j.socscimed.2014.04.042. Epub 2014 May 2.

Health worker (HW) performance is a critical issue facing many low- and middle-income countries (LMICs). The aim of this study was to test the

effects of factors in the work environment, such as organizational culture and climate, on HW non-task performance in rural health work settings in a LMIC. The data for the study are from a sample of 963 HWs from rural health centres (HCs) in 16 of the 20 provinces in Papua New Guinea. The reliability and validity of measures for organizational citizenship behaviour (OCB), counterproductive work behaviour (CWB) and work climate (WC) were tested. Multilevel linear regression models were used to test the relationship of individual and HC level factors with non-task performance. The survey found that 62% of HCs practised OCB "often to always" and 5% practised CWB "often to always". Multilevel analysis revealed that WC had a positive effect on organizational citizenship behaviour (OCB) and a negative effect on CWB. The mediation analyses provided evidence that the relationship between WC and OCB was mediated through CWB. Human resource policies that improve WC in rural health settings would increase positive non-task behaviour and improve the motivation and performance of HWs in rural settings in LMICs.

- 58 **Jewkes R, Sikweyiya Y, Jama-Shai N.**

The challenges of research on violence in post-conflict Bougainville.

Lancet 2014 Jun 14;383(9934):2039-2040.

- 59 **Joshua IB, Passmore PR, Parsons R, Sunderland VB.**

Appropriateness of prescribing in selected healthcare facilities in Papua New Guinea.

Health Policy Plan 2014 Mar;29(2):257-265. doi: 10.1093/heapol/czt012. Epub 2013 Mar 14.

OBJECTIVE: The objective of this study was to evaluate the level of appropriateness of prescribing to outpatients in selected healthcare facilities in Papua New Guinea (PNG), using health department guidelines as the benchmark. **METHODS:** A prospective study was carried out at Losuia Health Centre (LHC), Alotau Provincial Hospital (APH) and Port Moresby General Hospital (PMGH) in PNG. At each setting >300 consecutive prescriptions were evaluated in 2010. Diagnosis and prescribing data were collected from written prescription orders, patient health books and by patient interview. The appropriateness of prescribing was evaluated with respect to the relevant PNG Health Department guidelines. Differences in prescribing indices were evaluated using chi-squared tests as appropriate. **RESULTS:** There were 1090 patients (748 adults; 341 children) enrolled in the study with 356 at LHC, 318 at APH and 416 at PMGH. A total of 2495 medicines were prescribed. The most common were amoxicillins (355), paracetamol (344), artemether/artesunate (186) and chloroquine (162). The average number of drugs prescribed per patient was 2.3 (range: 1-7). The most common diseases treated were malaria (23.2%), acute soft tissue injuries (10.4%), anaemia (8.9%), respiratory problems (8.7%) and cough (5.9%). Overall, inappropriate prescribing was 33.4% in adults and 39.9% in children, the difference mainly arising from inappropriate drug dosage. There were statistically significant differences observed for the level of inappropriate prescribing by prescriber category on drug selection ($p < 0.0001$), drug dosage ($p < 0.0001$) and drug duration ($p < 0.0001$). **CONCLUSION:** The level of inappropriate prescribing was as high as 53.8% in the selected locations in PNG, which is

of great concern with respect to the quality of PNG healthcare delivery. Appropriate interventions such as review/upgrade of the guidelines, supervision/oversight of compliance to guidelines and/or publication of ongoing supervision/audit oversight reports need to occur to address the underlying causes.

- 60 **Jovel IT, Ferreira PE, Veiga MI, Malmberg M, Mårtensson A, Kaneko A, Zakeri S, Murillo C, Nosten F, Björkman A, Ursing J.**

Single nucleotide polymorphisms in *Plasmodium falciparum* V type H(+) pyrophosphatase gene (*pfvp2*) and their associations with *pfcr1* and *pfmdr1* polymorphisms.

Infect Genet Evol 2014 Jun;24:111-115. doi: 10.1016/j.meegid.2014.03.004. Epub 2014 Mar 20.

BACKGROUND: Chloroquine resistance in *Plasmodium falciparum* malaria has been associated with *pfcr1* 76T (chloroquine resistance transporter gene) and *pfmdr1* 86Y (multidrug resistance gene 1) alleles. *Pfcr1* 76T enables transport of protonated chloroquine out of the parasite's digestive vacuole resulting in a loss of hydrogen ions (H⁺). V type H(+) pyrophosphatase (PfVP2) is thought to pump H⁺ into the digestive vacuole. This study aimed to describe the geographic distribution of single nucleotide polymorphisms in *pfvp2* and their possible associations with *pfcr1* and *pfmdr1* polymorphisms. **METHODS:** Blood samples from 384 patients collected (1981-2009) in Honduras (n = 35), Colombia (n = 50), Liberia (n = 50), Guinea Bissau (n = 50), Tanzania (n = 50), Iran (n = 50), Thailand (n = 49) and Vanuatu (n = 50) were analysed. The *pfcr1* 72-76 haplotype, *pfmdr1* copy numbers, *pfmdr1* N86Y and *pfvp2* V405I, K582R and P711S alleles were identified using PCR based methods. **RESULTS:** *Pfvp2* was amplified in 344 samples. The *pfvp2* allele proportions were V405 (97%), 405I (3%), K582 (99%), 582R (1%), P711 (97%) and 711S (3%). The number of patients with any of *pfvp2* 405I, 582R and/or 711S were as follows: Honduras (2/30), Colombia (0/46), Liberia (7/48), Guinea-Bissau (4/50), Tanzania (3/48), Iran (3/50), Thailand (1/49) and Vanuatu (0/31). The alleles were most common in Liberia (p = 0.01) and Liberia+Guinea-Bissau (p = 0.01). The VKP haplotype was found in 189/194 (97%) and 131/145 (90%) samples harbouring *pfcr1* 76T and *pfcr1* K76 respectively (p = 0.007). **CONCLUSIONS:** The VKP haplotype was dominant. Most *pfvp2* 405I, 582R and 711S SNPs were seen where CQ resistance was not highly prevalent at the time of blood sampling possibly due to greater genetic variation prior to the bottle neck event of spreading CQ resistance. The association between the *pfvp2* VKP haplotype and *pfcr1* 76T, which may indicate that *pfvp2* is involved in CQ resistance, should therefore be interpreted with caution.

- 61 **Kamilar JM, Atkinson QD.**

Cultural assemblages show nested structure in humans and chimpanzees but not orangutans. *Proc Natl Acad Sci USA* 2014 Jan 7;111(1):111-115. doi: 10.1073/pnas.1313318110. Epub 2013 Dec 9.

The evolution of hominin culture is well-documented in the archaeological and fossil record, but such a record is largely absent for nonhuman primates. An alternative approach to studying cultural evolution is to examine patterns of modern cultural variation. In this article we measure

nestedness across human and great ape 'cultural repertoires' to gain insight into the accumulation and maintenance of putative cultural diversity in these species. Cultural assemblages are nested if cultures with a small repertoire of traits tend to comprise a proper subset of those traits present in more complex cultures. This nesting will occur if some traits are sequentially gained or lost, which may be because of the differential dispersal or extinction of traits. Here we apply statistical tools from ecology to examine the degree of nestedness in four datasets documenting the presence or absence of specific cultural traits across indigenous human populations in North America and New Guinea. We then compare the human data to patterns observed for putative cultural traits in chimpanzee and orangutan populations. In both humans and chimpanzees, cultural diversity is highly nonrandom, showing significant nested structure for all of the datasets examined. We find no evidence for nestedness in the orangutan cultural data. These findings are consistent with a sequential 'layering' of cultural diversity in humans and chimpanzees, but not orangutans. Such an interpretation implies that the traits required for sequential cultural evolution first appeared in the last common ancestor of chimpanzees and humans.

- 62 **Kaneko A, Chaves LF, Taleo G, Kalkoa M, Isozumi R, Wickremasinghe R, Perlmann H, Takeo S, Tsuboi T, Tachibana S, Kimura M, Björkman A, Troye-Blomberg M, Tanabe K, Drakeley C.**

Characteristic age distribution of *Plasmodium vivax* infections after malaria elimination on Aneityum Island, Vanuatu.

Infect Immun 2014 Jan;82(1):243-252. doi: 10.1128/IAI.00931-13. Epub 2013 Oct 28.

Resurgence is a major concern after malaria elimination. After the initiation of the elimination program on Aneityum Island in 1991, microscopy showed that *Plasmodium falciparum* disappeared immediately, whereas *P. vivax* disappeared from 1996 onward, until *P. vivax* cases were reported in January 2002. By conducting malariometric surveys of the entire population of Aneityum, we investigated the age distribution of individuals with parasites during this epidemic in the context of antimalarial antibody levels and parasite antigen diversity. In July 2002, *P. vivax* infections were detected by microscopy in 22/759 individuals: 20/298 born after the beginning of the elimination program in 1991, 2/126 born between 1982 and 1991, and none of 335 born before 1982. PCR increased the number of infections detected to 77, distributed among all age groups. Prevalences were 12.1%, 16.7%, and 6.0%, respectively (p < 0.001). In November, a similar age pattern was found, but with fewer infections: 6/746 and 39/741 individuals were found to be infected by microscopy and PCR, respectively. The frequencies of antibody responses to *P. vivax* were significantly higher in individuals born before 1991 than in younger age groups and were similar to those on Malakula Island, an area of endemicity. Remarkably low antigen diversity (h, 0.15) of *P. vivax* infections was observed on Aneityum compared with the other islands (h, 0.89 to 1.0). A *P. vivax* resurgence was observed among children and teenagers on Aneityum, an age distribution similar to those before elimination and on islands where *P. vivax* is endemic, suggesting that in the absence of significant exposure, immunity may persist, limiting infection levels in adults. The limited parasite gene

pool on islands may contribute to this protection.

- 63 **Karl S, Laman M, Koleala T, Ibam C, Kasian B, N'Dreweil N, Rosanas-Urgell A, Moore BR, Waltmann A, Koepfli C, Siba PM, Betuela I, Woodward RC, St Pierre TG, Mueller I, Davis TME.**

Comparison of three methods for detection of gametocytes in Melanesian children treated for uncomplicated malaria.

Malar J 2014 Aug 14;13:319. doi: 10.1186/1475-2875-13-319.

BACKGROUND: Gametocytes are the transmission stages of *Plasmodium* parasites, the causative agents of malaria. As their density in the human host is typically low, they are often undetected by conventional light microscopy. Furthermore, application of RNA-based molecular detection methods for gametocyte detection remains challenging in remote field settings. In the present study, a detailed comparison of three methods, namely light microscopy, magnetic fractionation and reverse transcriptase polymerase chain reaction for detection of *Plasmodium falciparum* and *Plasmodium vivax* gametocytes was conducted. **METHODS:** Peripheral blood samples from 70 children aged 0.5 to five years with uncomplicated malaria who were treated with either artemether-lumefantrine or artemisinin-naphthoquine were collected from two health facilities on the north coast of Papua New Guinea. The samples were taken prior to treatment (day 0) and at pre-specified intervals during follow-up. Gametocytes were measured in each sample by three methods: i) light microscopy (LM), ii) quantitative magnetic fractionation (MF) and, iii) reverse transcriptase PCR (RTPCR). Data were analysed using censored linear regression and Bland and Altman techniques. **RESULTS:** MF and RTPCR were similarly sensitive and specific, and both were superior to LM. Overall, there were approximately 20% gametocyte-positive samples by LM, whereas gametocyte positivity by MF and RTPCR were both more than twice this level. In the subset of samples collected prior to treatment, 29% of children were positive by LM, and 85% were gametocyte positive by MF and RTPCR, respectively. **CONCLUSIONS:** The present study represents the first direct comparison of standard LM, MF and RTPCR for gametocyte detection in field isolates. It provides strong evidence that MF is superior to LM and can be used to detect gametocytaemic patients under field conditions with similar sensitivity and specificity as RTPCR.

- 64 **Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, Shackelford KA, Steiner C, Heutou KR, Gonzalez-Medina D, Barber R, Huynh C, Dicker D, Templin T, Wolock TM, Ozgoren AA, Abd-Allah F, Abera SF, Abubakar I, Achoki T, Adelekan A, Ademi Z, Adou AK, Adsuar JC, Agardh EE, Akena D, Alasfoor D, Alemu ZA, Alfonso-Cristancho R, Alhabib S, Ali R, Al Khabouri MJ, Alla F, Allen PJ, Al Mazroa MA, Alsharif U, Alvarez E, Alvis-Guzmán N, Amankwaa AA, Amare AT, Amini H, Ammar W, Antonio CA, Anwari P, Arnlov J, Arsenijevic VS, Artaman A, Asad MM, Asghar RJ, Assadi R, Atkins LS, Badawi A, Balakrishnan K, Basu A, Basu S, Beardsley J, Bedi N, Bekele T, Bell ML, Bernabe E, Beyene TJ, Bhutta Z, Bin Abdulhak A, Blore JD, Basara BB, Bose D, Breitborde N, Cárdenas R, Castañeda-Orjuela**

CA, Castro RE, Catalá-López F, Cavlin A, Chang JC, Che X, Christophi CA, Chugh SS, Cirillo M, Colquhoun SM, Cooper LT, Cooper C, da Costa Leite I, Dandona L, Dandona R, Davis A, Dayama A, Degenhardt L, De Leo D, del Pozo-Cruz B, Deribe K, Dessalegn M, deVeber GA, Dharmaratne SD, Dilmen U, Ding EL, Dorrington RE, Driscoll TR, Ermakov SP, Esteghamati A, Faraon EJ, Farzadfar F, Felicio MM, Fereshtehnejad SM, de Lima GM, Forouzanfar MH, França EB, Gaffikin L, Gambashidze K, Gankpé FG, Garcia AC, Geleijnse JM, Gibney KB, Giroud M, Glaser EL, Goginashvili K, Gona P, González-Castell D, Goto A, Gouda HN, Gughani HC, Gupta R, Gupta R, Hafezi-Nejad N, Hamadeh RR, Hammami M, Hankey GJ, Harb HL, Havmoeller R, Hay SI, Pi IB, Hoek HW, Hosgood HD, Hoy DG, Hussein A, Idrisov BT, Innos K, Inoue M, Jacobsen KH, Jahangir E, Jee SH, Jensen PN, Jha V, Jiang G, Jonas JB, Juel K, Kabagambe EK, Kan H, Karam NE, Karch A, Karema CK, Kaul A, Kawakami N, Kazanjan K, Kazi DS, Kemp AH, Kengne AP, Kereselidze M, Khader YS, Khalifa SE, Khan EA, Khang YH, Knibbs L, Kokubo Y, Kosen S, Defo BK, Kulkarni C, Kulkarni VS, Kumar GA, Kumar K, Kumar RB, Kwan G, Lai T, Lalloo R, Lam H, Lansingh VC, Larsson A, Lee JT, Leigh J, Leinsalu M, Leung R, Li X, Li Y, Li Y, Liang J, Liang X, Lim SS, Lin HH, Lipschultz SE, Liu S, Liu Y, Lloyd BK, London SJ, Lotufo PA, Ma J, Ma S, Machado VM, Mainoo NK, Majdan M, Mapoma CC, Marcesnes W, Marzan MB, Mason-Jones AJ, Mehndiratta MM, Mejia-Rodriguez F, Memish ZA, Mendoza W, Miller TR, Mills EJ, Mokdad AH, Mola GL, Monasta L, de la Cruz Monis J, Hernandez JC, Moore AR, Moradi-Lakeh M, Mori R, Mueller UO, Mukaigawara M, Naheed A, Naidoo KS, Nand D, Nangia V, Nash D, Nejari C, Nelson RG, Neupane SP, Newton CR, Ng M, Nieuwenhuijsen MJ, Nisar MI, Nolte S, Norheim OF, Nyakarahuka L, Oh IH, Ohkubo T, Olusanya BO, Omer SB, Opio JN, Orisakwe OE, Pandian JD, Papachristou C, Park JH, Caicedo AJ, Patten SB, Paul VK, Pavlin BI, Pearce N, Pereira DM, Pesudovs K, Petzold M, Poenaru D, Polanczyk GV, Polinder S, Pope D, Pourmalek F, Qato D, Quistberg DA, Rafay A, Rahimi K, Rahimi-Movaghar V, ur Rahman S, Raju M, Rana SM, Refaat A, Ronfani L, Roy N, Pimienta TG, Sahraian MA, Salomon JA, Sampson U, Santos IS, Sawhney M, Sayinzoga F, Schneider IJ, Schumacher A, Schwebel DC, Seedat S, Sepanlou SG, Servan-Mori EE, Shakh-Nazarova M, Sheikhbahaei S, Shibuya K, Shin HH, Shiue I, Sigfusdottir ID, Silberberg DH, Silva AP, Singh JA, Skirbekk V, Sliwa K, Soshnikov SS, Sposato LA, Sreeramareddy CT, Stroupoulis K, Sturua L, Sykes BL, Tabb KM, Talongwa RT, Tan F, Teixeira CM, Tenkorang EY, Terkawi AS, Thorne-Lyman AL, Tirschwell DL, Towbin JA, Tran BX, Tsilimbaris M, Uchendu US, Ukwaja KN, Undurraga EA, Uzun SB, Valley AJ, van Gool CH, Vasankari TJ, Vavilala MS, Venketasubramanian N, Villalpando S, Violante FS, Vlassov VV, Vos T, Waller S, Wang H, Wang L, Wang X, Wang Y, Weichenthal S, Weiderpass E, Weintraub RG, Westerman R, Wilkinson JD, Woldeyohannes SM, Wong JQ, Wordofa KA, Xu G, Yang YC, Yano Y, Yentur GK, Yip P, Yonemoto N, Yoon SJ, Younis MZ, Yu C, Jin KY, El Sayed Zaki M, Zhao Y, Zheng Y, Zhou M, Zhu J, Zou XN, Lopez AD, Naghavi M, Murray CJ, Lozano R.

Global, regional, and national levels and causes of maternal mortality during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013.

Lancet 2014 Sep 13;384(9947):980-1004. doi: 10.1016/S0140-6736(14)60696-6. Epub 2014 May 2.

BACKGROUND: The fifth Millennium Development Goal (MDG 5) established the goal of a 75% reduction in the maternal mortality ratio (MMR; number of maternal deaths per 100,000 livebirths) between 1990 and 2015. We aimed to measure levels and track trends in maternal mortality, the key causes contributing to maternal death, and timing of maternal death with respect to delivery. **METHODS:** We used robust statistical methods including the Cause of Death Ensemble model (CODEm) to analyse a database of data for 7065 site-years and estimate the number of maternal deaths from all causes in 188 countries between 1990 and 2013. We estimated the number of pregnancy-related deaths caused by HIV on the basis of a systematic review of the relative risk of dying during pregnancy for HIV-positive women compared with HIV-negative women. We also estimated the fraction of these deaths aggravated by pregnancy on the basis of a systematic review. To estimate the numbers of maternal deaths due to nine different causes, we identified 61 sources from a systematic review and 943 site-years of vital registration data. We also did a systematic review of reports about the timing of maternal death, identifying 142 sources to use in our analysis. We developed estimates for each country for 1990-2013 using Bayesian meta-regression. We estimated 95% uncertainty intervals (UIs) for all values. **FINDINGS:** 292,982 (95% UI 261,017-327,792) maternal deaths occurred in 2013, compared with 376,034 (343,483-407,574) in 1990. The global annual rate of change in the MMR was -0.3% (-1.1 to 0.6) from 1990 to 2003, and -2.7% (-3.9 to -1.5) from 2003 to 2013, with evidence of continued acceleration. MMRs reduced consistently in south, east, and southeast Asia between 1990 and 2013, but maternal deaths increased in much of sub-Saharan Africa during the 1990s. 2070 (1290-2866) maternal deaths were related to HIV in 2013, 0.4% (0.2-0.6) of the global total. MMR was highest in the oldest age groups in both 1990 and 2013. In 2013, most deaths occurred intrapartum or postpartum. Causes varied by region and between 1990 and 2013. We recorded substantial variation in the MMR by country in 2013, from 956.8 (685.1-1262.8) in South Sudan to 2.4 (1.6-3.6) in Iceland. **INTERPRETATION:** Global rates of change suggest that only 16 countries will achieve the MDG 5 target by 2015. Accelerated reductions since the Millennium Declaration in 2000 coincide with increased development assistance for maternal, newborn, and child health. Setting of targets and associated interventions for after 2015 will need careful consideration of regions that are making slow progress, such as west and central Africa.

- 65 **Kazadi WM, Asiedu KB, Agana N, Mitjå O.** Epidemiology of yaws: an update. *Clin Epidemiol* 2014 Apr 2;6:119-128. doi: 10.2147/CLEP.S44553. eCollection 2014.

Yaws, a neglected tropical disease, is targeted for eradication by 2020 through large-scale mass-treatment programs of endemic communities. A

key determinant for the success of the eradication campaign is good understanding of the disease epidemiology. We did a review of historical trends and new information from endemic countries, with the aim of assessing the state of knowledge on yaws disease burden. Transmission of yaws is now present in Africa, Asia, and the South Pacific. At least 12 countries are known to harbor yaws cases and 21 to 42 million people live in endemic areas. Between 2008 and 2012 more than 300,000 new cases were reported to the World Health Organization. Yaws presented high geographical variation within a country or region, high seasonality for incidence of active disease, and evidence that low standards of hygiene predispose to suffering of the disease. Key data issues include low levels of reporting, potential misdiagnosis, and scarce documentation on prevalence of asymptomatic infections. Currently available data most likely underestimate the magnitude of the disease burden. More effort is needed in order to refine accuracy of data currently being reported. A better characterization of the epidemiology of yaws globally is likely to positively impact on planning and implementation of yaws eradication.

- 66 **Kelly-Hanku A, Aggleton P, Shih P.**

'We call it a virus but I want to say it's the devil inside': redemption, moral reform and relationships with God among people living with HIV in Papua New Guinea. *Soc Sci Med* 2014 Oct;119:106-113. doi: 10.1016/j.socscimed.2014.08.020. Epub 2014 Aug 19.

There is growing recognition of the importance of religion and religious beliefs as they relate to the experience of HIV, globally and in Papua New Guinea in particular. Based on 36 in-depth qualitative interviews conducted with people living with HIV receiving HIV antiretroviral therapy in 2008, this paper examines the cultural aetiology of HIV in Papua New Guinea, the country with the highest reported burden of HIV in the Pacific. Narratives provided drew upon a largely moral framework, which viewed HIV acquisition as a consequence of moral failing and living an un-Christian life. This explanation for suffering viewed the individual as responsible for their condition in much the same way that neo-liberal biomedical discourses do. Moral reform and re-establishing a relationship with God were seen as key actions necessary to effect healing on the material body infected with HIV. Religious understandings of HIV drew upon a pre-existing cultural aetiology of dis-ease and misfortune widespread in Papua New Guinea. Understanding the centrality of Christianity to explanations of disease, and subsequently the actions necessary to bring about health, is essential in order to understand how people with HIV in receipt of antiretroviral therapies internalise biomedical perspectives and reconcile these with Christian beliefs.

- 67 **Kelly-Hanku A, Rawstorne P, Kupul M, Worth H, Shih P, Man WY.**

Anal sex, vaginal sex and HIV risk among female sex workers in Papua New Guinea. *AIDS Behav* 2014 Mar;18(3):573-582. doi: 10.1007/s10461-013-0624-8.

