

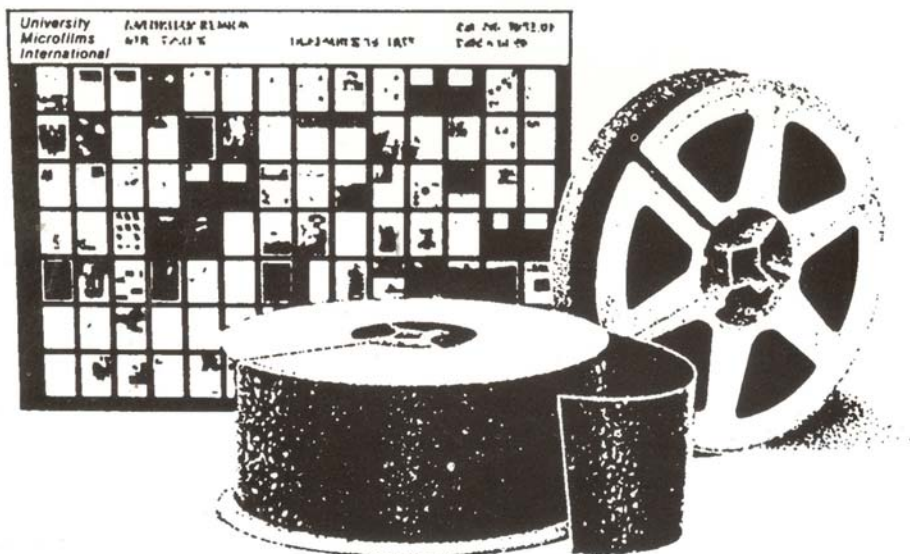
ISSN 0031-1480

PAPUA NEW GUINEA MEDICAL JOURNAL



VOL. 53, NO 1-2, MARCH-JUNE 2010

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ACKNOWLEDGEMENT

We are grateful to the Government of Australia through AusAID for providing funding for the publication of this issue of the Journal.

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Papua New Guinea Medical Journal

ISSN 0031-1480

March-June 2010, Volume 53, Number 1-2

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- ★ Printed by Moore Printing for the Medical Society of Papua New Guinea.
- ★ Authors preparing manuscripts for publication in the *Journal* should consult 'Information for Authors' inside back cover.

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EDITORIAL

The role of biomedical research in the fight against pneumonia in Papua New Guinea

Pneumonia remains the leading cause of death in Papua New Guinea (PNG), with the burden of disease greatest in children and the elderly. Globally, there are an estimated 156 million new cases of pneumonia in children under five years of age each year, resulting in 2 million deaths. Over 95% of all cases of childhood pneumonia occur in low-income countries (1). In PNG data are limited, but based on the National Health Plan (2) pneumonia is the major cause of death in children under 12 months of age, and second only to malaria in children 1-5 years old. The significance of pneumonia as a major cause of morbidity and mortality in PNG has been appreciated by researchers, clinicians and policy-makers for many years, and PNG has been at the forefront of pneumonia research in low-income settings. Nonetheless, the burden of disease remains unacceptably high, as it does in many other low-income countries. While much can be learnt from research and interventions in other low-income countries, there are specific epidemiological, cultural and social factors that contribute to the burden of pneumonia in PNG. As such, we must continue to conduct research and evaluate interventions specific for PNG. This is imperative if PNG is to reach the fourth Millennium Development Goal of reducing childhood mortality by two-thirds of the 1990 level by 2015.

The Global Action Plan for the Prevention and Control of Pneumonia (GAPP) has identified the key strategies for pneumonia control as vaccination, case management through integrated management of childhood illness (IMCI), improvement of nutrition, reduced incidence of low birthweight, control of indoor air pollution, and prevention and management of HIV (human immunodeficiency virus) infection (3). In recent years work conducted by the PNG Institute of Medical Research (IMR) and collaborators has concentrated on vaccine studies. While all strategies identified by GAPP must be pursued in order to make the greatest inroads into the burden of pneumonia, the introduction of appropriate vaccines is an important first step. This has

been recognized in our region by Australia21, a non-profit organization that is lobbying for the roll-out of appropriate vaccines in PNG and Indonesia, as well as ongoing research addressing the issues that impact upon the burden of pneumonia (4).

A better understanding of the aetiology of pneumonia is imperative to enable the introduction of targeted interventions, in particular vaccination. Globally the most important causes of severe pneumonia are *Streptococcus pneumoniae* and *Haemophilus influenzae* type b (Hib) (5). Past studies have revealed *S. pneumoniae* and *H. influenzae* to be the most common causes of pneumonia in PNG, with a variety of other pathogens known to be, or suspected of, playing a lesser role (6-9). However, the only thorough aetiological studies conducted in the country were in the highlands, and those studies were conducted some 20-30 years ago. We have little knowledge of the aetiology of pneumonia in lowland regions of the country, despite it being one of the major causes of death in children in lowland urban centres (10,11). Since the last aetiological studies were conducted the Hib vaccine has been introduced into the Expanded Program on Immunization (EPI) in PNG. Previous studies have shown non-encapsulated *H. influenzae* to be commonly isolated from lungs of children with pneumonia in PNG, often in association with serotypeable strains of *H. influenzae* and *S. pneumoniae* (7,12). We need to monitor for ongoing *H. influenzae* infection following vaccine introduction, and clarify the role of non-encapsulated *Haemophilus* spp. We also need up-to-date information on the serotypes of *S. pneumoniae* causing disease in order to establish the suitability of candidate vaccines, and these studies should be carried out in different locations in PNG. Monitoring of pathogenic pneumococcal serotypes after conjugate vaccine introduction will be important, as both nasopharyngeal colonization and invasive disease with non-vaccine strains of *S. pneumoniae* have been found in other countries where conjugate pneumococcal vaccine has been introduced.

In recent years viral diagnosis has improved through the application of molecular techniques; however, the role of viruses in moderate and severe pneumonia remains poorly understood. Our recent unpublished data show associations between pneumonia and the detection of influenza viruses, respiratory syncytial virus and adenoviruses in the upper respiratory tract (URT) of Papua New Guinean children. However, no data exist on the influence of viral load, multiple viral infection or bacterial and viral co-infection on severity of disease. A greater understanding of co-infection in the aetiology of pneumonia is particularly important, given that respiratory viruses may predispose people to secondary bacterial infection (13).

The rising prevalence of HIV in PNG is a further reason to improve our knowledge of the important respiratory pathogens in PNG. In other HIV-endemic countries opportunistic pathogens such as *Pneumocystis jirovecii* and *Penicillium marneffei* commonly infect HIV-positive people. However, perhaps of greater importance than the changing aetiology of pneumonia due to HIV infection is the increased susceptibility of HIV-positive people to pneumonia. In some countries rates of bacterial pneumonia are up to 25 times higher in HIV-positive people than in the general population, with *S. pneumoniae* being the most common cause (14). With the high rate of circulation of *S. pneumoniae* in the general population, this organism is likely to be an important pathogen in HIV-positive people in PNG. Pneumococcal polysaccharide vaccines administered to HIV-positive people have provided limited protection against *S. pneumoniae* infection. The introduction of conjugate vaccines into the EPI should reduce carriage of invasive serotypes leading to reduced transmission and hence herd immunity (15), which may be of benefit to HIV-positive people in this country. Determination of aetiological agents of respiratory tract infections in HIV-positive people is warranted.

Pneumonia that is slow to respond to standard antibiotic therapy occurs in a proportion of children in PNG and, in addition to viruses, the role of atypical organisms such as *Chlamydia* spp., *Mycoplasma* spp., *Mycobacterium tuberculosis*, *Pneumocystis jirovecii*, *Staphylococcus aureus* and enteric Gram-negative organisms need to be better understood in high-risk children, particularly those with HIV infection or malnutrition and

young infants.

The seven-valent pneumococcal conjugate vaccine (7vPCV) comprises the capsular polysaccharide of seven different pneumococcal serotypes conjugated to CRM₁₉₇ (a nontoxic variant of the diphtheria toxin) to improve immunogenicity in young children. The recent introduction of 7vPCV has resulted in a dramatic decrease in the incidence of invasive pneumococcal disease (IPD) and chest-X-ray-proven pneumonia in industrialized countries such as USA and Australia. An additional benefit of the 7vPCV has been the reduction in URT carriage of vaccine serotypes, which has interrupted their circulation in the community resulting in herd immunity. However, the 7vPCV may be less effective in low-income countries and Indigenous populations in industrialized countries, in view of the broader range of serotypes causing disease in these populations. Experience in the Alaskan Native population shows that replacement serotypes could reduce the impact of 7vPCV (16). A 10-valent PCV is now licensed for use in Australia, and it is likely to be introduced in PNG in the near future. Research is required to determine the best vaccine schedule for a 10vPCV in PNG and its impact on disease due to pneumococci as well as *H. influenzae*, in view of the *H. influenzae* protein D conjugate component of this vaccine in place of the CRM₁₉₇ used in the 7vPCV. An 11-valent pneumococcal conjugate vaccine has recently been trialed in the Philippines, and led to a 22% reduction in radiographically proven pneumonia in young children (17).

The use of the 23-valent pneumococcal polysaccharide vaccine (PPV) in children less than 2 years of age also warrants further consideration. This vaccine was shown to be efficacious in decreasing death due to acute lower respiratory tract infections in PNG when given to children from age 6 months onwards (18). Immunogenicity is variable in young children depending on the serotype. Our preliminary data indicate an excellent booster response to PPV given at 9 months, following three doses of 7vPCV in early infancy (19). In the Eastern Highlands Province over 50% of all deaths due to pneumonia occur in the first 6 months of life (20) and the carriage rate of *S. pneumoniae* is 84% at age 3 months (21). Novel vaccine schedules need to be evaluated, with a schedule that generates an adequate immune response and clinical protection at the earliest

age being the highest priority. However, the cost of administering the full schedule and protection throughout the first 4-5 years of life are also important considerations. It is unlikely that the 23-valent polysaccharide vaccine will be supported by the Global Alliance for Vaccines and Immunisation (GAVI), which is the current source of funding for Hib vaccine for PNG, and the proposed source for the conjugate pneumococcal vaccine.

The role of maternal vaccination in decreasing childhood mortality also warrants further investigation. Previous studies have shown encouraging results when PPV was administered to pregnant women in PNG (22). Antibody titres at birth were higher in children of immunized mothers than those of unimmunized mothers. Antibody titres fell rapidly over the first two months of life, but the increased protection afforded to children of immunized mothers may be an important way of preventing deaths in the very young. The feasibility of maternal immunization needs to be taken into consideration when trialing novel PCV schedules in children.

Some of the first penicillin-resistant pneumococci were detected in PNG (23); however, fully resistant pneumococci are still rare. In contrast multi-resistant strains of Hib have emerged (24), resulting in the need to change treatment protocols for meningitis (25). This highlights the need for monitoring antibiotic resistance patterns of bacterial pathogens.

In the immediate future, concerted efforts must be made, and appropriate research conducted, to enable the introduction of a PCV. In an editorial in this journal Duke (26) stated that "pneumococcal vaccination may be the single most useful new child health initiative in PNG for the next decade". Unfortunately, that decade has passed us by and pneumococcal vaccines are not routinely given in PNG. The introduction of vaccines should not be seen as the only end-point in the efforts to decrease the burden of pneumonia in PNG, but rather as one aspect of a holistic approach which incorporates the other areas identified by GAPP. In PNG the establishment of optimal surveillance, identification of key risk factors for pneumonia, and the identification of barriers to accessing appropriate preventive and curative health services are all needed.

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Mapping the prevalence of malaria in rural Papua New Guinea using a geographic information system

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SUMMARY

The application of geographic information systems (GIS) technology to malaria surveillance presents an opportunity for focusing intervention and prevention activities in the areas most affected. We used GIS technology to map the prevalence of malaria in the Wosera Health and Demographic Surveillance Site, East Sepik Province, Papua New Guinea (PNG). Malaria, demographic and GIS data collected between 2001 and 2003 were aggregated and analysed. This was achieved by geo-coding or linking the prevalence and demographic data to the village location. All GIS manipulation and cartographic displays were performed in MapInfo. The results suggest that malaria is endemic with high prevalence as observed across the 3 surveyed years. The optimized implementation of GIS can be of tremendous benefit in the fight against malaria and other public health challenges in PNG.

Introduction

Each year malaria infects 10% of humanity and is responsible for 2-3 million deaths and 400-900 million episodes of clinical illness throughout the world (1). Malaria continues to be a burden in developing and poor countries and is a major infectious disease in tropical areas. Because of drug and insecticide resistance and social and environmental changes the problem is still increasing. In Papua New Guinea (PNG) malaria is the most frequent diagnosis at outpatient departments, with an annual incidence of 303 per 1000 people at risk in endemic areas (2). In the face of a world changing in both abiotic and biotic respects, and complex infection and disease dynamics

that are not amenable to simple statistical interpretations, we must now take the next step of incorporating spatial information into biological models of the transmission of pathogens (3). Technologies such as geographic information systems (GIS) have now become increasingly popular in the study of spatial and temporal patterns of infectious diseases. As an information technology the World Health Organization (WHO) describes GIS as “an excellent means of analyzing epidemiological data, revealing trends, dependencies and inter-relationships that would be more difficult to discover” using traditional tabular approaches (4). In various locations it has been used as an epidemiological research tool for disease monitoring and management of public health

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programs, including malaria (4-6).

The usage of GIS in the health sector has become an important part of health management, policy making and the development of a health information system (5). However, few epidemiological studies have addressed the importance of spatial dimensions of public health problems at the district or national level (6,7). In the case of malaria, this makes it very difficult for decision-makers to understand spatial patterns of malaria epidemiology. This, in turn, makes it difficult for them to decide, in an objective and scientific manner, how best to manage public health problems, distribute resources to address them and determine which problems should be given priority over others. There are a few studies that have been done in PNG that used GIS for mapping malaria risk, prevalence and transmission. For instance, Mueller and colleagues (8,9) used GIS to forecast malaria risk in the highlands of PNG. Their studies demonstrated that a simple altitudinal GIS model could be used to stratify the risk of malaria into different strata: highly endemic malaria areas, epidemic-prone areas and malaria-free areas. The GIS-forecasted malaria risk model has been validated by recent cross-sectional surveys on malaria prevalence in the Simbu (9) and Western Highlands (8) Provinces. As a result different malaria control strategies were recommended for the strata. A more recent study by Myers et al. (10) used GIS technology to map risk factors for malaria prevalence in one of the remote villages (Oum) in East Sepik Province (ESP). The area was mapped using the global positioning system (GPS) information and overlaid with prevalence data. The produced map showed different zones representing the level of malaria prevalence (eg, low to high prevalence). Such maps could then be used as support tools for health planning and the targeting of malaria control activities.

In the present study we aimed to demonstrate how GIS technology can be optimized for malaria management and control efforts. We predicted that GIS could be a potential research tool in malaria control programs by: i) graphically portraying the prevalence of malaria, ii) capturing data and displaying features such as health facilities (clinics), road networks, village locations etc, iii) mapping populations at risk, and iv) determining environmental risk factors with

the help of satellite images. We present data from surveys conducted in the Wosera Health and Demographic Surveillance Site (HDSS) collected between 2001 and 2003.

Materials and Methods

Study site and population

The Wosera HDSS is located west-south-west (3°47'18.81" S 143°00'14.73" E) of the north-east coastal township of Wewak in the East Sepik Province (ESP) (Figure 1) (11), with a total population of approximately 13,000 (2003 Wosera HDSS census update). The village population size varies from 200 to over 1000. The altitude ranges from sea level to about 180 metres. The area is characterized by a tropical wet climate (12) with mean annual rainfall of 1847 mm. Most of the land is mixed regrowth with patches of sago palm (*Metroxylon sagu*) and swamp (13).

The natural vegetation in the area is lowland hill forest, but in most areas this has been disturbed by human activity and gardens. All households and roads linking all study villages have been mapped via a GPS technology and integrated into a GIS. Traditional Wosera houses consist of a timber frame covered with a sago roof that reaches the ground. However, more recently, houses with elevated floors, corrugated iron roofing and walls of split bamboo or sago stems have appeared.

Data collection

Between 2001 and 2003 a series of four cross-sectional surveys at 6-month intervals were conducted within 35 Wosera HDSS villages participating in collaborative research studies between Case Western Reserve University and the PNG Institute of Medical Research (PNGIMR). These surveys were performed during periods of the year characterized by different rainfall intensities (12), and were conducted primarily to collect blood samples to determine the prevalence of malaria. Based on the annually updated Wosera HDSS census, the combined population of the villages reached 13,000 at the completion of the surveys. Study participation was voluntary. Residents who participated in the study included all age groups, males and females. From every participant demographic information and finger-prick blood samples (approximately

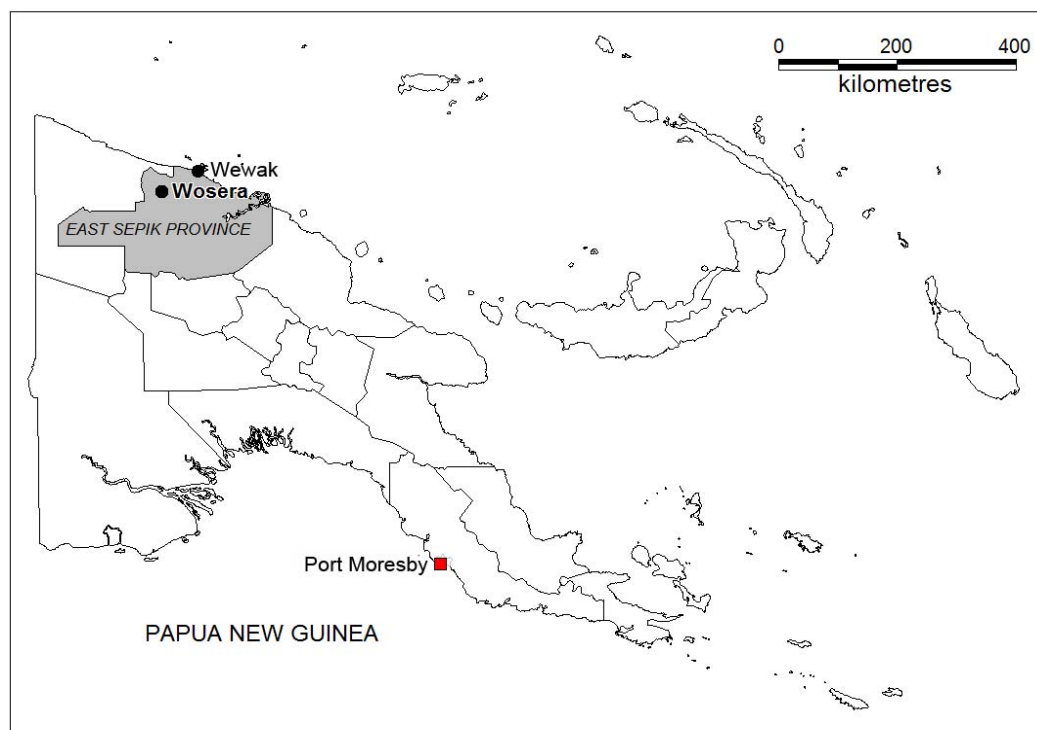


Figure1. Location of the study area in Papua New Guinea.

250-500 µl) were collected once each season for 4 consecutive seasons (2 dry and 2 wet). Blood samples were used to produce thick and thin blood smears, determine haemoglobin concentration and enable human host and parasite DNA extraction. In a subsample of cases polymerase chain reaction (PCR) was used to determine the presence of different *Plasmodium* species. In total 16,475 blood samples from all Wosera villages were collected during the four cross-sectional surveys. Double data entry was done using Microsoft FoxPro software at IMR Madang.

Other data sources

GIS data (village locations, roads etc) obtained from the Wosera HDSS cohort database were used for geographic analysis. All data collected during the surveys both in dry and wet seasons over the 3 years were aggregated and analysed. Besides location data (village, individual household and health centre locations) the GIS database contains information on house types and the use of bednets. Handheld GPS devices (Garmin International) were used to capture the position of village locations, health centres

and roads. A GPS is a satellite system used in navigation that allows one to determine one's current position 24 hours a day, for any place on the globe. A GPS receiver is a small electronic device that picks up signals from satellites. A satellite image of the Wosera HDSS region was also used; it served to identify potential risk factors influencing malaria transmission in relation to the physical environment. The satellite image was obtained from the Remote Sensing Centre, University of PNG.