Female sex workers (FSW) are considered one of the key affected populations in Papua New Guinea at risk of acquiring HIV. An integrated bio-behavioral survey of sex workers in Port Moresby was conducted to determine the nature and extent

of this risk. About half (51.1%) of the 411 FSW who reported having any sexual intercourse with clients had engaged in both anal and vaginal intercourse with clients in the last 6 months. In spite of having poorer HIV knowledge (OR 95% CI = 0.14-0.34), FSW who had anal intercourse with clients were significantly more likely to have used a condom at the last vaginal intercourse with a client (OR 95% CI = 1.04-2.87). Similarly, FSW who had anal intercourse with regular and casual partners were significantly more likely to have used a condom at the last vaginal intercourse. Those who engaged in both anal and vaginal intercourse with clients had similar condom use for both vaginal and anal intercourse, with the majority (78.1%) using a condom at the last occasion for both vaginal and anal intercourse. These FSW may have different risk and protective factors that affect their use of condom during sexual intercourse. Further research is needed to investigate this difference between those who practice anal intercourse and those who do not in order to provide evidence for better programming.

68 Kennedy EC, Bulu S, Harris J, Humphreys D, Malverus J, Gray NJ.

"These issues aren't talked about at home": a qualitative study of the sexual and reproductive health information preferences of adolescents in Vanuatu.

BMC Public Health 2014 Jul 30;14:770. doi: 10.1186/1471-2458-14-770.

BACKGROUND: Onset of sexual activity during adolescence is common in Vanuatu; however, access to comprehensive sexual and reproductive health (SRH) information is limited. Improving adolescents' knowledge about SRH is necessary to improve health outcomes; however, little is known about the information needs and preferences of adolescents in the Pacific to inform policy and programs in this region. **METHODS:** Sixty-six focus group discussions were conducted with 341 male and female adolescents aged 15-19 years from rural and urban communities on two islands of Vanuatu. Twelve key-informant interviews were also conducted with policymakers and health service providers. Data were analysed thematically using an inductive approach. **RESULTS:** Much of the SRH information targeting adolescents focused on sexually transmitted infections and HIV. While this information was valued, important gaps were identified including prevention of pregnancy, condom use, puberty, sexuality and relationships. Peer educators and health workers were adolescents' preferred sources of information because they were considered knowledgeable and trustworthy. Parents were not a common source but were preferred, particularly by girls, despite considerable socio-cultural barriers. Schools were an important but underutilised source of information, as were a range of media sources. **CONCLUSIONS:** Providing adolescents with comprehensive SRH information can have life-long protective benefits; however, there are important content gaps in information currently provided in Vanuatu. The broad range of sources preferred by adolescents highlights the need to strengthen information provision through multiple channels to reach in- and out-of-school youth and respond to individual needs and contexts.

69 Kinaston R, Bedford S, Richards M, Hawkins S, Gray A, Jaouen K, Valentin F, Buckley H.

Diet and human mobility from the Lapita to the early historic period on Uripiv Island, Northeast Malakula, Vanuatu.

PLoS One 2014 Aug 20;9(8):e104071. doi: 10.1371/journal.pone.0104071. eCollection 2014.

Vanuatu was first settled ca. 3000 years ago by populations associated with the Lapita culture. Models of diet, subsistence practices, and human interaction for the Lapita and subsequent occupation periods have been developed mainly using the available archaeological and paleoenvironmental data. We test these models using stable (carbon, nitrogen, and sulfur) and radiogenic (strontium) isotopes to assess the diet and childhood residency of past communities that lived on the small (<1 km²) island of Uripiv, located off the northeast coast of Malakula, Vanuatu. The burials are from the initial Lapita occupation of the island (ca. 2800-2600 BP), the subsequent later Lapita (LL, ca. 2600-2500 BP) and post-Lapita (PL, ca. 2500-2000 BP) occupations, in addition to a late prehistoric/historic (LPH, ca. 300-150 BP) occupation period. The human stable isotope results indicate a progressively more terrestrial diet over time, which supports the archaeological model of an intensification of horticultural and arboricultural systems as local resources were depleted, populations grew, and cultural situations changed. Pig diets were similar and included marine foods during the Lapita and PL periods but were highly terrestrial during the LPH period. This dietary pattern indicates that there was little variation in animal husbandry methods during the first 800 years of prehistory; however, there was a subsequent change as animal diets became more controlled in the LPH period. After comparison with the local bioavailable 87Sr/86Sr baseline, all of the Lapita and LPH individuals appeared to be 'local', but three of the PL individuals were identified as 'non-local'. We suggest that these 'non-locals' moved to the island after infancy or childhood from one of the larger islands, supporting the model of a high level of regional interaction during the post-Lapita period.

70 Kinaston R, Buckley H, Valentin F, Bedford S, Spriggs M, Hawkins S, Herrscher E.

Lapita diet in Remote Oceania: new stable isotope evidence from the 3000-year-old Teouma site, Efate Island, Vanuatu.

PLoS One 2014 Mar 5;9(3):e90376. doi: 10.1371/journal.pone.0090376. eCollection 2014.

Remote Oceania was colonized ca. 3000 BP by populations associated with the Lapita Cultural Complex, marking a major event in the prehistoric settlement of the Pacific Islands. Although over 250 Lapita sites have been found throughout the Western Pacific, human remains associated with Lapita period sites are rare. The site of Teouma, on Efate Island, Vanuatu has yielded the largest burial assemblage (n = 68 inhumations) of Lapita period humans ever discovered, providing a unique opportunity for assessing human adaptation to the environment in a colonizing population. Stable isotope ratios (δ¹³C, δ¹⁵N, δ³⁴S) of human bone collagen from forty-nine Teouma adults were analyzed against a comprehensive dietary baseline to assess the paleodiet of some of Vanuatu's earliest inhabitants. The isotopic dietary baseline included both modern plants and animals (n = 98) and prehistoric fauna from the site (n = 71). The human stable isotope data showed that dietary protein at Teouma included a mixture of reef fish and inshore organisms and a

variety of higher trophic marine (eg, marine turtle) and terrestrial animals (eg, domestic animals and fruit bats). The domestic pigs and chickens at Teouma primarily ate food from a C3 terrestrial environment but their $\delta^{15}\text{N}$ values indicated that they were eating foods from higher trophic levels than those of plants, such as insects or human fecal matter, suggesting that animal husbandry at the site may have included free range methods. The dietary interpretations for the humans suggest that broad-spectrum foraging and the consumption of domestic animals were the most important methods for procuring dietary protein at the site. Males displayed significantly higher $\delta^{15}\text{N}$ values compared with females, possibly suggesting dietary differences associated with labor specialization or socio-cultural practices relating to food distribution.

71 **Koinari M, Lymbery AJ, Ryan UM.**

Cryptosporidium species in sheep and goats from Papua New Guinea. *Exp Parasitol* 2014 Jun;141:134-137. doi: 10.1016/j.exppara.2014.03.021. Epub 2014 Apr 3.

Species of *Cryptosporidium* are extensively recognised as pathogens of domesticated livestock and poultry, companion animals and wildlife, and are a threat to public health. Little is known of the prevalence of *Cryptosporidium* spp. in humans, domesticated animals or wildlife in Papua New Guinea (PNG). The aim of the present study was to screen sheep and goats for *Cryptosporidium* using molecular tools. A total of 504 faecal samples were collected from sheep (n = 276) and goats (n = 228) in village, government and institutional farms in PNG. Samples were screened by nested PCR and genotyped at the 18S rRNA and at the 60kDa glycoprotein (gp60) loci. The overall prevalences were 2.2% for sheep (6/278) and 4.4% (10/228) for goats. The species/genotypes identified were *Cryptosporidium hominis* (subtype IdA15G1) in goats (n = 6), *Cryptosporidium parvum* (subtypes IlaA15G2R1 and IlaA19G4R1) in sheep (n = 4) and in goats (n = 2), *Cryptosporidium andersoni* (n = 1) and *Cryptosporidium scrofarum* (n = 1) in sheep, *Cryptosporidium xiao* (n = 1) and *Cryptosporidium rat* genotype II (n = 1) in goats. This is the first report of *Cryptosporidium* spp. identified in sheep and goats in PNG. Identification of *Cryptosporidium* in livestock warrants better care of farm animals to avoid contamination and illness in a vulnerable population. The detection of zoonotic *Cryptosporidium* in livestock suggests these animals may serve as reservoirs for human infection.

72 **Koka BE, Deane FP, Lyons GC, Lambert G.**

General health workers' description of mental health problems and treatment approaches used in Papua New Guinea.

Int J Soc Psychiatry 2014 Nov;60(7):711-719. doi: 10.1177/0020764013513441. Epub 2013 Dec 18.

BACKGROUND: Papua New Guinea is a developing country with limited resources for specialist mental health services. Little is known about the mental health and treatment services of Papua New Guinea. **AIM:** The aim of this study was to clarify the presenting mental health problems encountered by Papua New Guinean health workers and the common treatment approaches used. **METHODS:** A total of 203 Papua New Guinean health workers completed a retrospective quantitative survey about their three most recent mental health

patients. The survey asked about presenting symptomatology, diagnoses (including culture-bound diagnoses) and treatment approaches. **RESULTS:** The major presenting mental health problems for males included schizophrenia, substance use disorder, sorcery and spirit possession. Depression was the most common diagnoses for women, followed by sorcery and somatisation. Over 65% of patients were prescribed psychotropic medication, over 50% received some form of psychological intervention and 28% were receiving traditional treatments. **CONCLUSIONS:** Somatic symptoms are common among both male and female Papua New Guineans; however, males may be more likely to present with psychotic symptoms and females with mood-related problems. Schizophrenia and depression are commonly identified with substance use disorder, which was more problematic among males. Culture-specific explanations and treatment are commonly used.

73 **Kono J, Jonduo MH, Omena M, Siba PM, Horwood PF.**

Viruses associated with influenza-like-illnesses in Papua New Guinea, 2010.

J Med Virol 2014 May;86(5):899-904. doi: 10.1002/jmv.23786. Epub 2013 Oct 17.

Influenza-like-illness can be caused by a wide range of respiratory viruses. The etiology of influenza-like-illness in developing countries such as Papua New Guinea is poorly understood. The etiological agents associated with influenza-like-illness were investigated retrospectively for 300 nasopharyngeal swabs received by the Papua New Guinea National Influenza Centre in 2010. Real-time PCR/RT-PCR methods were used for the detection of 13 respiratory viruses. Patients with influenza-like-illness were identified according to the World Health Organization case definition: sudden onset of fever ($>38^{\circ}\text{C}$), with cough and/or sore throat, in the absence of other diagnoses. At least one viral respiratory pathogen was detected in 66.3% of the samples tested. Rhinoviruses (17.0%), influenza A (16.7%), and influenza B (12.7%) were the pathogens detected most frequently. Children <5 years of age presented with a significantly higher rate of at least one viral pathogen and a significantly higher rate of co-infections with multiple viruses, when compared to all other patients >5 years of age. Influenza B, adenovirus, and respiratory syncytial virus were all detected at significantly higher rates in children <5 years of age. This study confirmed that multiple respiratory viruses are circulating and contributing to the presentation of influenza-like-illness in Papua New Guinea.

74 **Lai Y, Grace R.**

Alternative medicine use at Vila Central Hospital: a survey of 'custom medicine' use in patients and staff a decade later.

Trop Doct 2014 Mar 6;44(3):140-142. [Epub ahead of print]

A structured questionnaire was administered to 50 medical patients, 50 surgical patients and 50 staff members at Vila Central Hospital, Vanuatu. A similar study was conducted 10 years earlier. In the intervening decade, Vanuatu has seen unprecedented population growth, increasing expatriate numbers, and the introduction of mobile phone and Internet networks. Given these social transformations, this study aimed to identify changes

in custom medicine use over this period. Fifty-nine percent of interviewees had used custom medicine at least once, compared to 86% reported in the 2003 study. Thirty-two percent had used custom medicine in the last 12 months, a significant decline from 60% in the previous study. Collectively, rates of custom medicine use have declined but especially in the physical therapies such as bone setting. We believe this declining custom medicine use reflects an overall weakening traditional culture within Vanuatu and believe that within a generation custom medicine knowledge will likely be lost.

- 75 **Laman M, Hwaiwhanje I, Bona C, Warrel J, Aipit S, Smith D, Noronha J, Siba P, Mueller I, Betuela I, Davis TME, Manning L.**

Viral pathogens in children hospitalized with features of central nervous system infection in a malaria-endemic region of Papua New Guinea.

BMC Infect Dis 2014 Nov 26;14:630. doi: 10.1186/s12879-014-0630-0.

BACKGROUND: Viral central nervous system (CNS) infections are common in countries where malaria is endemic but, due to limited laboratory facilities, few studies have systematically examined the prevalence and clinical consequences of the presence of viruses in cerebrospinal fluid (CSF) from children with suspected CNS infection. **METHODS:** We performed a prospective study of Papua New Guinean children hospitalized with signs and symptoms of CNS infection. CSF samples from 300 children without proven bacterial/fungal meningitis were analyzed for human herpes viruses (HHV), picornaviruses, influenza, adenoviruses, flaviviruses and bacteria. **RESULTS:** Fifty-five children (18%) had viral (42), bacterial (20) or both viral and bacterial (7) nucleic acids (NA) identified in their CSF. Human herpes viruses accounted for 91% of all viruses found. The identification of viral or bacterial NA was not associated with any characteristic clinical features. By contrast, malaria was associated with increased identification of viral and bacterial NA and with impaired consciousness, multiple convulsions and age. Malaria was also inversely associated with an adverse outcome. Amongst children with HHV infection, those with HHV-6 and -7 were younger, were more likely to have impaired consciousness and had a higher proportion of adverse outcomes than children with CMV. Dengue and enteroviral infections were infrequent. Adenoviral and influenza infections were not identified. **CONCLUSION:** Infections with HHV-6, HHV-7, dengue and enterovirus have the potential to cause serious CNS disease in young PNG children. However, most HHVs in this malaria-endemic setting should be considered to be the result of reactivation from a latent reservoir without clinical sequelae.

- 76 **Laman M, Davis TME, Manning L.**

Confirming cerebral malaria deaths in resource-limited settings.

Am J Trop Med Hyg 2014 Feb;90(2):192. doi: 10.4269/ajtmh.13-0280.

- 77 **Laman M, Moore BR, Benjamin JM, Yadi G, Bona C, Warrel J, Kattenberg JH, Koleala T, Manning L, Kasian B, Robinson LJ, Sambale N, Lorry L, Karl S, Davis WA, Rosanas-Urgell A, Mueller I, Siba PM, Betuela I, Davis TME.**

Artemisinin-naphthoquine versus artemether-lumefantrine for uncomplicated malaria in Papua

New Guinean children: an open-label randomized trial.

PLoS Med 2014 Dec 30;11(12):e1001773. doi: 10.1371/journal.pmed.1001773. eCollection 2014.

BACKGROUND: Artemisinin combination therapies (ACTs) with broad efficacy are needed where multiple *Plasmodium* species are transmitted, especially in children, who bear the brunt of infection in endemic areas. In Papua New Guinea (PNG), artemether-lumefantrine is the first-line treatment for uncomplicated malaria, but it has limited efficacy against *P. vivax*. Artemisinin-naphthoquine should have greater activity in vivax malaria because the elimination of naphthoquine is slower than that of lumefantrine. In this study, the efficacy, tolerability, and safety of these ACTs were assessed in PNG children aged 0.5-5 years. **METHODS AND FINDINGS:** An open-label, randomized, parallel-group trial of artemether-lumefantrine (six doses over 3 days) and artemisinin-naphthoquine (three daily doses) was conducted between 28 March 2011 and 22 April 2013. Parasitologic outcomes were assessed without knowledge of treatment allocation. Primary endpoints were the 42-d *P. falciparum* PCR-corrected adequate clinical and parasitologic response (ACPR) and the *P. vivax* PCR-uncorrected 42-d ACPR. Non-inferiority and superiority designs were used for falciparum and vivax malaria, respectively. Because the artemisinin-naphthoquine regimen involved three doses rather than the manufacturer-specified single dose, the first 188 children underwent detailed safety monitoring. Of 2,542 febrile children screened, 267 were randomized, and 186 with falciparum and 47 with vivax malaria completed the 42-d follow-up. Both ACTs were safe and well tolerated. *P. falciparum* ACPRs were 97.8% and 100.0% in artemether-lumefantrine- and artemisinin-naphthoquine-treated patients, respectively (difference 2.2% [95% CI -3.0% to 8.4%] versus -5.0% non-inferiority margin, $p = 0.24$), and *P. vivax* ACPRs were 30.0% and 100.0%, respectively (difference 70.0% [95% CI 40.9%-87.2%], $p < 0.001$). Limitations included the exclusion of 11% of randomized patients with sub-threshold parasitemias on confirmatory microscopy and direct observation of only morning artemether-lumefantrine dosing. **CONCLUSIONS:** Artemisinin-naphthoquine is non-inferior to artemether-lumefantrine in PNG children with falciparum malaria but has greater efficacy against vivax malaria, findings with implications in similar geo-epidemiologic settings within and beyond Oceania. **TRIAL REGISTRATION:** Australian New Zealand Clinical Trials Registry ACTRN12610000913077.

- 78 **Laman M, Moore BR, Benjamin J, Padapu N, Tarongka N, Siba P, Betuela I, Mueller I, Robinson LJ, Davis TME.**

Comparison of an assumed versus measured leucocyte count in parasite density calculations in Papua New Guinean children with uncomplicated malaria.

Malar J 2014 Apr 16;13:145. doi: 10.1186/1475-2875-13-145.

BACKGROUND: The accuracy of the World Health Organization method of estimating malaria parasite density from thick blood smears by assuming a white blood cell (WBC) count of 8,000/ μ L has been questioned in several studies. Since epidemiological investigations, anti-malarial efficacy trials and routine laboratory reporting in Papua New

Guinea (PNG) have all relied on this approach, its validity was assessed as part of a trial of artemisinin-based combination therapy, which included blood smear microscopy and automated measurement of leucocyte densities on Days 0, 3 and 7. **RESULTS:** 168 children with uncomplicated malaria (median (inter-quartile range) age 44 (39-47) months) were enrolled, 80.3% with *Plasmodium falciparum* monoinfection, 14.9% with *Plasmodium vivax* monoinfection, and 4.8% with mixed *P. falciparum/P. vivax* infection. All responded to allocated therapy and none had a malaria-positive slide on Day 3. Consistent with a median baseline WBC density of $7.3 (6.5-7.8) \times 10^9/L$, there was no significant difference in baseline parasite density between the two methods regardless of *Plasmodium* species. Bland Altman plots showed that, for both species, the mean difference between paired parasite densities calculated from assumed and measured WBC densities was close to zero. At parasite densities $<10,000/\mu L$ by measured WBC, almost all between-method differences were within the 95% limits of agreement. Above this range, there was increasing scatter but no systematic bias. **CONCLUSIONS:** Diagnostic thresholds and parasite clearance assessment in most PNG children with uncomplicated malaria are relatively robust, but accurate estimates of a higher parasitaemia, as a prognostic index, requires formal WBC measurement.

- 79 **Larson EC, Hathaway LB, Lamb JG, Pond CD, Rai PP, Matainaho TK, Piskaut P, Barrows LR, Franklin MR.**

Interactions of Papua New Guinea medicinal plant extracts with antiretroviral therapy. *J Ethnopharmacol* 2014 Sep 29;155(3):1433-1440. doi: 10.1016/j.jep.2014.07.023. Epub 2014 Aug 17.

ETHNOPHARMACOLOGICAL RELEVANCE: A substantial proportion of the population in Papua New Guinea (PNG) lives with human immunodeficiency virus (HIV). Treatment requires lifelong use of antiretroviral therapy (ART). The majority of people in PNG use traditional medicines (TM) derived from plants for all types of health promotions. Consequently, there is a concern that herb-drug interactions may impact the efficacy of ART. Herb-drug, or drug-drug, interactions occur at the level of metabolism through two major mechanisms: enzyme induction or enzyme inhibition. In this study, extracts of commonly used medicinal plants from PNG were screened for herb-drug interactions related to cytochrome P450s (CYPs). **MATERIALS AND METHODS:** Sixty-nine methanol extracts of TM plants were screened for their ability to induce CYPs by human aryl hydrocarbon receptor- (hAhR-) and human pregnane X receptor- (hPXR-) dependent mechanisms, utilizing a commercially available cell-based luciferase reporter system. Inhibition of three major CYPs, CYP1A2, CYP3A4, and CYP2D6, was determined using human liver microsomes and enzyme-selective model substrates. **RESULTS:** Almost one-third of the TM plant extracts induced the hAhR-dependent expression of CYP1A2, the hPXR-dependent expression of CYP3A4, or both. Almost two-thirds inhibited CYP1A2, CYP3A4, or CYP2D6, or combinations thereof. Many plant extracts exhibited both induction and inhibition properties. **CONCLUSIONS:** We demonstrated that the potent and selective ability of extracts from PNG medicinal plants to affect drug metabolizing enzymes through induction and/or inhibition is a

common phenomenon. Use of traditional medicines concomitantly with ART could dramatically alter the concentrations of antiretroviral drugs in the body and their efficacy. PNG healthcare providers should counsel HIV patients because of this consequence.

- 80 **Ley SD, Harino P, Vanuga K, Kamus R, Carter R, Coulter C, Pandey S, Feldmann J, Ballif M, Siba PM, Phuanukoonnon S, Gagneux S, Beck HP.**

Diversity of *Mycobacterium tuberculosis* and drug resistance in different provinces of Papua New Guinea.

BMC Microbiol 2014 Dec 5;14:307. doi: 10.1186/s12866-014-0307-2.

BACKGROUND: Papua New Guinea (PNG) is a high tuberculosis (TB) burden country of the WHO Western Pacific Region, but so far research on drug resistance (DR) and genotypes of *Mycobacterium tuberculosis* (*M. tuberculosis*) was only conducted in a few provinces in the country. The aim of the present study was to obtain baseline data on the level of drug resistance and the genotypic diversity of circulating *M. tuberculosis* in additional provinces and to investigate the differences between three selected sites across PNG. **RESULTS:** Genotyping of 147 *M. tuberculosis* clinical isolates collected in Goroka, Eastern Highlands Province, in Alotau, Milne Bay Province and in Madang, Madang Province revealed three main lineages of *M. tuberculosis*: Lineage 4 (European-American lineage), Lineage 2 (East-Asian lineage) and Lineage 1 (Indo-Oceanic lineage). All three lineages were detected in all three sites, but the individual lineage compositions varied significantly between sites. In Madang Lineage 4 was the most prevalent lineage (76.6%), whereas in Goroka and Alotau Lineage 2 was dominating (60.5% and 84.4%, respectively) ($p < 0.001$). Overall, phenotypic drug susceptibility testing showed 10.8% resistance to at least one of the first-line drugs tested. Of all resistant strains (23/212) 30.4% were Streptomycin mono-resistant, 17.4% were Isoniazid mono-resistant and 13% were Rifampicin mono-resistant. Multi-drug resistant (MDR) TB was found in 2.8% of all tested cases (6/212). The highest amount of MDR TB was found in Alotau in Milne Bay Province (4.6%). **CONCLUSION:** A large number of drug resistant TB infections are present in the country and MDR TB has already been detected in all three surveyed regions of PNG, highlighting the importance of monitoring drug resistance and making it a high priority for the National Control Program. Due to the high prevalence of Lineage 2 in Milne Bay Province and given the frequent association of this lineage with drug resistance, monitoring of the latter should especially be scaled up in that province.

- 81 **Ley SD, Riley I, Beck HP.**

Tuberculosis in Papua New Guinea: from yesterday until today.

Microbes Infect 2014 Aug;16(8):607-614. doi: 10.1016/j.micinf.2014.06.012. Epub 2014 Jul 12.

Little is known about the situation of tuberculosis in Papua New Guinea despite its high TB burden, emerging drug resistance and rising HIV co-infection. This review gives an overview on the current situation of TB in PNG and identifies knowledge gaps that should urgently be addressed in the future.

- 82 **Lu Z, Van Wagener RM, Pond CD, Pole AR, Jensen JB, Blankenship D, Grimberg BT, Kiapranis R, Matainaho TK, Barrows LR, Ireland CM.**

Myristicyclins A and B: antimalarial procyanidins from *Horsfieldia spicata* from Papua New Guinea.

Org Lett 2014 Jan 17;16(2):346-349. doi: 10.1021/ol4022639. Epub 2013 Dec 19.

An antimalarial screen for plants collected from Papua New Guinea identified an extract of *Horsfieldia spicata* as having activity. Isolation of the active constituents led to the identification of two new compounds: myristicyclins A (1) and B (2). Both compounds are procyanidin-like congeners of myristinins lacking a pendant aromatic ring. Myristicyclin A was found to inhibit the ring, trophozoite, and schizont stages of *Plasmodium falciparum* at similar concentrations in the mid- μ M range.

- 83 **Ludlow LE, Hasang W, Umbers AJ, Forbes EK, Ome M, Unger HW, Mueller I, Siba PM, Jaworowski A, Rogerson SJ.**

Peripheral blood mononuclear cells derived from grand multigravidae display a distinct cytokine profile in response to *P. falciparum* infected erythrocytes. *PLoS One* 2014 Jan 22;9(1):e86160. doi: 10.1371/journal.pone.0086160. eCollection 2014.

Immunopathology of placental malaria is most significant in women in their first pregnancy especially in endemic areas, due to a lack of protective immunity to *Plasmodium falciparum*, which is acquired in successive pregnancies. In some studies (but not all), grand multigravidae (defined as 5 or more pregnancies, G5-7) are more susceptible to poor birth outcomes associated with malaria compared to earlier gravidities. By comparing peripheral cellular responses in primigravidae (G1), women in their second to fourth pregnancy (G2-4) and grand multigravidae we sought to identify key components of the dysregulated immune response. PBMC were exposed to CS2-infected erythrocytes (IE) opsonised with autologous plasma or unopsonised IE, and cytokine and chemokine secretion was measured. Higher levels of opsonising antibody were present in plasma derived from multigravid compared to primigravid women. Significant differences in the levels of cytokines and chemokines secreted in response to IE were observed. Less IL-10, IL-1 β , IL-6 and TNF but more CXCL8, CCL8, IFN γ and CXCL10 were detected in G5-7 compared to G2-4 women. Our study provides fresh insight into the modulation of peripheral blood cell function and effects on the balance between host protection and immunopathology during placental malaria infection.

- 84 **Lumb R, Bastian IB, Jelfs PJ, Keehner TJ, Pandey SK, Sievers A.**

Tuberculosis in Australia: bacteriologically-confirmed cases and drug resistance, 2011. A report of the Australian Mycobacterium Reference Laboratory Network.

Commun Dis Intell Q Rep 2014 Dec 31;38(4):E369-E375.

The Australian Mycobacterium Reference Laboratory Network collects and analyses laboratory data on new cases of disease caused by the *Mycobacterium tuberculosis* complex. In 2011, a total of 1,057 cases were identified bacteriologically; an annual reporting rate of 4.6 cases per 100,000 population. Eighteen children aged less than 15 years plus an additional 11 children from the Torres Strait Protected Zone had bacteriologically-confirmed tuberculosis. Results of in vitro drug susceptibility testing were available for 1,056

isolates for isoniazid, rifampicin, ethambutol, and pyrazinamide. A total of 107 (10.0%) isolates of *M. tuberculosis* were resistant to at least one of these anti-tuberculosis agents. Resistance to at least isoniazid and rifampicin (defined as multi-drug resistance, MDR) was detected in 25 (2.4%) isolates; 18 were from the respiratory tract (sputum n = 14, bronchoscopy n = 3, tissue n = 1). Ten (55.6%) of the MDR-TB-positive sputum specimens were smear-positive, as was a single sample from a lymph node. Ten patients with MDR-TB were Papua New Guinea (PNG) nationals in the Torres Strait Protected Zone. If these PNG nationals are excluded from the analysis, the underlying MDR-TB rate in Australia was 1.4%. No cases of extensively drug-resistant TB (defined as MDR-TB with additional resistance to a fluoroquinolone and an injectable agent) were detected in 2011.

- 85 **Makaen J, Maure T.**

Bleach processed smear for acid fast bacilli staining in Papua New Guinea.

Lab Med 2014 Fall;45(4):e140-e141.

The conventional method of processing sputum for acid fast bacilli microscopy has been a primary tool for laboratory diagnosis of pulmonary tuberculosis in Papua New Guinea. In routine preparation, untreated sputum is directly smeared on a glass slide without undergoing any stage of processing. Mounting evidence suggests that direct smearing is less sensitive and, to a certain degree, compromises infection control. A few alternatives for processing sputum have been recommended in the literature; however, their consumables are not easily accessible and are expensive for wide use in rural laboratories. The bleach concentration and processing method appears to be the most preferable choice because bleach is inexpensive, readily available, and has bactericidal properties.

- 86 **Malagun M, Nano G, Chevallier C, Opina R, Sawiya G, Kivavia J, Kalinoe A, Nathaniel K, Kaminil O, Millan J, Carmone A, Dini M, Palou T, Topma K, Lavu E, Markby J.**

Multisite evaluation of point of care CD4 testing in Papua New Guinea.

PLoS One 2014 Nov 26;9(11):e112173. doi: 10.1371/journal.pone.0112173. eCollection 2014.

Laboratory-based CD4 monitoring of HIV patients presents challenges in resource limited settings (RLS) including frequent machine breakdown, poor engineering support and limited cold chain and specimen transport logistics. This study assessed the performance of two CD4 tests designed for use in RLS: the Dynal assay and the Alere PIMA test (PIMA). Accuracy of Dynal and PIMA using venous blood was assessed in a centralised laboratory by comparison to BD FACSCount (BD FACS). Dynal had a mean bias of -50.35 cells/ μ l ($r^2 = 0.973$, $p < 0.0001$, $n = 101$) and PIMA -22.43 cells/ μ l ($r^2 = 0.964$, $p < 0.0001$, $n = 139$) compared to BD FACS. Similar results were observed for PIMA operated by clinicians in one urban ($n = 117$) and two rural clinics ($n = 98$). Using internal control beads, PIMA precision was 10.34% CV (low bead mean 214.24 cells/ μ l) and 8.29% (high bead mean 920.73 cells/ μ l) and similar %CV results were observed in external quality assurance (EQA) and replicate patient samples. Dynal did not perform using EQA and no internal controls are supplied by the manufacturer; however, duplicate testing of samples resulted in $r^2 =$

0.961, $p < 0.0001$, mean bias = -1.44 cells/ μ l. Using the cut-off of 350 cells/ μ l compared to BD FACS, PIMA had a sensitivity of 88.85% and specificity of 98.71% and Dynal 88.61% and 100%. A total of 0.44% (2/452) of patient samples were misclassified as 'no treat' and 7.30% (33/452) 'treat' using PIMA whereas with Dynal 8.91% (9/101) as 'treat' and 0% as 'no treat'. In our setting PIMA was found to be accurate, precise and user-friendly in both laboratory and clinic settings. Dynal performed well in initial centralized laboratory evaluation; however, it lacks requisite quality control measures, and was technically more difficult to use, making it less suitable for use at lower tiered laboratories.

- 87 **Man WYN, Worth H, Kelly A, Wilson DP, Siba P.** Is endemic political corruption hampering provision of ART and PMTCT in developing countries? *J Int AIDS Soc* 2014 May 2;17:18568. doi: 10.7448/IAS.17.1.18568. eCollection 2014.

INTRODUCTION: Leadership is a key factor in the success of HIV prevention and treatment. Positive HIV-related outcomes are also affected by funding levels for HIV, health sector resources, disease burden and the socio-economic environment. Leadership on HIV as well as these other factors is affected by the quality of political governance of the country, which may be an overarching factor that influences the making of effective responses to the HIV epidemic. **AIM:** The aim of the study was to investigate the association between quality of political governance, on one hand, and coverage of antiretroviral therapy (ART) and prevention of mother-to-child transmission (PMTCT), on the other, in low- to middle-income countries. **METHODS:** This investigation was carried out through a global review, online data sourcing and statistical analyses. We collected data on health burden and resources, the socio-economic environment, HIV prevalence, ART and PMTCT coverage and indicators of political governance. Outcome variables were coverage of ART (from 2004) and PMTCT (from 2007) to 2009 as a percentage of persons needing it. Potential predictors of treatment coverage were fitted with a baseline multilevel model for univariable and multivariable analyses. **RESULTS:** Countries with higher levels of political voice and accountability, more political stability and better control of corruption have higher levels of ART coverage but not PMTCT coverage. Control of corruption (in standard deviation units) had a strong association with ART (AOR = 1.82, $p = 0.002$) and PMTCT (AOR = 1.97, $p = 0.01$) coverage. Indicators of economic development were not significant when control of corruption was included in the multivariable regression model. Many countries in all income groups had high ART but not PMTCT coverage (eg, Mexico, Brazil and Romania in the upper-middle-income group; Papua New Guinea and Philippines in the lower-middle-income group; and Cambodia, Laos and Comoros in the low-income group). Very few low-income countries (notably, Haiti and Kenya) had high PMTCT coverage. **CONCLUSIONS:** Our research found a significant relationship between quality of political governance and treatment coverage. Measures and policies for improving the quality of political governance should be considered as a part of HIV programme implementation to more effectively improve the welfare of people living with HIV, particularly mothers living with HIV and their

babies.

- 88 **Manning L, Laman M, Mare T, Hwaihanje I, Siba P, Davis TME.**

Accuracy of cerebrospinal leucocyte count, protein and culture for the diagnosis of acute bacterial meningitis: a comparative study using Bayesian latent class analysis.

Trop Med Int Health 2014 Dec;19(12):1520-1524. doi: 10.1111/tmi.12400. Epub 2014 Oct 14.

OBJECTIVE: To examine the utility of laboratory methods other than bacterial culture in diagnosing acute bacterial meningitis (ABM). **METHODS:** Bayesian latent class analysis was used to estimate diagnostic precision of cerebrospinal fluid (CSF) culture, leucocyte counts and protein concentrations for ABM in Melanesian children. **RESULTS:** With a cut-off of ≥ 20 leucocytes/ mm^3 , the area under the receiver operating characteristic curve (AUC ROC) was $> 97.5\%$ for leucocyte counts. A lower (93%) AUC ROC was observed for CSF protein concentrations ≥ 1 g/l. CSF culture had poor sensitivity and high specificity. **CONCLUSION:** Leucocyte counts provide sufficient diagnostic precision to aid clinical decision-making in ABM.

- 89 **Margarucci L, Monti MC, Esposito R, Tosco A, Hamel E, Riccio R, Casapullo A.**

N-Formyl-7-amino-11-cycloamphilectene, a marine sponge metabolite, binds to tubulin and modulates microtubule depolymerization.

Mol Biosyst 2014 Apr;10(4):862-867. doi: 10.1039/c3mb70315k. Epub 2014 Feb 4.

The importance of protein-small molecule interaction in drug discovery, medicinal chemistry and biology has driven the development of new analytical methods to disclose the whole interactome of bioactive compounds. To accelerate targets discovery of N-formyl-7-amino-11-cycloamphilectene (CALE), a marine bioactive diterpene isolated from the Vanuatu sponge *Axinella* sp., a chemoproteomic-based approach has been successfully developed. CALE is a potent anti-inflammatory agent, modulating NO and prostaglandin E2 overproduction by dual inhibition of the enhanced inducible NO synthase expression and cyclo-oxygenase-2 activity, without any evidence of cytotoxic effects. In this paper, several isoforms of tubulin have been identified as CALE off-targets by chemical proteomics combined with bio-physical orthogonal approaches. In the following biological analysis of its cellular effect, CALE was found to protect microtubules against the colcemid depolymerizing effect.

- 90 **Mark TB, Radcliffe J, Laman M.**

Indications for caesarean sections in a rural hospital in the highlands of Papua New Guinea.

Trop Doct 2014 Mar 25;44(3):171-172. [Epub ahead of print]

We retrospectively documented indications for caesarean sections in a rural district level hospital in the highlands of Papua New Guinea. Over a 53-month study period, 745 caesarean sections were performed. Prolonged labour, previous history of caesarean section, cephalopelvic disproportion, malpresentation and fetal distress accounted for over 88% of caesarean sections performed. In older mothers (aged > 30 years), antepartum haemorrhage (Fisher exact test, $p = 0.05$) and multiple indications ($p = 0.001$) were leading reasons for caesarean sections while cephalopelvic disproportion

($p=0.005$) was the leading indication in younger mothers. Further prospective studies incorporating perinatal and maternal mortality rates are required to optimise the value of caesarean sections at district level hospitals in Papua New Guinea.

- 91 **Marks M, Goncalves A, Vahi V, Sokana O, Puiahi E, Zhang Z, Dalipanda T, Bottomley C, Mabey D, Solomon AW.**

Evaluation of a rapid diagnostic test for yaws infection in a community surveillance setting.

PLoS Negl Trop Dis 2014 Sep 11;8(9):e3156. doi: 10.1371/journal.pntd.0003156. eCollection 2014.

Yaws is a non-venereal treponemal infection caused by *Treponema pallidum* ssp. *pertenue*. The WHO has launched a worldwide control programme, which aims to eradicate yaws by 2020. The development of a rapid diagnostic test (RDT) for serological diagnosis in the isolated communities affected by yaws is a key requirement for the successful implementation of the WHO strategy. We conducted a study to evaluate the utility of the DPP test in screening for yaws, utilizing samples collected as part of a community prevalence survey conducted in the Solomon Islands. 415 serum samples were tested using both traditional syphilis serology (TPPA and quantitative RPR) and the Chembio DPP Syphilis Screen and Confirm RDT. We calculated the sensitivity and specificity of the RDT as compared to gold standard serology. The sensitivity of the RDT against TPPA was 58.5% and the specificity was 97.6%. The sensitivity of the RDT against RPR was 41.7% and the specificity was 95.2%. The sensitivity of the DPP was strongly related to the RPR titre with a sensitivity of 92.0% for an RPR titre of >16 . Wider access to DPP testing would improve our understanding of worldwide yaws case reporting and the test may play a key role in assessing patients presenting with yaws-like lesions in a post-mass drug administration (MDA) setting.

- 92 **Marks M, Chi KH, Vahi V, Pillay A, Sokana O, Pavluck A, Mabey DC, Chen CY, Solomon AW.**
Haemophilus ducreyi associated with skin ulcers among children, Solomon Islands.
Emerg Infect Dis 2014 Oct;20(10):1705-1707. doi: 10.3201/eid2010.140573.

During a survey of yaws prevalence in the Solomon Islands, we collected samples from skin ulcers of 41 children. Using PCR, we identified *Haemophilus ducreyi* infection in 13 (32%) children. PCR-positive and PCR-negative ulcers were phenotypically indistinguishable. Emergence of *H. ducreyi* as a cause of nongenital ulcers may affect the World Health Organization's yaws eradication program.

- 93 **Marston L, Kelly GC, Hale E, Clements AC, Hodge A, Jimenez-Soto E.**

Cost analysis of the development and implementation of a spatial decision support system for malaria elimination in Solomon Islands.

Malar J 2014 Aug 18;13:325. doi: 10.1186/1475-2875-13-325.

BACKGROUND: The goal of malaria elimination faces numerous challenges. New tools are required to support the scale up of interventions and improve national malaria programme capacity to conduct detailed surveillance. This study investigates the cost factors influencing the development and implementation of a spatial decision support system

(SDSS) for malaria elimination in the two elimination provinces of Isabel and Temotu, Solomon Islands. **METHOD:** Financial and economic costs to develop and implement a SDSS were estimated using the Solomon Islands programme's financial records. Using an ingredients approach, verified by stakeholders and operational reports, total costs for each province were quantified. A budget impact sensitivity analysis was conducted to investigate the influence of variations in standard budgetary components on the costs and to identify potential cost savings. **RESULTS:** A total investment of US\$ 96,046 (2012 constant dollars) was required to develop and implement the SDSS in two provinces (Temotu Province US\$ 49,806 and Isabel Province US\$ 46,240). The single largest expense category was for computerized equipment totalling approximately US\$ 30,085. Geographical reconnaissance was the most expensive phase of development and implementation, accounting for approximately 62% of total costs. Sensitivity analysis identified different cost factors between the provinces. Reduced equipment costs would deliver a budget saving of approximately 10% in Isabel Province. Combined travel costs represented the greatest influence on the total budget in the more remote Temotu Province. **CONCLUSION:** This study provides the first cost analysis of an operational surveillance tool used specifically for malaria elimination in the South-West Pacific. It is demonstrated that the costs of such a decision support system are driven by specialized equipment and travel expenses. Such factors should be closely scrutinized in future programme budgets to ensure maximum efficiencies are gained and available resources are allocated effectively.

- 94 **Masterton JP, Moss D, Korin SJ, Watters DA.**
Evaluation of the medium-term outcomes and impact of the Rowan Nicks Scholarship Programme.
ANZ J Surg 2014 Mar;84(3):110-116. doi: 10.1111/ans.12493. Epub 2014 Jan 9.

BACKGROUND: Rowan Nicks was a cardiothoracic surgeon in Sydney. He endowed the Rowan Nicks Scholarship Programme of the Royal Australasian College of Surgeons, which was initiated in 1991 to provide opportunities for clinicians from developing countries so that they return to their countries as leaders and teachers. This paper's objective was to evaluate the outcomes and impact of the scholarship on individuals and their communities. **METHODS:** A survey was undertaken of 34 eligible scholars of whom 29 participated. It was directed at whether objectives were achieved in technical skills, patient management and in competency in research and leadership. **RESULTS:** Ninety-eight per cent of scholars returned to work in their home country. Twenty-eight of 29 were working in their chosen specialty and had returned to their former positions. The clinical/operative skills obtained were regarded as useful by 86%, and 22/29 (76%) scholars reported they had gained worthwhile leadership and administrative skills. Improved clinical outcomes for patients were achieved as evidenced by reduced mortality and less disability. There was also a positive impact on health systems. The best documented of these were improved trauma management, development of paediatric surgery in rural Bangladesh, a new cardiac unit in Myanmar, organ transplantation and better injury outcomes in Papua New Guinea. **CONCLUSION:**

The programme has resulted in potential and actual leaders returning to their home countries where they positively impacted on health and surgical services. This has resulted in a reduced burden of surgical disease in the scholars' countries as measured by less death, disability and deformity.

- 95 **Mevers E, Matainaho T, Allarà M, Di Marzo V, Gerwick WH.**

Mooreamide A: a cannabinomimetic lipid from the marine cyanobacterium *Moorea bouillonii*. *Lipids* 2014 Nov;49(11):1127-1132. doi: 10.1007/s11745-014-3949-9. Epub 2014 Sep 10.

Bioassay-guided fractionation of a collection of *Moorea bouillonii* from Papua New Guinea led to the isolation of a new alkyl amide, mooreamide A (1), along with the cytotoxic apratoxins A-C and E. The planar structure of 1 was elucidated by NMR spectroscopy and mass spectrometry analysis. Structural homology between mooreamide A and the endogenous cannabinoid ligands, anandamide, and 2-arachidonoyl glycerol inspired its evaluation against the neuroreceptors CB(1) and CB(2). Mooreamide A was found to possess relatively potent and selective ligand binding activity to CB(1) ($K(1) = 0.47 \mu\text{M}$) versus CB(2) ($K(1) > 25 \mu\text{M}$). This represents the most potent marine-derived CB(1) ligand described to date and adds to the growing family of marine metabolites that exhibit cannabinomimetic activity.

- 96 **Miles K, Conlon M, Stinshoff J, Hutton R.**

Public-private partnerships in the response to HIV: experience from the resource industry in Papua New Guinea. *Rural Remote Health* 2014;14(3):2868. Epub 2014 Sep 25.

CONTEXT: Although Papua New Guinea (PNG) has made some progress in social development over the past 30 years, the country's Human Development Index has slowed in recent years, placing it below the regional average. In 2012, the estimated HIV prevalence for adults aged 15-49 years was 0.5% and an estimated 25,000 people were living with HIV. Although reduced from previous estimates, the country's HIV prevalence remains the highest in the South Pacific region. While the faith-based and non-governmental sectors have engaged in HIV interventions since the epidemic began, until recently the corporate sector has remained on the margins of the national response. In 2008, the country's largest oil and gas producer began partnering with national and provincial health authorities, development partners and global financing institutions to contribute to the national HIV strategy and implementation plan. This article provides an overview of public-private partnerships (PPPs) and their application to public health program management, and then describes the PPP that was developed in PNG. ISSUES: Innovative national and local PPPs have become a core component of healthcare strategy in many countries. PPPs have many forms and their use in low- and middle-income countries has progressively demonstrated increased service outputs and health outcomes beyond what the public sector alone could achieve. A PPP in PNG has resulted in an oil and gas producer engaging in the response to HIV, including managing the country's US\$46 million HIV grant from the Global Fund to Fight AIDS, Tuberculosis and Malaria. LESSONS LEARNED: Given the increasing expectations of the international community in

relation to corporate responsibility and sustainability, the role of the corporate sector in countries like PNG is critical. Combining philanthropic investment with business strategy, expertise and organisational resource can contribute to enhancing health system structures and capacity.

- 97 **Mita T, Ohashi J, Venkatesan M, Marma AS, Nakamura M, Plowe CV, Tanabe K.**

Ordered accumulation of mutations conferring resistance to sulfadoxine-pyrimethamine in the *Plasmodium falciparum* parasite. *J Infect Dis* 2014 Jan 1;209(1):130-139. doi: 10.1093/infdis/jit415. Epub 2013 Aug 6.

BACKGROUND: Monitoring the prevalence of drug resistant *Plasmodium falciparum* is essential for effective malaria control. Resistance to pyrimethamine and sulfadoxine increases as mutations accumulate in the parasite genes encoding dihydrofolate reductase (*dhfr*) and dihydropteroate synthase (*dhps*), respectively. Although parasites are exposed to these antifolate drugs simultaneously, it remains virtually unknown whether *dhfr* and *dhps* mutations accumulate along interrelated paths. METHODS: We investigated the order of step-wise accumulation in *dhfr* and *dhps* by cumulative analyses using binomial tests in 575 *P. falciparum* isolates obtained from 7 countries in Asia and Melanesia. RESULTS: An initial step in the accumulation of mutations preferentially occurred in *dhfr* (2 mutations), followed by 1 mutation in *dhps*. In a subsequent step, mutations were estimated separately for 5 *dhfr*/*dhps*-resistant lineages identified using 12 microsatellites flanking *dhfr* and *dhps*. Among these lineages, we found 3 major mutational paths, each of which follows a unique stepwise trajectory to produce the most highly resistant form with 4 mutations in *dhfr* and 3 in *dhps*. CONCLUSIONS: The ordered accumulation of mutations in *dhfr* and *dhps* elucidated here will assist in predicting the status and progression of antifolate resistance in malaria-endemic regions where antifolate drugs are used for intermittent preventive treatment.

- 98 **Mitjà O, Lukehart SA, Pokowas G, Moses P, Kapa A, Godornes C, Robson J, Cherian S, Houineil W, Kazadi W, Siba P, de Lazzari E, Bassat Q.**

Haemophilus ducreyi as a cause of skin ulcers in children from a yaws-endemic area of Papua New Guinea: a prospective cohort study. *Lancet Glob Health* 2014 Apr;2(4):e235-241. doi: 10.1016/S2214-109X(14)70019-1. Epub 2014 Mar 27.