GIS analysis and cartographic display

All GIS manipulation and cartographic displays were performed in MapInfo version 6. GIS is a computer database that stores and manipulates geographic data (14). The use of GIS technology for data collection, storing, manipulation, integrating and retrieval makes it a valuable tool in research enhanced by its capability to combine different layers of geographic data. All secondary data were cleaned, linked and imported into MapInfo. The data were aggregated and analysed by village location. This was achieved by geo-coding or linking the malaria prevalence and demographic data to the village locations (GIS

data). Individuals were geo-located by linking them to their last recorded village location. The Wosera local-level government (LLG) boundaries and selected census units were first overlaid and delineated from the Wosera-Gawi District and the total area for each LLG was calculated. The satellite image of the Wosera region was used as a backdrop and all spatial data such as river systems (major or minor rivers), land cover types and vegetation were digitized and stored in various GIS data layers. The satellite image forms the basis for extracting relevant information in relation to the physical environment, and for identifying potential breeding sites (ie, rivers, wetland areas, vegetation types) that may influence the local malaria epidemiology.

Results

A total of 4813 participants, both male and female, were included in the 2001 survey and of these participants 45% were male and 55% female. Of these, 66% were infected with *Plasmodium* parasites. In the 2002 and 2003 surveys the total number of participants had decreased to 3480 and 3598, respectively.

Of the participants in the 2002 survey 49% were male and 51% female, while in 2003 47% were male and 53% female. Of those participating in the 2002 and 2003 surveys, 61% and 62% were infected with *Plasmodium* parasites, respectively.

Figure 2 presents the prevalence of each malaria species in the Wosera HDSS across the 3 surveyed years. It can be seen that *Plasmodium falciparum* (Pf) is the most predominant species (>40%) followed in order by *Plasmodium vivax* (Pv), *Plasmodium malariae* (Pm) and *Plasmodium ovale* (Po).

Table 1 presents the geographic data: LLG, village, distance (linear distance) to the nearest health subcentre, distance (linear) to the nearest road system and infection rates across the Wosera HDSS.

Figure 3 shows the spatial (geographic) distribution of malaria prevalence in the Wosera HDSS. Each village (approximated area) represented in the study is colour-coded from low (white) to high (black) prevalence. Other geographic features – roads, rivers and

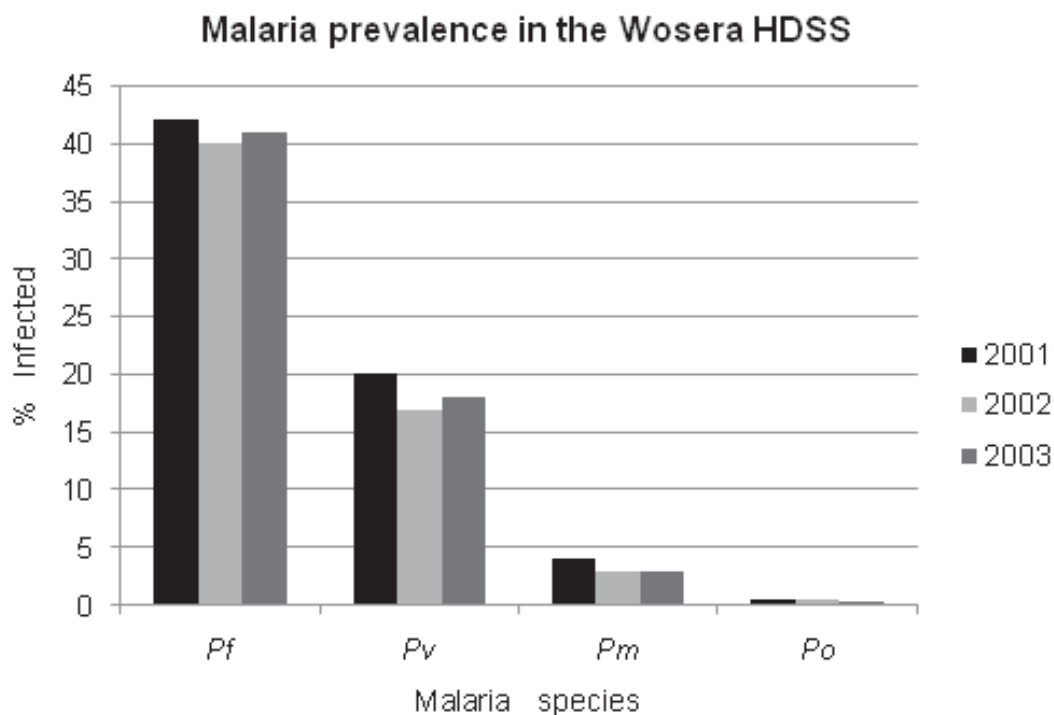


Figure 2. Prevalence of each malaria species by year, 2001-2003, in the Wosera Health and Demographic Surveillance Site. Pf = *Plasmodium falciparum*; Pv = *P. vivax*; Pm = *P. malariae*; Po = *P. ovale*

TABLE 1

GEOGRAPHIC DATA AND PERCENT INFECTED WITH MALARIA BY VILLAGE

LLG	Village	Distance from health centre*	Distance from road*	% infected
NW	Tatamba	3.79	2.75	66
NW	Kuminikum 1, 2, 3	2.89, 3.67, 2.81	0.15, 1.20, 0.87	44, 63, 38
NW	Rubukum 3	3.44	0.94	43
NW	Gwaiwaru	2.63	0.16	41
NW	Gartikum	1.10	0.20	37
NW	Blamda	2.20	0.19	41
NW	Moundu	2.40	0.14	67
NW	Kamge	3.11	0.24	62
NW	Kitikum 1, 2	2.28, 1.50	1.71, 1.37	66, 44
NW	Numbunge 1, 2, 3	0.33, 1, 1.98	0.55, 0.19, 0.64	20, 30, 41
NW	Wisikum 1, 2	0.94, 1.75	0.76, 1.54	30, 45
NW	Stapikum	2.55	2.13	69
SW	Miko 1, 2	4.52, 4.06	0.12, 1.71	45, 68
SW	Gwinyingi	3.34	0.13	32
SW	Apusit	1.78	1.05	46
SW	Leongai	3.56	4.26	67
SW	Nale 1, 2	3.25, 4.38	2.35, 3.41	43, 63
SW	Kunjingini 1, 2	0.29, 1	0.80, 2.02	19, 42
SW	Bethlem	0.52	1.10	20
SW	Mul	1.40	2.30	42
SW	Wegior	2.16	0.71	43
SW	Patigo	2.77	0.06	32
SW	Palgere	3.07	0.44	42
SW	Nangda	4.34	1.58	64
SW	Nindingo	5.15	1.49	66
SW	Kausagu	3.08	0.22	43

LLG = Local-Level Government; NW = North Wosera; SW = South Wosera

*distances (linear) are in kilometres

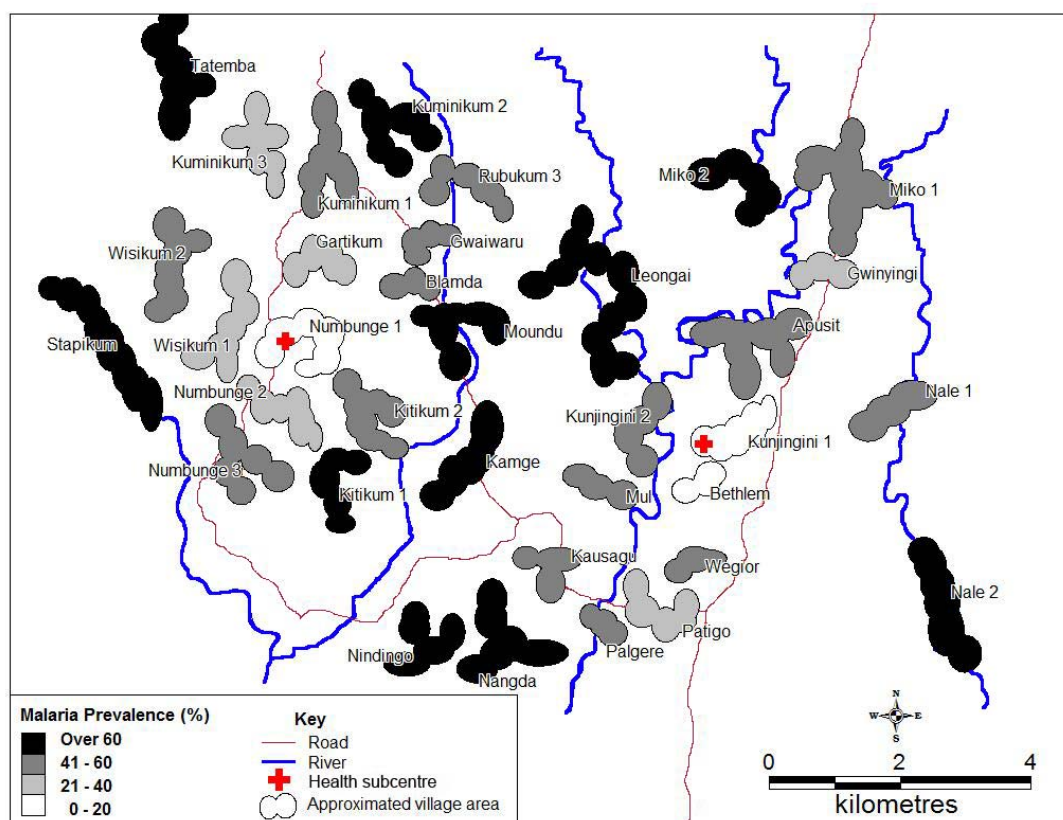


Figure 3. Spatial distribution of malaria prevalence by village in North and South Wosera.

health subcentres – are also presented.

Figure 4 presents the total population size of the Wosera HDSS overlaid with malaria prevalence. The map shows the population size of respective study villages that participated in the study during the 3 surveyed years. Population size across the HDSS is depicted in grayscale (background) from low (white shades) to high (dark shades).

Figure 5 shows the major landforms and vegetation types that exist within the Wosera HDSS area. The landforms, vegetation and water bodies (eg, river systems) were overlaid with malaria prevalence. The landform and vegetation data were extracted (digitized) from the Wosera satellite image. It is seen that there is evidence that some environmental conditions such as flood plains are favourable for malaria vector habitation.

Discussion

Recent advances in technologies such as

GIS offer potential for mapping malaria risk and predicting malaria transmission. Consequently, in the present study we have applied GIS to: 1) determine the spatial distribution of malaria prevalence, 2) present other spatial data such as health facilities, road networks, rivers, village locations and LLG boundaries, 3) determine the total population size or at-risk population and 4) determine risk factors influencing malaria transmission in relation to the surrounding environment using satellite images. The above are further discussed in detail below.

Determining the spatial distribution of malaria prevalence

The surveys conducted within the Wosera HDSS between 2001 and 2003 have confirmed the existence of all four *Plasmodium* species that infect humans, with *Pf* and *Pv* highly endemic and *Pm* and *Po* frequently encountered. This study also confirmed that *Pf* is the leading and most

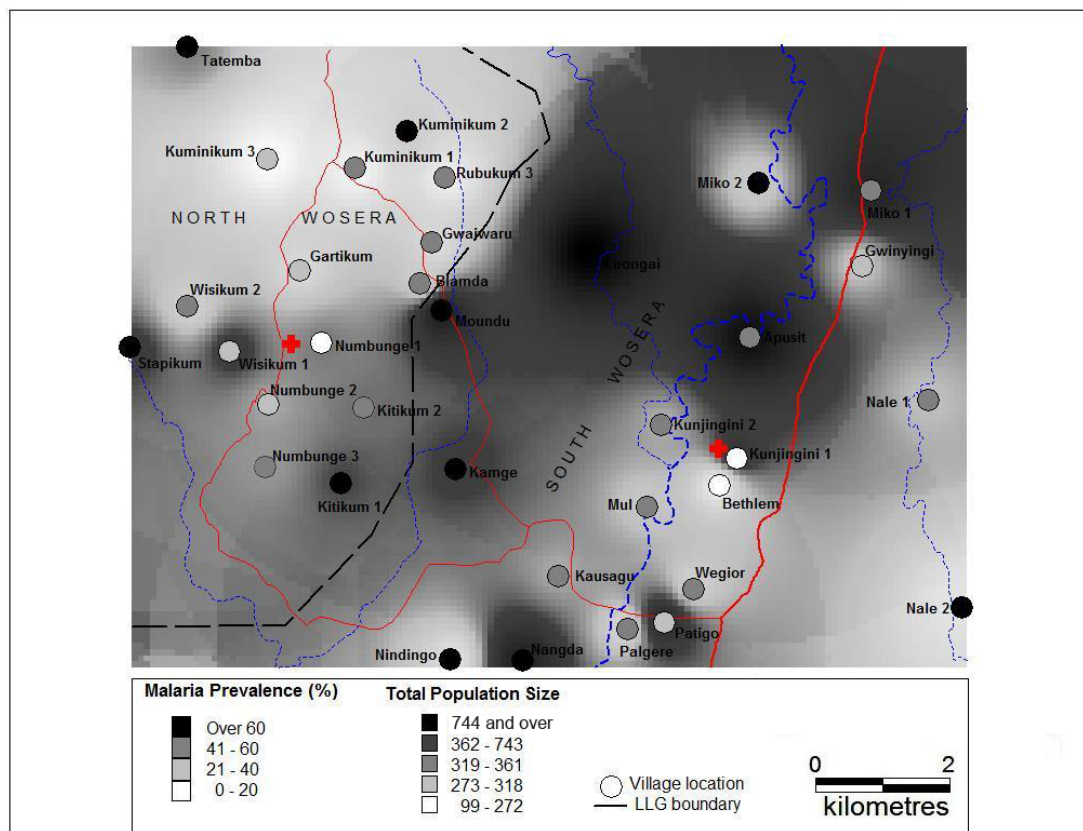


Figure 4. Total population size and malaria prevalence across the Wosera Health and Demographic Surveillance Site between 2001 and 2003. LLG = Local-Level Government

predominant species (>40%) in the HDSS area, followed, in order, by *Pv*, *Pm* and *Po* (Figure 2). Before the malaria control program, mainly the introduction of residual spraying with dichlorodiphenyltrichloroethane (DDT) and dieldrin, and mostly in the Maprik area, *Pv* was the predominant species followed by *Pf*, *Pm* and *Po* (12,15). However, the spraying program ceased in the late 1970s when it became clear that eradication would not be achieved any more (15). Following the cessation of spraying, *Pf* began to increase in numbers, resulting in its predominance over *Pv* (12,16). Compared to the situation before and at the end of the malaria eradication era, there has been a dramatic shift from *Pv* to *Pf* dominance, with the proportion of *Pf* increasing dramatically and dominating in almost all locations (12). Although the Wosera HDSS is a fairly small geographic area (3143 km²) and neighbouring villages often share similar ecological characteristics, malaria species prevalence has been observed to vary greatly from village

to village (11,12). In the present study Table 1 and the spatial distribution of malaria prevalence (Figure 3) reveal that most of the villages in the Wosera HDSS located within the North and South Wosera LLGs had high prevalence rates, which ranged from 19% to 69%. Interestingly, our spatial analysis (Figure 3) has also revealed that villages located further away from a health subcentre had higher prevalence rates than those located nearer. Despite the variation in malaria prevalence across the HDSS area, malaria is endemic (12) and is a public health problem in this part of the region. The spatial presentation of malaria prevalence data may help in determining where malaria is high, moderate or low across the Wosera HDSS. The produced maps can be very helpful for understanding small-scale variation in malaria prevalence. Such disease maps could be used as support tools for health planning and targeting of malaria control activities. The malaria prevalence maps we created combined wet and dry season data (Figure

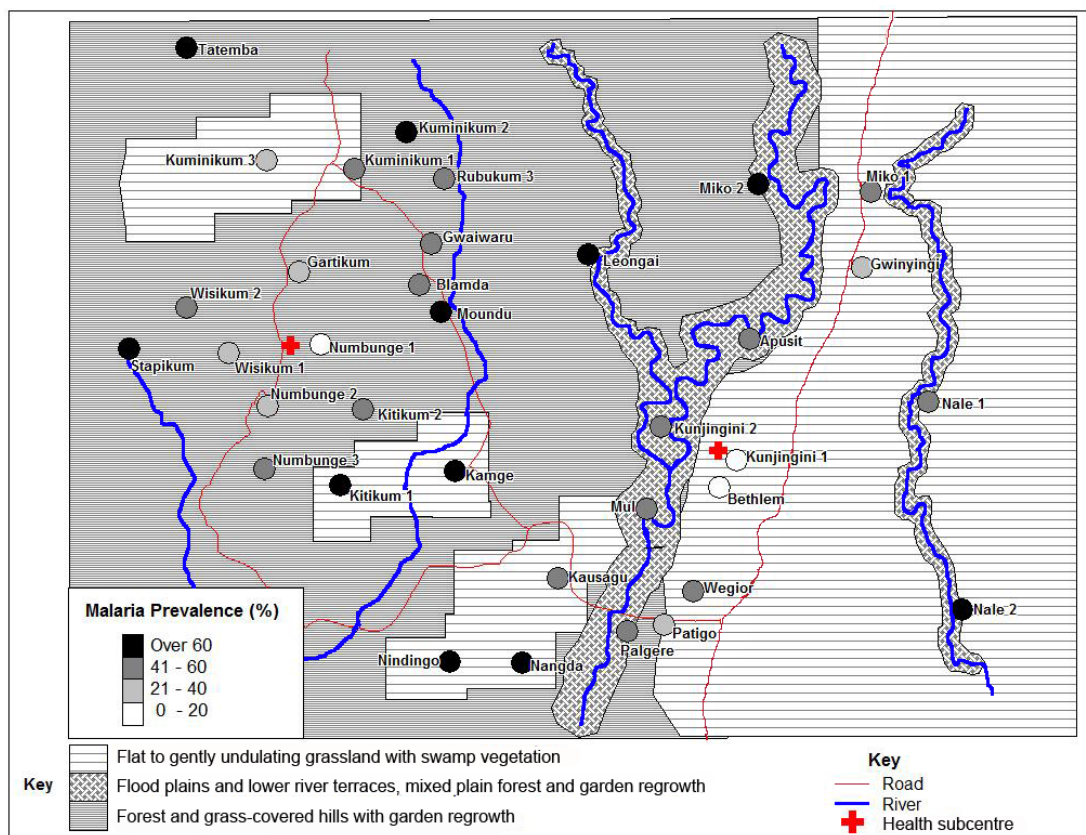


Figure 5. Major landform and vegetation of Wosera Health and Demographic Surveillance Site.

3). Separate maps showing malaria prevalence during the dry and wet seasons could also be generated.

Presenting other spatial data

The development and evaluation of effective programs to reduce the burden of disease require a detailed knowledge of the spatial distribution of the disease and causal pathways (17) since many diseases are related to location. Using GIS we were able to show other geographical features, such as the location of clinics (important for the purposes of accessing resource allocation and future planning), measuring the linear distance between each village and its nearest health subcentre, determining accessibility to good road networks, and identifying the geographical locations of study villages. In the Wosera HDSS some of the factors contributing to transmission and high infection are poor road links and long distances from home to a health centre and the main road

(Table 1). Bad roads make it harder for sick people to reach a health centre to seek care. This may contribute to transmission of the infection from a sick person to others. As shown on the maps (Figures 3 and 4) villages located closer to a health centre seem to have lower malaria prevalence rates than those located further away. For instance, the linear distance between Tatemba village in the North Wosera LLG and the nearest health centre is 3.79 km and the distance to a road is 2.75 km with a high infection rate (66%), as opposed to Numbunge 1 village with 0.33 km to a health centre and 0.55 km to a road and a low infection rate (20%) (Table 1). This result suggests that there is a spatial correlation between distance from home to the nearest health centre and the prevalence of malaria. This finding is also supported by a previous study in the same area by Mueller and colleagues (18) which found that attendance at a health centre decreased markedly with distance, both for patients in general (50% decrease at 3.5 km) and for

patients with malaria or acute respiratory infections in particular. Previous malaria work elsewhere has also found that proximity to health facilities and higher socioeconomic status were associated with less malaria (19). In the Hlabisa subdistrict in rural South Africa, GIS has been used to document the effect of distance to treatment location on community-based tuberculosis (TB) treatment (20), to equitably distribute fieldworker workload in a large population-based survey (21), and to investigate an ecological relationship between proximity to roads and HIV prevalence among women attending antenatal clinics (22).