BACKGROUND: Skin infections with ulceration are a major health problem in countries of the South Pacific region. Yaws, caused by *Treponema pallidum* subspecies *pertenue* and diagnosed by the presence of skin ulcers and a reactive syphilis serology, is one major cause, but this infection can be confused clinically with ulcers due to other causative agents. We investigated *T. pallidum* *pertenue* and another bacterium known to cause skin infections in the Pacific islands - *Haemophilus ducreyi* - as causes of skin ulceration in a yaws-endemic region. Additionally, we identified specific signs and symptoms associated with these causative agents of cutaneous ulcers and compared these findings with laboratory-based diagnoses. METHODS: We did a prospective cohort study of five yaws-endemic villages (total population 3117

people) during a yaws elimination campaign in Papua New Guinea in April, 2013. We enrolled all consenting patients with chronic moist or exudative skin ulcers. We undertook a detailed dermatological assessment, syphilis serology, and PCR on lesional swabs to detect the presence of *T. pallidum pertenue* and *H. ducreyi*. Patients with PCR-confirmed bacterial infections were included in a comparative analysis of demographics and clinical features. FINDINGS: Full outcome data were available for 90 people with skin ulcers. Of these patients, 17 (19%) had negative results in all molecular tests and were therefore excluded from the comparative analyses. A bacterial cause was identified in 73 (81%) participants – either *H. ducreyi* (n = 42), *T. pallidum pertenue* (yaws; n = 19), or coinfection with both organisms (dual infection; n = 12). The demographic characteristics of the patients infected with yaws and with *H. ducreyi* were similar. Skin lesions in patients with yaws and in those with dual infection were larger than those in patients infected with *H. ducreyi* (p = 0.071). The lesions in patients with yaws and dual infection were more circular in shape (79% and 67%) than in those infected with *H. ducreyi* (21%; p < 0.0001), more likely to have central granulating tissue (90% and 67% vs 14%; p < 0.0001), and more likely to have indurated edges (74% and 83% vs 31%; p = 0.0003). The prevalence of reactive combined serology (positive *T. pallidum* haemagglutination test and rapid plasmin reagin titre of ≥ 8) was higher in cases of yaws (63%) and dual infections (92%) than in *H. ducreyi* infections (29%; p < 0.0001). INTERPRETATION: In this yaws-endemic community, *H. ducreyi* is an important and previously unrecognised cause of chronic skin ulceration. Reactive syphilis serology caused by latent yaws can occur in ulcers with the presence of *H. ducreyi* alone. The introduction of PCR for ulcer surveillance could improve the accuracy of diagnosis in countries with yaws eradication campaigns. FUNDING: Newcrest Mining Company.

- 99 **Moore BR, Benjamin JM, Salman S, Griffin S, Ginny E, Page-Sharp M, Robinson LJ, Siba P, Batty KT, Mueller I, Davis TME.**

Effect of coadministered fat on the tolerability, safety, and pharmacokinetic properties of dihydroartemisinin-piperaquine in Papua New Guinean children with uncomplicated malaria.

Antimicrob Agents Chemother 2014 Oct;58(10):5784-5794. doi: 10.1128/AAC.03314-14. Epub 2014 Jul 21.

Coadministration of dihydroartemisinin-piperaquine (DHA-PQ) with fat may improve bioavailability and antimalarial efficacy, but it might also increase toxicity. There have been no studies of these potential effects in the pediatric age group. The tolerability, safety, efficacy, and pharmacokinetics of DHA-PQ administered with or without 8.5 g fat were investigated in 30 Papua New Guinean children aged 5 to 10 years diagnosed with uncomplicated falciparum malaria. Three daily 2.5:11.5-mg-base/kg doses were given with water (n = 14, group A) or milk (n = 16, group B), with regular clinical/laboratory assessment and blood sampling over 42 days. Plasma PQ was assayed by high-performance liquid chromatography with UV detection, and DHA was assayed using liquid chromatography-mass spectrometry. Compartmental pharmacokinetic models for PQ and DHA were developed using a population-based approach. DHA-PQ was

generally well tolerated, and initial fever and parasite clearance were prompt. There were no differences in the areas under the concentration-time curve (AUC_{0-∞}) for PQ (median, 41,906 versus 36,752 µg h/liter in groups A and B, respectively; p = 0.24) or DHA (4,047 versus 4,190 µg h/liter; p = 0.67). There were also no significant between-group differences in prolongation of the corrected electrocardiographic QT interval (QTc) initially during follow-up, but the QTc tended to be higher in group B children at 24 h (mean ± standard deviation [SD], 15 ± 10 versus 6 ± 15 ms(0.5) in group A, p = 0.067) and 168 h (10 ± 18 versus 1 ± 23 ms(0.5), p = 0.24) when plasma PQ concentrations were relatively low. A small amount of fat does not change the bioavailability of DHA-PQ in children, but a delayed persistent effect on ventricular repolarization cannot be excluded.

- 100 **Moore BR, Salman S, Benjamin J, Page-Sharp M, Robinson LJ, Waita E, Batty KT, Siba P, Mueller I, Davis TME, Betuela I.**

Pharmacokinetic properties of single-dose primaquine in Papua New Guinean children: feasibility of abbreviated high-dose regimens for radical cure of vivax malaria.

Antimicrob Agents Chemother 2014;58(1):432-439. doi: 10.1128/AAC.01437-13. Epub 2013 Nov 4.

Since conventional 14-day primaquine (PMQ) radical cure of vivax malaria is associated with poor compliance, and as total dose, not therapy duration, determines efficacy, a preliminary pharmacokinetic study of two doses (0.5 and 1.0 mg/kg of body weight) was conducted in 28 healthy glucose-6-phosphate dehydrogenase-normal Papua New Guinean children, aged 5 to 12 years, to facilitate development of abbreviated high-dose regimens. Dosing was with food and was directly observed, and venous blood samples were drawn during a 168-hour postdose period. Detailed safety monitoring was performed for hepatorenal function and hemoglobin and methemoglobin concentrations. Plasma concentrations of PMQ and its metabolite carboxyprimaquine (CPMQ) were determined by liquid chromatography-mass spectrometry and analyzed using population pharmacokinetic methods. The derived models were used in simulations. Both single-dose regimens were well tolerated with no changes in safety parameters. The mean PMQ central volume of distribution and clearance relative to bioavailability (200 liters/70 kg and 24.6 liters/h/70 kg) were within published ranges for adults. The median predicted maximal concentrations (C_{max}) for both PMQ and CPMQ after the last dose of a 1.0 mg/kg 7-day PMQ regimen were approximately double those at the end of 14 days of 0.5 mg/kg daily, while a regimen of 1.0 mg/kg twice daily resulted in a 2.38 and 3.33 times higher C_{max} for PMQ and CPMQ, respectively. All predicted median C_{max} concentrations were within ranges for adult high-dose studies that also showed acceptable safety and tolerability. The present pharmacokinetic data, the first for PMQ in children, show that further studies of abbreviated high-dose regimens are feasible in this age group.

- 101 **Murray CJ, Ortblad KF, Guinovart C, Lim SS, Wolock TM, Roberts DA, Dansereau EA, Graetz N, Barber RM, Brown JC, Wang H, Duber HC, Naghavi M, Dicker D, Dandona L, Salomon JA, Heuton KR, Foreman K, Phillips DE, Fleming TD, Flaxman AD, Phillips BK, Johnson EK,**

- Coggeshall MS, Abd-Allah F, Abera SF, Abraham JP, Abubakar I, Abu-Raddad LJ, Abu-Rmeileh NM, Achoki T, Adeyemo AO, Adou AK, Adsuar JC, Agardh EE, Akena D, Al Kahbouri MJ, Alasfoor D, Albittar MI, Alcalá-Cerrá G, Alegretti MA, Alemu ZA, Alfonso-Cristancho R, Alhabib S, Ali R, Alla F, Allen PJ, Alsharif U, Alvarez E, Alvis-Guzman N, Amankwaa AA, Amare AT, Amini H, Ammar W, Anderson BO, Antonio CA, Anwari P, Arnlov J, Arsenijevic VS, Artaman A, Asghar RJ, Assadi R, Atkins LS, Badawi A, Balakrishnan K, Banerjee A, Basu S, Beardsley J, Bekele T, Bell ML, Bernabe E, Beyene TJ, Bhala N, Bhalla A, Bhutta ZA, Abdulhak AB, Binagwaho A, Blore JD, Basara BB, Bose D, Brainin M, Breitborde N, Castañeda-Orjuela CA, Catalá-López F, Chadha VK, Chang JC, Chiang PP, Chuang TW, Colomar M, Cooper LT, Cooper C, Courville KJ, Cowie BC, Criqui MH, Dandona R, Dayama A, De Leo D, Degenhardt L, Del Pozo-Cruz B, Deribe K, Des Jarlais DC, Dessalegn M, Dharmaratne SD, Dilmen U, Ding EL, Driscoll TR, Durrani AM, Ellenbogen RG, Ermakov SP, Esteghamati A, Faraon EJ, Farzadfar F, Fereshtehnejad SM, Fijabi DO, Forouzanfar MH, Fra Paleo U, Gaffikin L, Gamkrelidze A, Gankpé FG, Geleijnse JM, Gessner BD, Gibney KB, Ginawi IA, Glaser EL, Gona P, Goto A, Gouda HN, Gughani HC, Gupta R, Gupta R, Hafezi-Nejad N, Hamadeh RR, Hammami M, Hankey GJ, Harb HL, Haro JM, Havmoeller R, Hay SI, Hedayati MT, Pi IB, Hoek HW, Hornberger JC, Hosgood HD, Hotez PJ, Hoy DG, Huang JJ, Iburg KM, Idrisov BT, Innos K, Jacobsen KH, Jeemon P, Jensen PN, Jha V, Jiang G, Jonas JB, Juel K, Kan H, Kankindi I, Karam NE, Karch A, Karema CK, Kaul A, Kawakami N, Kazi DS, Kemp AH, Kengne AP, Keren A, Kereselidze M, Khader YS, Khalifa SE, Khan EA, Khang YH, Khonelidze I, Kinfu Y, Kinge JM, Knibbs L, Kokubo Y, Kosen S, Defo BK, Kulkarni VS, Kulkarni C, Kumar K, Kumar RB, Kumar GA, Kwan GF, Lai T, Balaji AL, Lam H, Lan Q, Lansingh VC, Larson HJ, Larsson A, Lee JT, Leigh J, Leinsalu M, Leung R, Li Y, Li Y, De Lima GM, Lin HH, Lipshultz SE, Liu S, Liu Y, Lloyd BK, Lotufo PA, Machado VM, MacLachlan JH, Magis-Rodriguez C, Majdan M, Mapoma CC, Marceses W, Marzan MB, Masci JR, Mashal MT, Mason-Jones AJ, Mayosi BM, Mazarodze TT, Mckay AC, Meaney PA, Mehndiratta MM, Mejia-Rodriguez F, Melaku YA, Memish ZA, Mendoza W, Miller TR, Mills EJ, Mohammad KA, Mokdad AH, Mola GL, Monasta L, Montico M, Moore AR, Mori R, Moturi WN, Mukaigawara M, Murthy KS, Naheed A, Naidoo KS, Naldi L, Nangia V, Narayan KM, Nash D, Nejari C, Nelson RG, Neupane SP, Newton CR, Ng M, Nisar MI, Nolte S, Norheim OF, Nowaseb V, Nyakarahuka L, Oh IH, Ohkubo T, Olusanya BO, Omer SB, Opio JN, Orisakwe OE, Pandian JD, Papachristou C, Caicedo AJ, Patten SB, Paul VK, Pavlin BI, Pearce N, Pereira DM, Pervaz A, Pesudovs K, Petzold M, Pourmalek F, Qato D, Quezada AD, Quistberg DA, Rafay A, Rahimi K, Rahimi-Movaghar V, Ur Rahman S, Raju M, Rana SM, Razavi H, Reilly RQ, Remuzzi G, Richardus JH, Ronfani L, Roy N, Sabin N, Saeedi MY, Sahraian MA, Samonte GM, Sawhney M, Schneider IJ, Schwebel DC, Seedat S, Sepanlou SG, Servan-Mori EE, Sheikhbahaei S, Shibuya K, Shin HH, Shiue I, Shvakoti R, Sigfusdottir ID, Silberberg DH, Silva AP, Simard EP, Singh JA, Skirbekk V, Sliwa K, Soneji S, Soshnikov SS, Sreeramareddy CT, Stathopoulou VK, Stroumpoulis K, Swaminathan S, Sykes BL, Tabb KM, Talongwa RT, Tenkorang EY, Terkawi AS, Thomson AJ, Thorne-Lyman AL, Towbin JA, Traebert J, Tran BX, Dimbuene ZT, Tsilimbiris M, Uchendu US, Ukwaja KN, Uzun SB, Valley AJ, Vasankari TJ, Venketasubramanian N, Violante FS, Vlassov VV, Vollset SE, Waller S, Wallin MT, Wang L, Wang X, Wang Y, Weichenthal S, Weiderpass E, Weintraub RG, Westerman R, White RA, Wilkinson JD, Williams TN, Woldeyohannes SM, Wong JQ, Xu G, Yang YC, Yano Y, Yentur GK, Yip P, Yonemoto N, Yoon SJ, Younis M, Yu C, Jin KY, El Sayed Zaki M, Zhao Y, Zheng Y, Zhou M, Zhu J, Zou XN, Lopez AD, Vos T.
- Global, regional, and national incidence and mortality for HIV, tuberculosis, and malaria during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014 Sep 13;384(9947):1005-1070. doi: 10.1016/S0140-6736(14)60844-8. Epub 2014 Jul 22.
- BACKGROUND:** The Millennium Declaration in 2000 brought special global attention to HIV, tuberculosis, and malaria through the formulation of Millennium Development Goal (MDG) 6. The Global Burden of Disease 2013 study provides a consistent and comprehensive approach to disease estimation for between 1990 and 2013, and an opportunity to assess whether accelerated progress has occurred since the Millennium Declaration. **METHODS:** To estimate incidence and mortality for HIV, we used the UNAIDS Spectrum model appropriately modified based on a systematic review of available studies of mortality with and without antiretroviral therapy (ART). For concentrated epidemics, we calibrated Spectrum models to fit vital registration data corrected for misclassification of HIV deaths. In generalised epidemics, we minimised a loss function to select epidemic curves most consistent with prevalence data and demographic data for all-cause mortality. We analysed counterfactual scenarios for HIV to assess years of life saved through prevention of mother-to-child transmission (PMTCT) and ART. For tuberculosis, we analysed vital registration and verbal autopsy data to estimate mortality using cause of death ensemble modelling. We analysed data for corrected case-notifications, expert opinions on the case-detection rate, prevalence surveys, and estimated cause-specific mortality using Bayesian meta-regression to generate consistent trends in all parameters. We analysed malaria mortality and incidence using an updated cause of death database, a systematic analysis of verbal autopsy validation studies for malaria, and recent studies (2010-13) of incidence, drug resistance, and coverage of insecticide-treated bednets. **FINDINGS:** Globally in 2013, there were 1.8 million new HIV infections (95% uncertainty interval 1.7 million to 2.1 million), 29.2 million prevalent HIV cases (28.1 to 31.7), and 1.3 million HIV deaths (1.3 to 1.5). At the peak of the epidemic in 2005, HIV caused 1.7 million deaths (1.6 million to 1.9 million). Concentrated epidemics in Latin America and eastern Europe are substantially smaller than previously estimated. Through interventions including PMTCT and ART, 19.1 million life-years (16.6 million to 21.5 million) have been saved, 70.3% (65.4 to 76.1) in developing countries. From 2000 to 2011, the ratio of development assistance for health for HIV to years of life saved

through intervention was US\$4498 in developing countries. Including HIV-positive individuals, all-form tuberculosis incidence was 7.5 million (7.4 million to 7.7 million), prevalence was 11.9 million (11.6 million to 12.2 million), and number of deaths was 1.4 million (1.3 million to 1.5 million) in 2013. In the same year and in only individuals who were HIV-negative, all-form tuberculosis incidence was 7.1 million (6.9 million to 7.3 million), prevalence was 11.2 million (10.8 million to 11.6 million), and number of deaths was 1.3 million (1.2 million to 1.4 million). Annualised rates of change (ARC) for incidence, prevalence, and death became negative after 2000. Tuberculosis in HIV-negative individuals disproportionately occurs in men and boys (versus women and girls): 64.0% of cases (63.6 to 64.3) and 64.7% of deaths (60.8 to 70.3). Globally, malaria cases and deaths grew rapidly from 1990 reaching a peak of 232 million cases (143 million to 387 million) in 2003 and 1.2 million deaths (1.1 million to 1.4 million) in 2004. Since 2004, child deaths from malaria in sub-Saharan Africa have decreased by 31.5% (15.7 to 44.1). Outside of Africa, malaria mortality has been steadily decreasing since 1990. INTERPRETATION: Our estimates of the number of people living with HIV are 18.7% smaller than UNAIDS's estimates in 2012. The number of people living with malaria is larger than estimated by WHO. The number of people living with HIV, tuberculosis, or malaria have all decreased since 2000. At the global level, upward trends for malaria and HIV deaths have been reversed and declines in tuberculosis deaths have accelerated. 101 countries (74 of which are developing) still have increasing HIV incidence. Substantial progress since the Millennium Declaration is an encouraging sign of the effect of global action. FUNDING: Bill & Melinda Gates Foundation.

102 Nakaseko E, Matsuda N, Kotera S.

Factors related to smoking and consumption of alcohol and kava in children attending the upper grades of primary schools in Vanuatu. [Jp] *Nihon Koshu Eisei Zasshi* 2014;61(12):718-731. doi: 10.11236/jph.61.12.718.

OBJECTIVES: To identify factors related to smoking and consumption of alcohol and kava in children attending the upper grades of primary schools in Vanuatu. METHODS: We conducted a self-administered survey of 6th, 7th, and 8th grade students attending primary schools in both urban and rural areas of Vanuatu. The main survey items included questions on personal attributes (sex, age, grade); experience of smoking and consumption of alcohol and kava; food consumption (local food/store-bought food); perceptions of local foods and store-bought foods; attitudes toward smoking and consumption of alcohol and kava; knowledge related to non-communicable diseases; attitudes toward health practices; guardians' health-related parenting attitudes; and family members' use of tobacco, alcohol, and kava. The responses for the main outcome variables (smoking and consumption of alcohol and kava) were dichotomized as 'ever' versus 'never'. Factors related to smoking and consumption of alcohol and kava were examined using logistic regression analysis. The significance level was set at $p < 0.05$. RESULTS: A total of 415 (194 urban and 221 rural) students participated in our study that had total and valid response rates of 100% for both. Of the participants, 8%, 12.4%, and 5.8% had

previously smoked, consumed alcohol, or consumed kava, respectively. Students' experience of smoking and consumption of alcohol and kava were mutually associated. Student sex and family members' smoking status were significantly associated with the participants' smoking status. Student grades, attitudes toward drinking, and perceptions of local and store-bought food were significantly associated with alcohol consumption. Lastly, attitudes toward kava and alcohol consumption and perceptions of local food were significantly associated with kava consumption. CONCLUSION: Our results indicate that food consumption, attitudes toward smoking and consumption of alcohol and kava, and family members' smoking status were associated with the participants' smoking and consumption of alcohol and kava. In conclusion, it may be necessary to consider these factors when establishing measures to prevent smoking and consumption of alcohol and kava among primary school students.

103 Negin J, Vizintin P, Houasia P, Martiniuk AL.

Barking up the wrong tree: injuries due to falls from trees in Solomon Islands.

Med J Aust 2014 Dec 11;201(11):698-700.

OBJECTIVE: To investigate tree-related injuries in Solomon Islands by the types of trees involved, who is affected and the types of injuries caused. DESIGN AND SETTING: Descriptive case series of all cases of injuries related to trees presenting to the National Referral Hospital in Honiara from 1994 to 2011. Data were collected by the attending clinician using a Trauma Epidemiology form, which provides information on age, sex, cause of injury and type of fracture. MAIN OUTCOME MEASURES: Number of injuries by tree type, sex and age. RESULTS: Of the 7651 injuries in the database, 1107 (14%) were caused by falls from trees. Falls from coconut trees led to the highest number of injuries, followed by falls from mango, guava, apple and nut trees. Overall, 85% of injuries occurred in individuals aged <20 years. For injuries involving guava trees, 77% of patients were aged <10 years, compared with 46% for the five most commonly involved tree types. Overall, 71% of injuries occurred among males. Of all injuries, 92% were fractures, 3% were dislocations and 5% were non-fracture, non-dislocation injuries. The arm (including wrist, elbow and hand) was the most common location of injury across all tree types. Distal radius fractures in the forearm were particularly common, as were ulna fractures. CONCLUSION: While mangos and guavas are undeniably delicious, the quest for their flesh can be hazardous. Children will always climb trees, but the search for food among children in lower-income settings may lead to higher rates of injury.

104 Neve JE, Wijesekera HP, Duffy S, Jenkins ID, Ripper JA, Teague SJ, Campitelli M, Garavelas A, Nikolakopoulos G, Le PV, de A Leone P, Pham NB, Shelton P, Fraser N, Carroll AR, Avery VM, McCrae C, Williams N, Quinn RJ.

Euodenine A: a small-molecule agonist of human TLR4.

J Med Chem 2014 Feb 27;57(4):1252-1275. doi: 10.1021/jm401321v. Epub 2014 Feb 7.

A small-molecule natural product, euodenine A (1), was identified as an agonist of the human TLR4 receptor. Euodenine A was isolated from the leaves of *Euodia asteridula* (Rutaceae) found in Papua New Guinea and has an unusual U-shaped structure. It

was synthesized along with a series of analogues that exhibit potent and selective agonism of the TLR4 receptor. SAR development around the cyclobutane ring resulted in a 10-fold increase in potency. The natural product demonstrated an extracellular site of action, which requires the extracellular domain of TLR4 to stimulate a NF- κ B reporter response. 1 is a human-selective agonist that is CD14-independent, and it requires both TLR4 and MD-2 for full efficacy. Testing for immunomodulation in PBMC cells shows the induction of the cytokines IL-8, IL-10, TNF- α , and IL-12p40 as well as suppression of IL-5 from activated PBMCs, indicating that compounds like 1 could modulate the Th2 immune response without causing lung damage.

105 **Norton HL, Correa EA, Koki G, Friedlaender JS.**

Distribution of an allele associated with blond hair color across northern island Melanesia.

Am J Phys Anthropol 2014 Apr;153(4):653-662. doi: 10.1002/ajpa.22466. Epub 2014 Jan 22.

Pigmentation of the skin, hair, and eyes is a complex trait controlled by multiple genetic loci. Recently a non-synonymous mutation in the pigmentation candidate gene TYRP1 was shown to be significantly associated with a blond-hair phenotype in populations from the Solomon Islands. The distribution of this mutation in the islands of northern island Melanesia, where the blondism phenotype is also prevalent, was unknown. Here, we present data describing the distribution of this allele in 550 individuals sampled from across this region, and test for associations between genotype at this locus and quantitatively measured skin and hair pigmentation phenotype. We report that the frequency of the 93C allele is notably lower than observed in the Solomons (0.12 vs. 0.26). The allele exhibits significant geographic heterogeneity across the islands sampled ($\chi^2 = 108.4$, $p < 0.0001$). It is observed at its highest frequencies on the islands of New Ireland and New Hanover, while being almost completely absent from the large island of New Britain. Using linear regression with age, sex, and island as covariates we report that, as in the Solomons, the 93C allele is significantly associated with a decrease in hair pigmentation but not skin pigmentation. We discuss the distribution of the 93C allele across the Southwest Pacific in light of its possible place of origin and dispersal.