Determining the total population size or at-risk population

People at risk of most public health problems often live in remote areas with very limited resources, and the first step in reaching these people in order to organize and coordinate appropriate responses to their problems is to put them on the map. Therefore, using GIS as a research tool can assist by graphically portraying populations at risk so that appropriate health measures can be targeted more appropriately. There are things we can do with GIS that we could not have done with tabular methods, for example, mapping and displaying the size of populations at risk. Using GIS we created a map showing population size at risk across the HDSS and overlaid with malaria prevalence data (Figure 4). Our results suggest that malaria is endemic with high prevalence in both highly and lowly populated areas across the HDSS (Figure 4). In other words, despite the variations in population size, malaria is endemic in most villages and intervention should be targeted at high prevalence areas or locations. Recent evidence suggests that geographic approaches to control and prevention may enhance public health efforts (23) and improve public health care delivery systems. Poverty alleviation programs such as 'Roll Back Malaria' are using GIS to link indicators of health to indicators of access to target resources of the poorest communities. We have shown that GIS is an important epidemiological research tool for disease surveillance in the Wosera HDSS. It can provide additional benefits to malaria disease surveillance and targeting of control measures in a resource-limited setting and thus improve health care delivery to populations at risk, as proven in Africa (6) and elsewhere. The maps produced can be used

as a decision support tool to target high-risk areas, thus enabling scarce public health resources to be more rationally distributed to those communities most in need.

Determining risk factors influencing malaria transmission in relation to the surrounding environment

Remote sensing images on environmental conditions and seasonal climate are powerful predictors of mosquito distribution patterns and average levels of transmission of malaria parasites (3). Recent developments in the access of remotely sensed vegetation data, and their analysis along with other data sources within a GIS, have opened up new possibilities, especially in the health sector. Remote sensing data can be used for a surprising variety of applications. For instance, during the last three decades, data acquired by satellite-borne sensors have become available and have been applied in many environmental and regional studies (24,25) including malaria. From the Wosera image, potential risk factors were identified and mapped, including landforms, vegetation types (eg, swamp vegetation), permanent streams (major and minor rivers), forest etc (Figure 5). The data extracted from the Wosera image (eg, landform and vegetation) were overlaid with malaria prevalence data to see how these environmental risk factors correlated with the prevalence of malaria. The result (Figure 5) suggests that there are environmental conditions favourable for malaria vectors that potentially contribute to the transmission of malaria infection. Other information is required to enhance the results further. For instance, climatic factors, particularly elevation, rainfall, temperature and relative humidity, are major factors influencing the ecology of mosquitoes. These environmental variables can be mapped to determine their association with the distribution of the disease. This would greatly enhance the quality of such a study.

Conclusion

In conclusion, the results of the present study confirm that malaria is highly endemic in the Wosera HDSS. The study extends our understanding of the geographic distribution of malaria prevalence, populations at risk and environmental risk factors associated with malaria transmission at the local scale. The study has also demonstrated that the use of existing health and GIS technology can

provide public health officials with additional information that is useful for disease surveillance and targeting of control measures in resource-limited settings. The applications of GIS are now becoming increasingly important globally in the epidemiology and control of infectious disease (26) and our work in the Wosera HDSS extends that importance to PNG. Thus the GIS mapping approach might be of greatest benefit to PNG if employed at the national level, although our study has shown its benefits so far only at the local scale. The GIS empirical mapping approach to malaria surveillance is an opportunity for focusing intervention and prevention activities in areas with the greatest need, which can be of tremendous benefit in the fight against malaria and other public health problems in PNG.

ACKNOWLEDGEMENTS

Financial support for this work and training was provided by the University of Papua New Guinea School of Natural and Physical Sciences through the Remote Sensing Centre. We extend special thanks to the Wosera Health and Demographic Surveillance Site community and the study participants. We thank the management and staff of the Papua New Guinea Institute of Medical Research for their logistical support.

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***Neisseria gonorrhoeae* isolates from four centres in Papua New Guinea remain susceptible to amoxycillin-clavulanate therapy**

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SUMMARY

Antibiotic-resistant strains of *Neisseria gonorrhoeae* have the potential to undermine treatment and control of gonorrhoea, which remains a highly prevalent sexually transmitted infection (STI) in Papua New Guinea (PNG). The standard treatment regimen for gonorrhoea in PNG based on amoxycillin and clavulanic acid (amoxycillin-clavulanate) was introduced about 15 years ago and there is some concern that over time circulating strains may have developed resistance to this therapy. To investigate this, *N. gonorrhoeae* isolates (n=52) were collected from STI clinics in geographically representative centres in PNG and tested for their in vitro susceptibility to a range of antibiotics. All 52 isolates tested were found susceptible to amoxycillin-clavulanate, despite 40% (n=21) being penicillinase producers and thus resistant to penicillin. These findings indicate that amoxycillin-clavulanate therapy remains an effective treatment for gonococcal infections in PNG, and support the maintenance of the present standard treatment for gonorrhoea in PNG.

Introduction

Gonorrhoea, caused by the Gram-negative coccoid bacterium *Neisseria gonorrhoeae*, remains one of the most common sexually transmitted infections (STIs) in Papua New Guinea (PNG) (1-4). Rates have been steadily increasing over the last four decades (5) and the National Health Plan for 2001-2010 estimates the incidence rate for gonorrhoea to be 131 per 100,000 population (6). However, various studies have shown higher rates of gonococcal infection in selected populations within PNG and a survey of STI clinics reported that 54% of male attenders were clinically diagnosed with gonorrhoea (2). A high prevalence of gonococcal infection, detected by polymerase chain reaction (PCR), has also been reported among female sex workers in Port Moresby (34%), Lae (24%)

and the Eastern Highlands Province (21%) (1,4). Furthermore, in a seemingly asymptomatic rural population, gonococcal infection was detected in 18% of women (3).

While data on STIs in PNG are limited, the National Department of Health (NDoH) recently reported over 17,000 cases of genital discharge syndrome (GDS) nationally in the first half of 2008 alone (7). The large burden of STIs in PNG prompted the prioritization of STI management in the National Health Plan 2001-2010 and the PNG National Strategic Plan on HIV/AIDS [human immunodeficiency virus/acquired immune deficiency syndrome] 2006-2010 (6,8). Accordingly, the NDoH has made it a priority to improve STI case management through a syndromic management approach. Currently all cases of GDS, including vaginal discharge

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syndrome (VDS) and lower abdominal pain syndrome (LAPS) in women, and urethral discharge syndrome (UDS) in men, are treated for gonorrhoea, chlamydia and trichomoniasis in a single-dose therapy. This regimen consists of 1 g Augmentin 500, 2 g amoxycillin, 1 g probenecid and 1 g azithromycin with either 1 g tinidazole twice daily for three days (women) or 2 g tinidazole (men) (9). Augmentin 500 contains 500 mg of amoxycillin and 125 mg of clavulanic acid.

The treatment of gonorrhoea could potentially be undermined by the ability of the aetiological agent, *N. gonorrhoeae*, to develop and acquire antibiotic resistance genes (10,11). Thus, the monitoring of antibiotic resistance in *N. gonorrhoeae* is essential for informing and developing treatment guidelines within the country (12).

PNG has been a part of the World Health Organization Western Pacific Region Gonococcal Antimicrobial Surveillance Programme (WPR GASP) since 1993 (13). However, the source of PNG isolates tested in this program is unknown. In PNG, routine culture of *N. gonorrhoeae* is conducted only at the Port Moresby General Hospital (PMGH) (14), so there is concern that the PNG data included in the WPR GASP may not be representative of susceptibility patterns throughout the rest of the country. There is also a lack of data from either PMGH or WPR GASP on the susceptibility of gonococcal isolates to amoxycillin and clavulanic acid (amoxycillin-clavulanate), which is the basis of gonorrhoea treatment in the country (13,14). Furthermore, despite the importance of resistance monitoring, the most recent multicentre investigation into gonococcal antimicrobial susceptibility patterns in PNG was carried out well over fifteen years ago (2).

Amoxycillin-clavulanate has been used to treat gonorrhoea in PNG for the last 15 years, raising concern that isolates in current circulation may be developing resistance to therapy (9). To investigate this, we conducted surveillance of antibiotic resistance in *N. gonorrhoeae* in four major centres in PNG.

Methods

Study population and sample collection

This study was conducted between 2004

and 2005 at the STI clinics in Port Moresby, Lae, Mt Hagen and Goroka. During the study period, patients were invited to participate if they presented at the STI clinic with UDS (men), or VDS or LAPS (women). Eligible patients were asked to provide informed consent and then undergo a physical examination. A urethral swab was collected from men and an endocervical swab was taken from women. Ethics approval was obtained from the PNG Medical Research Advisory Committee.

Isolation of *N. gonorrhoeae*

The swab was used to inoculate GC (gonococcal) agar containing VCN (vancomycin, Colistin sulphate and nystatin) selective supplement (Oxoid Limited, Thebarton, SA, Australia) and chocolate agar. The inoculated media were placed in a candle jar (12-15% CO₂) and kept at room temperature until transported to the laboratory, where the media were streaked and incubated at 37°C in the candle jar for up to 48 hours.

Suspected colonies that grew within the 48-hour incubation period were presumptively identified as *N. gonorrhoeae* if they were Gram-negative diplococci, oxidase positive and superoxol positive. The rapid carbon utilization test as described by the WHO was used to confirm the identity of *N. gonorrhoeae* isolates (15).

Antimicrobial susceptibility testing

Antimicrobial susceptibility testing of *N. gonorrhoeae* isolates was done using the disk diffusion method on Columbia chocolate agar as described by the WHO (15). The antibiotic discs (Oxoid Limited, Thebarton, SA, Australia) used contained amoxycillin and clavulanic acid in a 2:1 ratio (30 µg), azithromycin (15 µg), ceftriaxone (0.5 µg), ciprofloxacin (1 µg), erythromycin (15 µg), penicillin G (0.1 IU), spectinomycin (100 µg) and tetracycline (10 µg). The minimum inhibitory concentration (MIC) was measured for isolates that displayed a diminished susceptibility to an antibiotic using the Etest® system (AB Biodisk, Dalvågen, Solna, Sweden). Penicillinase-producing *N. gonorrhoeae* (PPNG) were identified using a β-lactamase indicator stick (Oxoid Limited, Thebarton, SA, Australia).

Results

Samples were collected from a total of 145 women and 65 men during the study period. *N. gonorrhoeae* was cultured from 31% (n=65) of patients : 14% (n=21) of women and 68% (n=44) of men. *N. gonorrhoeae* was isolated more commonly from urethral swabs of men than cervical swabs of women (odds ratio 12.4, $p < 0.001$). A total of 65 gonococcal strains were isolated, of which 52 (80%) underwent full antimicrobial susceptibility testing (Table 1).

21 isolates resistant to penicillin were PPNG and accounted for 40% of isolates tested. Of these, 7 isolates (33%) had an MIC of $\geq 32 \mu\text{g/l}$, the highest concentration on the penicillin Etest® strip used (Table 2). All isolates remained susceptible to amoxycillin-clavulanate, including the PPNG isolates. All non-PPNG (60%, n=31) were susceptible to penicillin (Table 1). One isolate (2%) from Lae was resistant to ciprofloxacin and had an MIC of $2 \mu\text{g/l}$. Elevated MICs to tetracycline were observed in 19% (n=10) of isolates tested (Table 2). All isolates collected in the study were susceptible to spectinomycin, erythromycin, azithromycin

and ceftriaxone (Table 1).

Discussion

All gonococcal isolates tested in this study were susceptible in vitro to amoxycillin-clavulanate. On the basis of this finding, the current treatment regimen of 1 g of Augmentin 500 with an additional 2 g of amoxycillin and 1 g of probenecid should remain the standard treatment for gonorrhoea, as part of the syndromic management protocol for GDS in PNG.

Similar to other studies in PNG (2,13,16,17), this study found that PPNG represented a large proportion (40%) of gonococcal isolates that cause disease in the community. PPNG are characteristically resistant to β -lactam antibiotics, because the penicillinase produced by PPNG hydrolyses the active component of β -lactam antibiotics, particularly penicillins (11,18). All PPNG detected in this study were resistant to penicillin, with high MICs to the antibiotic. However, all PPNG were susceptible to amoxycillin-clavulanate. Clavulanic acid, a β -lactamase inhibitor, blocks the activity of penicillinase making the organism susceptible

TABLE 1

ANTIMICROBIAL SUSCEPTIBILITY OF *NEISSERIA GONORRHOEAE* ISOLATES

		Port Moresby n=4	Lae n=18	Mt Hagen n=13	Goroka n=17	Total n=52
β -lactamase	Positive	2	6	5	8	21
Penicillin G	Resistant	2	6	5	8	21
Amoxycillin-clavulanate	Resistant	0	0	0	0	0
Ciprofloxacin	Resistant	0	1	0	0	1
Tetracycline	Resistant	0	0	0	0	0
Spectinomycin	Resistant	0	0	0	0	0
Erythromycin	Resistant	0	0	0	0	0
Azithromycin	Resistant	0	0	0	0	0
Ceftriaxone	Resistant	0	0	0	0	0

TABLE 2

NUMBER OF *NEISSERIA GONORRHOEAE* ISOLATES WITH ELEVATED MINIMUM INHIBITORY CONCENTRATIONS

Antimicrobial agent	MIC (µg/l)	Number of isolates
Penicillin	6	1
	8	3
	12	3
	16	4
	24	3
	32	7
Tetracycline	64	5
	96	4
	256	1
Ciprofloxacin	2	1

MIC = minimum inhibitory concentration

to amoxycillin (11,18). In spite of the persistence of PPNG in the community, the standard treatment for gonorrhoea remains effective and thus should be maintained.

Chromosomal-mediated resistance (CMR) to penicillin has been reported previously in PNG (2,16,19). CMR to penicillin is usually manifested in PPNG resistant to amoxycillin-clavulanate or with elevated MICs to penicillin in non-PPNG. CMR to penicillin was not detected in any of the isolates tested, as all isolates were susceptible to amoxycillin-clavulanate and all non-PPNG were susceptible to penicillin.

Resistance to ciprofloxacin and tetracycline have been reported in isolates from PNG (2,13,16,17). Quinolones, such as ciprofloxacin, are not commonly used to treat gonorrhoea in PNG and selective pressure from quinolone use would be minimal. The occurrence of quinolone resistance has been low and sporadic suggesting that quinolone-resistant strains may be introduced organisms, as their occurrence is widespread

throughout Asia and parts of the Pacific (13). In this study, one isolate (2%) was resistant to ciprofloxacin but remained susceptible to amoxycillin-clavulanate. Elevated MICs to tetracycline were observed in 19% of the isolates tested suggesting that the common use of doxycycline is selecting strains that are becoming resistant to tetracycline. While doxycycline is not used to treat gonorrhoea in PNG, it is occasionally used to treat chlamydia, pelvic inflammatory disease and associated sequelae (9).

Despite the shortcomings of culture *N. gonorrhoeae* was isolated from 31% of patients, suggesting that gonorrhoea remains a common STI in the country. As such, it is imperative that the standard treatment protocol be regularly monitored. To inform the development of future treatment protocols, susceptibility to a range of antibiotics must be regularly monitored in case the present standard treatment becomes ineffective (11,12). On the basis of our findings, spectinomycin,

erythromycin, azithromycin and ceftriaxone remain effective and could offer alternative options for gonococcal treatment in PNG.

The diversity of the terrain, people, language and culture in PNG give rise to complex transmission dynamics of STIs in the country. Hence it is vital that gonococcal susceptibility patterns be monitored across different sites within PNG. The four centres in this study were selected for their moderate to high incidence of gonococcal infection (8). Port Moresby, the capital and most populated city of PNG, is considered the gateway to the country. Lae, the second largest city, is also a strategic port and the start of the Okuk Highway, which links the coast to the Highlands Region. Mt Hagen and Goroka are major centres in the Highlands Region and are situated along the Okuk Highway. Obviously, a national standard treatment protocol should be effective throughout the entire country. Isolates collected across all four sites were susceptible to amoxycillin-clavulanate indicating that the standard treatment is still effective across PNG.

At present, culture-based methods are the gold standard for antibiotic susceptibility testing (11) but there are many challenges associated with the culture of *N. gonorrhoeae*, particularly in a resource-limited setting such as PNG. Firstly, *N. gonorrhoeae* is fastidious and difficult to culture, particularly from women because of the presence of competing flora in the female genital tract (20). The presence of competing flora might in part explain the significant difference in isolation of the organism from men compared to women. Secondly, most hospitals in PNG do not have the laboratory capacity and resources to carry out routine gonococcal culture. This is particularly important since successful culture of *N. gonorrhoeae* is dependent on many factors such as technique of specimen collection, transportation conditions, quality of culture medium and incubation conditions (20). The development of an assay that is able to detect relevant factors associated with resistance in *N. gonorrhoeae* without the need for a viable organism would allow a more representative monitoring of antibiotic susceptibility patterns throughout the country. Recently, a number of molecular assays have been developed to detect specific mutations associated with *N. gonorrhoeae* antimicrobial resistance using non-viable organisms (21,22). Such assays, perhaps at reference centres, should be

considered for future monitoring of gonococcal susceptibility in PNG.

Conclusion

Given the high prevalence of STIs in PNG, their effective treatment is important in itself but also an integral part of PNG's response to the HIV epidemic. Gonorrhoea, while easily curable, continues to be a significant STI in the country. Amoxycillin-clavulanate remains effective in clearing circulating strains of *N. gonorrhoeae* in PNG and therefore the current standard treatment regimen for gonorrhoea should be maintained. However, it is vital that gonococcal antibiotic susceptibility be regularly monitored so that the national treatment protocols continue to be evidence based.

ACKNOWLEDGEMENTS

This study was funded through the National HIV and AIDS Support Project. The authors sincerely thank the participating staff and patients of Heduru Clinic, Friends Clinic, Tininga Clinic and Michael Alpers Clinic. The authors also thank the Management of Port Moresby General Hospital, Angau Memorial Hospital, Mt Hagen General Hospital and Goroka General Hospital for their support of this study. Tilda Orami and Mitton Yoannes provided invaluable laboratory support and technical advice for this study. Dr Andrew Greenhill and Dr Claire Ryan provided critical feedback on this manuscript.

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The management of paediatric patients in a general Emergency Department in Papua New Guinea

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SUMMARY

Children less than 13 years of age account for 27% of the case mix at the Emergency Department (ED) of the Port Moresby General Hospital (PMGH). The ED is busy, usually overcrowded, understaffed and under-equipped, resulting in less than optimal patient management. Children are a highly vulnerable group of patients and have the potential to deteriorate rapidly. This prospective descriptive study aimed to assess the adequacy of management of children presenting to the ED between 1600 and 0800 hours. A standardized and individually administered questionnaire was used to assess the management of 107 children. The median age was 13 months, interquartile range 6-36 months, with a male to female ratio of 1.5:1. The most frequent diagnoses were pneumonia/bronchiolitis, diarrhoea, malaria, asthma and febrile convulsions. Three-quarters of the sample were classified as being triage 1 and 2, ie, requiring either immediate life-saving treatment or treatment within 30 minutes to an hour of presentation. Median and interquartile ranges for time from arrival to assessment were 60 (15-110) minutes for triage 1, and 60 (30-121) minutes for triage 2 patients. Time from assessment to management was 5 (5-45) minutes for triage 1 and 40 (30-63) minutes for triage 2 patients. Treatment instituted was appropriate in 93% of cases but the drug dosage was incorrect in 26%. 49 children (46%) were admitted to the wards either directly or following further observation in the ED or Children's Outpatient Department, the rest being treated and discharged, except for one child with probable septicaemia who died following a prolonged and unattended wait in the ED. Management was assessed as adequate in only 40% of cases. The major causes of inadequate management were delayed treatment, under- or over-dosing, under- or over-treatment, omission of appropriate investigations, misdiagnosis and failure of judicious consultation with the paediatric team. Many patients were nursed on the floor. Recommendations emanating from the study include ensuring adequate staffing levels and the training of all staff working in ED in the rapid identification of sick children to improve triage and subsequent management.

Introduction

Of the population of Papua New Guinea (PNG) 40% is aged less than 15 years and 15% less than 5 years (1). Neonatal, infant and under-five mortality rates (29, 57 and 75 per thousand live births) are high (2). The top five causes of childhood mortality are pneumonia, malaria, diarrhoeal diseases,

meningitis and tuberculosis. These are often associated with malnutrition and, in a country with a moderate HIV (human immunodeficiency virus) burden, increasingly with HIV infection. Illness in children is a very common presentation to the country's health services. Children differ from adults in anatomical, physiological, biochemical and sociological parameters, and although they

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may demonstrate remarkable ability to recover from illness, they may also be more vulnerable than adults and may deteriorate more rapidly when ill.

Emergency Medicine (EM) is a relatively new and growing specialty, and specialty training in the discipline was only commenced in Papua New Guinea in 2003 (3,4). Paediatric Emergency Medicine is a sub-specialist field which incorporates the medical fields of paediatrics and emergency medicine. It is well established in countries like the USA (United States of America), UK (United Kingdom) and Australia. Paediatric EM courses and practice guidelines are being promulgated in developing nations like China, Cambodia and Vietnam (5,6). Paediatric EM stems from the recognition that children with critical illness and injury need special attention and care. Some hospitals in some countries have dedicated Paediatric Emergency Departments (EDs). However, even in resource-rich countries, up to 90% of children still share EDs with adults and sometimes do not get the care that they require (7-9). In one study from the USA only 6% of the EDs studied had all the recommended equipment and supplies for children (10).

Port Moresby General Hospital (PMGH) has a Children's Outpatient Department (COPD) serving as a referral centre for the city and surrounding areas, and as a clinic for the immediate area of the city. It is, however, only open between the hours of 0800 and 1600. Ill children presenting to the hospital between 1600 and 0800 hours are seen in the hospital's Emergency Department and account for 27% of the patient load. 85% of the paediatric presentations are with infectious diseases, with respiratory infections and diarrhoeal disease predominating; surgical cases and traumatic injuries account for the remaining 15% (Port Moresby General Hospital Emergency Department attendance registry 17 April to 17 July 2008). The ED is an extremely busy place, with a turnover of 1500-2000 patients per month. It is where the sickest patients present, and is usually busiest between 1600 and 0800 hours when other public and many private health facilities are closed and when there is an influx of patients requiring outpatient services as well as those requiring emergency attention. It is the major point of entry or admission to the wards for the medical and surgical specialties. Unfortunately, and although the situation is changing for the better, it has generally been

staffed by junior and often inexperienced medical staff. It also regularly experiences shortage of nursing staff, and of essential and life-saving equipment, drugs and other consumables. All these factors put considerable constraints on the efficiency of the ED and considerable stress on those working there and the patients they serve. Data are recorded manually in work registers and are often incomplete. Information such as time intervals to triage and treatment, access block – “the term which describes the delay patients who need hospital admission experience in the emergency department when their inpatient bed is unavailable” (11) – and outcome, which would be routinely collected and recorded electronically in a more sophisticated setting and would be used as a Continuous Quality Improvement project, is recorded haphazardly if at all. This lack of information prompted the present study and necessitated a researcher to document and analyse the data required.

Aim

The study aimed to answer the question, “Are children presenting to the PMGH ED being adequately managed?”, and to determine an outcome with a view to making recommendations for improvement. The specific objectives were to assess the following:

- disease pattern in paediatric presentations
- time interval from arrival to assessment
- time interval between assessment and treatment
- treatment of sick children in relation to national guidelines for treatment (12) and other management guidelines
- access block
- overall adequacy of management
- outcome of all paediatric patients who presented to ED.

Methods

This prospective, descriptive study was carried out at the Emergency Department of Port Moresby General Hospital between May and August 2009 in two phases. In the first

phase consecutive patients presenting to the department between 1600 hours and 0800 hours were recruited during a single designated research week. In the second phase opportunistic sampling was employed over a period of 3 months.

Infants and children up to the age of 12 years were included in the study. Those presenting with trauma or obvious surgical conditions were excluded.

A three-scale triage system is in use in all PNG EDs rather than the five-scale system which is used internationally (Accident and Emergency Department Policy and Procedure Manual. National Department of Health, Port Moresby, 2001). It classifies children into Triage 1 (Resuscitation/Immediately life-threatening), Triage 2 (Life-threatening) or Triage 3 (Semi-urgent to Non-urgent).

Whilst the ED staff were aware that a research project was being carried out they were unaware of its aims and objectives. A standardized questionnaire was completed entirely by the researcher (JT) using the information in the patient's health record book (the book kept by the child's mother in which details of contacts with the health services, including those made in the ED, are recorded). The data collected for each patient included the patient's bio-data, the triage category to which the patient was allocated by the ED medical staff, presenting complaints, nutritional status, systemic examination findings, investigations done and the working diagnosis. Time management indicators included the times of arrival, consultation and treatment. The treatment instituted and whether or not it was correct (including dosage) were noted, using the Paediatric Standard Treatment book (12) and other management protocols (Acute Paediatric Life Support, Emergency Management of Severe Trauma, Primary Trauma Course) where appropriate as representing internationally accepted best practice. Other patient issues were taken into account when making the final assessment of management. The final outcome (treated and discharged, or admitted to the wards) was noted. The number of ED staff working in each shift was recorded.

The study used a maximum of 24 hours as the time by which admitted patients should have accessed a hospital bed. Access block

was determined by noting the time from recommendation for paediatric admission to actual admission. This included all patients who were seen at ED, and who were either admitted to the Children's Ward directly from ED or who were transferred to the Children's Outpatient Department observation room in the morning to await consultation or to access a ward bed.

The results were analysed using SPSS version 10.0.

Results

A total of 107 children were recruited, 50 in the first (consecutive sampling) and 57 in the second (opportunistic sampling) phase.

Patient characteristics

Ages ranged from 1 to 132 months with a median of 13 and an interquartile range of 6-36 months. The male to female ratio was 1.5:1. 20 children (19%) had a weight between 60 to 80 percent standard weight for age (SWA) and 7 (7%) below 60 percent SWA.

Presentations and diagnoses

35 (33%) of patients were in triage category 1 (resuscitation/immediately life-threatening), 46 (43%) in category 2 (life-threatening) and 26 (24%) in category 3 (semi-urgent to non-urgent).

The presenting complaints are shown in Table 1 and the clinical findings in Table 2. The top five presenting complaints were fever, shortness of breath, diarrhoea, vomiting and irritability. Respiratory system signs and tachycardia predominated but reduced conscious state and signs of dehydration were common.

Pneumonia/bronchiolitis, acute gastroenteritis, malaria, asthma and febrile fits were the leading five provisional diagnoses made by the ED staff, and were also the leading diagnoses made by the paediatric staff for the 49 children admitted to the wards.

Management

The time intervals from arrival to assessment and from assessment to treatment are shown for the total study group

TABLE 1

PRESENTING COMPLAINTS OF 107 STUDY CASES

Presenting complaints	Frequency
Fever	73
Shortness of breath (SOB)	60
Diarrhoea	31
Vomiting	29
Irritability	18
Seizures	11
Anorexia	8
Rhinorrhoea	3
Neck stiffness	3
Stary eyes*	3
Skin sores	3
Weight loss	1
Headache	1
Others	10

*The term commonly used by parents and health workers to describe episodes in which the child appears to stare fixedly and is recognized as being abnormal behaviour

and by triage category in Table 3. Time from arrival to assessment ranged from 5 to 420 minutes. The median and interquartile ranges were 60 (15-110) minutes for triage 1, 60 (30-121) for triage 2 and 50 (20-90) for triage 3 patients. Times from assessment to treatment were 5 (5-45) minutes for triage 1, 40 (30-63) for triage 2 and 40 (20-65) for triage 3 patients.

The majority (80%) of paediatric patients who presented to the ED were assessed and managed by medical officers (fully registered officers who have completed undergraduate training and a two-year internship) while resident medical officers (those undergoing their internship) saw 17% and nurses/ community health workers saw 3%.

The most common treatments that were

instituted at the ED – antibiotics, antimalarials, analgesics/antipyretics, IV fluids and bronchodilators – were a reflection of the common disease presentations.

Treatment modalities and medications ordered and given by the ED staff were correct according to the available standard treatment guidelines in 93% of the cases, but the dose ordered was incorrect in 26% of cases.

Of the 107 paediatric cases who were included in the study 50 (47%) were seen, managed and discharged from ED, 26 (24%) were admitted straight to the wards while 6 were admitted but had to wait and be transferred to the COPD before getting a bed the next day. 24 children (22%) were observed at ED and then were transferred

TABLE 2

CLINICAL SIGNS AT PRESENTATION

	Frequency
Respiratory signs	
Tachypnoea	78
Recessions	59
Crepitations	56
Wheezes/Rhonchi	27
Reduced air entry	6
Dull percussion note	1
Others	4
Cardiovascular signs	
Tachycardia	78
Murmur	1
Displaced apex beat	1
Central nervous system signs	
Reduced conscious state	18
Decreased muscle tone/power	12
Neck stiffness	5
Hyporeflexia	4
Bulging fontanelle	2
Gastrointestinal system signs	
Signs of dehydration	25
Abdominal pain	1
Hepatomegaly	1
Oral thrush	1

TABLE 3

TIME INTERVALS (MINUTES) FROM ARRIVAL TO ASSESSMENT AND MANAGEMENT IN
THE EMERGENCY DEPARTMENT

		Time intervals (minutes)	
	Number of patients	Range	Median (Interquartile range)
From arrival to assessment			
Overall	107	5-420	60 (25-110)
Triage 1	35 (33%)	5-420	60 (15-110)
Triage 2	46 (43%)	5-375	60 (30-121)
Triage 3	26 (24%)	5-300	50 (20-90)
From assessment to treatment			
Overall	107	5-210	30 (10-65)
Triage 1	35 (33%)	5-210	5 (5-45)
Triage 2	46 (43%)	5-210	40 (30-63)
Triage 3	26 (24%)	5-120	40 (20-65)

the next day to COPD, from where 7 were subsequently discharged and 17 admitted to the wards. In all 57 were discharged and 49 (46%) were admitted. One child died – probably of septicaemia – after an unattended wait of several hours in the ED. The mother in desperation took the child directly to the Children's Ward, where resuscitation was attempted but was unsuccessful.

Management of paediatric patients at ED was assessed as adequate in only 43/107 children (40%). The main reasons relating to inadequate management were delayed assessment and/or delayed treatment (45%), failure to consult the paediatric division appropriately (11%) and under-treatment (9%). Others included under-dosing, over-dosing, inappropriate treatment, over-treating, omission of appropriate investigations and misdiagnosis. More than one factor applied in some of the children. 10% of the patients were nursed on the floor after assessment and treatment.

Resources

The average number of ED health workers in each shift during the duration of the study was 8. The actual number ranged from 2 to 11. The average number of medical officers/residents in each shift was 4, as was the average number of nurses and CHWs.

The first contact between patients and hospital personnel was usually at the entrance of the ED with security guards who had had no detailed training in triage.

Discussion

The study found that only 4 out of 10 children presenting to the ED between 1600 and 0800 hours were being adequately managed. Delayed assessment and/or delayed treatment occurred in almost half of the study group.

Triage is the process of sorting the patients into categories on the basis of severity of

illness and urgency of treatment. Accurate and rapid triaging which allows for critically and severely ill children to be properly assessed and appropriately managed is fundamental to the provision of adequate care for sick children (13), and assessment of the triaging system and adherence to triaging times is regarded as a key performance indicator in EDs in sophisticated settings. PMGH ED guidelines state that patients in triage category 1 (immediately life-threatening) should be assessed immediately and treated within 30 minutes, those in category 2 (life-threatening conditions but stable) should be assessed within 30 minutes and treated within an hour and those in category 3 (semi-urgent and non-urgent) should be assessed and treated within 2-4 hours. 76% (81/107) of the children in our study were allocated to triage categories 1 or 2. In 75% of these critically and seriously ill children the time from arrival to assessment was greater than 15 minutes for category 1 and 30 minutes for category 2. The median time intervals to assessment of children in triage categories 1 and 2 were 60 minutes and, paradoxically, 50 minutes for those in category 3 (Table 3). Effective triage was, therefore, not being practised, and our study indicated major problems at the 'entry point' in the ED. This is clearly unacceptable. Time intervals from assessment to treatment were more acceptable.

Triage systems used in adults may not necessarily be completely appropriate for children. A recent assessment of the use in children of the internationally accepted Emergency Severity Index (v4), which uses 5 triage categories, found it to be only moderately reliable (14). A 3-stage triaging system is used in Papua New Guinea. However, determining to which category a sick child belongs requires knowledge of and familiarity with presentations of serious illness in children. An easy-to-use 3-category triage system specific for children designed for use in the hospital setting and which is based on emergency signs (airway and breathing, circulation, central nervous system and dehydration), priority signs and non-urgent cases is detailed in the World Health Organization (WHO) publication Hospital Care for Children (15). This system has similarities to the Integrated Management of Childhood Illness (IMCI) check list approach, being symptom based (16). The IMCI uses a simple 'Ask, Look and Feel' approach. The first step in the IMCI check list for infants and

children poses the question, "Is the Child Too Sick?", the latter being determined by the inability to feed, vomiting of everything the child takes, a recent history of convulsions and the presence of convulsions or impaired consciousness. This is followed in a stepwise fashion by careful assessment of respiratory symptoms and signs, hydration status, fever and other parameters. The IMCI algorithms have been validated in many settings, including Papua New Guinea (17), and IMCI, which has three components, improving assessment of children through the check list algorithmic approach, improving health facility infrastructure and staffing, and involving the community in its own health issues, is one of 7 pillars of the Child Survival Strategy (18). Whilst the IMCI approach is more suited to an Outpatient than an Emergency Department setting, the ability of those on the front line to assess the child as being 'too sick' and to take appropriate action is essential. Whatever triaging system is used depends for its success on the initial training of those health workers using it and its constant reinforcement. Triage guidelines and recommended waiting times for triage categories should be clearly displayed and performance measured against them. Regular refresher courses should be an integral part of staff activities. Crucially, effective triage requires that there be adequately trained personnel 'at the door' of the ED. In our setting security personnel are usually the first point of contact for patients at the ED. It might be theoretically possible to allocate the job of basic triaging to specifically designated and trained security personnel but staff turnover, the demands of the security work itself, and issues of salary and of legal responsibility would make this difficult. It is more practical to have trained health staff working nearer to the point of entry, in conjunction with security personnel.

Our study found that 5% of the children were misdiagnosed, 10% under-treated and 1% over-treated, and that 26% were treated with the incorrect drug dose. All medical staff should have their own copy of or have ready access to the Paediatric Standard Treatment book (12), which clearly gives the appropriate doses for the commonly used drugs. Copies of the Melbourne Royal Children's Hospital's Drug Doses pocket handbook (19) are available through the Paediatric Society of Papua New Guinea and should be available in all EDs in the country for reference in using the less common drugs sometimes required

in the management of paediatric emergencies. Clearly the use of these treatment guidelines needs to be more widely emphasized.

A study of 21 hospitals in Asia and Africa that evaluated the management of 131 children with critical illness showed that more than half of them were under-treated or inappropriately treated with antibiotics, fluids, feeding or oxygen (20). Contributing factors included inadequate triage and assessment, poor treatment and insufficient monitoring, which adversely affected the outcome of a significant proportion of hospitalized children and resulted in unnecessary suffering or avoidable deaths. The same study showed that in some settings, over-hospitalization, over-diagnosis of severe illness and over-medication also occurred, resulting in adverse consequences and wastage of health resources. In contrast a recent report from Malawi demonstrates that emergency triage, assessment and treatment guidelines can be used to good effect by nurses and other health professionals to identify children needing high-priority treatment and to significantly reduce overall case fatality (21).

There were several limitations to this study. Although the full scope of the study was not revealed to the ED staff, they were aware that a research project was under way and this may have introduced bias into the manner in which paediatric patients were managed.

The first author JT found it impossible to be an observer when seriously ill children were involved and intervened in their management where he felt this to be necessary because of delays. This resulted in many sick children being excluded from the study, and biased the sample towards the less severely ill children.

The number of children included in the study was less than originally planned, but nevertheless proved sufficient to answer the research question.

Recommendations

Recommendations emanating from this study are as follows:

1. The triage system needs to be applied rapidly and effectively. This may necessitate changes in the organization of patient movement into

the ED with triage categories being allocated 'at the door'. This will entail ensuring that adequate numbers of adequately trained staff should be on site at all times. Triage guidelines including respective waiting times should be prominently displayed in the ED, and regular audit should be carried out to ensure that they are followed.

2. Training in triaging should be mandatory for all nurses and doctors in the ED. Staff in COPD should be trained in IMCI. Regular refresher courses should be built into staff activities.
3. Full-time EM specialists or senior trainee registrars should be stationed in the ED at all times.
4. Staff should be encouraged to use the Standard Treatment Manual and other guidelines where appropriate to determine drug doses for children.
5. The ED should be adequately staffed and equipped for treating patients requiring emergency care, whatever their age and at any time of day.

Conclusions

More than half of the children presenting to the ED after hours had immediately life-threatening to urgent conditions and most of these were eventually admitted. The triage system in place at the time of the study failed. Patient management was assessed to be satisfactory in only 40%. The main reasons for inadequate management were delay in assessing and allocating triage category and treatment, incorrect treatment or drug dosage, and failure to consult the paediatric team early. Many paediatric patients do not receive an adequate level of care. There are inherent problems in the ED that need to be addressed so that service delivery can improve. The most important improvement would be the provision of adequately trained personnel 'at the door' to enable effective triaging and rapid and appropriate treatment.

ACKNOWLEDGEMENTS

Prof. Chris Curry assisted with references and with preparation of the manuscript, and Prof. Trevor Duke provided constructive comment. We gratefully acknowledge the

paediatric patients and their guardians who generously gave themselves and their time in the midst of disease and adversity to give information for the research. We thank Dr Sam Yokapua and the staff at Port Moresby General Hospital's Emergency Department who kindly helped JT and allowed access to their department.

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Study of depression and anxiety in prenatal and postnatal women at Port Moresby General Hospital

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SUMMARY

Papua New Guinea, a country of diverse languages, culture and customs, is undergoing rapid developmental changes in its environment and society. These changes can lead to the development of medical problems both physical and mental. This preliminary descriptive study of depression in 50 prenatal and 50 postnatal women using the Harding Self Report Questionnaire and mental status examination was conducted at Port Moresby General Hospital. The study found 20% of depression in the prenatal women and 30% in the postnatal women immediately postpartum. Anxiety was present in 6% of prenatal women and in 4% of postnatal women. 14% of the women interviewed had experienced physical abuse in the month before the interview.

Introduction

Pregnancy and psychiatric disorders

It is often thought that pregnancy and the postpartum period are a time of joy for a woman but for many this is not the experience (1). According to Snaith pregnancy is an emotionally turbulent time for many women; the woman may be in a state of conflict about the pregnancy for many reasons, but especially if she is young and unmarried or married and multiparous (2).

In Papua New Guinea (PNG) pregnancy is regarded as special and important and is seen as a means of increasing the population of one's clan or tribal group or as a means of survival of one's clan if it is on the verge of extinction. In a patrilineal society a man with many children is regarded as being of a higher social status than a man who has no children. It is also known that women who desperately want children but who fail to conceive often leave their husbands and marry someone else in order to have children. This is because a woman who is barren is regarded as a 'nobody' in her community. In traditional Papua New Guinea a pregnant woman receives support from her mother and other

womenfolk, but the situation is changing, especially in the urban areas, where there is a lack of traditional social networks and more western attitudes are impinging on individual women.

The postpartum period is also a time of great change for a woman. During the process of delivery itself, she has undergone a lot of stress. Now that she has delivered, there is a change in her body image and shape and also a shift in the hormonal balance (1). In addition to this, the woman is now left with a new role of mothering if she is primiparous. Whilst most women cope with the change some may find it difficult as they have to change routines. For example, a new mother needs to give up her former independence and pursuits and this may result in psychiatric disorders (2).

Mood disorders that occur following childbirth include the 'maternal blues', postpartum depression and puerperal psychosis.

The 'blues' occur in about 70% of women peaking at day 3-5 postpartum and the symptoms consist of anxiety, depression, tearfulness, lability of mood and irritability (1,

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2). It is a transient phenomenon and it resolves on its own although severe blues often indicate increased risk of subsequent depression (1).

Postnatal depression is very common and has a gradual onset (1). Epidemiological studies have shown that it affects 10-20% of women in western societies (3-10). It is usually manifested clinically in the first 3-6 months postpartum. Clinical features include tearfulness, irritability, feelings of inadequacy, poor concentration, inability to cope with minor tasks, guilt, anxiety, feelings of failure as a mother, decreased libido, and exhaustion and sleep disturbances, especially difficulty in getting to sleep. The baby may be the focus of anxiety or of obsessional thoughts of harm (1). If postnatal depression goes unrecognized and untreated, it often will become a chronic problem becoming damaging to the woman, the baby, any other children and the marriage, and also resulting in problems for the next generation of parents (11).