106 **O'Connor S, Robertson G, Aplin KP.**

Are osseous artefacts a window to perishable material culture? Implications of an unusually complex bone tool from the Late Pleistocene of East Timor.

J Hum Evol 2014 Feb;67:108-119. doi: 10.1016/j.jhevol.2013.12.002. Epub 2014 Jan 15.

We report the discovery of an unusually complex and regionally unique bone artefact in a Late Pleistocene archaeological assemblage (c. 35 ka [thousands of years ago]) from the site of Matja Kuru 2 on the island of Timor, in Wallacea. The artefact is interpreted as the broken butt of a formerly hafted projectile point, and it preserves evidence of a complex hafting mechanism including insertion into a shaped or split shaft, a complex pattern of binding including lateral stabilization of the cordage within a bilateral series of notches, and the application of mastic at several stages in the hafting process. The artefact provides the earliest direct evidence for the use of this combination of hafting technologies in the

wider region of Southeast Asia, Wallacea, Melanesia and Australasia, and is morphologically unparalleled in deposits of any age. By contrast, it bears a close morphological resemblance to certain bone artefacts from the Middle Stone Age of Africa and South Asia. Examination of ethnographic projectile technology from the region of Melanesia and Australasia shows that all of the technological elements observed in the Matja Kuru 2 artefact were in use historically in the region, including the unusual feature of bilateral notching to stabilize a hafted point. This artefact challenges the notion that complex bone-working and hafting technologies were a relatively late innovation in this part of the world. Moreover, its regional uniqueness encourages us to abandon the perception of bone artefacts as a discrete class of material culture, and to adopt a new interpretative framework in which they are treated as manifestations of a more general class of artefacts that more typically were produced on perishable raw materials including wood.

107 **Okumiya K, Wada T, Fujisawa M, Ishine M, Garcia Del Saz E, Hirata Y, Kuzuhara S, Kokubo Y, Seguchi H, Sakamoto R, Manuaba I, Watofa P, Rantetampang AL, Matsubayashi K.**

Amyotrophic lateral sclerosis and parkinsonism in Papua, Indonesia: 2001-2012 survey results.

BMJ Open 2014 Apr 16;4(4):e004353. doi: 10.1136/bmjopen-2013-004353.

OBJECTIVE: Only one previous follow-up study of amyotrophic lateral sclerosis (ALS) and parkinsonism in Papua, Indonesia has been carried out since a survey undertaken in 1962-1981 by Gajdusek and colleagues. Therefore, to clarify the clinical epidemiology of ALS and parkinsonism in the southern coastal region of Papua, the clinical characteristics and prevalence of the diseases in this region were examined and assessed. **METHODS:** Cases of ALS and parkinsonism were clinically examined during a 2001-2012 survey in Bade and other villages along the Ila, Edera, Dumut and Obaa rivers in Papua, Indonesia. Possible, probable and definite ALS was diagnosed clinically by certified neurologists based on El Escorial criteria. The criteria for a diagnosis of parkinsonism were the presence of at least two of the four following signs: tremor, rigidity, bradykinesia and postural impairment with a progressive course. **RESULTS:** During the survey, 46 cases of ALS and/or parkinsonism were diagnosed within a population range of 7000 (2001-2002) to 13 900 (2007-2012). The 46 cases consisted of 17 probable-definite cases of ALS, including three with cognitive impairment (CI), 13 cases of overlapping possible, probable or definite ALS and parkinsonism, including five with CI, and 16 cases of parkinsonism, including one with CI. The crude point prevalence rate of pure ALS was estimated to be at least 73 (95% CI 0 to 156) to 133 (27 to 240)/100 000 people and that of overlapping ALS and parkinsonism at least 53 (0 to 126) to 98 (2 to 193)/100 000 in 2007, or 2010 in some regions. **CONCLUSIONS:** While the prevalence of ALS in Papua has decreased over the past ~30-35 years, it remains higher than the global average. There was a high prevalence of overlapping ALS, parkinsonism and CI, which has also been previously reported in Guam and Kii.

108 **Olita'a D, Vince J, Ripa P, Tefuarani N.**

Risk factors for malnutrition in children at Port Moresby General Hospital, Papua New Guinea: a

case-control study.

J Trop Pediatr 2014 Dec;60(6):442-448. doi: 10.1093/tropej/ffmu049. Epub 2014 Sep 17.

Fifty children admitted for malnutrition were age matched with 50 admitted for other reasons. These children were more likely to be female ($p = 0.003$), born low birth weight ($p = 0.02$), after a short birth interval ($p = 0.014$) and to be incompletely vaccinated ($p < 0.001$) than control children, and to be living in rural villages or settlement housing ($p < 0.001$) with inadequate water supply ($p < 0.001$) and sanitation ($p = 0.037$), with overcrowding ($p = 0.016$) and low household income ($p = 0.04$). Their parents were more likely to have had no or only rudimentary education than parents of control children [Odds ratio (OR) 3.58 for mothers, 4.12 for fathers]. Parental consumption of alcohol as well as smoking in the mother was more common in the malnourished children. Running water in the house was an independent protective factor (OR 0.23) and the fathers' poor employment status (OR 4.12) an independent risk factor. The solution to malnutrition involves improving community understanding of nutrition and in reducing social inequalities.

- 109 **Oloifana-Polosovai H, Gwala J, Harrington H, Massey PD, Ribeyro E, Flores A, Speare C, McBride E, MacLaren D, Speare R.**

A marked decline in the incidence of malaria in a remote region of Malaita, Solomon Islands, 2008 to 2013.

Western Pac Surveill Response J 2014 Sep 30;5(3):30-39. doi: 10.5365/WPSAR.2014.5.3.002.

SETTING: Atoifi Adventist Hospital (AAH), Solomon Islands, the only hospital in the East Kwaio region. OBJECTIVE: To use routine surveillance data to assess the trends in malaria from 2008 to 2013. DESIGN: Descriptive study of records from (1) AAH laboratory malaria records; (2) admissions to AAH for malaria; and (3) malaria treatments from outpatient records. RESULTS: AAH examined 35 608 blood films and diagnosed malaria in 4443 samples comprised of 2667 *Plasmodium falciparum* (Pf) and 1776 *Plasmodium vivax* (Pv). Between 2008 and 2013 the total number of malaria cases detected annually decreased by 86.5%, Pf by 96.7% and Pv by 65.3%. The ratio of Pf to Pv reversed in 2010 from 2.06 in 2008 to 0.19 in 2013. For 2013, Pf showed a seasonal pattern with no cases diagnosed in four months. From 2008 to 2013 admissions in AAH for malaria declined by 90.8%, and malaria mortality fell from 54 per 100 000 to zero. The annual parasite index (API) for 2008 and 2013 was 195 and 24, respectively. Village API has identified a group of villages with higher malaria incidence rates. CONCLUSION: The decline in malaria cases in the AAH catchment area has been spectacular, particularly for Pf. This was supported by three sources of hospital surveillance data (laboratory, admissions and treatment records). The decline was associated with the use of artemisinin-based combined therapy and improved vertical social capital between the AAH and the local communities. Calculating village-specific API has highlighted which villages need to be targeted by the AAH malaria control team.

- 110 **Paiva O, Pla D, Wright CE, Beutler M, Sanz L, Gutiérrez JM, Williams DJ, Calvete JJ.**

Combined venom gland cDNA sequencing and venomomics of the New Guinea small-eyed snake,

Micropechis ikaheka.

J Proteomics 2014 Oct 14;110:209-229. doi: 10.1016/j.jprote.2014.07.019. Epub 2014 Aug 8.

The venom arsenal of the New Guinea small-eyed snake, *Micropechis ikaheka*, was investigated by a joint cDNA sequencing and venomomics approach. Twenty-seven full-length DNA sequences encoding novel venom proteins were recovered in this study. Using this cDNA dataset we achieved locus-specific resolution for 19 out of the approximately 50 reverse-phase- and SDS-PAGE-separated venom proteins. The venom proteome of *M. ikaheka* is dominated by at least 29 D49-phospholipase A₂ (PLA₂) and 14 short and long neurotoxins of the three-finger toxin (3FTx) family. These protein classes represent, respectively, 80% and 9.2% of the total venom proteins. Two PIII-metalloproteinase (SVMP) molecules (7.6%), three CRISP isoforms (1.8%), and a single Kunitz-type inhibitor, vespryn, 5'-nucleotidase, serine proteinase and LAO molecules, none of which represents more than 0.7% of the total venom proteome, complete the protein arsenal of *M. ikaheka*. In concordance with clinical observations, this venom composition points to a central role for post-synaptically-acting neurotoxic toxins in the envenomation strategy developed by this species. PLA₂ molecules represent the main myotoxic components of *M. ikaheka* venom. In addition, the estimated LD₅₀ for mice of the reverse-phase-isolated 3FTx (0.22 mg/kg) and PLA₂ (1.62 mg/kg) enriched fractions strongly suggests that these two toxin classes contribute synergistically to venom lethality, with the 3FTxs playing a dominant role. The high structural and functional conservation exhibited by *M. ikaheka* and Australian elapid venoms may underlay the positive clinical outcomes of envenoming resulting from bites by *M. ikaheka* that have been documented through the use of bioCSL polyvalent antivenom. BIOLOGICAL SIGNIFICANCE: The poorly understood venom proteome of the New Guinea small-eyed snake, *Micropechis ikaheka*, a large and powerfully built elapid endemic to Papua New Guinea and Indonesian West Papua province, was investigated through a combined venomomics and venom gland transcriptomics approach. Although *M. ikaheka* accounts for only a small proportion of snakebites on the mainland, 40% of snakebites on Karkar Island are attributed to bites by this snake. Major effects of envenoming include life-threatening post-synaptic neuromuscular blockade resulting in respiratory paralysis, myotoxicity, severe bleeding, hypotension and cardiovascular abnormalities. We have investigated the contribution of 3FTxs and PLA₂ molecules in venom lethality, myotoxicity, and cardiovascular function. Our work provides important correlations between venom composition and its pharmacological activity. In conjunction with the antivenomics work reported in the companion paper, our study may contribute to improve treatment outcomes for snakebite victims of *M. ikaheka*.

- 111 **Pihau-Tulo ST, Parsons RW, Hughes JD.**

An evaluation of patients' adherence with hypoglycemic medications among Papua New Guineans with type 2 diabetes: influencing factors. *Patient Prefer Adherence* 2014 Sep 16;8:1229-1237. doi: 10.2147/PPA.S66655. eCollection 2014.

PURPOSE: The aims of this study were to evaluate the extent of adherence to hypoglycemic medications, assess the relationship between adherence and glycemic control, and evaluate

factors affecting adherence. **RESEARCH DESIGN AND METHODS:** This was a cross-sectional study of patients with established type 2 diabetes attending the Port Moresby General Hospital Diabetes Clinic. Face-to-face interviews were conducted using a questionnaire designed for the study and data were collected concerning the 3 months prior to interview. The questionnaire covered demographic details, lifestyle, biochemical and physical measurements, and medication management. Glycemic control was investigated among patients adhering to their medications (not missing doses) to different degrees (100%, 95%, 90%, and 80%). **RESULTS:** Of a total of 356 participants who were prescribed hypoglycemic medications, 59.6% omitted some of their doses. Age appeared to have a significant impact on adherence at some levels of adherence, with those aged >60 years being more likely to be adherent (logistic regression). Those who were 95%-99% and those who were <80% adherent had a statistically significant risk of a high glycated hemoglobin of >10% (85.5 mmol/mol). Multiple factors were identified as contributors to nonadherence, with patient-based issues (86.0%) and the health care system (21.7%) being the most common. **CONCLUSION:** This study showed a significant level of nonadherence among patients with type 2 diabetes in Papua New Guinea. Nonadherence to medication appeared to be associated with poor glycemic control and was due to a variety of reasons. Future interventions aimed at improving adherence will need to take these into account.

112 **Pla D, Paiva OK, Sanz L, Beutler M, Wright CE, Calvete JJ, Williams DJ, Gutiérrez JM.**

Preclinical efficacy of Australian antivenoms against the venom of the small-eyed snake, *Micropechis ikaheka*, from Papua New Guinea: an antivenomics and neutralization study.

J Proteomics 2014 Oct 14;110:198-208. doi: 10.1016/j.jprot.2014.06.016. Epub 2014 Jun 28.

There is no specific antivenom for the treatment of envenoming by the small-eyed snake, *Micropechis ikaheka*, a dangerous fossorial species endemic to Papua New Guinea, Irian Jaya (West Papua) and neighbouring islands. This study evaluated one marine (sea snake) and four terrestrial (tiger snake, brown snake, black snake and polyvalent) antivenoms, manufactured in Australia by bioCSL Limited, for their ability to immunoreact ('antivenomic' analysis) and neutralize enzymatic and toxic activities of *M. ikaheka* venom. All antivenoms neutralized lethality of the venom and attenuated, dose-dependently, myotoxic activity. The polyvalent antivenom also neutralized cardiotoxic activity. In contrast, antivenoms were ineffective in the neutralization of phospholipase A₂ (PLA₂) and anticoagulant activities. Antivenomics outcomes were in concordance with neutralization tests, for chromatographic peaks corresponding to α -neurotoxins of the three finger family, responsible for lethality, were quantitatively retained in the immunoaffinity columns, whereas peaks corresponding to PLA₂s were immunocaptured only to a partial extent. The ability of antivenoms to neutralize lethal, ie, neurotoxic, and myotoxic activities of *M. ikaheka* venom, which represent the most relevant clinical manifestations of envenoming, suggests that these antivenoms may provide paraspecific protection in humans, although the poor neutralization of PLA₂ supports the need for

well-designed clinical studies to not only determine which antivenoms are most appropriate for treatment of *M. ikaheka* envenoming, but to also fully describe the syndrome of envenoming caused by this beautiful, but lethal species. **BIOLOGICAL SIGNIFICANCE:** Snakebite by the small-eyed snake, *Micropechis ikaheka*, in Papua New Guinea can be life-threatening. The predominant clinical features in this envenoming are neurotoxicity and systemic myotoxicity. Although it accounts for only a small proportion of snakebites on the mainland, 40% of snakebites on Karkar Island are attributed to bites by the Ikaheka snake. However, no specific antivenom is available for the treatment of *M. ikaheka* envenoming in Papua New Guinea. This study evaluated a panel of Australian bioCSL antivenoms for their paraspecific immunoreaction and neutralization of the toxic activities of *M. ikaheka* venom. All antivenoms exhibited strong immunorecognition of α -neurotoxins of the 3FTx family and neutralized the lethal, ie, neurotoxic, and myotoxic activities of *M. ikaheka* venom. However, these antivenoms exhibited poor neutralization of PLA₂ and anticoagulant activities. This study suggests that the Australian antivenoms may provide paraspecific protection against *M. ikaheka* venom in humans, a hypothesis that demands studies aimed at assessing whether these antivenoms neutralize neurotoxicity and myotoxicity in the clinical setting.

113 **Poespoprodjo JR, Fobia W, Kenangalem E, Lampah DA, Sugiarto P, Tjitra E, Anstey NM, Price RN.**

Dihydroartemisinin-piperaquine treatment of multidrug resistant falciparum and vivax malaria in pregnancy.

PLoS One 2014 Jan 17;9(1):e84976. doi: 10.1371/journal.pone.0084976. eCollection 2014.

BACKGROUND: Artemisinin combination therapy (ACT) is recommended for the treatment of multidrug resistant malaria in the second and third trimesters of pregnancy, but the experience with ACTs is limited. We review the exposure of pregnant women to the combination dihydroartemisinin-piperaquine over a 6-year period. **METHODS:** From April 2004 to June 2009, a prospective hospital-based surveillance screened all pregnant women for malaria and documented maternal and neonatal outcomes. **RESULTS:** Data were available on 6519 pregnant women admitted to hospital; 332 (5.1%) women presented in the first trimester, 324 (5.0%) in the second, 5843 (89.6%) in the third, and in 20 women the trimester was undocumented. Peripheral parasitaemia was confirmed in 1682 women, of whom 106 (6.3%) had severe malaria. Of the 1217 women admitted with malaria in the second and third trimesters without an impending adverse outcome, those treated with DHP were more likely to be discharged with an ongoing pregnancy compared to those treated with a non-ACT regimen (Odds Ratio OR = 2.48 [1.26-4.86]; $p = 0.006$). However, in the first trimester 63% (5/8) of women treated with oral DHP miscarried compared to 2.6% (1/38) of those receiving oral quinine; $p < 0.001$. Of the 847 women admitted for delivery those reporting a history of malaria during their pregnancy who had been treated with quinine-based regimens rather than DHP had a higher risk of malaria at delivery (adjusted OR = 1.56 [95%CI 0.97-2.5], $p = 0.068$) and perinatal mortality (adjusted OR = 3.17 [95%CI 1.17-8.60]; $p = 0.023$). **CONCLUSIONS:** In the

second and third trimesters of pregnancy, a three-day course of DHP simplified antimalarial treatment and had significant benefits over quinine-based regimens in reducing recurrent malaria and poor fetal outcome. These data provide reassuring evidence for the rational design of prospective randomized clinical trials and pharmacokinetic studies.

114 **Pratiwi E, Setiawaty V, Putranto RH.**

Molecular characteristics of rotavirus isolated from a diarrhea outbreak in October 2008 in Bintuni Bay, Papua, Indonesia. *Virology (Auckl)* 2014 Mar 9;5:11-14. doi: 10.4137/VRT.S13555. eCollection 2014.

BACKGROUND: Viral diarrhea continues to be a health problem in Indonesia that often causes outbreaks, in particular, acute viral diarrhea in young children. Rotavirus is the leading cause of severe diarrhea in children under two years of age. This study aimed to determine the genotypes of rotavirus in Bintuni Bay, Papua. **METHODS:** Stool specimens from 15 patients were collected and analyzed for rotavirus using an enzyme immunoassay (EIA) and reverse transcriptase-polymerase chain reaction (RT-PCR). Subsequently, we sequenced the genetic material of rotavirus positive samples by RT-PCR and analyzed the results using Mega-4 software. **RESULTS:** Two rotavirus serotypes were identified from the diarrhea outbreak in Bintuni, Papua in October 2008: serotype G1 with G1P[6] (50%) and G1P[8] (16.7%) strains, and serotype G2 with G2P[4] (23.3%) strain. Phylogenetic tree analyses of VP7 protein showed that rotavirus-infected diarrhea in Bintuni Bay, Papua at that time was dominated by the G1 serotype (83%). **CONCLUSION:** The laboratory results showed that G1 serotype rotavirus was a cause of the outbreak of diarrhea in October 2008 in Bintuni, Papua.

115 **Preston MD, Campino S, Assefa SA, Echeverry DF, Ocholla H, Amambua-Ngwa A, Stewart LB, Conway DJ, Borrmann S, Michon P, Zongo I, Ouédraogo JB, Djimde AA, Doumbo OK, Nosten F, Pain A, Bousema T, Drakeley CJ, Fairhurst RM, Sutherland CJ, Roper C, Clark TG.**

A barcode of organellar genome polymorphisms identifies the geographic origin of *Plasmodium falciparum* strains. *Nat Commun* 2014 Jun 13;5:4052. doi: 10.1038/ncomms5052.

Malaria is a major public health problem that is actively being addressed in a global eradication campaign. Increased population mobility through international air travel has elevated the risk of re-introducing parasites to elimination areas and dispersing drug-resistant parasites to new regions. A simple genetic marker that quickly and accurately identifies the geographic origin of infections would be a valuable public health tool for locating the source of imported outbreaks. Here we analyse the mitochondrion and apicoplast genomes of 711 *Plasmodium falciparum* isolates from 14 countries, and find evidence that they are non-recombining and co-inherited. The high degree of linkage produces a panel of relatively few single-nucleotide polymorphisms (SNPs) that is geographically informative. We design a 23-SNP barcode that is highly predictive (~92%) and easily adapted to aid case management in the field and survey parasite migration worldwide.

116 **Pulford J, Siba PM, Mueller I, Hetzel MW.**

The exit interview as a proxy measure of malaria case management practice: sensitivity and specificity relative to direct observation. *BMC Health Serv Res* 2014 Dec 3;14:628. doi: 10.1186/s12913-014-0628-8.

BACKGROUND: This paper aims to assess the sensitivity and specificity of exit interviews as a measure of malaria case management practice as compared to direct observation. **METHODS:** The malaria case management of 1654 febrile patients attending 110 health facilities from across Papua New Guinea was directly observed by a trained research officer as part of a repeat cross sectional survey. Patient recall of 5 forms of clinical advice and 5 forms of clinical action were then assessed at service exit and statistical analyses on matched observation/exit interview data conducted. **RESULTS:** The sensitivity of exit interviews with respect to clinical advice ranged from 36.2% to 96.4% and specificity from 53.5% to 98.6%. With respect to clinical actions, sensitivity of the exit interviews ranged from 83.9% to 98.3% and specificity from 70.6% to 98.1%. **CONCLUSION:** The exit interview appears to be a valid measure of objective malaria case management practices such as the completion of a diagnostic test or the provision of antimalarial medication, but may be a less valid measure of low frequency, subjective practices such as the provision of malaria prevention advice.

117 **Redman-MacLaren M, Mills J, Tommbe R.**

Interpretive focus groups: a participatory method for interpreting and extending secondary analysis of qualitative data. *Glob Health Action* 2014 Aug 18;7:25214. doi: 10.3402/gha.v7.25214. eCollection 2014.

BACKGROUND: Participatory approaches to qualitative research practice constantly change in response to evolving research environments. Researchers are increasingly encouraged to undertake secondary analysis of qualitative data, despite epistemological and ethical challenges. Interpretive focus groups can be described as a more participative method for groups to analyse qualitative data. **OBJECTIVE:** To facilitate interpretive focus groups with women in Papua New Guinea to extend analysis of existing qualitative data and co-create new primary data. The purpose of this was to inform a transformational grounded theory and subsequent health promoting action. **DESIGN:** A two-step approach was used in a grounded theory study about how women experience male circumcision in Papua New Guinea. Participants analysed portions or 'chunks' of existing qualitative data in story circles and built upon this analysis by using the visual research method of storyboarding. **RESULTS:** New understandings of the data were evoked when women in interpretive focus groups analysed the data 'chunks'. Interpretive focus groups encouraged women to share their personal experiences about male circumcision. The visual method of storyboarding enabled women to draw pictures to represent their experiences. This provided an additional focus for whole-of-group discussions about the research topic. **CONCLUSIONS:** Interpretive focus groups offer opportunity to enhance trustworthiness of findings when researchers undertake secondary analysis of qualitative data. The co-analysis of existing data and co-generation of new data between research

participants and researchers informed an emergent transformational grounded theory and subsequent health promoting action.

118 **Redman-MacLaren ML, Api UK, Darius M, Tommbe R, Mafile'o TA, MacLaren DJ.**

Co-interviewing across gender and culture: expanding qualitative research methods in Melanesia.

BMC Public Health 2014 Sep 6;14:922. doi: 10.1186/1471-2458-14-922.

BACKGROUND: The social and cultural positions of both researchers and research participants influence qualitative methods and study findings. In Papua New Guinea (PNG), as in other contexts, gender is a key organising characteristic and needs to be central to the design and conduct of research. The colonial history between researcher and participant is also critical to understanding potential power differences. This is particularly relevant to public health research, much of which has emerged from a positivist paradigm. This paper describes our critical reflection of flexible researcher responses enacted during qualitative research in PNG. **METHODS:** Led by a senior male HIV researcher from PNG, a male from a PNG university and a female from an Australian university conducted qualitative interviews about faith-based responses to HIV in PNG. The two researchers planned to conduct one-on-one interviews matching gender of participants and interviewer. However, while conducting the study, four participants explicitly requested to be interviewed by both researchers. This experience led us to critically consider socially and culturally situated ways of understanding semi-structured interviewing for public health research in Melanesia. **RESULTS:** New understandings about public health research include: (i) a challenge to the convention that the researcher holds more power than the research participant, (ii) the importance of audience in Melanesia, (iii) cultural safety can be provided when two people co-interview and (iv) the effect an esteemed leader heading the research may have on people's willingness to participate. Researchers who occupy insider-outsider roles in PNG may provide participants new possibilities to communicate key ideas. **CONCLUSIONS:** Our recent experience has taught us that public health research methods that are gender sensitive and culturally situated are pivotal to successful research in Melanesia. Qualitative research requires adaptability and reflexivity. Public health research methods must continue to expand to reflect the diverse worldviews of research participants. Researchers need to remain open to new possibilities for learning.

119 **Reeve D, Melrose W.**

Evaluation of the Og4C3 filter paper technique in lymphatic filariasis prevalence studies.

Lymphology 2014 Jun;47(2):65-72.

Currently there are several tests which can be used for monitoring and evaluating lymphatic filariasis prevalence in mass drug administration (MDA) programs with the ICT as most commonly accepted field test. However, other techniques to determine circulating antigen are available that also could be suitable in these programs. Our aim was to determine the suitability of the Og4C3 filter paper technique to determine antigen prevalence for lymphatic filariasis. We compared multiple antigen methods during the course of baseline clinical

prevalence studies in Papua New Guinea in over 800 subjects. We found that the ICT and Og4C3 filter paper techniques and using blood from the ICT card in the Og4C3 ELISA were equivalent in performance and that the serum Og4C3 ELISA test detected significantly more antigenic individuals. In addition, we found that modification of the Og4C3 assay by removing the boiling step did not affect its performance. Our results indicate that the Og4C3 filter paper technique is suitable for use in elimination of transmission of lymphatic filariasis monitoring and evaluation programs, quality control of ICT testing could be accomplished by using blood from the ICT test card, and with appropriate logistics in place, venous sampling and testing by the serum Og4C3 ELISA is achievable in monitoring and evaluation and would better identify areas with low level antigenaemia prevalence and possible ongoing transmission.

120 **Requena P, Campo JJ, Umbers AJ, Ome M, Wangnapi R, Barrios D, Robinson LJ, Samol P, Rosanas-Urgell A, Ubillos I, Mayor A, López M, de Lazzari E, Arévalo-Herrera M, Fernández-Becerra C, del Portillo H, Chitnis CE, Siba PM, Bardaji A, Mueller I, Rogerson S, Menéndez C, Dobaño C.**

Pregnancy and malaria exposure are associated with changes in the B cell pool and in plasma eotaxin levels.

J Immunol 2014 Sep 15;193(6):2971-2983. doi: 10.4049/jimmunol.1401037. Epub 2014 Aug 18.

Pregnancy triggers immunological changes aimed to tolerate the fetus, but its impact on B lymphocytes is poorly understood. In addition, exposure to the *Plasmodium* parasite is associated with altered distribution of peripheral memory B cell (MBC) subsets. To study the combined impact of high malaria exposure and pregnancy in B cell subpopulations, we analyzed PBMCs from pregnant and nonpregnant individuals from a malaria-nonendemic country (Spain) and from a high malaria-endemic country (Papua New Guinea). In the malaria-naïve cohorts, pregnancy was associated with a significant expansion of all switched (IgD(-)) MBC and a decrease of naïve B cells. Malaria-exposed women had more atypical MBC and fewer marginal zone-like MBC, and their levels correlated with both *Plasmodium vivax*- and *Plasmodium falciparum*-specific plasma IgG levels. Classical but not atypical MBC were increased in *P. falciparum* infections. Moreover, active atypical MBC positively correlated with proinflammatory cytokine plasma concentrations and had lower surface IgG levels than the average. Decreased plasma eotaxin (CCL11) levels were associated with pregnancy and malaria exposure and also correlated with B cell subset frequencies. Additionally, active atypical and active classical MBC expressed higher levels of eotaxin receptor CCR3 than the other B cell subsets, suggesting a chemotactic effect of eotaxin on these B cell subsets. These findings are important to understand immunity to infections like malaria that result in negative outcomes for both the mother and the newborn and may have important implications on vaccine development.

121 **Roth A, Hoy D, Horwood PF, Ropa B, Hancock T, Guillaumot L, Rickart K, Frison P, Pavlin B, Souares Y.**

Preparedness for threat of chikungunya in the Pacific.

Emerg Infect Dis 2014 Aug;20(8). doi: 10.3201/eid2008.130696.

Chikungunya virus (CHIKV) caused significant outbreaks of illness during 2005-2007 in the Indian Ocean region. Chikungunya outbreaks have also occurred in the Pacific region, including in Papua New Guinea in 2012, New Caledonia in April 2013, and Yap State, Federated States of Micronesia, in August 2013. CHIKV is a threat in the Pacific, and the risk for further spread is high, given several similarities between the Pacific and Indian Ocean chikungunya outbreaks. Island health care systems have difficulties coping with high caseloads, which highlights the need for early multidisciplinary preparedness. The Pacific Public Health Surveillance Network has developed several strategies focusing on surveillance, case management, vector control, laboratory confirmation, and communication. The management of this CHIKV threat will likely have broad implications for global public health.

- 122 **Rumsey M, Fletcher SM, Thiessen J, Gero A, Kuruppu N, Daly J, Buchan J, Willetts J.**

A qualitative examination of the health workforce needs during climate change disaster response in Pacific Island Countries.

Hum Resour Health 2014 Feb 12;12:9. doi: 10.1186/1478-4491-12-9.

BACKGROUND: There is a growing body of evidence that the impacts of climate change are affecting population health negatively. The Pacific region is particularly vulnerable to climate change; a strong health-care system is required to respond during times of disaster. This paper examines the capacity of the health sector in Pacific Island Countries to adapt to changing disaster response needs, in terms of: (i) health workforce governance, management, policy and involvement; (ii) health-care capacity and skills; and (iii) human resources for health training and workforce development. **METHODS:** Key stakeholder interviews informed the assessment of the capacity of the health sector and disaster response organizations in Pacific Island Countries to adapt to disaster response needs under a changing climate. The research specifically drew upon and examined the adaptive capacity of individual organizations and the broader system of disaster response in four case study countries (Fiji, Cook Islands, Vanuatu and Samoa). **RESULTS:** 'Capacity' including health-care capacity was one of the objective determinants identified as most significant in influencing the adaptive capacity of disaster response systems in the Pacific. The research identified several elements that could support the adaptive capacity of the health sector such as: inclusive involvement in disaster coordination; policies in place for health workforce coordination; belief in their abilities; and strong donor support. Factors constraining adaptive capacity included: weak coordination of international health personnel; lack of policies to address health worker welfare; limited human resources and material resources; shortages of personnel to deal with psychosocial needs; inadequate skills in field triage and counselling; and limited capacity for training. **CONCLUSION:** Findings from this study can be used to inform the development of human resources for health policies and strategic plans, and to support the development of a coordinated and collaborative approach to disaster response training across the Pacific and other developing contexts. This study

also provides an overview of health-care capacity and some of the challenges and strengths that can inform future development work by humanitarian organizations, regional and international donors involved in climate change adaptation, and disaster risk reduction in the Pacific region.

- 123 **Russell TL, Morgan JC, Ismail H, Kaur H, Eggelte T, Oladepo F, Amon J, Hemingway J, Iata H, Paine MJ.**

Evaluating the feasibility of using insecticide quantification kits (IQK) for estimating cyanopyrethroid levels for indoor residual spraying in Vanuatu.

Malar J 2014 May 9;13:178. doi: 10.1186/1475-2875-13-178.

BACKGROUND: The quality of routine indoor residual spraying (IRS) operations is rarely assessed because of the limited choice of methods available for quantifying insecticide content in the field. This study, therefore, evaluated a user-friendly, rapid colorimetric assay for detecting insecticide content after routine IRS operations were conducted. **METHODS:** This study was conducted in Tafea Province, Vanuatu. Routine IRS was conducted with lambda cyhalothrin. Two methods were used to quantify the IRS activities: 1) pre-spray application of small felt pads and 2) post-spray removal of insecticide with adhesive. The insecticide content was quantified using a colorimetric assay (Insecticide Quantification Kit [IQK]), which involved exposing each sample to the test reagents for 15 minutes. The concentration of insecticide was indicated by the depth of red colour. **RESULTS:** The IQK proved simple to perform in the field and results could be immediately interpreted by the programme staff. The insecticide content was successfully sampled by attaching felt pads to the house walls prior to spraying. The IRS operation was well conducted, with 83% of houses being sprayed at the target dose (20 - 30 mg AI/m²). The average reading across all houses was 24.4 ± 1.5 mg AI/m². The results from the felt pads applied pre-spray were used as a base to compare methods for sampling insecticide from walls post-spray. The adhesive of Sellotape did not collect adequate samples. However, the adhesive of the felt pads provided accurate samples of the insecticide content on walls. **CONCLUSION:** The IQK colorimetric assay proved to be a useful tool that was simple to use under realistic field conditions. The assay provided rapid information on IRS spray dynamics and spray team performance, facilitating timely decision making and reporting for programme managers. The IQK colorimetric assay will have direct applications for routine quality control in malaria control programmes globally and has the potential to improve the efficacy of vector control operations.

- 124 **Ryan CE, Simbiken CS, Agius PA, Allen J, Sauk J, Kaima P, Kombati Z, Siba P, Kaldor JM, Vallely A.**

Comparative performance of the Kalon and HerpeSelect enzyme-linked immunosorbent assays to determine the prevalence of herpes simplex virus type 2 in Papua New Guinea.

Sex Health 2014 Dec;11(6):575-579. doi: 10.1071/SH14055.

Background infection with herpes simplex virus type 2 (HSV-2) is common worldwide and an important risk factor for HIV infection. Aetiological

diagnosis of HSV-2 is typically determined with the use of commercially available type-specific enzyme-linked immunosorbent assays (ELISAs). This study aimed to determine the prevalence of HSV-2 among people attending sexual health clinics in the Highlands of Papua New Guinea. The study also aimed to compare the performance of two type-specific ELISA assays, the Kalon and HerpeSelect glycoprotein G2 assays, in this context. **METHODS:** Participants were recruited as part of a longitudinal sexual health study. Participants attended four appointments over a 12-month period and had blood taken for HSV-2 serology at each time point. Both the Kalon and HerpeSelect assays were performed as per manufacturer's instructions. **RESULTS:** A total of 132 participants were tested for HSV-2 using the Kalon and HerpeSelect ELISAs. HSV-2 prevalence was 52% (95% CI, 43-60) and 61% (95% CI, 52-69) with Kalon and HerpeSelect assays respectively. There was high concordance (87%, $\kappa = 0.75$, $p < 0.001$, $n = 115$) between the two assays at the manufacturer-recommended index value cut-offs. For participants with discordant results at baseline ($n = 16$), three sero-conversions were observed over the 12-month period when sequential sera were tested. **CONCLUSIONS:** A high HSV-2 prevalence was observed in this clinic-based population. Our longitudinal data indicate the higher prevalence of HSV-2 detected with the HerpeSelect ELISA was likely due to false positives rather than a higher sensitivity in the early stages of infection.

125 Sa'avu M, Duke T, Matai S.

Improving paediatric and neonatal care in rural district hospitals in the highlands of Papua New Guinea: a quality improvement approach. *Paediatr Int Child Health* 2014 May;34(2):75-83. doi: 10.1179/2046905513Y.0000000081. Epub 2013 Dec 6.

BACKGROUND: In developing countries such as Papua New Guinea (PNG), district hospitals play a vital role in clinical care, training health-care workers, implementing immunization and other public health programmes and providing necessary data on disease burdens and outcomes. Pneumonia and neonatal conditions are a major cause of child admission and death in hospitals throughout PNG. Oxygen therapy is an essential component of the management of pneumonia and neonatal conditions, but facilities for oxygen and care of the sick newborn are often inadequate, especially in district hospitals. Improving this area may be a vehicle for improving overall quality of care. **METHOD:** A qualitative study of five rural district hospitals in the highlands provinces of Papua New Guinea was undertaken. A structured survey instrument was used by a paediatrician and a biomedical technician to assess the quality of paediatric care, the case-mix and outcomes, resources for delivery of good-quality care for children with pneumonia and neonatal illnesses, existing oxygen systems and equipment, drugs and consumables, infection control facilities and the reliability of the electricity supply to each hospital. A floor plan was drawn up for the installation of the oxygen concentrators and a plan for improving care of sick neonates, and a process of addressing other priorities was begun. **RESULTS:** In remote parts of PNG, many district hospitals are run by under-resourced non-government organizations. Most hospitals had general wards in which both adults and children were managed together. Paediatric case-

loads ranged between 232 and 840 patients per year with overall case-fatality rates (CFR) of 3-6% and up to 15% among sick neonates. Pneumonia accounts for 28-37% of admissions with a CFR of up to 8%. There were no supervisory visits by paediatricians, and little or no continuing professional development of staff. Essential drugs were mostly available, but basic equipment for the care of sick neonates was often absent or incomplete. Infection control measures were inadequate in most hospitals. Cylinders were the major source of oxygen for the district hospitals, and logistical problems and large indirect costs meant that oxygen was under-utilized. There were multiple electricity interruptions, but hospitals had back-up generators to enable the use of oxygen concentrators. After 6 months in each of the five hospitals, high-dependency care areas were planned, oxygen concentrators installed, staff trained in their use, and a plan was set out for improving neonatal care. **INTERPRETATION:** If MGD-4 targets for child health are to be met, reducing neonatal mortality and deaths from pneumonia will have to include better quality services in district hospitals. Establishing better oxygen supplies with a systems approach can be a vehicle for addressing other areas of quality and safety in district hospitals.

126 Sahal Estimé M, Lutz B, Strobel F.

Trade as a structural driver of dietary risk factors for noncommunicable diseases in the Pacific: an analysis of household income and expenditure survey data. *Global Health* 2014 Jun 13;10:48. doi: 10.1186/1744-8603-10-48.

BACKGROUND: Noncommunicable diseases are a health and development challenge. Pacific Island countries are heavily affected by NCDs, with diabetes and obesity rates among the highest in the world. Trade is one of multiple structural drivers of NCDs in the Pacific, but country-level data linking trade, diets and NCD risk factors are scarce. We attempted to illustrate these links in five countries. The study had three objectives: generate cross-country profiles of food consumption and expenditure patterns; highlight the main 'unhealthy' food imports in each country to inform targeted policymaking; and demonstrate the potential of HIES data to analyze links between trade, diets and NCD risk factors, such as obesity. **METHODS:** We used two types of data: obesity rates as reported by WHO and aggregated household-level food expenditure and consumption from Household Income and Expenditure Survey reports. We classified foods in HIES data into four categories: imported/local, 'unhealthy'/'healthy', nontraditional/traditional, processed/unprocessed. We generated cross-country profiles and cross-country regressions to examine the relationships between imported foods and unhealthy foods, and between imported foods and obesity. **RESULTS:** Expenditure on imported foods was considerable in all countries but varied across countries, with highest values in Kiribati (53%) and Tonga (52%) and lowest values in Solomon Islands and Vanuatu (30%). Rice and sugar accounted for significant amounts of imported foods in terms of expenditure and calories, ranking among the top 3 foods in most countries. We found significant or near-significant associations in expenditure and caloric intake between 'unhealthy' and imported foods as well as between imported foods and obesity, though inferences based on these associations should be made carefully due to

data constraints. **CONCLUSIONS:** While additional research is needed, this study supports previous findings on trade as a structural driver of NCD risk and identifies the top imported foods that could serve as policy targets. Moreover, this analysis is proof-of-concept that the methodology is a cost-effective way for countries to use existing data to generate policy-relevant evidence on links between trade and NCDs. We believe that the methodology is replicable to other countries globally. A user-friendly Excel tool is available upon request to assist such analyses.

127 Sanga K, Mola G, Wattimena J, Justesen A, Black KI.

Unintended pregnancy amongst women attending antenatal clinics at the Port Moresby General Hospital.

Aust NZ J Obstet Gynaecol 2014 Aug;54(4):360-365. doi: 10.1111/ajo.12219. Epub 2014 May 21.

BACKGROUND: National survey data from Papua New Guinea (PNG) suggest that women are having almost 1.5 times the number of children they desire. Women's ability to space and limit the number of children could have a significant impact on the country's high infant and maternal mortality rates. **AIM:** To determine the prevalence and demographic associations of unintended pregnancy in women presenting for antenatal care to Port Moresby General Hospital. **METHODS:** From November 2011 to February 2012, we administered a structured questionnaire to women attending antenatal clinics covering pregnancy intention, contraceptive use and demographic information. **RESULTS:** Amongst the 1198 respondents, 49.4% of the pregnancies were reported as unintended with significantly higher proportions amongst women with no education or education only to primary school level (OR:1.46, CI: 1.10-1.92), unmarried women (OR:7.16, CI: 4.08-12.58), women whose first sexual encounter was under the age of 20 (OR 1.55, CI: 1.20-1.99) and women with three or more children compared to those having their first child (OR: 2.70, CI:1.86-3.93). Amongst multiparous women, a short birth interval of less than two years was significantly associated with unintended pregnancy ($p < 0.001$). **CONCLUSIONS:** Unintended pregnancy was common and occurred more frequently amongst women who already had three or more children, often leading to birth spacing of under two years. There is a need for effective programs and strategies to increase access to contraceptive information and services. Immediate provision of long-acting reversible contraceptive methods in the postnatal period could facilitate such access and reduce unplanned pregnancy amongst multiparous women.

128 Sankoh O, Sharrow D, Herbst K, Whiteson Kabudula C, Alam N, Kant S, Ravn H, Bhuiya A, Thi Vui L, Darikwa T, Gyapong M, Jasseh M, Chuc Thi Kim N, Abdullah S, Crampin A, Ojal J, Owusu-Agyei S, Odhiambo F, Urassa M, Streatfield K, Shimada M, Sacoor C, Beguy D, Derra K, Wak G, Delaunay V, Sie A, Soura A, Diallo D, Wilopo S, Masanja H, Bonfoh B, Phuanukoonnon S, Clark SJ.

The INDEPTH standard population for low- and middle-income countries, 2013.

Glob Health Action 2014 Mar 27;7:23286. doi: 10.3402/gha.v7.23286. eCollection 2014.

Crude rates such as the crude death rate are functions of both the age-specific rates and the age

composition of a population. However, differences in the age structure between two populations or two time periods can result in spurious differences in the corresponding crude rates making direct comparisons between populations or across time inappropriate. Therefore, when comparing crude rates between populations, it is desirable to eliminate or minimize the influence of age composition. This task is accomplished by using a standard age structure yielding an age-standardized rate. This paper proposes an updated International Network for the Demographic Evaluation of Populations and Their Health (INDEPTH) standard for use in low- and middle-income countries (LMICs) based on newly available data from the health and demographic surveillance system site members of the INDEPTH network located throughout Africa and southern Asia. The updated INDEPTH standard should better reflect the age structure of LMICs and result in more accurate health indicators and demographic rates. We demonstrate use of the new INDEPTH standard along with several existing 'world' standards and show how resulting age-standardized crude death rates differ when using the various standard age compositions.

129 Schmidt MS, King CL, Thomsen EK, Siba PM, Sanuku N, Fleckenstein L.

Liquid chromatography-mass spectrometry analysis of diethylcarbamazine in human plasma for clinical pharmacokinetic studies.

J Pharm Biomed Anal 2014 Sep;98:307-310. doi: 10.1016/j.jpba.2014.05.016. Epub 2014 May 22.

A sensitive and selective liquid chromatographic method using mass spectrometric detection was developed for the determination of diethylcarbamazine (DEC) in human plasma. DEC and its stable isotope internal standard d3-DEC were extracted from 0.25mL of human plasma using solid phase extraction. Chromatography was performed using a Phenomenex Synergi 4 μ Fusion-RP column (2mm \times 250mm) with gradient elution. The retention time was approximately 4.8 minutes. The assay was linear from 4 to 2200ng/mL. Analysis of quality control samples at 12, 300, and 1700ng/mL ($N = 15$) had interday coefficients of variation of 8.4%, 5.4%, and 6.2%, respectively ($N = 15$). Interday bias results were -2.2%, 6.0%, and 0.8%, respectively. Recovery of DEC from plasma ranged from 84.2% to 90.1%. The method was successfully applied to clinical samples from patients with lymphatic filariasis from a drug-drug interaction study between DEC and albendazole and/or ivermectin.

130 Science

The circumcision conundrum.

Science 2014 Jul 11;345(6193):161. doi: 10.1126/science.345.6193.161.

131 Science

Prevention, Papua New Guinea style.

Science 2014 Jul 11;345(6193):160-161. doi: 10.1126/science.345.6193.160.

132 Science

Papua New Guinea. In PNG, the epidemic that wasn't.

Science 2014 Jul 11;345(6193):158-161. doi: 10.1126/science.345.6193.158.

133 Senn N, Rarau P, Salib M, Manong D, Siba P,

Rogerson S, Mueller I, Genton B.

Use of antibiotics within the IMCI guidelines in outpatient settings in Papua New Guinean children: an observational and effectiveness study.

PLoS One 2014 Mar 13;9(3):e90990. doi: 10.1371/journal.pone.0090990. eCollection 2014.

INTRODUCTION: There is a need to investigate the effectiveness and appropriateness of antibiotics prescription within the Integrated Management of Childhood Illness (IMCI) strategy in the context of routine outpatient clinics. **METHODS:** Making use of a passive case detection system established for a malaria prevention trial in outpatient clinics in Papua New Guinea, the appropriateness and effectiveness of the use of antibiotics within the IMCI was assessed in 1605 young children. Main outcomes were prescription of antibiotics and re-attendances within 14 days for mild pneumonia, mild diarrhoea and uncomplicated malaria whether they were managed with or without antibiotics (proxy of effectiveness). Appropriateness was assessed for both mild and severe cases, while effectiveness was assessed only for mild diseases. **RESULTS:** A total of 6975 illness episodes out of 8944 fulfilled inclusion criteria (no previous attendance <14 days + full medical records). Clinical incidence rates (episodes/child/year; 95% CI) were 0.85 (0.81-0.90) for pneumonia, 0.62 (0.58-0.66) for malaria and 0.72 (0.65-0.93) for diarrhoea. Fifty-three percent of 6975 sick children were treated with antibiotics, 11% were not treated with antibiotics when they should have been and in 29% antibiotics were prescribed when they should not have been. Re-attendance rates within 14 days following clinical diagnosis of mild pneumonia were 9% (126/1401) when managed with antibiotics compared to 8% (56/701) when managed without (adjusted Hazard Ratio (aHR)=1.00 (0.57-1.76), $p = 0.98$). Rates for mild diarrhoea were 8% (73/874) and 9% (79/866) respectively (aHR = 0.8 (0.42-1.57), $p = 0.53$). **CONCLUSION:** Non-adherence to IMCI recommendations for prescription of antibiotics is common in routine settings in Papua New Guinea. Although recommended, the use of antibiotics in young children with mild pneumonia as defined by IMCI criteria did not impact on their outcome. Better tools and new strategies for the identification of bacterial infections that require antibiotics are urgently needed.

134 Sheridan SA, Brolan CE, Fitzgerald L, Tasserei J, Maleb MF, Rory JJ, Hill PS.

Facilitating health and wellbeing is 'everybody's role': youth perspectives from Vanuatu on health and the post-2015 sustainable development goal agenda.