Puerperal psychosis is the most severe and least common of the puerperal disorders with an incidence estimated to be 2-3 per 1000 births. Characteristic features include emotional lability, distractibility, anxiety, pressured speech, insomnia, depression, perplexity, agitation, auditory and visual hallucination, intermittent memory impairment, mutism, disturbances of body image, apathy and delusions. Those affected may develop non-puerperal affective psychosis later on (1).

Risk factors involved in the genesis of postpartum depression include recent stressful life events, previous history of a psychiatric disorder, young age, poor marital relationship, unemployment, previous divorce, polygamy, low and high parity and having a close relative with substance abuse problems (6,9).

The aim of the research, the first of its kind in Papua New Guinea, was to find out the prevalence of depression and anxiety among prenatal and postnatal women in Port Moresby and to determine differences between the prenatal and postnatal women.

Methods

This descriptive case series study of prenatal and postnatal women was conducted

at the Port Moresby General Hospital over a 6-month period from April to September 1999.

Sample

Subjects in the study were women aged 15-40 years attending the Prenatal Clinic and the Postnatal Ward of Port Moresby General Hospital. Their selection was based on availability during the times the interviewer was physically present. The prenatal subjects were interviewed at the Antenatal Clinic before their obstetric consultation during their second or third trimester. They were recruited after the midwives' morning health talk and as they were waiting their turn to be seen by the nurses, waiting for their blood samples to be taken for routine investigations or waiting to be seen by their doctor. A few were recruited as they were leaving the clinic after their treatment.

Postnatal women were interviewed at day 2 post delivery at the Postnatal Ward. Selection was based on availability and willingness to be interviewed. Type of delivery was not a selection criterion.

50 prenatal and 50 postnatal women were included in the survey. Demographic data on all subjects included age, current residential address, home village, province, parity, marital status (whether single, divorced, married or in a de facto marital relationship) and current medical and obstetric problems.

Measures

Both groups of women were interviewed using the Harding Self Report Questionnaire (HSRQ) (Table 1). This is a screening instrument designed to identify subjects with a high likelihood of a clinical disorder.

The HSRQ was developed and used by Harding and co-workers in their large four-country study and has 24 questions with a response of either 'Yes' or 'No' (12). It asks questions such as "Do you feel unhappy?" and "Do your hands shake?" (12). The HSRQ was designed to screen for psychiatric disturbances in primary health care settings especially in developing countries (12,13). As initially developed, the first 20 questions were designed to detect a likelihood of anxiety or depression while the last four items (not used in this study) were designed to detect a likelihood of psychotic disorders.

TABLE 1**HARDING SELF REPORT QUESTIONNAIRE****Non-psychotic items**

1. Do you often have headache?
2. Is your appetite poor?
3. Do you sleep badly?
4. Are you easily frightened?
5. Do your hands shake?
6. Do you feel nervous, tense and worried?
7. Is your digestion poor?
8. Do you have trouble thinking clearly?
9. Do you feel unhappy?
10. Do you cry more than usual?
11. Do you find it difficult to enjoy your daily activity?
12. Do you find it difficult to make decisions?
13. Is your daily work suffering?
14. Are you unable to play a useful part in life?
15. Have you lost interest in things?
16. Do you feel that you are a worthless person?
17. Has the thought of ending your life been in your mind?
18. Do you feel tired all the time?
19. Do you have uncomfortable feelings in your stomach?
20. Are you easily tired?

Psychotic items

21. Do you feel that somebody has been trying to harm you in any way?
22. Are you a much more important person than most people think?
23. Have you noticed any interference or anything else unusual in your thinking?
24. Do you ever hear voices without knowing where they come from or which people cannot hear?

Women in both groups were interviewed in English, Tok Pisin and in very few cases by an interpreter. A cut-off point of 7 Yes answers on the HSRQ was used. Thus a woman with a total score of 7 or more was deemed to be at a higher risk of having depression or anxiety. This cut-off point was used in an earlier Zimbabwean study and was in line with other studies using the questionnaire (14,15).

Procedure

Selected individuals were informed about the study and had its purpose explained to them before being interviewed. They were interviewed only when they indicated that they were willing and happy to take part in the survey. Only one prenatal woman was reluctant to be interviewed initially, although she changed her mind later and asked to be interviewed too.

Subjects who scored a total of 7 and above had a clinical psychiatric interview and had their mental status clinically examined.

All subjects were also asked whether or not they were physically abused over the last one month by their spouses or partners. Questions asked included, "Over the last one month were you in any way physically abused by your husband or partner?"

Results

Details of the women are shown in Table 2.

There were no significant differences in age or marital status. During the month preceding the interview 14% of the prenatal and 14% of the postnatal women admitted to being physically abused by their husbands or partners.

Overall the two groups of women were similar in their characteristics. The women in this study came from all over the country and from Table 2 it can be seen that for both the prenatal and postnatal women the highest number came from the Southern Region and least number from the New Guinea Islands Region. There were more prenatal than postnatal women from the Highlands Region but this difference was not considered statistically significant (Yates corrected χ^2 test $p=0.07$). Out of the prenatal women 48 (96%) lived in the city and 2 (4%) in villages while

for the postnatal women 42 (84%) were from the city and 8 (16%) came from neighbouring villages.

The HSRQ identified 21 (42%) prenatal and 19 (38%) postnatal women to be at high risk of a clinical diagnosis of anxiety or depression. At clinical interview it was found that of the prenatal women 10 (20%) were depressed and 3 (6%) were anxious while for the postnatal women 15 (30%) were depressed and 2 (4%) were anxious.

At the time of the interview 4 (8%) prenatal women had medical problems: 2 with oedema and 1 each with back pain and hypertension. Two of those with medical problems had depression.

Most women who had had caesarean section were too sick to be interviewed by day 2 post delivery so only two who were up and about by then were interviewed.

A total of 9 (18%) postnatal women had medical or surgical problems. These included 4 with lower abdominal pain, one of whom also had an ovarian cyst with additional itchiness of the body, and 1 each with tuberculosis, severe backache, pain in the back following tubal ligation, pain in the episiotomy site and hypertension. 5 postnatal women out of the 9 with medical or surgical problems were depressed.

Discussion

There are several limitations identified in this study. Firstly, the questionnaire used in the study had not officially been translated into Tok Pisin, and there were some, if not most, words in psychiatry in English which do not have a word of equivalent meaning in Tok Pisin. For example, the Tok Pisin word 'sik wari' is used as a general screen for both depression and anxiety.

Secondly, the cut-off point of 7 on the HSRQ used in other countries has not been validated for our setting.

The interview for the postnatal women was done at day 2 postpartum. Though it is a difficult time in view of the postpartum maternal blues it was chosen firstly because there is a high turnover rate of postnatal women in the postnatal ward – women tend to have a short hospital stay unless they have complications or their babies are under the

TABLE 2

CHARACTERISTICS OF THE PRENATAL AND THE POSTNATAL WOMEN IN THE STUDY

Characteristics	Prenatal women (50)	Postnatal women (50)
Mean age (range) years	23.3 (16-39)	25.9 (15-39)
Physical abuse reported	7 (14%)	7 (14%)
Married	48 (96%)	49 (98%)
Divorced	1 (2%)	1 (2%)
Single	1 (2%)	0
Region of Origin		
Southern	27 (54%)	33 (66%)
Momase	3 (6%)	6 (12%)
Highlands	18 (36%)	9 (18%)
New Guinea Islands	2 (4%)	2 (4%)
Parity		
Primigravida/Primiparous	19 (38%)	17 (34%)
Multigravida/Multiparous	31 (62%)	33 (66%)
Residence		
City suburbs	48 (96%)	42 (84%)
Villages	2 (4%)	8 (16%)

care of the paediatrician. Secondly, there is no routine postnatal clinic. There is one only for those mothers who had complications such as infected wounds, lower uterine segment caesarean section, postpartum haemorrhage or tubal ligation, and this would represent a highly selected population.

Early postnatal interview may have picked up the 'blues' rather than the depression. Postnatal depression is known to begin as late as 3-6 months after delivery. Severe 'blues' is more likely to proceed on to postnatal depression. On the other hand it is known that postnatal depression may also start in the prenatal period.

Pregnancy-related depression and anxiety

is present in this Melanesian (Papua New Guinean) sample. The HSRQ indicated that 21 (42%) of prenatal and 19 (38%) of postnatal women were at risk of having a clinical disorder. At clinical psychiatric interview, depression was found in 20% of prenatal women and 30% of postnatal women in the early postpartum period; 6% of prenatal women and 4% of postnatal women were clinically anxious.

The prevalence rate of postnatal depression in this early postpartum sample is high; at 30% it is one and a half to three times higher than that found in western society (1,3,4,8,9). However, it is similar to that found in a South African periurban settlement of Khayelitsha (16) and in Melbourne among

multiethnic women of lower socioeconomic status (17).

The high rate of depression found in these early postpartum women could be due to maternal 'blues'. Maternal blues are usually self-limiting. However, a proportion of them proceed to postnatal depression.

Depression in prenatal and postnatal women should be treated conservatively where possible because of the possible adverse effects medication may have on the baby – though such effects are not well established yet (18) – and the fact that many cases resolve spontaneously. A study done by Yoshida and colleagues on breastfed infants whose mothers were on treatment with tricyclic antidepressants failed to establish any toxic effects on the infants and there was also no developmental delays found when these babies were compared to bottle-fed babies (19). A single case of a 9-day-old breastfed infant of a mother on the tricyclic antidepressant doxepin who developed poor sucking and swallowing, vomiting, muscular weakness and drowsiness that improved 48 hours after the breastfeeds were stopped has been reported (20). Management of depression should be prompt and effective to prevent the development of poor mother-infant attachment and bonding that could result in poor psychological, social and physical development (21).

Those women in this study who were diagnosed as having depression and anxiety were given a psycho-educative counselling session after the formal interview and then advised of areas such as the welfare office, the churches and church leaders where they are more likely to obtain help, especially if they had marital problems. It is important to follow such women but unfortunately this was not done in this study.

Depression that occurs in the first few months postpartum may be associated with marked impairment in maternal interaction with the infant. Depressed mothers may be withdrawn, disengaged, hostile or intrusive. As a result the infants can show avoidance and distress (22).

Early experience of insensitive and negative maternal interaction has been associated with adverse cognitive functioning (22,23). As a result the infant cannot sustain attention and concentration. This then

renders the child vulnerable particularly in the context of adjustment to school (24). Disturbed behaviour associated with postnatal depression has been observed in late infancy and early childhood, particularly among boys and those from low socioeconomic backgrounds (25).

It is now well recognized that the fetus while in utero is able to sense what is happening to the mother. In this sample 14% of the prenatal and 14% of the postnatal women were subjected to physical abuse by their husbands during the latest pregnancy. This is just a tip of the iceberg. Studies done in different countries show that the prevalence of domestic violence and physical abuse during pregnancy varies. For example, Dathner and colleagues at the University of Pennsylvania School of Medicine, United States of America found that 15% of their clients experienced violence during pregnancy (26). In Pakistan, Fikree and his colleagues found a 23% prevalence rate and it is estimated that at least one million pregnant women in Pakistan are physically abused at least once during pregnancy (27). In Turkey 9.7% of women were beaten by their partners during pregnancy (28).

Physical abuse during pregnancy is an important public and mental health issue because it is associated with obstetric complications and poor outcome of the pregnancy. Studies report its association with increased risk of antepartum hospitalization for conditions such as hypertension and premature rupture of membranes, low birthweight delivery and both perinatal and neonatal mortality (29-31).

Risk factors for physical abuse during pregnancy include young age, use of alcohol and marijuana by the spouse, being poorly educated, presence of a diagnosis of sexually transmitted diseases, worries about the arrival and care of a new baby, financial worries, the fact that the woman is less available both physically and emotionally during pregnancy, doubts about paternity and the lack of support from the male partner (26, 32).

Conclusion

This preliminary study of depression in the prenatal and immediate postpartum period demonstrated a prevalence of 20% and 30% respectively. It also demonstrated a small proportion of prenatal and postnatal women

to be anxious and a disturbing level of physical abuse of women during pregnancy.

ACKNOWLEDGEMENT

I thank my supervisors both in PNG and overseas who contributed in one way or another to enable me to complete this study.

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The 'Reach Every Village' strategy for community-based health improvement interventions in the Momase Region of Papua New Guinea

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SUMMARY

A principal difficulty in providing adequate health services to the rural and remote population of Papua New Guinea is the extremely high transport costs due to the difficult terrain. An operational strategy was needed to overcome the cost barriers to improving rural health. The World Health Organization's 'Reach Every District' (RED) strategy of decentralized capacity building was adapted to increase immunization coverage in a district or health centre catchment area. The strategy is a rigorous application of the microplanning technique used in community development, and is planning at the lowest unit of population. The operational components of the RED program for immunization, including planning, implementation and monitoring, can be readily adapted to other population-based interventions. However, where RED has been successfully introduced it has generally been in situations with easy access to low-cost transportation and so bundling programs is not a high priority. This paper describes the work undertaken to implement an expanded RED strategy, 'Reach Every Village' (REV), which is aimed at improving the health services provided in all health facility catchment areas, including aid post catchment areas, in the Momase Region of Papua New Guinea. The region's common characteristic is remoteness, with transport limitations resulting in some health facilities isolated for over three months. In such an operating environment, particularly with minimal resources, isolated staff and low staff morale, the all-program strategy has the potential to lead to effective and efficient population-based interventions which maintain and improve health. The strategy builds on previous public health and community interventions, which are integrated into the village health services model. Recent developments are discussed, together with future proposed community-based interventions, and management and resource implications.

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Introduction

Geographical setting

The Momase Region comprises four provinces with 25 administrative districts situated on the northern coast of the mainland of Papua New Guinea (PNG). It has an area of 122,600 square kilometres. There are a scattering of islands off shore. Tall mountain ranges just inland from the coast dominate the landscape. The Bismarck Range is generally over 4000 metres with PNG's tallest mountain, Mount Wilhelm, rising to over 4500 m. As a result, inland districts are remote, relying on air for access. Sandaun Province has the most remote district in PNG, Telefomin, which shares a border with Papua Province in Indonesia.

Numerous rivers rise in the mountains and flow down to the ocean. The largest of these is the Sepik River, which rises near Telefomin and has its mouth in East Sepik Province. This is one of the largest rivers in the world in terms of water flow, and levels can alter by over five metres in the course of the year. There are three large river plains (Sepik, Ramu and Markham) where there can be extensive flooding, which, in the absence of bridges, makes road trips on the river plains and coastal strip very hazardous.

Many of the offshore islands are volcanic, forming part of the Pacific Ring of Fire. Volcanic eruptions are common requiring the evacuation of up to 3000 people to the mainland. Resulting waves (tsunamis) have been catastrophic, wiping out many villages along with populations that were not evacuated.

Most of the land has poor agricultural potential due to problems of climate, mountains, swamps, soil and access. The little development that has occurred is typically small-scale tropical production of forest logs, copra, cocoa and sugar. There are several gold mines and one nickel mine.

Demographics

The last census was held in 2000, and estimates of the current population are subject to a wide range of error. Data from birth registers and immunization clinics in many districts show considerably higher numbers than census projections. Field data from health facilities indicate that the birth rate

is increasing, making official estimates for 2007, extrapolated from the 2000 census, far too low for accurate planning purposes.

Official 2007 census projections of the number of people living in each province are as follows: Morobe – 672,756; Madang – 451,835; East Sepik – 408,447; and Sandaun – 224,547 (1). This makes a total of 1,757,585, which comprises 26% of the total population of PNG. Approximately 20% of the population is under 7 years of age.

Due to the wide range of geographical conditions and isolation, there are diverse cultural groups, with over 200 languages spoken in the Region (2). A majority of the population rely on subsistence living. Diet can be adequate where vegetables and fruit grow well, or there is a good fish supply or sufficient forest animals. However, in many areas the limited range of available foods can lead to malnutrition. A recent survey on nutrition shows that the Momase Region has the worst malnutrition rates in PNG (Papua New Guinea Department of Health, The National Micronutrient Nutrition Survey 2006, unpublished data).

The existing health infrastructure

According to the PNG Department of Health (3), there are 157 health facilities in the region, comprising four provincial hospitals (one in each province, with Morobe and Madang Provinces having Level 2 hospitals, East Sepik Level 3 and Sandaun Level 4), 15 urban clinics, 58 health centres (this includes some small government and mission hospitals) and 68 health subcentres. In addition there are 896 aid posts, though only 68% were open as of December 2007. 47% of facilities are run by missions. In Momase there are 1460 urban health staff and 1907 rural staff. This equates to a rural health staff per population ratio of 80 per 100,000 population – 50 community health workers (CHWs), 25 nursing officers (NOs) and 5 health extension officers (HEOs) or medical officers. This is below the national average and international standards.

Access to health facilities

Only two of the provinces are connected by road and that has unsealed rough sections of 20 degree slope over the mountain ranges. Travel by road is seasonal as river floods make roads impassable and the few bridges

are frequently destroyed by major flooding. Travel by boat to remote islands and coastal villages is often risky due to rough ocean conditions. The typical vessel is a 'banana boat', a narrow open 23-foot boat with 60 hp outboard engine. Long distance trips are made at night when there are usually calmer winds and less swell.

For the isolated aid posts and health centres air transport or a very difficult 10-14 day walk are the only means of transport. There are very few scheduled plane services to remote districts and adverse weather conditions frequently cause flights to be cancelled or diverted. At times it takes up to three weeks to obtain a flight unless you are a priority case. The last third-level airline (flying small planes with from 6 to about 24 seats) went out of business in 2007 causing increased access problems throughout the region. Charter flights are extremely costly when the occasional plane or helicopter is available. This means many locations are cut off for up to three months.

In summary, access is a major problem both for patients and health service providers trying to transport medical supplies and infrastructure and give support to very isolated health workers.

Health status of the people of Momase

The Government of Papua New Guinea's National Health Plan 2001-2010 has a priority to improve the health of its people (4). The National Department of Health (NDoH) has identified key priority public health strategic directions to address the poor status of core indicators (Papua New Guinea Department of Health, 2006 Annual Health Sector Review, unpublished data). These are:

- fully immunize every child under one year;
- reduce the prevalence of malaria;
- reduce high maternal mortality rates;
- reduce the rate of increase in HIV/AIDS (human immunodeficiency virus/acquired immune deficiency syndrome) and other STIs (sexually transmitted infections); and
- reduce the rate of increase in tuberculosis (TB) (added to strategic

directions by NDoH in 2007).

The National Annual Health Sector Review in 2006 assessed Momase Region as performing under the national average on some key health status indicators, which appears to relate, to a considerable extent, to its specific geographical situation, and difficulties in access to remote districts and health facilities. These included:

- Only an average of 45% of Momase children under one received three doses of triple antigen vaccine compared with the national average of 80% (ranging from Sandaun 37% to East Sepik 85%).
- Only 48% of children received their 9-11 month dose of measles vaccine compared with the national average of 59% (ranging from Sandaun 37% to East Sepik 61%).
- 15% of infants born in health facilities weighed less than 2500 g, compared with the national average of 9% (ranging from Morobe 6% to Sandaun 22%).
- 34% of births are supervised in health facilities or in villages, compared with a national average of 40% (ranging from Sandaun 26% to Morobe 45%).
- 54% of women attended for antenatal care compared with the national average of 58% (ranging from Morobe 45% to East Sepik 60%).
- Outreach clinics per 1000 children under 5 years were only 15% compared with the national figure of 26% (ranging from Sandaun 10% to East Sepik 23%).
- Only 34% of health centres received an annual supervisory visit from the Provincial Health Offices in Momase, compared with the national average of 49% (ranging from Morobe 18% to Sandaun 55%).

Health improvement priorities

Improvement of health in rural areas is the priority of the new Secretary for Health (Clement Malau, unpublished speech on taking office in Sep 2007). The successful

operation of aid posts and health centres, using the priority public health strategic directions, is the key to achieving better health in rural areas. To achieve success requires four essential conditions:

- trained and motivated staff with improved morale;
- effective support and supervision from the districts and provinces;
- adequate and appropriate resources, with accountability of use; and
- a sound overall strategy of intervention and education.