Int J Equity Health 2014 Oct 10;13(1):80. doi: 10.1186/s12939-014-0080-8.

BACKGROUND: Progress towards achievement of the Millennium Development Goals (MDGs) amongst Pacific island countries (PICs) has seen mixed results. As focus shifts to formulation of new health-related development goals beyond 2015, there is a need for bringing community consultation into this process. For this purpose, Go4Health is a global consortium examining the development of these goals, with Work Package 2 capturing viewpoints of marginalised populations regarding health. This paper examines the perspectives of youth in Vanuatu on essential health needs in the context of the post-2015 development agenda, to make these concerns more visible for their communities, stakeholders and health policy decision

makers. **METHODS:** As part of a larger investigation undertaken in Vanuatu involving 100 residents from various rural and urban communities, this paper explores the perspectives of twenty 17-year-old secondary school students gathered through two focus group discussions during September 2013. Questions sought viewpoints across areas including health ideals, essential needs, responsibility for health services and their governance. Focus group discussions were conducted in English and digitally recorded, with resulting transcripts subjected to thematic analysis. **RESULTS:** This youth cohort from Vanuatu had a strong understanding of the social determinants of health. They placed value on all aspects of health, indicating the need for youth to have access to positive lifestyle opportunities (sport, community participation) and also increased protection from the impact of harmful substances and causes of chronic illness. Participants identified barriers to health due to unevenly distributed health services throughout Vanuatu, with members at all levels of society ultimately perceived as responsible for improving health throughout the nation. **CONCLUSION:** Against a background of a weak health system and significant challenges to public health, young people are acutely aware that improving Vanuatu's health status requires a communal effort. While contributing factors to health depend on actions taken at individual, local, national and global levels, no single actor currently provides enough support to cover all essential health needs. As a consequence, they see health in the Pacific as 'everybody's role', of importance for the post-2015 sustainable development goal agenda and health policy makers in general.

135 Siefken K, Schofield G, Schulenkorf N.

'Laefstael jenses': an investigation of barriers and facilitators for healthy lifestyles of women in an urban Pacific island context.

J Phys Act Health 2014 Jan;11(1):30-37. doi: 10.1123/jpah.2012-0013. Epub 2012 Dec 17.

BACKGROUND: The Pacific region has experienced rapid urbanization and lifestyle changes, which lead to high rates of noncommunicable disease (NCD) prevalence. There is no information on barriers and facilitators for healthy lifestyles in this region. In response, we present the first stage of a rigorous development of an urban Pacific health intervention program. This paper describes formative work conducted in Port Vila, Vanuatu. The objective of this paper was to understand cultural barriers and facilitators in Pacific women to lifestyle change and use the findings to inform future health interventions. **METHODS:** Semistructured focus groups with 37 female civil servants divided into 6 groups were held verbally to understand barriers and facilitators for healthy lifestyles. **RESULTS:** Several perceived barriers and facilitators were identified. Inter alia, barriers include financial limitations, time issues, family commitments, environmental aspects, and motivational hindrances that limit time and opportunities for healthy lifestyle behavior. Facilitators include more supportive environments, social support mechanisms, and the implementation of rigorous health policies. **CONCLUSIONS:** Formative work is essential in designing health intervention programs. Uncovered barriers and facilitators help inform the development of culturally relevant health interventions.

136 **Small ST, Tisch DJ, Zimmerman PA.**

Molecular epidemiology, phylogeny and evolution of the filarial nematode *Wuchereria bancrofti*. *Infect Genet Evol* 2014 Dec;28:33-43. doi: 10.1016/j.meegid.2014.08.018. Epub 2014 Aug 29.

Wuchereria bancrofti (Wb) is the most widely distributed of the three nematodes known to cause lymphatic filariasis (LF), the other two being *Brugia malayi* and *Brugia timori*. Current tools available to monitor LF are limited to diagnostic tests targeting DNA repeats, filarial antigens, and anti-filarial antibodies. While these tools are useful for detection and surveillance, elimination programs have yet to take full advantage of molecular typing for inferring infection history, strain fingerprinting, and evolution. To date, molecular typing approaches have included whole mitochondrial genomes, genotyping, targeted sequencing, and random amplified polymorphic DNA (RAPDs). These studies have revealed much about Wb biology. For example, in one study in Papua New Guinea researchers identified 5 major strains that were widespread and many minor strains, some of which exhibit geographic stratification. Genome data, while rare, have been utilized to reconstruct evolutionary relationships among taxa of the Onchocercidae (the clade of filarial nematodes) and identify gene synteny. Their phylogeny reveals that speciation from the common ancestor of both *B. malayi* and Wb occurred around 5-6 million years ago with shared ancestry to other filarial nematodes as recent as 15 million years ago. These discoveries hold promise for gene discovery and identifying drug targets in species that are more amenable to in vivo experiments. Continued technological developments in whole genome sequencing and data analysis will likely replace many other forms of molecular typing, multiplying the amount of data available on population structure, genetic diversity, and phylogenetics. Once widely available, the addition of population genetic data from genomic studies should hasten the elimination of LF parasites like Wb. Infectious disease control programs have benefited greatly from population genetics data and recently from population genomics data. However, while there is currently a surplus of data for diseases like malaria and HIV, there is a scarcity of these data for filarial nematodes. With the falling cost of genome sequencing, research on filarial nematodes could benefit from the addition of population genetics statistics and phylogenetics especially in dealing with elimination programs. A comprehensive review focusing on population genetics of filarial nematodes does not yet exist. Here our goal is to provide a current overview of the molecular epidemiology of *W. bancrofti* (Wb), the primary causative agent of LF. We begin by reviewing studies utilizing molecular typing techniques with specific focus on genomic and population datasets. Next, we used whole mitochondrial genome data to construct a phylogeny and examine the evolutionary history of the Onchocercidae. Then, we provide a perspective to aid in understanding how population genetic techniques translate to modern epidemiology. Finally, we introduce the concept of genomic epidemiology and provide some examples that will aid in future studies of Wb.

137 **Snowdon W, Malakellis M, Millar L, Swinburn B.**

Ability of body mass index and waist circumference to identify risk factors for non-communicable disease in the Pacific Islands.

Obes Res Clin Pract 2014 Jan-Feb;8(1):e36-45. doi: 10.1016/j.orcp.2012.06.005.

Body mass index and waist circumference are widely used tools to identify risk of non-communicable diseases. Research has indicated that the risk relationships differ by ethnicity. In this study, data from chronic disease surveys in Fiji, Nauru, Solomon Islands and Wallis and Futuna were merged and analysed using receiver operator curves. The action points for body mass index and waist circumference with the highest specificity and sensitivity for identifying the risk of NCDs were identified. The analysis showed considerable differences between Melanesians and other Pacific Islanders, and also gender differences. Action points for non-Melanesians were higher than for Melanesians, and region-wide values are therefore inappropriate.

138 **Soli KW, Maure T, Kas MP, Bande G, Bebes S, Luang-Suarkia D, Siba PM, Morita A, Umezaki M, Greenhill AR, Horwood PF.**

Detection of enteric viral and bacterial pathogens associated with paediatric diarrhoea in Goroka, Papua New Guinea.

Int J Infect Dis 2014 Oct;27:54-58. doi: 10.1016/j.ijid.2014.02.023. Epub 2014 Sep 1.

OBJECTIVES: The aim of this study was to investigate the viral and bacterial causes of acute watery diarrhoea in hospitalized children in Papua New Guinea. **METHODS:** A retrospective analysis was conducted on stool samples collected from 199 children (age <5 years) admitted to the paediatric ward of Goroka General Hospital from August 2009 through November 2010. A large range of viral and bacterial enteric pathogens were targeted using real-time PCR/RT-PCR assays. **RESULTS:** Young children were much more likely to be admitted with acute gastroenteritis, with 62.8% of patients aged <1 year and 88.4% aged <2 years. An enteric pathogen was detected in 69.8% (n = 138) of patients. The most commonly detected pathogens were *Shigella* spp. (26.6%), rotavirus (25.6%), adenovirus types 40/41 (11.6%), enterotoxigenic *Escherichia coli* (11.1%), enteropathogenic *E. coli* (8.5%), norovirus G2 (6.0%), and *Campylobacter* spp. (4.0%). Norovirus G1, sapovirus, and *Salmonella* spp. were also detected, but below our statistical limit of detection. *Vibrio cholerae* and astrovirus were not detected in any patients. Mixed infections were detected in 22.1% of patients, with *Shigella* and rotavirus most commonly detected in co-infections with other pathogens. **CONCLUSIONS:** This study demonstrates that *Shigella* and rotavirus are the major pathogens associated with acute paediatric gastroenteritis in this setting.

139 **Speare R, Harrington H, Canyon D, Massey PD.**

A systematic literature review of pediculosis due to head lice in the Pacific Island Countries and Territories: what country specific research on head lice is needed?

BMC Dermatol 2014 Jun 24;14:11. doi: 10.1186/1471-5945-14-11.

BACKGROUND: Lack of guidelines on control of pediculosis in the Solomon Islands led to a search for relevant evidence on head lice in the Pacific Island Countries and Territories (PICTs). The aim of this search was to systematically evaluate evidence in the peer reviewed literature on pediculosis due to head lice (*Pediculus humanus* var. *capitis*) in

the 22 PICTs from the perspective of its value in informing national guidelines and control strategies. METHODS: PubMed, Web of Science, CINAHL and Scopus were searched using the terms (pediculosis OR head lice) AND each of the 22 PICTs individually. PRISMA methodology was used. Exclusion criteria were: i) not on topic; ii) publications on pediculosis not relevant to the country of the particular search; iii) in grey literature. RESULTS: Of 24 publications identified, only 5 were included. Four related to treatment and one to epidemiology. None contained information relevant to informing national guidelines. CONCLUSIONS: Current local evidence on head lice in the PICTs is minimal and totally inadequate to guide any recommendations for treatment or control. We recommend that local research is required to generate evidence on: i) epidemiology; ii) knowledge, attitudes and practices of health care providers and community members; iii) efficacy of local commercially available pharmaceutical treatments and local customary treatments; iv) acceptability, accessibility and affordability of available treatment strategies; and v) appropriate control strategies for families, groups and institutions. We also recommend that operational research be done by local researchers based in the PICTs, supported by experienced head lice researchers, using a two way research capacity building model.

140 Spickett JT, Katscherian D.

Health impacts of climate change in the Solomon Islands: an assessment and adaptation action plan. *Glob J Health Sci* 2014 Jun 25;6(5):261-273. doi: 10.5539/gjhs.v6n5p261.

The Pacific island countries are particularly vulnerable to the environmental changes wrought by global climate change such as sea level rise, more frequent and intense extreme weather events and increasing temperatures. The potential biophysical changes likely to affect these countries have been identified and it is important that consideration be given to the implications of these changes on the health of their citizens. The potential health impacts of climatic changes on the population of the Solomon Islands were assessed through the use of a Health Impact Assessment framework. The process used a collaborative and consultative approach with local experts to identify the impacts to health that could arise from local environmental changes, considered the risks associated with these and proposed appropriate potential adaptive responses. Participants included knowledgeable representatives from the biophysical, socio-economic, infrastructure, environmental diseases and food sectors. The risk assessments considered both the likelihood and consequences of the health impacts occurring using a qualitative process. To mitigate the adverse effects of the health impacts, an extensive range of potential adaptation strategies were developed. The overall process provided an approach that could be used for further assessments as well as an extensive range of responses which could be used by sectors and to assist future decision making associated with the Solomon Islands' responses to climate change.

141 Stanisic DI, Cutts J, Eriksson E, Fowkes FJ, Rosanas-Urgell A, Siba P, Laman M, Davis TME, Manning L, Mueller I, Schofield L.

$\gamma\delta$ T cells and CD14⁺ monocytes are predominant cellular sources of cytokines and chemokines associated with severe malaria.

J Infect Dis 2014 Jul 15;210(2):295-305. doi: 10.1093/infdis/jiu083. Epub 2014 Feb 12.

BACKGROUND: Severe malaria (SM) is associated with high levels of cytokines such as tumor necrosis factor (TNF), interleukin 1 (IL-1), and interleukin 6 (IL-6). The role of chemokines is less clear, as is their cellular source. METHODS: In a case-control study of children with SM (n = 200), uncomplicated malaria (UM) (n = 153) and healthy community controls (HC) (n = 162) in Papua New Guinea, we measured cytokine/chemokine production by peripheral blood mononuclear cells (PBMCs) stimulated with live *Plasmodium falciparum* parasitized red blood cells (pRBC). Cellular sources were determined. Associations between immunological endpoints and clinical/parasitological variables were tested. RESULTS: Compared to HC and UM, children with SM produced significantly higher IL-10, IP-10, MIP-1 β and MCP-2. TNF and MIP-1 α were significantly higher in the SM compared to the UM group. IL-10, IL-6, MIP-1 α , MIP-1 β , and MCP-2 were associated with increased odds of SM. SM syndromes were associated with distinct cytokine/chemokine response profiles compared to UM cases. TNF, MIP-1 β , and MIP-1 α were produced predominantly by monocytes and $\gamma\delta$ T cells, and IL-10 by CD4⁺ T cells. CONCLUSIONS: Early/innate PBMC responses to pRBC in vitro are informative as to cytokines/chemokines associated with SM. Predominant cellular sources are monocytes and $\gamma\delta$ T cells. Monocyte-derived chemokines support a role for monocyte infiltrates in the etiology of SM.

142 Teo A, Hasang W, Randall LM, Feng G, Bell L, Unger H, Langer C, Beeson JG, Siba PM, Mueller I, Molyneux ME, Brown GV, Rogerson SJ.

Decreasing malaria prevalence and its potential consequences for immunity in pregnant women.

J Infect Dis 2014 Nov 1;210(9):1444-1455. doi: 10.1093/infdis/jiu264. Epub 2014 May 5.

BACKGROUND: As malaria control is intensified, pregnant women may be less exposed to malaria, thus affecting the acquisition of protective antibody. METHODS: Plasma samples were collected from Malawian and Papua New Guinean (PNG) pregnant women enrolled over 7-year periods, during which malaria prevalence fell by over two-thirds. Immunoglobulin G (IgG) levels to schizont extract, merozoite antigens, and VAR2CSA-DBL5 ϵ were measured by enzyme-linked immunosorbent assay (ELISA). Levels of IgG to variant surface antigens of infected erythrocytes (IEs) and merozoites and levels of opsonizing IgG to IEs were measured by flow cytometry. RESULTS: In both settings, levels of antibodies in pregnant women to recombinant antigens and to intact IEs but not of opsonizing antibodies decreased over time. After adjustment for coverage with insecticide-treated bed nets (ITNs), these differences disappeared in the Malawian cohort, whereas in the PNG cohort, time was independently associated with a decrease in several antibody responses measured by ELISA. CONCLUSIONS: The impact of falling parasite prevalence on anti-*Plasmodium falciparum* serological indicators in pregnant women varies by setting. Increased ITN coverage may affect development of antibodies to recombinant antigens, but levels of opsonizing IgG remained stable over time. Opsonizing IgG against placental-binding IEs may persist, thus offering longer-lasting protection against malaria during pregnancy.

- 143 **Terheggen U, Drew DR, Hodder AN, Cross NJ, Mugenyi CK, Barry AE, Anders RF, Dutta S, Osier FH, Elliott SR, Senn N, Stanisic DI, Marsh K, Siba PM, Mueller I, Richards JS, Beeson JG.** Limited antigenic diversity of *Plasmodium falciparum* apical membrane antigen 1 supports the development of effective multi-allele vaccines. *BMC Med* 2014 Oct 16;12:183. doi: 10.1186/s12916-014-0183-5.

BACKGROUND: Polymorphism in antigens is a common mechanism for immune evasion used by many important pathogens, and presents major challenges in vaccine development. In malaria, many key immune targets and vaccine candidates show substantial polymorphism. However, knowledge on antigenic diversity of key antigens, the impact of polymorphism on potential vaccine escape, and how sequence polymorphism relates to antigenic differences is very limited, yet crucial for vaccine development. *Plasmodium falciparum* apical membrane antigen 1 (AMA1) is an important target of naturally acquired antibodies in malaria immunity and a leading vaccine candidate. However, AMA1 has extensive allelic diversity with more than 60 polymorphic amino acid residues and more than 200 haplotypes in a single population. Therefore, AMA1 serves as an excellent model to assess antigenic diversity in malaria vaccine antigens and the feasibility of multi-allele vaccine approaches. While most previous research has focused on sequence diversity and antibody responses in laboratory animals, little has been done on the cross-reactivity of human antibodies. **METHODS:** We aimed to determine the extent of antigenic diversity of AMA1, defined by reactivity with human antibodies, and to aid the identification of specific alleles for potential inclusion in a multi-allele vaccine. We developed an approach using a multiple-antigen-competition enzyme-linked immunosorbent assay (ELISA) to examine cross-reactivity of naturally acquired antibodies in Papua New Guinea and Kenya, and related this to differences in AMA1 sequence. **RESULTS:** We found that adults had greater cross-reactivity of antibodies than children, although the patterns of cross-reactivity to alleles were the same. Patterns of antibody cross-reactivity were very similar between populations (Papua New Guinea and Kenya), and over time. Further, our results show that antigenic diversity of AMA1 alleles is surprisingly restricted, despite extensive sequence polymorphism. Our findings suggest that a combination of three different alleles, if selected appropriately, may be sufficient to cover the majority of antigenic diversity in polymorphic AMA1 antigens. Antigenic properties were not strongly related to existing haplotype groupings based on sequence analysis. **CONCLUSIONS:** Antigenic diversity of AMA1 is limited and a vaccine including a small number of alleles might be sufficient for coverage against naturally circulating strains, supporting a multi-allele approach for developing polymorphic antigens as malaria vaccines.

- 144 **Ting F, Bhat A, Savdie R, Ende D, Shein TT.** Urological vignette. Satellite lesion in the bladder from urachal enteric adenocarcinoma. *Int J Surg Case Rep* 2014;5(3):145-148. doi: 10.1016/j.ijscr.2014.01.014. Epub 2014 Jan 29.

INTRODUCTION: We present, to the best of our knowledge, the first published case report of a satellite lesion within the bladder from enteric type

urachal adenocarcinoma (UA). **PRESENTATION OF CASE:** Our case report involves a 38-year-old man from the Solomon Islands who underwent open partial cystectomy for UA. However, resection margins were positive due to the novel finding of a satellite lesion on histopathological assessment. Salvage cystectomy was subsequently performed and the patient had an uncomplicated post-operative recovery. **DISCUSSION:** This case highlights the importance of achieving negative soft tissue and bladder margins on initial resection of UA, as the consequences of incomplete resection can place significant additional morbidity on the patient. **CONCLUSION:** We aim to highlight the possibility of satellite lesions within the bladder in UA and suggest that further studies looking at this phenomenon are required to establish its incidence and overall impact on management of UA.

- 145 **Trejaut JA, Poloni ES, Yen JC, Lai YH, Loo JH, Lee CL, He CL, Lin M.**

Taiwan Y-chromosomal DNA variation and its relationship with Island Southeast Asia. *BMC Genet* 2014 Jun 26;15:77. doi: 10.1186/1471-2156-15-77.

BACKGROUND: Much of the data resolution of the haploid non-recombining Y chromosome (NRY) haplogroup O in East Asia is still rudimentary and could be an explanatory factor for current debates on the settlement history of Island Southeast Asia (ISEA). Here, 81 slowly evolving markers (mostly SNPs) and 17 Y-chromosomal short tandem repeats were used to achieve higher level molecular resolution. Our aim is to investigate if the distribution of NRY DNA variation in Taiwan and ISEA is consistent with a single pre-Neolithic expansion scenario from Southeast China to all ISEA, or if it better fits an expansion model from Taiwan (the OOT model), or whether a more complex history of settlement and dispersals throughout ISEA should be envisioned. **RESULTS:** We examined DNA samples from 1658 individuals from Vietnam, Thailand, Fujian, Taiwan (Han, plain tribes and 14 indigenous groups), the Philippines and Indonesia. While haplogroups O1a*-M119, O1a1*-P203, O1a2-M50 and O3a2-P201 follow a decreasing cline from Taiwan towards Western Indonesia, O2a1-M95/M88, O3a*-M324, O3a1c-IMS-JST002611 and O3a2c1a-M133 decline northward from Western Indonesia towards Taiwan. Compared to the Taiwan plain tribe minority groups the Taiwanese Austronesian speaking groups show little genetic paternal contribution from Han. They are also characterized by low Y-chromosome diversity, thus testifying for fast drift in these populations. However, in contrast to data provided from other regions of the genome, Y-chromosome gene diversity in Taiwan mountain tribes significantly increases from North to South. **CONCLUSION:** The geographic distribution and the diversity accumulated in the O1a*-M119, O1a1*-P203, O1a2-M50 and O3a2-P201 haplogroups on one hand, and in the O2a1-M95/M88, O3a*-M324, O3a1c-IMS-JST002611 and O3a2c1a-M133 haplogroups on the other, support a pincer model of dispersals and gene flow from the mainland to the islands which likely started during the late upper Paleolithic, 18,000 to 15,000 years ago. The branches of the pincer contributed separately to the paternal gene pool of the Philippines and conjointly to the gene pools of Madagascar and the Solomon Islands. The North to South increase in

diversity found for Taiwanese Austronesian speaking groups contrasts with observations based on mitochondrial DNA, thus hinting to a differentiated demographic history of men and women in these populations.

146 Tynan A, Vallely A, Kelly A, Kupul M, Naketrumb R, Aeno H, Siba P, Kaldor JM, Hill PS.

Building social currency with foreskin cuts: a coping mechanism of Papua New Guinea health workers and the implications for new programmes.

Health Policy Plan 2014 Oct;29(7):902-911. doi: 10.1093/heapol/czt072. Epub 2013 Oct 8.

BACKGROUND: Recent research as part of a multi-disciplinary investigation on the acceptability and impact of male circumcision for HIV prevention in Papua New Guinea (PNG) has shown that health workers (HWs) undertake unauthorized forms of penile cutting practices in public health facilities or in community settings, at times within a traditional context. Participation in these activities shares common features with coping mechanisms, strategies used by HWs to alleviate the burden of unsatisfactory living and working conditions. Coping mechanisms, however, are typically described as motivated by economic advantage, but in PNG evidence exists that the behaviours of HWs are also influenced by opportunities for social capital. **METHODS:** Twenty-five in-depth interviews (IDIs) were completed with a variety of HWs from 2009 until 2011 and were triangulated with findings from 45 focus group discussions and 82 IDIs completed with community members as part of a wider qualitative study. Thematic analysis examined HW participation in unauthorized penile cutting services. **RESULTS:** The emergence of unauthorized practices as a coping mechanism in PNG is compelled by mutual obligations and social capital arising from community recognition and satisfaction of moral, professional and cultural obligations. Using the example of unauthorized penile cutting practices amongst HWs in PNG, the research shows that although economic gains are not explicitly derived, evidence exists that they meet other community and sociocultural responsibilities forming a social currency within local traditional economies. **CONCLUSIONS:** Coping mechanisms create an opportunity to extend the boundaries of a health system at the discretion of the HW. Fragile health systems create opportunities for coping mechanisms to become institutionalized, pre-empting appropriate policy development or regulation in the introduction of new programmes. In order to ensure the success of new programmes, the existence of such practices and their potential implications must be addressed within programme design, and in implementation and regulation.

147 Vallely A, Ryan CE, Allen J, Sauk JC, Simbiken CS, Wapling J, Kaima P, Kombati Z, Law G, Fehler G, Murray JM, Siba P, Kaldor JM.

High prevalence and incidence of HIV, sexually transmissible infections and penile foreskin cutting among sexual health clinic attendees in Papua New Guinea.