How can the goal of improvement in rural health be achieved? The Momase Region Provincial Health Advisers (who are responsible for the Provincial Health Offices that manage public health and clinical services, excluding the provincial hospital) are very concerned to implement effective public health programs in all districts, with special focus on 'hot spot' (problem) areas.

They believe that there will always be problems of limited finances and inaccessibility, but there are ways to limit their negative impacts. They suggest that in order to improve health indicators in Momase (and in many other parts of PNG) there must be:

- effort to reduce poverty and increase health knowledge in communities, so that effective community development leading to support for health initiatives occurs in their communities; and
- a focus on adequately resourcing trained senior staff so they can on-train and supervise district and aid post staff, and effectively manage and sustain reliable health services.

There has been a commitment over many years to the World Health Organization (WHO) 'Health for All' strategy, through primary health care, the Hot Spot Aidpost Model, and the 'Healthy Islands' (5) concept of community health development. Various interventions have been implemented, with the assistance of international donors, many with non-government organization (NGO) support, but limited sustainable impact has been observed.

Therefore, the approach being taken in the

Momase Region is to develop a strategy for community-based health improvement interventions aiming to reach all villages, using the operational principles of the WHO RED ('Reach Every District') strategy (6) across a broad spectrum of priority public health interventions.

The Momase strategy is designed to provide the four essential conditions and develop an effective interlocking set of plans covering health facilities (aid posts, health centres, hospital clinics) as well as district and provincial level management. To ensure the plans are implemented successfully, work is under way to build additional realistic targets into the strategy management system and effective monthly monitoring of performance data so that early remedial action can be taken as required.

The initial strategy implemented in Momase Region, focusing on immunization

In 2001 the World Health Organization launched the 'Reach Every District' strategy to increase immunization coverage, with a focus on planning, reliable and consistent service implementation, monitoring and supervision. The critical component of the strategy was the use of microplanning workshops so that health workers could plan effective interventions. The strategy has been successfully used in many countries for immunization (7-12).

The Global Alliance for Vaccines and Immunization (GAVI) in January 2005 committed US\$1,824,000 in annual tranches over 5 years to support immunization services in PNG, including microplanning training, subject to strict performance monitoring. The PNG WHO office worked with the PNG National Department of Health Expanded Program of Immunization (EPI) Unit and provided some technical expertise to launch a trial of the RED strategy for immunization in all provinces in PNG. The plan was to run a microplanning workshop which provided training in planning, budgeting and monitoring, while at the same time bringing technical skills up to date. In 2006, the WHO and the EPI Unit, NDoH jointly ran a pilot project in one district of one province. Based on evaluation of the trial, changes in the procedures were designed so that it could be introduced nationally. A critical change to the schedule and budget used in other countries was to

reduce the frequency of immunization visits to the catchment areas of hard-to-reach health facilities (those often only reached by overnight patrols) to once every three months rather than monthly. This was a much more realistic option. In Africa, where most of the microplanning has been done, most areas are readily accessible and fulfilling monthly targets is logistically feasible. As discussed earlier, in PNG access is a real problem. The option to further lengthen the intervention schedule was not feasible, due to the clinical requirements of the immunization schedule and cold chain maintenance requirements.

The first workshop (new format) of the PNG-oriented implementation of the RED strategy was conducted in the Highlands Region for the highlands provincial family health and immunization staff as well as the advisory staff supporting NDoH in each of the four regions (so that they could support further roll-out in all the regions). This workshop was also supported by team members from the United States Centers for Disease Control and Prevention (CDC). The NDoH has a Technical Adviser and a Logistics Program Officer based in each of the four regions of PNG. The medium-term objective was to build the capacity of provincial staff to a level where they were self-sufficient and required no outside assistance. GAVI funds were provided through the Health Services Improvement Program (HSIP) to the provinces for a series of microplanning workshops to be attended by the relevant staff from all health facilities, whether health centres, hospital clinics or aid posts. The HSIP secretariat manages a trust account which receives funds from international donors and distributes and acquits the use of the funds. These training workshops complemented, at the provincial level, support provided on microplanning for other program areas. This additional training had been conducted by the NDoH with government and development partner support, but had not previously been rolled out to districts and health facility catchment areas.

Preliminary results from the implementation of the first stage of the 'Reach Every Village' strategy

Conduct of workshops

By the end of November 2007, the workshops had been run in all districts of Momase Region. The officers in charge of

the great majority of health facilities attended (and in some cases the aid post worker from a very isolated autonomous post). In a few cases where an officer could not get to the training, usually due to transport problems, his/her district program manager (or another officer) undertook the planning on their behalf so that they could on-train and provide support in implementation. The total number trained was in the order of 170 participants (one or more from each facility), the 25 District Program Managers and 25 trainers/facilitators to do the on-training. In addition, some Provincial Health Advisers and Chief Executive Officers (CEOs) of the hospitals, and some other members of the senior management teams in the Provincial Health Offices attended part of the workshops.

Two NDoH Momase advisers (technical and logistics) were trainers/facilitators in the first training workshop for staff from each health facility in a district, and also trained senior staff who would be trainers/facilitators for the roll-out of workshops. These advisers then attended the second district workshops to observe the training done by the provincial facilitators, and provide support/feedback as required. The provincial facilitators ran the second workshops, and achieved the desired outcomes, and then continued the roll-out in the rest of the districts. Feedback from Family Health Services Program Coordinators was that the roll-outs were successful as participants completed the planning documents and were ready to implement.

It was very important to train participants to complete the key tasks relating to their own catchment areas while at the workshop. Merely learning how to undertake the tasks would have been a very limited outcome for the workshops. The key tasks of the participants were:

- mapping their catchment area to show villages, schools, airports, roads, target population of under-ones for immunization in each village, transport route, mode of transport and time it would take, fixed clinics, mobile (one-day visit) clinics and patrols (more than one-day visits to many villages);
- completing planning sheets which provided details of health staff required (including vaccine carriers), number of days required for patrols, and a schedule showing how all villages

could be visited in 3 months (allowing for plane/boat schedules and availability of vehicles);

- preparing budgets to show travel costs, accommodation/allowance costs, equipment costs etc; and
- charting of 2006 or 2007 (to date) data so they could see progress, determine drop-out rates and discuss remedial action needed.

In one province, there were large numbers at the initial workshops and not all completed their budgets in the time allocated. Some participants spent another day with the Family Health Services Program Coordinator completing these documents. The lesson learned from this was that future workshops should have timetables based on the number of participants, so that all participants could complete, present and discuss all tasks at the workshops. As a result, in subsequent workshops all participants completed their tasks to the required level, and could take their implementation plans back to their health facility for immediate action.

The discussions of the maps and worksheets were excellent, with very creative ideas coming forward to deal with operational problems in the following key areas.

Re-drawing of catchment areas

For a number of health facility catchment areas (especially in very remote areas) access to some villages in the area is only possible from another health facility. It was therefore agreed that some villages would be transferred to the health facility from which there was easier access.

Travel to hard-to-reach locations

- In the remote air-transport-reliant areas, eg, Telefomin, where there are no regular scheduled planes, it was agreed that the hospital would have details of catchment area supplies needed to conduct patrols to health subcentres. Cold boxes and gas cylinders would be stored ready to load, and as soon as word arrived of a charter plane going to any of the hard-to-reach locations, a couple of health workers would jump on the plane, if there was room, and go there. It was

understood that in many cases the only way to return after the patrol would be by trekking over steep mountains and down into deep valleys for anything from 5 days to 3 weeks. In some of these areas, the plan is to train aid post workers to conduct the vaccinations and maintain the cold chain, so the hospital would only have to send the vaccines and equipment via the pilot, and a supervisor would visit once a year.

- During periods of hazardous river, flood and swamp conditions it was agreed that the focus would be on hot-spot areas defined as large populations of unimmunized or under-immunized children. For example, health workers would not be expected to travel chest deep through a swamp if there were only 5 children to immunize. However, for an area with large numbers, it would be necessary to try and organize a helicopter or charter plane, if the budget allowed. Participants were asked to calculate two costings – one for travel to the location when it was not flooded, and one for travel by an alternative route. Both sets of costings needed to be included in the budget documentation.
- Access to transport, including adequate vehicles, boats, motors and fuel, was a problem in all areas. Although the Provincial Health Offices were trying to improve the resource situation, in the short term creative solutions were suggested, such as 'hitching a ride' with other government or business people going to the same location. Community networking can be very effective. Many public transport providers have been happy to transport tables, chairs and cold boxes for health workers. Hire vehicles can and have been used cost-effectively for transport by planning a number of teams and locations in a large area over a short period of time with one vehicle.

Staffing issues and timing of clinics

It was recognized that there was a need to budget for increased staff time requirements for mobile clinics. The timing of clinics needed to be altered to meet the needs of the

children's carers to attend work (field or office) whilst ensuring the safety of the health staff in working out-of-normal hours. There was a need for casual or 'locum' staff or teams to relieve staff working in remote and one-person aid posts and to ensure a budget item to cover this activity; there was a need for training of village health volunteers to assist in immunization activities. Younger fitter staff were needed to resource remote locations that require walking and climbing to provide services. Cost-effective strategies for supervision of remote staff needed to be identified. It was suggested that supervisors should on-train their staff, and focus on praising results first (as health workers work in very tough conditions) before correcting problems and assisting them plan strategies to improve rates; this could include assisting them compare the same quarters for the current year and the last, in order to assess seasonal variations.

Determining target populations

Because of the concerns about the reliability of the national census data from 2000 and the growth projections utilized in that data set, the limited use of village-based birth registration and the low levels of deliveries in health facilities where births are routinely recorded, a range of methods is needed to determine under-1-year-old target populations. These methods include the role of village recorders, and amendments to facility maps and planning documents with the best population estimates, rather than using census projections. Another complication is that many mobile clinics are getting babies from outside their catchment areas. This is distorting the statistics as staff have been reporting them as babies immunized from their catchment area. Good strategies include: separate records (child health register) for in-area children, and use of tally sheets for those from out-of-area; and encouraging staff to report the out-of-area children to their originating facility catchment area for monitoring purposes. However, this situation is likely to continue for some time, due to the 'convenience' of going into town or the lack of a local clinic, so it is important to organize the budget, ordering of vaccines and equipment, etc to allow for vaccinating these out-of-area children.

Equipment and supplies

Issues identified which needed resolution

by the provincial offices were: not enough child register books; training of people in repair of solar equipment and fridges; provision of spare parts for out-dated fridges; lack of icemakers in some remote areas, necessitating travelling long distances to get ice bricks to put in cold boxes for patrols; and inability to get fridges to isolated areas. One province brainstorming on this issue resulted in the decision to ask the Defence Force, which sometimes does training manoeuvres in the area, to carry fridges and water tanks to the locations in nets underneath helicopters, the charter hire of which would be prohibitively expensive.

Finance issues

Many participants had experienced problems in getting funds when required, as they had not been taught how to use alternative methods in conforming with the PNG Government's Financial Management Act. Problems occurred when they could only get one quote, and when, due to transport limitations, this had to be radioed to the Provincial Health Office from isolated districts with limited communications (no fax or email). Providing receipts was also a problem. Strategies discussed included: staff taking receipt books with them everywhere, including on public transport; verification by work statistics; and developing individual methods of verification with trustworthy individuals. A key issue that was interfering with regular patrols was the non-payment of adequate allowances to community health workers and vaccine carriers for undertaking patrols. Working gratis is not acceptable except in short-term emergencies.

Extended use of the principles of microplanning

- Based on the lessons learnt from the Supplementary Immunization Activity (SIA) for measles in 2006 (13), and the roll-out of the microplanning for routine immunization, the NDoH EPI Unit and WHO decided that in the SIA for the second quarter of 2008 the routine and SIA activities would be combined, with the microplanning approach being expanded. As a result, in the later workshops (after the SIA was announced) there was considerable discussion about adaptation of the microplanning process so as to include a wider target group up to 7 years of

age, longer schedules and increased budgets. Also there would need to be a refresher on injection technique for the additional team members required.

- There was also considerable discussion about using the microplanning process for other programs – the same maps could be used with the addition of target populations for other programs, with hot-spots for TB DOTS (Directly Observed Treatment, Short Course) and leprosy marked. The duration of patrols needed to be extended to enable work to be undertaken on malaria, STI/AIDS, TB DOTS, childhood nutrition, family planning, antenatal care, school health etc. These patrols would need to include health promotion, environmental health (hygiene and infection control) and treatment/service delivery.

Proposed expanded strategy to cover all public health interventions

Concept

The experience in implementing the RED strategy for immunization is the foundation stone for an expanded strategy to meet PNG's health service needs. The concept is to expand the WHO RED strategy, using its successful principles, to provide effective interventions in all health facility catchment areas, including aid posts, relating to the five public health strategic directions (malaria, immunization, safe motherhood, tuberculosis and STI/HIV) and potentially other public health issues.

When fully implemented, the expanded strategy called the 'Reach Every Village' (REV) strategy would involve using the microplanning techniques developed in the implementation of the RED strategy to address every aspect of health facility operation from public health areas, such as family planning, nutrition, hygiene, infection control and environmental health, to clinical services. As part of the strategy process, there could also be planning, scheduling, implementation and monitoring of priority health promotion activities, including 'healthy village', 'Healthy Islands' and formal and informal staff professional development activities. The new strategy is being developed by provincial health staff with

assistance from NDoH staff and development partners. The Provincial Health Advisers strongly support the concept as they can see the benefits in health improvements and the development of a more efficient and effective rural health service.

The strategy, which evolved through the discussions in the microplanning workshops, is to use immunization as the cornerstone of the strategy, but integrate all the other community-based health improvement interventions into the planning and scheduling. This would significantly reduce unit costs for each public health intervention, by reducing duplication of travel, while providing a more holistic approach to health. This would be efficient for the health staff and more accessible and acceptable for the population. While the original WHO RED strategy mentioned there could be an opportunity to integrate other health interventions, no-one has previously implemented a full-scale integrated approach to community-based health improvement interventions. Primarily because of ease of access in many countries there was little pressure to integrate services. Momase Region is different and access and transport costs are a major consideration. In Momase Region it is a case of the transport/access 'tail' wagging the health service 'dog'.

The implementation of the strategy is building on the experience of each immunization microplanning workshop which has been run for each district in the four provinces. The expansion to other public health issues will be iteratively introduced over time, and began in late 2007. The aim is for supervisors to make regular visits to health facilities to provide one-to-one advice and assistance to health facility staff so they can expand the schedules and budgets on an ongoing basis and can, over time, implement the strategy for all the other key public health and clinical priority areas. These visits have begun by provincial staff, including Rural Health Service Coordinators, Family Health Service Coordinators, Logistics Officers, Training Officers, and in many cases the District Health Administrator. Support from the NDoH staff and advisers is provided as required.

Key practical operational steps

- Using the map of each health facility catchment area and expanding it to

include the number of people in each target group for each public health and clinical program (using local accurate data). In some cases the maps will just identify 'hot spots' for a problem such as TB, malaria or leprosy, rather than have an 'all village' focus.

- Preparing a detailed operational schedule to deliver programs so that they are delivered at least once within the required time-span set for that program (3, 6, 9 or 12 months). Keeping the schedule realistic is essential, as keeping to the schedule will build trust.
- Preparing a realistic budget. This will require an estimation of travel requirements, and the acquisition and maintenance of needed equipment, such as water tanks, fridges, vehicles, radios and essential medical supplies.
- Aggregation of health facility catchment area plans and budgets into district and provincial level plans. At the higher levels, additional items will be added such as supervision, training, coordination, and equipment supply and replacement.
- Monitoring and analysis of performance for all programs monthly, with corrective action taken if required by the officer in charge.

Integration of associated interventions relating to targets and monitoring

An associated activity in progress is to use the provincial health targets monitoring reports, strengthened to include more operational management information, as a key tool within the process. During the latter part of 2007 two developments occurred: capacity building support through twinning between Health Information Officers in Provincial Health Offices, and NDoH Momase-based technical assistance in strengthening reports to include more management information. The reports included:

- Updated targets for the key strategic directions, which are based on realistic estimations of what can be achieved with existing resources, in each province. These targets sometimes

are the same as national targets, and sometimes lower. This updating is resulting in additional targets being included for STI/HIV, TB DOTS, environmental health and health promotion.

- Updated Excel programs (providing district analysis relating to provincial targets, as an adjunct to the national health information system data on national targets) so that staff can print out monthly charts showing progress to date by district and facility, for each target.
- Providing the charts produced to the senior management team and to provincial and district program managers each month, so they can analyse root causes of poor results and take remedial action, or congratulate staff on good results.

For monitoring purposes, a simple checklist was drafted based on discussions with a number of officers in charge, District Health Administrators and provincial health staff, so that, by program, they could check how they are going according to:

- targets – year to date;
- annual activity plan activities – year to date;
- finances (Had they put in a proposal? Had they got money? Had they acquitted the last allocation?);
- equipment/resources (If program had not been implemented was it due to lack of essential resources, eg, vaccines, cold chain equipment?); and
- staffing (eg, Did they have adequate staff? Did some need training to do the task? Did they have staff management problems?).

On the form they also listed what remedial action they had taken to try to solve the problems they identified. This approach began being trialed in a few health facilities in different provinces in the last quarter of 2007.

Following initial piloting of these reporting and monitoring initiatives, it was gratifying to

visit a health facility in late 2007 and see that the officer in charge had monitoring charts on the wall which showed antenatal visits as well as immunizations to date. A few health facilities were beginning to use monitoring charts to monitor other family health programs – childhood nutrition, supervised births, family planning etc.

It was also gratifying to have meetings with staff (HEOs, CHWs and NOs) in health facilities, where they expressed excitement about reporting as they could see that it does not have to be complex and it is a way of making sure their supervisors know what is happening and what resources they need to deal with problems.

Management, resource implications and evaluation

The major cost in implementing the strategy effectively is to ensure adequate funds for transport every three months to each catchment area. There should be only minimal increased costs for human resources, as combining of programs should save costs, but increased supervision visits will cost more. A major need will be for forward planning to ensure that requisitions for equipment, supplies, transport and staff costs are submitted as per the regular schedules so they can occur on time. The REV strategy has the potential to achieve considerable efficiencies.

The success of the introduction of the REV strategy can only be truly evaluated in terms of whether health indicators improve. Measurable changes in health status only occur slowly, and thus it will take up to five years before the necessary epidemiological evidence is available.

The RED strategy was introduced by WHO in 2000. Excellent research papers are now being produced on lessons learnt over a five-year period, for example immunization of children in Zambia (10). The implementation of REV uses many of the operational aspects of the earlier RED; thus the lessons learnt are transferable to the more holistic approach to community-based health interventions in PNG.

Part of the REV strategy involves improvements in data collection and analysis, in particular the development of simplified and more relevant reporting forms. Information

will now be provided on a timelier basis so as to enable program managers to make better decisions on both operational and administrative matters. Changes in health system process performance will provide an interim indication of success of the REV strategy. However, plans should be developed to track the long-term changes in health outcomes, heading towards a definitive evaluation report in 2012. These evaluation activities could be the focus of research required to fulfil academic requirements for public health trainees.

Conclusions

In the Momase Region difficult terrain and high transport costs are major impediments to the provision of community health services. Inconsistent services in the past have meant that health services have not been well supported. The Reach Every Village strategy, in combining the delivery of different programs, has two main objectives:

- for the government, a more holistic approach to providing regular health services, including a reduction in costs (especially transport) and coordinated supervision and monitoring; and
- for the community, regular consistent services covering all major health programs, so their needs can be met.

There will be difficulties in implementation, in particular to achieve coordination between various public health programs, their provincial and national coordinators and development partners. However, in the context of a sector-wide approach in a highly decentralized health service, it will be a village-level application of the principles of the Sector Wide Approach (SWAp).

Implementation of the REV strategy is a work in progress which should lead to enhanced health without substantial increases in resource use. Currently REV is being gradually and progressively introduced in the Momase Region following the microplanning workshops which have been run in each of the 25 districts of the four provinces of the region. Links with other program activities, follow-up and further refinement are occurring during routine planned visits to each district. When fully implemented, the strategy has the potential to significantly improve PNG rural health using

a world best-practice strategy.

Improving rural health is one of the main aims of the Government. REV has the potential to be a major tool in achieving health for all Papua New Guineans.

ACKNOWLEDGEMENTS

Steven Toikilik, Director of EPI Section, National Department of Health and Richard Duncan, Technical Officer, EPI Program, WHO PNG Office were the drivers of the national microplanning/RED initiative, enabling it to be rolled out to provinces and districts. Without their commitment and energy this initiative would not have occurred. Maxine Whittaker, Senior Technical Health Specialist (NDoH) also provided valuable support and advice.