Sex Health 2014 Mar;11(1):58-66. doi: 10.1071/SH13197.

BACKGROUND: Papua New Guinea (PNG) has one of the highest prevalences of HIV and sexually transmissible infections (STIs) in the Asia-Pacific region, and one of the highest burdens of maternal syphilis and cervical cancer globally. Despite this

disease burden, only limited clinical research in sexual and reproductive health has been conducted in PNG. **METHODS:** A longitudinal clinical cohort study was conducted at two sexual health clinics. Participants completed a behavioural interview, clinical assessment and genital examination at baseline, and at 12, 24 and 50 weeks, including specimen collection for STI diagnostics. **RESULTS:** In total, 154 people attended a screening visit. Reattendance at 12, 24 and 50 weeks was 87%, 78% and 80% respectively. At baseline, HIV prevalence was 3.3%; chlamydia (*Chlamydia trachomatis*), 29.2%; gonorrhoea (*Neisseria gonorrhoeae*), 22.1%; *Trichomonas vaginalis* 15.6%; herpes simplex type-2 (HSV-2), 46.1%; active syphilis, 11.7%. Multiple infections were common particularly among women. The incidence of chlamydia was 27 per 100 person-years (PY); gonorrhoea, 15 out of 100 PY; *T. vaginalis*, 29 out of 100 PY; HSV-2, 12 out of 100 PY; syphilis, 8 out of 100 PY. No incident HIV cases were recorded. At baseline, 39% of men in Mt Hagen and 65% in Port Moresby had a penile foreskin cut, with a dorsal slit being the most common. Two men underwent penile cutting during the follow-up period. **CONCLUSIONS:** The prevalence and incidence of STIs, HIV and penile cutting were high among sexual health clinic attendees. High retention figures suggest that this population may be suitable for future interventions research and clinical trials.

148 Vallely LM, Homiehombo P, Kelly-Hanku A, Kumbia A, Mola GD, Whittaker A.

Hospital admission following induced abortion in Eastern Highlands Province, Papua New Guinea – a descriptive study.

PLoS One 2014 Oct 17;9(10):e110791. doi: 10.1371/journal.pone.0110791. eCollection 2014.

BACKGROUND: In Papua New Guinea abortion is restricted under the Criminal Code Act. While safe abortions should be available in certain situations, frequently they are not available to the majority of women. Sepsis from unsafe abortion is a leading cause of maternal mortality. Our findings form part of a wider, mixed methods study designed to identify complications requiring hospital treatment for post abortion care and to explore the circumstances surrounding unsafe abortion. **METHODS:** Through a six month prospective study we identified all women presenting to the Eastern Highlands Provincial Hospital following spontaneous and induced abortions. We undertook semi-structured interviews with women and reviewed individual case notes, extracting demographic and clinical information. **FINDINGS:** Case notes were reviewed for 56% (67/119) of women presenting for post abortion care. At least 24% (28/119) of these admissions were due to induced abortion. Women presenting following induced abortions were significantly more likely to be younger, single and in education at the time of the abortion and report that the baby was unplanned and unwanted, compared to those reporting spontaneous abortion. Obtained illegally, misoprostol was the method most frequently used to end the pregnancy. Physical and mechanical means and traditional herbs were also widely reported. **CONCLUSION:** In a country with a low contraceptive prevalence rate and high unmet need for family planning, all reproductive age women need access to contraceptive information and services to avoid, postpone or space pregnancies. In the absence of this, women are resorting to unsafe means to end an

unwanted pregnancy, putting their lives at risk and putting an increased strain on an already struggling health system. Women in this setting need access to safe, effective means of abortion.

- 149 **van Gemert C, Stooze M, Kwarteng T, Bulu S, Bergeri I, Wanyeki I, Badman S, Malverus J, Vella A, Tarivonda L, Johnston LG.**

Chlamydia prevalence and associated behaviours among female sex workers in Vanuatu: results from an integrated bio-behavioural survey, 2011. *AIDS Behav* 2014 Oct;18(10):2040-2049. doi: 10.1007/s10461-014-0791-2.

There are insufficient data on sexually transmitted infections (STI) and related behaviours among key populations, including female sex workers (FSW), in the Pacific region. Using respondent driven sampling, we conducted an integrated bio-behavioural survey with FSW in Vanuatu (aged ≥ 18 years) to investigate risk behaviours associated with *Chlamydia trachomatis* (CT). Weighted population estimates and correlates of CT infection were calculated. Among 149 FSW, prevalence of CT was 36% (95% CI 26-48%). Few FSW reported consistent condom use with recent transactional sex partners (TSP) (8%; 95% CI 2-13%). CT infection was positively associated with increasing number of TSP (adjusted odds ratio [AOR] 1.1; 95% CI 1.0-1.2) and group sex (AOR 2.9; 95% CI 1.1-8.2). CT was negatively associated with increasing age of first sex (AOR 0.6; 95% CI 0.5-0.9) and previous STI treatment (AOR 0.1; 95% CI 0.0-0.4). A comprehensive public health strategy for prevention and treatment of STI among FSW, incorporating community empowerment strategies, FSW-targeted health services and periodic presumptive treatment, is urgently needed in Vanuatu.

- 150 **van Oven M, Brauer S, Choi Y, Ensing J, Schiefenhövel W, Stoneking M, Kayser M.**

Human genetics of the Kula Ring: Y-chromosome and mitochondrial DNA variation in the Massim of Papua New Guinea.

Eur J Hum Genet 2014 Dec;22(12):1393-1403. doi: 10.1038/ejhg.2014.38. Epub 2014 Mar 12.

The island region at the southeastern-most tip of New Guinea and its inhabitants known as Massim are well known for a unique traditional inter-island trading system, called Kula or Kula Ring. To characterize the Massim genetically, and to evaluate the influence of the Kula Ring on patterns of human genetic variation, we analyzed paternally inherited Y-chromosome (NRY) and maternally inherited mitochondrial (mt) DNA polymorphisms in >400 individuals from this region. We found that the nearly exclusively Austronesian-speaking Massim people harbor genetic ancestry components of both Asian (AS) and Near Oceanian (NO) origin, with a proportionally larger NO NRY component versus a larger AS mtDNA component. This is similar to previous observations in other Austronesian-speaking populations from Near and Remote Oceania and suggests sex-biased genetic admixture between Asians and Near Oceanians before the occupation of Remote Oceania, in line with the Slow Boat from Asia hypothesis on the expansion of Austronesians into the Pacific. Contrary to linguistic expectations, Rossel Islanders, the only Papuan speakers of the Massim, showed a lower amount of NO genetic ancestry than their Austronesian-speaking Massim neighbors. For the islands

traditionally involved in the Kula Ring, a significant correlation between inter-island travelling distances and genetic distances was observed for mtDNA, but not for NRY, suggesting more male- than female-mediated gene flow. As traditionally only males take part in the Kula voyages, this finding may indicate a genetic signature of the Kula Ring, serving as another example of how cultural tradition has shaped human genetic diversity.

- 151 **Vaughan C.**

Participatory research with youth: idealising safe social spaces or building transformative links in difficult environments?

J Health Psychol 2014 Jan;19(1):184-192. doi: 10.1177/1359105313500258. Epub 2013 Sep 20.

Freire's theory of social change informs analysis of youth-focused participatory research, with researchers describing links between participation and young people's critical thinking. There is less analysis of how youth move from the safe social space of a participatory research project to take health-promoting action in difficult real-world contexts. This article analyses a project conducted with Papua New Guinean youth, disrupting assumptions that critical thinking inevitably leads to critical action on health. Findings suggest the need to shift the focus of participatory research from supporting 'safe social spaces' to supporting 'transformative action in context' to concretely contribute to improving youth health.

- 152 **Vengiau G, Umezaki M, Phuanukoonnon S, Siba P, Watanabe C.**

Associations of socioeconomic status with diet and physical activity in migrant Bougainvillians in Port Moresby, Papua New Guinea.

Ecol Food Nutr 2014 September-October;53(5):471-483.

Urban migrants in Papua New Guinea have undergone a nutritional transition. The present study investigated associations of socioeconomic status with dietary and physical activity patterns among migrant Bougainvillians from Naasioi territory in the capital city of Port Moresby, Papua New Guinea. All adult Naasioi migrants residing in Port Moresby were identified (N = 185) and 70 were included. The International Physical Activity Questionnaire was used to evaluate physical activity, and dietary patterns were assessed by per-week consumption frequency of food items. Principal component analysis was applied to produce a composite score for socioeconomic status. Least square regression analysis indicated that socioeconomic status was positively correlated with consumption of a traditional diet ($p = 0.03$) and negatively with walking-related physical activity ($p = 0.02$), but it was not correlated with MET-minutes of moderate/vigorous activity. Different patterns of nutritional transition occur among migrants in urban Papua New Guinea, depending on socioeconomic status.

- 153 **Viergever RF, Kitur IU, Chan G, Airi J, Kaleva W, Sikosana P, N'Dreland G, Morgan C.**

The Papua New Guinea national health and HIV research agenda.

Lancet Glob Health 2014 Feb;2(2):e74-75. doi: 10.1016/S2214-109X(13)70165-7. Epub 2014 Jan 23.

- 154 **Vince JD, Datta SS, Toikilik S, Lagani W.**

Integrated package approach in delivering interventions during immunization campaigns in a complex environment in Papua New Guinea: a case study.

Vaccine 2014 Aug 6;32(36):4614-4619. doi: 10.1016/j.vaccine.2014.04.056. Epub 2014 Apr 30.

Papua New Guinea's difficult and varied topography, poor transport infrastructure, changing dynamics of population and economy in recent times and understaffed and poorly financed health service present major challenges for successful delivery of vaccination and other preventative health interventions to both the rural majority and urban populations, thereby posing risks for vaccine preventable disease outbreaks in the country. The country has struggled to meet the vaccination coverage targets required for the eradication of poliomyelitis and elimination of measles. Escalation of inter and intra country migration resulting from major industrial developments, particularly in extraction industries, has substantially increased the risk of infectious disease importation. This case study documents the evolution of immunisation programmes since the introduction of supplementary immunisation activities (SIAs). Single antigen SIAs have advantages and disadvantages. In situations in which the delivery of preventative health interventions is difficult, it is likely that the cost benefit is greater for multiple than for single interventions. The lessons learned from the conduct of single antigen SIAs can be effectively used for programmes delivering multiple SIA antigens, routine immunisations, and other health interventions. This paper describes a successful and cost effective multiple intervention programme in Papua New Guinea. The review of the last SIA in Papua New Guinea showed relatively high coverage of all the interventions and demonstrated the operational feasibility of delivering multiple interventions in resource constrained settings. Studies in other developing countries such as Lesotho and Ethiopia have also successfully integrated health interventions with SIA. In settings such as Papua New Guinea there is a strong case for integrating supplementary immunisation activity with routine immunisation and other health interventions through a comprehensive outreach programme.

155 Viney K, Johnson P, Tagaro M, Fanai S, Linh NN, Kelly P, Harley D, Sleight A.

Traditional healers and the potential for collaboration with the national tuberculosis programme in Vanuatu: results from a mixed methods study.

BMC Public Health 2014 Apr 23;14:393. doi: 10.1186/1471-2458-14-393.

BACKGROUND: This study was conducted in the Pacific island nation of Vanuatu. Our objective was to assess knowledge, attitudes and practice of traditional healers who treat lung diseases and tuberculosis (TB), including their willingness to collaborate with the national TB programme. **METHODS:** This was a descriptive study using both qualitative and quantitative methods. Quantitative analysis was based on the responses provided to closed-ended questions, and we used descriptive analysis (frequencies) to describe the knowledge, attitudes and practice of the traditional healers towards TB. Qualitative analysis was based on open-ended questions permitting fuller explanations. We used thematic analysis and developed a posteriori inductive categories to draw original and unbiased conclusions. **RESULTS:** Nineteen traditional

healers were interviewed; 18 were male. Fifteen of the healers reported treating short wind (a local term to describe lung, chest or breathing illnesses) which they attributed to food, alcohol, smoking or pollution from contact with menstrual blood, and a range of other physical and spiritual causes. Ten said that they would treat TB with leaf medicine. Four traditional healers said that they would not treat TB. Twelve of the healers had referred someone to a hospital for a strong wet-cough and just over half of the healers reported a previous collaboration with the Government health care system. Eighteen of the traditional healers would be willing to collaborate with the national TB programme, with or without compensation. **CONCLUSIONS:** Traditional healers in Vanuatu treat lung diseases including TB. Many have previously collaborated with the Government funded health care system, and almost all of them indicated a willingness to collaborate with the national TB programme. The engagement of traditional healers in TB management should be considered, using an evidence based and culturally sensitive approach.

156 Viney KA, Johnson P, Tagaro M, Fanai S, Linh NN, Kelly P, Harley D, Sleight A.

Tuberculosis patients' knowledge and beliefs about tuberculosis: a mixed methods study from the Pacific island nation of Vanuatu.

BMC Public Health 2014 May 17;14:467. doi: 10.1186/1471-2458-14-467.

BACKGROUND: The setting for this study was the Pacific island nation of Vanuatu, an archipelago of 82 islands, located in the South Pacific Ocean. Our objective was to assess the knowledge, attitudes and practices of tuberculosis (TB) patients towards TB. **METHODS:** This was a descriptive study using qualitative and quantitative methods. Quantitative analysis was based on the responses provided to closed questions, and we present frequencies to describe the TB patients' knowledge, attitudes and practice relating to TB. Qualitative analysis was based on open questions permitting fuller explanations. We used thematic analysis and developed a posteriori inductive categories to draw conclusions. **RESULTS:** Thirty-five TB patients were interviewed; 22 (63%) were male. They attributed TB to cigarettes, kava, alcohol, contaminated food, sharing eating utensils and "kastom" (the local term for the traditional way of life, but also for sorcery). Most (94%) did not attribute TB to a bacterial cause. However, almost all TB patients (89%) thought that TB was best treated at a hospital with antibiotics. Three-quarters (74%) experienced stigma after their TB diagnosis. Seeking health care from a traditional healer was common; 54% of TB patients stated that they would first consult a traditional healer for any illness. When seeking a diagnosis for signs and symptoms of TB, 34% first consulted a traditional healer. Patients cited cost, distance and beliefs about TB causation as reasons for first consulting a traditional healer or going to the hospital. Of the TB patients who consulted a traditional healer first, there was an average of two weeks delay before they consulted the health service. In some cases, however, the delay was up to six years. **CONCLUSION:** The majority of the TB patients interviewed did not attribute TB to a bacterial cause. Consulting a traditional healer for health care, including while seeking a diagnosis for TB symptoms, was common and may have delayed

diagnosis. People require better information about TB to correct commonly held misperceptions about the disease. Traditional healers could also be engaged with the national TB programme, in order to refer people with signs and symptoms of TB to the nearest health service.

157 Wampfler R, Timinao L, Beck HP, Soulama I, Tiono AB, Siba P, Mueller I, Felger I.

Novel genotyping tools for investigating transmission dynamics of *Plasmodium falciparum*. *J Infect Dis* 2014 Oct 15;210(8):1188-1197. doi: 10.1093/infdis/jiu236. Epub 2014 Apr 25.

BACKGROUND: Differentiation between gametocyte-producing *Plasmodium falciparum* clones depends on both high levels of stage-specific transcripts and high genetic diversity of the selected genotyping marker obtained by a high-resolution typing method. By analyzing consecutive samples of one host, the contribution of each infecting clone to transmission and the dynamics of gametocyte production in multiclonal infections can be studied. **METHODS:** We have evaluated capillary electrophoresis based differentiation of 6 length-polymorphic gametocyte genes. RNA and DNA from 25 µL whole blood from 46 individuals from Burkina Faso were simultaneously genotyped. **RESULTS:** Highest discrimination power was achieved by *pfs230* with 18 alleles, followed by *pfg377* with 15 alleles. When assays were performed in parallel on RNA and DNA, 85.7% of all *pfs230* samples and 59.5% of all *pfg377* samples contained at least one matching genotype in DNA and RNA. **CONCLUSIONS:** The imperfect detection in both DNA and RNA was identified as a major limitation for investigating transmission dynamics, owing primarily to the volume of blood processed and the incomplete representation of all clones in the sample tested. Abundant low-density gametocyte carriers impede clone detectability, which may be improved by analyzing larger volumes and detecting initially sequestered gametocyte clones in follow-up samples.

158 Warrilow D, Hall-Mendelin S, Hobson-Peters J, Prow NA, Alicock R, Hall RA.

Complete coding sequences of three members of the Kokobera group of flaviviruses. *Genome Announc* 2014 Sep 18;2(5). pii: e00890-14. doi: 10.1128/genomeA.00890-14.

The Kokobera group of flaviviruses circulates in Australia and Papua New Guinea, and has been associated with occasional human polyarticular disease. To facilitate future studies to identify virulence determinants, the complete coding regions of the Stratford virus, and isolates of the Bainyik virus and Torres virus were obtained.

159 Watanabe N, Kaneko A, Yamar S, Leodoro H, Taleo G, Tanihata T, Lum JK, Larson PS.

Determinants of the use of insecticide-treated bed nets on islands of pre- and post-malaria elimination: an application of the health belief model in Vanuatu. *Malar J* 2014 Nov 20;13:441. doi: 10.1186/1475-2875-13-441.

BACKGROUND: Insecticide-treated nets (ITNs) are an integral piece of any malaria elimination strategy, but compliance remains a challenge and determinants of use vary by location and context. The Health Belief Model (HBM) is a tool to explore perceptions and beliefs about malaria and ITN use.

Insights from the model can be used to increase coverage to control malaria transmission in island contexts. **METHODS:** A mixed methods study consisting of a questionnaire and interviews was carried out in July 2012 on two islands of Vanuatu: Ambae Island where malaria transmission continues to occur at low levels, and Aneityum Island, where an elimination programme initiated in 1991 has halted transmission for several years. **RESULTS:** For most HBM constructs, no significant difference was found in the findings between the two islands: the fear of malaria (99%), severity of malaria (55%), malaria-prevention benefits of ITN use (79%) and willingness to use ITNs (93%). ITN use the previous night on Aneityum (73%) was higher than that on Ambae (68%) though not statistically significant. Results from interviews and group discussions showed that participants on Ambae tended to believe that risk was low due to the perceived absence of malaria, while participants on Aneityum believed that they were still at risk despite the long absence of malaria. On both islands, seasonal variation in perceived risk, thermal discomfort, costs of replacing nets, a lack of money, a lack of nets, nets in poor condition and the inconvenience of hanging had negative influences, while free mass distribution with awareness campaigns and the malaria-prevention benefits had positive influences on ITN use. **CONCLUSIONS:** The results on Ambae highlight the challenges of motivating communities to engage in elimination efforts when transmission continues to occur, while the results from Aneityum suggest the possibility of continued compliance to malaria elimination efforts given the threat of resurgence. Where a high degree of community engagement is possible, malaria elimination programmes may prove successful.

160 Weitz CA, Friedlaender FY, Friedlaender JS.

Adult lipids associated with early life growth in traditional Melanesian societies undergoing rapid modernization: a longitudinal study of the mid-20th century.

Am J Phys Anthropol 2014 Apr;153(4):551-558. doi: 10.1002/ajpa.22453. Epub 2013 Dec 30.

Both poor fetal development and accelerated post-natal growth have been linked to adult dyslipidemias in many studies conducted in developed societies. It is not known, however, whether these relationships only characterize populations with typical Western diets or if they also may develop in groups at the early stages of a dietary transition. Our longitudinal study of traditional rural populations in the Southwest Pacific during a period of extremely rapid modernization in diet and life-styles shows a nascent association between child growth retardation, subsequent growth acceleration, and adult lipid values in spite of a continuing prevalence of very low lipid levels. However, our results do not entirely conform to results from populations with 'modern' diets. Outcome (ie, young adult) cholesterol and triglyceride levels are more consistently related to initial measures of body fat and growth in body fat measures than with stature, while outcome apo A-1 is more consistently related to initial stature or stature growth than to measures of body fat. We suggest this may reflect a pattern characteristic of the initial stages of 'modernization' associated with dietary change, with stronger and more pervasive relationships emerging only later as populations complete the dietary transition.

- 161 **Widmer A.**
Making blood 'Melanesian': fieldwork and isolating techniques in genetic epidemiology (1963-1976). *Stud Hist Philos Biol Biomed Sci* 2014 Sep;47 Pt A:118-129. doi: 10.1016/j.shpsc.2014.05.012. Epub 2014 Jul 16.
'Isolated' populations did not exist unproblematically for life scientists to study. This article examines the practical and conceptual labour, and the historical contingencies that rendered populations legible as 'isolates' for population geneticists. Though a standard historiographical narrative tells us that population geneticists were moving from typological understandings of biological variation to processual ones, cultural variation was understood as vulnerable to homogenisation. I chart the importance that D. Carleton Gajdusek placed on isolates from his promotion of genetic epidemiology in WHO technical reports and at a Cold Spring Harbour symposium to his fieldwork routines and collection practices in a group of South Pacific islands. His fieldwork techniques combined social, cultural and historical knowledge of the research subjects in order to isolate biological descent using genealogies. Having isolated a population, Gajdusek incorporated biological materials derived from that population into broad categories of 'Melanesian' and 'race' to generate statements about the genetics of abnormal haemoglobins and malaria. Alongside an analysis of Gajdusek's practices, I present different narratives of descent, kinship and identities learned during my ethnographic work in Vanuatu. These alternatives show tacit decisions made pertaining to scale in the production of 'isolates'.
- 162 **Williams CJ.**
Maternal deaths and their impact on children in Papua New Guinea. *Aust NZ J Public Health* 2014 Oct;38(5):405-407. doi: 10.1111/1753-6405.12263.
- 163 **Win Tin ST, Kenilorea G, Gadabu E, Tasserei J, Colagiuri R.**
The prevalence of diabetes complications and associated risk factors in Pacific Islands countries. *Diabetes Res Clin Pract* 2014 Jan;103(1):114-118. doi: 10.1016/j.diabres.2013.09.017. Epub 2013 Nov 9.
AIM: To determine the prevalence of diabetes complications and associated risk factors among people with type 2 diabetes in three Pacific Island countries, Nauru, Solomon Islands and Vanuatu. METHODS: This cross-sectional study was carried out on a sample of 459 people with diabetes. Subjects were screened for complications using a standardized protocol which gathered information on demographics and physical and biochemical parameters. RESULTS: Of the 459 subjects, 47% were female, mean age was 54 years and mean duration of diabetes was eight years. The prevalence of diabetes complications was significantly higher in Nauru compared with the Solomon Islands and Vanuatu – microalbuminuria 71%, 36% and 51% respectively ($p < 0.001$), retinopathy 69%, 40% and 42% respectively ($p < 0.001$), and abnormal foot sensation 30%, 23% and 19% respectively ($p = 0.036$). The prevalences of hypertension, overweight/obesity and poor glycaemic control were high. The percentages of subjects achieving recommended clinical targets were low. Microalbuminuria was significantly associated with duration of diabetes, hypertension and glycaemic control. Diabetic retinopathy was significantly associated with duration of diabetes whereas abnormal foot sensation was significantly associated with duration of diabetes and glycaemic control. CONCLUSIONS: This study found a high prevalence of diabetes complications and associated risk factors, which indicate the need to improve diabetes care and strengthen preventive efforts to reduce complications.

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We acknowledge the help of the following colleagues who have contributed reports on papers which were published in the Journal - or rejected - during the period 2012-2014. Many have undertaken this task more than once, some many times. We thank them all for their essential contribution to the Journal. We apologize for any omissions: since each year we have a focus issue with a guest editor, the work of some referees may not have come to our attention.

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