The Family Health Services Coordinators and Logistics Officers in each of the four provinces coordinated the implementation in each province, and the Provincial Technical Program/Rural Services Coordinators were key people in developing and driving the extension of activities to programs other than immunization, and in supporting improved supervision and reporting on a monthly basis. District Health Administrators were key people in introducing and supporting the supervision and monitoring activities. Officers in charge were important in roll-out training and in developing workable solutions. An initiative such as this needs to acknowledge large numbers of dedicated and hardworking health workers whose passion and energy have resulted in the strategy having some successful initial stages. AusAID (Australian Agency for International Development), UNICEF (United Nations Children's Fund), JICA (Japan International Cooperation Agency) and WHO support to the PNG immunization program is acknowledged.

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A review of cancer in Papua New Guinea

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Papua New Guinea (PNG) is a geographically and culturally diverse and complex country. The mainland is characterized by lowland swamps and plains and a central mountain range. Within these mountains is a complex system of ranges, upland valleys and volcanoes. The five island provinces lie to the north and east of the mainland. There are 850 languages and linguistic and cultural patterns show a remarkable lack of uniformity. Up to approximately 80 years ago many groups remained physically and socially isolated. Modern health services were established after World War 2 with aid posts and rural health centres forming the backbone to the health care delivery system. During the 1950s and well into the 1960s doctors were limited to provincial hospitals and specialist medical services were only available at base hospitals in Port Moresby, Lae, Goroka and Rabaul. The pathologist was in Port Moresby and samples for histology were sent there.

There have been several reviews of the PNG Tumour Registry, originally the Territory Tumour Registry, since its establishment in 1958. The first reviews were performed in 1962 and 1965 at which time there was a reported preponderance of oral and skin cancers in lowland and island regions, followed by digestive system cancers, including liver cancer, and female genital tumours, lymphomas and leukaemia (1, 2). Solid tumours had peak incidences in late adulthood.

Data from these early reviews and subsequent larger reviews are not population-based surveys; rather they are reviews of incident data and reflected the distribution of medical personnel in the country more so than any real population or disease characteristics. It was presumed that the preponderance of oral cancer (mostly squamous cell lesions of

the buccal mucosa, lip and tongue) was due to chewing betelnut. Certainly the distribution of betelnut crops and its chewing and oral cancer in those days suggested a strong relationship. However, and in contrast to Asiatic countries, Papua New Guineans did not, and still do not, mix tobacco with the betelnut mixture. The preponderance of skin cancers, mainly squamous cell carcinomas (SCCs) below the knee, was thought to be due to the occurrence of chronic tropical ulcers. Skin SCCs on other regions of the body were thought to be related to old burn scars.

Amongst cancers in females, cervical cancer predominated, as is indeed the case today. In children leukaemia, lymphosarcoma, eye tumours, soft tissue sarcomas, bone tumours and neuroblastomas were found. Burkitt's tumour was not listed separately in these early reports. Lung cancer was relatively uncommon and this was thought to be due to the use of locally grown tobacco, rather than manufactured cigarettes.

In 1974 a more comprehensive review of the Tumour Registry was completed (3, 4). Cancer remained an infrequent cause of admission to hospital, when viewed alongside infectious diseases and pregnancy-related conditions. Again the preponderance of oral cancer was noted with a ten times lower frequency in the highlands (0.3/100,000) than on the north coast and in Papua (excluding Western District/Province) (3.2 and 3.3/100,000 respectively). Also noted were high rates of cancer of the liver, lung and stomach, ameloblastomas, malignant tropical ulcers and malignant melanomas 'in the non-pigmented sites in unshod rural workers', namely the heel, soles of the feet and toes.

Three times more males than females

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presented with oral cancer in this period, probably reflecting the greater tendency for males to seek medical advice rather than any differences in sex-specific incidence. Lip cancer was regarded as an extension of cancer from the buccal mucous membranes, in contrast to the SCCs of the lips seen in Caucasians that resulted from sun exposure. Cancer of the tongue was also noted with a similar sex distribution to buccal mucosal cancer.

Notwithstanding, or maybe because of, the anecdotally attributed virtues of chewing betel, namely its aphrodisiac qualities, its ability to make a drunk man sober or a sober man drunk, its appetite-stimulating properties and its ability to protect against malaria, the habit has extended far beyond the lowland and coastal regions in PNG. Throughout the 1960s and 1970s many previously isolated areas became accessible by road and air and betelnut is now found and chewed throughout the country. Even when medical supplies cannot be delivered to health facilities, betelnut still manages to get through. It is a major trade item from coast to highlands and features prominently in cultural exchange ceremonies.

An early question focused on the role of areca nut (*Areca catechu*), betel pepper vine (*Piper betel*) and the addition of lime, as opposed to the addition of tobacco, in the formation of a carcinogenic alkaloid mixture comprising arecoline and other compounds. Addition of lime produces heat and inflammation and certainly leukoplakia in the mouth appeared to be related to areas to which lime had been applied.

As noted above, tobacco was not and is still not used in the quid during betel chewing in PNG. However, commercially cured tobacco is now smoked widely in PNG, as elsewhere in the Pacific. In addition, alcohol is drunk widely, and although it was only legally allowed for indigenous people from 1962, it is likely that production of alcohol in villages preceded this date, especially in parts of New Britain and New Ireland.

In 1985 MacLennan and co-workers (5) noted that approximately 100 cases of oral cancer were reported annually in PNG but suspected that at least twice as many actually occurred. As noted, in contrast to the Asian use of betel, in Melanesia the areca nut, betel pepper vine and lime are mixed in the mouth.

They proposed that the resultant production of heat and chemical irritation caused increased cell division that could stimulate carcinogenesis. They reviewed studies from Asia that strived to establish an aetiological relationship between betel chewing and oral cancer, suggesting that the irritant effects of betelnut and lime increased cell replication and that any tobacco used also promoted this effect. They suggested that ethanol might act synergistically, possibly acting as a solvent that increased access of any carcinogens to cells. In addition they noted that dietary lack of beta-carotene may enhance genotoxicity and suggested that co-administration of retinols and beta-carotene may modify these effects.

Thomas and co-workers conducted longitudinal population-based studies in New Ireland Province throughout 1985-1987 and established that chewing of betel produced a threshold and dose-related increased risk of oral cancer. The addition of smoking enhanced this risk considerably and in a dose-related manner, with an odds ratio of up to 4.85 for chewers of betel who were also heavy smokers (6). A similar relationship was seen with leukoplakia of the buccal mucosa. 11.7% of New Ireland adults had leukoplakia and the odds ratio was 9.8 in those who both chewed betel and were smokers. Leukoplakia was noted to occur in younger age groups during the period of the study, with rates far in excess of those in India and other countries where betel was traditionally chewed (7).

Similar high rates of oral cancer were noted in Milne Bay, Madang and East New Britain provinces and along the Sepik River. In the Maprik area high rates were associated with the use of highly caustic builders' lime, rather than the more traditional stone ash, coral or shell lime (8).

In 1974, SCCs of the skin occurred mainly on the legs (85%) of lowland people and were, once again, noted to be related to chronic ulcers, the sinuses of chronic bone infections and scarring from untreated burns and wounds. SCCs were twice as common in males as females. The suggestion was that a 20-year period was needed for a tropical ulcer to develop malignant change, with the majority of cases occurring in the 30-60 year age groups. SCCs in locations other than the legs were related to sun exposure and were hundreds of times more common amongst white expatriates than Melanesians,

especially males.

In contrast, basal cell carcinomas (BCCs) were more common in the highland populations and on the head and neck. The sex ratio for BCCs was almost equal between men and women. Kaposi's sarcoma was, and still is, quite rare.

Liver cancer, mostly hepatoma, was four times more common in males than females and occurred in all areas of the country. It will be interesting to observe the frequency of this cancer since the introduction of hepatitis B vaccination in the late 1990s.

Burkitt lymphoma was noted and its relationship to low altitudes leads to the suspicion that an insect vector might be responsible. The Burkitt lymphoma picture was similar to that seen in East Africa. Hodgkin's disease was uncommon.

The Atkinson et al. publication in 1974 (3) described the various cancers of PNG in great detail. In the same year the Cancer Workshop produced a Guide to the Management of Malignant Diseases in Papua New Guinea (9). These guidelines have more recently been updated in the 'Guidelines for the Treatment of Cancer in Papua New Guinea' (10). Combinations of surgery, radiotherapy and chemotherapy are described which are appropriate for a country with very limited access to any treatment modality. The unusual infrequency of metastases in solid malignant tumours in PNG should have been a stimulus to medical staff to establish an early diagnosis and attempt radical treatment (11). However, surgical facilities were limited to the larger district hospitals and base hospitals where experienced surgeons were located, and radiotherapy was, and still is, limited to Lae. Thus large areas of the country were effectively without cancer treatment services.

These early surveys of the Tumour Registry were updated by Atkinson et al. (12) and Martin et al. (13) for the periods up to 1978 and 1988. Although increased numbers of cancers were seen there were few significant changes to disease patterns from earlier surveys. Cancer registration rates increased from 13.8/100,000 in 1958-1970 to 25.5/100,000 in 1984-1988 but this was almost certainly the result of increased access to medical services, although probably not just access to doctors (14). Also, and of equal if

not more importance, a willingness of people to leave their villages for medical treatment probably contributed to this apparent rise in incidence.

Increases in the quality and accessibility of health services certainly increased reporting of neoplasia overall, although the general increase was not reflected in cancer reporting in females (15). Traditionally gynaecological functions and symptoms are the subject of taboos in many PNG societies. Gynaecological and breast neoplasms composed 24.5% and 9.0% of all neoplasms in females, with ovarian tumours composing another 5.0%. For cervical cancer, as elsewhere, the lesions were mostly SCCs. Murthy (16) reviewed ovarian tumours and noted that 85% were benign and, of the malignant tumours, a mixture of serous epithelial, mucinous epithelial and undifferentiated carcinomas and dysgerminomas were seen.

Breast cancer had a reported incidence of 2.7/100,000, with the condition being slightly more common in the Islands Region. The age group 40-49 years was most commonly affected with an age-specific incidence rate of 74/100,000 (17). Most breast carcinomas were invasive ductal carcinomas (66%), with poorly differentiated carcinomas, adenocarcinomas and medullary carcinomas composing 6.8%, 5.4% and 5.7% respectively. Most cases presented late, with metastases present in 65.2%.

It is likely that as women become more educated and secure, and with greater access to health services, the frequencies of malignancies in females will rise. Breast cancer now forms a major part of the radiotherapy workload in Lae and may be more common than has been suggested in these reviews from the 1980s (John Niblett, personal communication). Indeed it may be that with the radiotherapy unit in Lae now functioning again (it was non-functional during a large part of the 1990s and early 2000s) we will see changes in the pattern of solid tumour types presenting at clinics and hospitals. However, access to cytotoxic drugs remains tenuous and the radiotherapy service suffers the same infrastructural problems that other services do in Angau Hospital.

In addition to enhanced access to medical services, diagnostic techniques, for example alpha-fetoprotein estimation, ultrasound

scanning and fine-needle aspiration, assisted in the diagnosis of many liver and solid tumours. Improved management of tropical ulcers did result in a decline in SCCs of the lower limb.

Overall the incidence of cancer in adults in PNG remained low; even oral cancer in men and cervical cancer in women was less frequent than in New South Wales, Australia (13), even though cancer in PNG presented at an earlier age and in a more advanced state. Martin et al. noted that the four most common cancers in PNG – oral, cervix, liver and SCC of the skin – are all preventable. “Betel nut chewing and promiscuity are rising”, he states (13).

In children, the rate of cancer in PNG was low for the period 1971-1985 at 36.5/100,000/year (18). Cancer was slightly more commonly seen in male children than females, with a ratio of 1.6:1. Lymphomas were common and 53% of these were Burkitt lymphoma. The sex ratio was even more skewed for Burkitt lymphoma, with males being eight times more affected than females (19). The median age for Burkitt lymphoma was 6 years and the face was most commonly affected. Other tumours of children were retinoblastomas, 6.9%, and other embryonal tumours, 4.8%. An equal frequency of Ewing's tumour and osteosarcoma was seen amongst bone cancers, and in soft tissues rhabdomyosarcomas, fibrosarcomas and Kaposi's sarcoma accounted for the majority of tumours.

Leukaemia in PNG children constituted 17.6% of all childhood malignancies with an overall low incidence rate in all age groups of 0.79/100,000 (20). However, high childhood mortality from mostly infectious causes and a low life expectancy could have contributed to this anomalous low leukaemia rate in children. Leukaemia in PNG is unusual in not demonstrating a childhood or older age peak in incidence, and in having a low proportion (31%) of acute lymphatic leukaemia (ALL) and a higher proportion (49%) of acute myeloid leukaemia (AML) (21). Only 22% of ALL was type L1, the type most responsive to chemotherapy. Also of note was a relatively high frequency of chronic myeloid leukaemia in children (14%) in PNG. Survival rates were very poor for all forms of childhood leukaemia.

The cancer data for children in PNG closely

resembled that of children in Africa with a preponderance of lymphomas and a lower incidence of leukaemia than in North American or European children. The lymphoma:leukaemia ratio in PNG children decreased from 40.0:10.2 (3.9) in 1958-1970 to 30.1:17.6 (1.7) in 1971-1985. The highest rate of Burkitt lymphoma was noted to be from Gulf Province (13.4/100,000) and most cases came from areas also holoendemic for malaria. The relationship between Burkitt lymphoma, Epstein-Barr virus and *P. falciparum* malaria has been documented in East Africa and the changing frequency of lymphoma in PNG is likely to be the result of changes in the lifestyle of children, resulting in decreased exposure to both the Epstein-Barr virus and malaria. We may expect further changes in the incidence of Burkitt lymphoma if malaria control by impregnated bednets is successful.

Like adults, children presented late with cancers (22) leading to a five-year mortality rate in excess of 63% for those who received treatment. Infections were common in treated children. Childhood malignant diseases caused enormous family problems and financial hardship, with delays in treatment and repatriation adding to these problems.

A national review of cancer management in PNG in 2001 produced fourteen key recommendations, including the establishment of a National Cancer Control Programme and a PNG Cancer Centre at Lae (23). The Cancer Centre in Lae is operational again. A National Cancer Technical Group has been established within the Department of Health, but further progress with the recommendations seems to have been limited.

Resources for the diagnosis and treatment of cancer remain severely depleted throughout the country. Diagnosis remains the province of mostly general physicians and surgeons, and only a few doctors have specific skills in cancer management, and these are based in Port Moresby and Lae. Training of oncologists remains fragile and dependent on overseas training and the support of overseas donor agencies. Patients present late in the disease, so the usefulness of radical surgery for cancer, even when it is available, remains limited. The supply of anticancer drugs similarly remains very fragile.

Histopathology services are severely strained, resulting in delays of several months in preparation and examination of samples and reporting of results. This service is plagued by lack of specialist histopathologists, with currently only one in Port Moresby. The tumour registry is in Port Moresby and is a cumbersome, paper-based system. The workload to maintain this registry is overwhelming and the prospects of any meaningful epidemiological research on these data, in its current form, seem slim. Telepathology options may yet enable greater efficiency as the workload on the Port Moresby service will be reduced. Telepathology will enable regional centres to liaise directly with diagnostic centres nationally and internationally. This will, of course, require considerable investment in information technology (IT) services, which currently are rudimentary or non-existent at the University of PNG, the Department of Health and provincial health offices and hospitals.

Population-based screening for cancer is unlikely to be available to, or useful for, the general public in the foreseeable future. For breast cancer we have noted that almost two-thirds of patients present with metastases and most of these are in premenopausal women, who are difficult to screen with mammography. Breast self-examination and the vigorous investigation of breast lumps will remain the cornerstones of management. A cervical screening program is similarly unlikely to be successful, with very limited cytopathology services and resources for treatment. In addition, the prospects of such an invasive screening program being acceptable and successful in any but the most informed populations remain remote.

It was noted above that hepatitis B vaccine was added to the national vaccination schedule approximately 20 years ago and it may be only within the next 20 years that we will see a reduction in the incidence of liver cirrhosis and cancer. Human papilloma virus (HPV) vaccine was more recently introduced in more developed countries and has been widely accepted, but it will be a generation before reduction in cervical cancer can be expected in these countries. This vaccine remains very expensive; the prospects for its use in PNG may be considered when the price is reduced. Fortunately PNG has never had an acceptability problem with the roll-out of new vaccines and an HPV vaccine can be readily incorporated into existing vaccination

programs in schools and maternal and child health (MCH) services, if and when it becomes available.

I have alluded above to the severe resource shortages for cancer diagnosis and management. In addition, follow-up of patients remains very fragile and is at the mercy of geography, personal circumstances and a host of non-medical constraints. The prognosis for most forms of cancer is unlikely to improve for patients who live outside of a major urban centre. In this vein we should note that pain management in cancer is under-utilized. When definitive treatment options have failed we should, as a very minimum, be able to ensure that patients are pain-free. The Guidelines mentioned above (10) describe cheap and effective protocols for pain management. We need to ensure that health staff in urban and rural areas are trained in the use of these drugs and that supplies are secure.

Legislation on tobacco sale and use was enacted in 1987 with the Tobacco Products Act, but the relevant regulations, which would provide more specific details, do not appear to have been made, particularly with regard to places where tobacco use is restricted. Thus we find smoking occurring in most public buildings, forms of transport, eating places and public spaces. The Minister and Department of Health should progress with the relevant codes of conduct on tobacco use as a matter of priority. Recent attempts by local government authorities to curb the sale and use of betelnut may have been newsworthy but they were largely enforced in a socially unacceptable manner and have proven to be unsustainable. Thus betelnut is, once again, freely available on the streets of most urban centres in PNG.

Cancer remains a relatively infrequent cause of admission to health facilities in PNG, other than in the cancer wards at Angau Hospital in Lae and Port Moresby General Hospital. Unlike in more developed countries, it is likely that much disease remains undiagnosed and untreated in villages in PNG and we may expect that the actual prevalence of cancer is much higher than that recorded to date. Late presentation and limited treatment facilities in areas other than base hospitals result in much patient suffering and poor survival statistics.

The efforts of the Port Moresby Cancer

Relief Society, the PNG Breast Cancer Foundation and similar local organizations have secured periodic, high-profile impacts into cancer awareness and they have lobbied extensively for better services for cancer sufferers. However, their efforts have not always been followed up by an equally vigorous response by the responsible government agencies. Our collective efforts, therefore, should be towards enacting the recommendations of multiple reviews and reports that have attempted to improve cancer management in PNG.

ACKNOWLEDGEMENT

I am indebted to Prof. John Vince for his editorial comments.

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OBITUARY

Daniel Carleton Gajdusek, 1923-2008: an appreciation of his life and his love for Papua New Guinea

Daniel Carleton Gajdusek was born in Yonkers, New York, USA on 9 September 1923 and died in Tromsø, Norway on 11 December 2008. His American parents were of Central European origin, his father Slovak and his mother Hungarian. His father was a butcher and businessman who had a generous capacity for enjoying life. His mother's enthusiasms were quieter and had a more enduring influence; before he could read Carleton was nurtured on the classics of ancient literature and mythology. He was very close to his younger brother, Robert, usually called Robin or Bobby, a poet and a distinguished scholar and teacher of English literature, known for his work on Ernest Hemingway and D.H. Lawrence; Carleton was devastated when Bobby died in 2003. His maternal aunt, Irene Dobroscky, was a scientist and an important influence while he was growing up (1). When he was a schoolboy his aunt arranged summer employment for him at the Boyce Thompson Institute for Plant Research, where she worked; there he synthesized one of the first herbicides, the importance of which he was made aware of only many years later. He was a precocious child and an avid reader in science and literature from an early age. In the family house in Yonkers Carleton had written the names of famous microbiologists from Paul de Kruif's 'Microbe Hunters' on the steps leading to the attic. Carleton remained proud of his youthful ambitions to emulate these scientists and, whenever I stayed with him in Yonkers, he would enjoin me to climb the stairs to stardom; since they led to a book-lined attic I was more than happy to do so. Carleton from the age of 10 years was determined on a career in medical research, the best preparation for which he believed was the study of mathematics, physics and chemistry.

Carleton's first degree was from the University of Rochester in New York State, where from 1940 to 1943 he studied physics, biology, mathematics and chemistry. During these years he also learned the delights of hiking and camping in the woods and

mountains. He then went to Harvard Medical School. As a medical student he was captivated by children and clinical paediatrics, and spent much of his time at the Boston Children's Hospital. After graduation in 1946 he did his internship and residency at the Babies Hospital, Columbia Presbyterian Medical Center in New York and the Cincinnati Children's Hospital and obtained his Specialty Board certification in paediatrics. In 1948-1949 he had an intensely rewarding and creative period at the California Institute of Technology (Caltech) with Linus Pauling, John Kirkwood and Max Delbrück and made many lifelong friends among his teachers and fellow-students. He moved back to Harvard to work in virology with John Enders. From there he was drafted into military service during the Korean War to work under Joseph Smadel at the Walter Reed Army Medical Center studying Korean haemorrhagic fever. Though they did not find the causative agent (now known to be a hantavirus) they determined that it was spread through rodent urine (which made the army cooks particularly susceptible). There was a considerable body of literature in many languages describing haemorrhagic fevers right across Eurasia, and Carleton used his scientific and linguistic skills to produce a definitive monograph on the subject (2).

Carleton loved working among children, was a highly respected paediatrician and never lost his interest in clinical paediatrics, but his professional life could never have been restricted to conventional paediatric practice. His particular passion was for viral, rickettsial and other infections and, his military service over, he joined Ted Woodward at the University of Maryland and went off, in 1954, to study rabies, haemorrhagic fevers, arbovirus infections and plague in Iran, Afghanistan and Turkey with Marcel Baltazard. The excitement and challenge of these studies led to his realization that there was an urgent need to investigate epidemiological problems in remote and isolated populations while there was still an opportunity to do so. The quest for these

problems was to occupy and fulfil much of his subsequent life.

As a young man Carleton befriended younger men and adolescent boys who were from disadvantaged backgrounds or in personal trouble. He nurtured them over many years in their psychological and professional development. He was very proud of their subsequent achievements and maintained close contact with them and their families throughout his life. It is significant that Carleton began to create his own extended family even as he was reaching his own manhood. The family of adopted Melanesian and Micronesian sons and daughters that came later can be seen as a direct extension of Carleton's urge to strengthen the bonds of friendship until they were family ties. In a wider context, for as long as I knew him, Carleton always blurred the distinctions between colleagues, friends and family, which was exemplified by his famous Family and Friends List of addresses and contact information. Judith Farquhar describes how the list was maintained in the early days of Carleton's laboratory at the National Institutes of Health (NIH) (3); and right to the end of his life Carleton was pleased to be able to turn to his friend and extended family member Dorrie Runman to bring the List up to date. The List, moreover, was in constant use since, wherever he was in the world, Carleton lost no opportunity to see his friends and their families. When he could not see them he wrote to them – he had an amazing energy for correspondence. Carleton also kept in touch through sharing his publications, sent out from the lab in 'frequent marathon mailings of reprints' (3). Again, distinctions were blurred: people from all walks of life whom Carleton had befriended were suddenly subjected to a flow of abstruse scientific papers arriving in their mailbox; and colleagues who had recently made Carleton's acquaintance were surprised to receive his friendly postcards, with comments about science and art intermingled, sent from obscure corners of the world.

Carleton's love of travel was particularly directed to places challenging to reach. Though he found the natural environment interesting, and indeed inspiring if it was wild and rugged, the people living in these remote places and what they had created there provided the principal attractions for him. He had an uncanny facility for making contact with people through non-verbal

communication and by picking up words in their language. Characteristically he would make his entrance into the community through the children, with whom he seemed to have a universal rapport. He was never a tourist. Wherever he went he showed an interest in every aspect of life in that locality and studied as many of them as he could, in his inimitable way. In 1950 and 1951 he visited the Sierra Tarahumara of Mexico and studied the people and the environment, which he described in a paper in a geographical journal (4); this was Carleton's sixth publication. He also reported the local people's way of catching fish (5). After that time, in all his travels he was too busy discovering diseases or undertaking biomedical studies to make separate papers of his geographical or cultural findings; these data were confided to his journals or, occasionally, published in papers related to disease studies (6), nutrition (7) or genetics (8) or, if there was a paediatric slant to them, presented at meetings of the American Pediatric Society or the Society for Pediatric Research.

In 1955 Carleton made the first of several trips to South America. Among groups of indigenous people he began his studies of child growth and development that he added to for the rest of his working life: observing, talking, examining, collecting samples for medical and genetic studies, filming, photographing and recording it all in his journal. He would spend the night writing his journal, into which he poured not only the information collected during the day but his whole personality. He believed that his journals were his greatest achievement and made every effort, particularly in his later years, to have them all transcribed and collated; as each was finished he indulged in the pleasure of having copies bound. The number of bound copies and their distribution depended on their 'sensitivity' but, as far as Carleton was concerned, even his most confidential journals with the most restricted circulation were still in the public domain. In practice this was true since any legal restriction placed on their use did not prevent them being misused against him during his time of trouble in the 1990s. Carleton did not have much respect for bureaucrats or functionaries but he somehow always managed to enlist their aid in getting his samples out from the wildest places and sent to laboratories in the USA and elsewhere for testing. The films that he took were designed

to become part of a comprehensive global record, for which an innovative scientific methodology was created (9).

It was inevitable that Carleton, with his passion and purpose to encompass the world, would visit Melanesia. His opportunity came when he received a National Foundation for Infantile Paralysis Visiting Investigator award in virus genetics and immunology that enabled him to work with Frank Macfarlane Burnet at the Walter and Eliza Hall Institute of Medical Research (WEHI) in Melbourne. He describes his journal of the time (August to October 1955) as a period spent meandering toward Australia with travels in France, Belgium, Holland, Germany, Sweden, Austria, Yugoslavia, Greece, Turkey, Iran, Pakistan, Thailand, Malaya and Singapore. He reached Western Australia by boat and crossed to Melbourne by train. While in Australia he visited Aboriginal Australian communities in north Queensland and went to the Australian Territory of Papua and New Guinea, arriving in Port Moresby for the first time on 29 June 1956. He stayed until mid-August; after a few days in the Popondetta area he flew to Rabaul and spent the rest of his time with the West Nakanai and Mamusi people of central New Britain. In Melbourne he worked initially on the genetics of influenza virus. Macfarlane Burnet and the Institute of which he was Director were renowned for virological research. However, Carleton, in studying hepatitis, included a chronic form of hepatitis that was under investigation by Ian Mackay at the Institute and veered in a new direction; by the end of his time at WEHI he had described a test for autoimmune disease that was positive in several chronic diseases (10), a significant and novel finding with wide implications. One of the consequences of this was that Burnet decided to switch the emphasis of WEHI from virology to immunology. This led to a surge in creative scientific work and the subsequent award of a Nobel Prize to Burnet for his work in immunology.

After his time at WEHI was over Carleton set off back to the USA, where he had been offered a position as a visiting scientist at the NIH by Joe Smadel, with whom he had worked during the Korean War and who was now Associate Director of the NIH. On his way home Carleton took the opportunity of paying another visit to the Territory of Papua and New Guinea. He planned to see the people he had previously got on so well with

and also visit Ian Burnet, Macfarlane Burnet's son, who was an agricultural officer in Lufa, a remote post in the Eastern Highlands. On Thursday 7 March 1957 in Port Moresby he met Dr Roy Scragg, who told him about a new disease called kuru that had been found in the Okapa area of the Eastern Highlands (11). On the following Monday he flew to Goroka. He was fascinated by kuru but concerned that Burnet had already been asked to investigate the disease. He made plans to fly to Lae and then on to New Britain, but he also arranged that the doctor in Kainantu, Vincent Zigas, would meet him at the airport with some kuru patients for him to see. Zigas had examined cases of kuru in Okapa and had brought several patients to Kainantu Hospital. Previously he had sent tissue samples to Burnet for investigation in Melbourne. Carleton got off the plane in Kainantu, and on examining the two patients brought to the airport by Dr Zigas recognized immediately that kuru was a significant neurological disease. He abandoned his plans, had his bag taken off the plane and stayed in Kainantu (as described by Gloria Chalmers, Vin Zigas' former wife, at a meeting held in Melbourne in 2009 to celebrate Carleton's life and legacy). Vin and Carleton then set off for Okapa to investigate kuru; they were welcomed and assisted by Jack Baker, who was the patrol officer in charge of the subdistrict. They worked frantically on their investigations and it was not until the following January that Carleton completed the first phase of his research studies on kuru and left Okapa (12). His decision to stay and investigate kuru was endorsed by Joe Smadel, who allowed him to take up his new 'visiting' position at the NIH from the highlands of what is now the Independent State of Papua New Guinea (PNG) – but was then an Australian Trust Territory – and provided logistic support to enable his research work in the field to go ahead. He also arranged for the receipt of Carleton's field samples and their analysis at the NIH. Burnet and the Australian authorities were very put out by Carleton's passionate pursuit of kuru and his continuing research presence but, despite many attempts, they could not get rid of him; nor, in fact, did they have anyone willing to go to the field and work in his place. Meanwhile Carleton was pouring forth information and ideas about kuru in long letters to Burnet and other colleagues. This saga is part of history (12,13). Carleton and Vin published their first papers on kuru in the United States and Australia almost

simultaneously in November 1957 (but with the shorter US paper having slight priority – which, revealingly, was important to Carleton) (14,15). Later, they published in German (16) and in the *Papua New Guinea Medical Journal* (17).

Carleton made several epic walks in Papua New Guinea. Though they mostly arose out of his kuru work they quickly assumed a life and purpose of their own. In 1957 he and Jack Baker defined the geographical limits of the kuru region, the area that enclosed all village communities with a history of kuru (18). There were 172 of them, of which 155 have had cases of kuru reported since the beginning of 1957 – the latest version of the village map may be found in Collinge et al. (19). This mapping exercise was a significant achievement and was, moreover, completed remarkably quickly. The disease incidence faded out in the north and west but in the south-east the boundary was sharp: on the Fore side of the Lamari River the incidence was at its highest and on the Anga side it was zero. Establishing this important fact required long walks among the Anga. Carleton also walked south and west on a major expedition through the remote lands of the Yar Pawaian and Gimi peoples to Lufa. Then Carleton and Jack struck south and walked to the Gulf of Papua. Carleton's arrival in Port Moresby after this expedition is described vividly by Roy Scragg (11). In 1962 I joined him in a walk from Okapa to Menyamya. We crossed known and then unknown Anga territory and met the patrol officer from Wonenara making his initial patrol south. We walked over the top of Mt Yelia and found that it was a volcano, a fact not then known by the government vulcanologist. Taka Gomea also remembers this walk and its sequel (20). Carleton was proud of his speed and stamina on patrol, but he also took care of his support staff and carrier line. Of course, one had to do so in order to get through, but Carleton's care was abundant and personal – and this meant caring for a large number of people since carriers were afraid to go far from their home territory and had to be replaced at every new stage of the journey. Carleton also studied diseases and walked extensively in West New Guinea (then Netherlands New Guinea, now Indonesian Papua). Once, at the time the authorities were doing their utmost to stop him working in the Territory of Papua and New Guinea, he turned up in Okapa not by the usual route but by walking across the border from West New Guinea.

In Okapa Carleton acquired assistants from among the local people, mostly young men and boys, to help him with fieldwork, and he made many local friends of all ages, from the Fore and Anga groups in particular. These friendships endured and were renewed each time Carleton returned to work in the field. In 1957 the early team of investigators was augmented by the arrival of two women, Lucy Hamilton (later Reid) and Lois Larkin. Lucy was a nutritionist and undertook important studies on Fore nutrition, especially in Moke, the home village of the Okapa patrol post (21). Lois had assisted Carleton in the laboratory work carried out at WEHI on the autoimmune complement fixation test (10) and came to Okapa to enhance the laboratory aspects of their investigations. Lois was a close personal friend; in fact, Carleton always maintained that, if he had been of the marrying kind, Lois would have been his choice. Of course, despite this reservation, marriage might still have happened: but it didn't – and Lois married Jack Baker.

Carleton's work on kuru brought him back to Papua New Guinea many times in the next 30 years. It was by no means his only research interest or achievement but it was the one that made him famous and led to his Nobel Prize in 1976 (22). The principal significant outcomes of this work, after the initial description of the disease with Vin Zigas, were the experimental transmission of kuru to chimpanzees, with an incubation period of about 2 years, carried out in collaboration with Clarence J. (Joe) Gibbs and myself (23), and the subsequent transmission of Creutzfeldt-Jakob disease (24). This showed that kuru, though geographically restricted to a remote part of the Eastern Highlands of PNG, was a disease of unquestioned global significance.

Of course Carleton did not do all the work on kuru on his own, even though, particularly after he had won the Nobel Prize, the media – universally – and the scientific community – for the most part – believed that he did. This is a consequence of the enduring myth of the lone scientific genius succeeding against all odds, and is part of the media's fixation with stardom, which in science is exacerbated by the hype surrounding the Nobel Prizes. However, Carleton relished the stardom that had been thrust upon him and made little effort to deny it or share it. Therefore, apart from his colleagues already mentioned, we should acknowledge here the work on kuru carried out by others. This may be done most

conveniently by reference to papers in the proceedings of the End of Kuru conference held in 2007, in particular to the early work of Bob Glasse and Shirley Lindenbaum (25,26), Richard Hornabrook (27), John Mathews (28) and others (29) and to the recent studies – for research on kuru still continues – by myself (30) and by John Collinge and Jerome Whitfield and their colleagues (19,31).

Carleton became interested in other neurological diseases found in remote and isolated populations. He studied the complex of motor neurone disease, parkinsonism and dementia in the Chamorro people of Guam and in isolated populations in the swamps of the south-east of West New Guinea. He visited many other places in West New Guinea and in particular investigated hyperendemic goitre in the highland populations and the spread of cysticercosis after its introduction through pigs brought in from Java (32). From Guam he travelled widely throughout the islands and atolls of Micronesia and expanded his paediatric and genetic studies into the many small island populations of Micronesia. In the course of doing so he entered into the life of Micronesian communities and made many new friends.

After the success of the work on kuru and Creutzfeldt-Jakob disease Carleton's laboratory at the NIH expanded considerably. His team studied the transmissible spongiform encephalopathies (TSEs), as they now called this group of diseases. How the laboratory functioned and its achievements during these years have been described by David Asher (33), Judith Farquhar (3) and Richard Benfante (34). The nature of the unconventional infectious agent that caused kuru and other TSEs was finally shown to be a pure protein, called a prion by Stanley Prusiner (35). Even after he had left his laboratory Carleton was engaged in the expansion of these new ideas in biology, and in seeking an explanation as to how these proteins might self-propagate to cause disease, finding speculative parallels from the atomic level to outer space (36). Prusiner's contribution to this revolutionary discovery led to his own Nobel Prize in 1997. However, Carleton adamantly refused to use the term 'prion' (37) and always called these agents 'unconventional viruses' or 'infectious amyloids'.

Carleton never married, though he took a

delighted interest in his brother's various marriages and relationships and in his two nephews, Mark Terry and Karl Lawrence Gajdusek. As a young man in Boston Carleton had a relationship with a Chinese paediatrician, Chen-Ting Chin. When she returned to China she gave birth to their son. China then became closed to US citizens. As the son grew up he developed a chronic respiratory disease. Carleton was very worried about him and was determined to be the first US citizen into China when entry finally became possible in the Nixon era. However, sadly, he was too late. His son died aged in his mid-20s before Carleton ever had the chance of seeing him. Nevertheless, it was not long before Chen-Ting, by then a nationally renowned paediatrician in Beijing, was able to come out. She worked at the NIH as a visiting scientist – though her main aim, it seemed, was to take care of Carleton and mother his adopted children. She eventually returned again to China, where she died aged in her 90s.

In 1963 Carleton brought Josede Figirliyong from Micronesia and Ivan Mbaginta'o from PNG to live with him in Maryland in the United States. Ivan was originally from Dunkwi village of the Anga people but had been brought up in the South Fore village of Agakamatasa, where Carleton for a long time had a home. Over the next 30 years Carleton brought another 21 young Micronesians and another 15 young Papua New Guineans to live with him as part of his family in the US and be educated there. They came in small groups and stayed for a variable length of time, so they were not all there at the same time. Of these 38 children 5 were girls. Several of the Micronesians stayed in the US after they had finished their education in high school or college, but all the Papua New Guineans, except for one, went back home. However, irrespective of where they lived and their relationship with their extended families at home, they regarded themselves, and continued to be regarded by Carleton, as members of his family. The family bond was a strong and permanent one and continues after Carleton's death to bind the siblings together. In the Melanesian concept of family Carleton was unequivocally the father and his children brothers and sisters, no matter how many other fathers the children may have had in their home communities. This concept is hard to explain to outsiders, including those working in PNG, who will usually be

completely bewildered when they learn that a colleague has taken leave for the third time to attend the funeral of their father.

When they formed part of the same household the Micronesians and Melanesians interacted very closely. They chose informal names for their groups of origin, the Mikes and the Moros, and the names stuck. Carleton was proud of his Mikes and Moros and they too were proud to be part of Carleton's large family. Since Carleton was away a lot it would not have been a viable family if there had been no-one to take care of them. The mothering was done by Joe Wegstein, a mathematician who worked for the National Bureau of Standards and never left home – except when he took some of the kids fishing. It was a perfect arrangement. Joe, with his regular habits and help with homework when it was needed, was a stabilizing influence on the family and the household. Joe and his helpers rostered for the day prepared the evening meal, for the family alone or, as was more common, for the family and a large number of guests – even when Carleton was away there were often guests for dinner. It did not matter to Joe how many there were for dinner just so long as he knew the exact number before he left his office to do the shopping on his way home. It was a lovely household to be part of, as I was on many occasions during my working visits to the NIH. Many colleagues from around the world will testify to the pleasures of dining at Carleton's table with all the kids there and a cosmopolitan gathering of colleagues and friends. On weekends we would go to one or two of the many museums in downtown Washington and wander around the city from Capitol Hill to Georgetown. Occasionally we would drive to Yonkers and spend a long weekend in New York, exploring the city, its parks and museums. Carleton loved to visit museums and share his delight in art or natural history or American Indian culture with his family and friends.

There are several misunderstandings about the purpose of Carleton's family. In principle it had the same purpose as any functional family: to nurture and educate children and to engage them all in family activities in a loving and caring home environment. It was not an experiment in child development or personal 'civilizing' processes. It was not an experiment in social development or creating leaders who would

bring their 'primitive societies' into the modern world. Nor was it a form of payment for services rendered to him in the field. It was his indulgence: his unique way of creating his own family. Carleton knew that children in Papua New Guinea had the same range of potential abilities as children everywhere but he had no preconceived expectations about the potential or achieved capabilities of his individual children. They developed their own potential and Carleton, like any good father, was pleased when that happened. They completed their high school education, and two went back to Papua New Guinea with a university degree. Yavine Borima, the only Papua New Guinean who stayed in the US, was an artist and completed a Bachelor of Fine Arts degree at the Corcoran School of Art (now the Corcoran College of Art and Design) in Washington, DC. Ivan Mbaginta'o became Curator of the J.K. McCarthy Museum in Goroka and later returned to the US on a Wenner-Gren scholarship to study at the Smithsonian Institution in Washington and the Peabody Essex Museum in Salem, Massachusetts. Sadly, Ivan died of asthma in Goroka Hospital in 2005. Okovi Yrao, the youngest of Carleton's sons, has also died more recently. The others are now scattered in PNG, some in their home village, some in Goroka, some in Lae, some in Port Moresby. Ceridwen Spark, an anthropologist with a special interest in adoption, has written a sympathetic account of 'Carleton's kids' (38). Carleton's 80th birthday was celebrated in Bologna in 2003 and the party was attended by friends and family, including Yavine and Ivan (Figure 1).

Writing the obituary – or even an appreciation – of a person does not normally require an examination of their sexuality. However, almost every obituary of Carleton that has been published has addressed this issue, and in most cases the implications have been derogatory and egregiously wrong, especially those in the major newspapers. Though not all the accusations have been explicit the implications have always been that Carleton as a practising 'paedophile' brought children (or simply 'boys') from Melanesia and Micronesia to be educated in the United States so that he could abuse them. This statement is so far from the truth and so painful to members of his family that it is hard to record, but it has been implied so often that, in deference to Carleton's memory, it must be confronted, and denied. We need to look calmly at the facts, firstly about



Figure 1. At the celebration of Carleton's 80th birthday in Bologna in 2003: left to right, Ivan Mbaginta'o, Carleton Gajdusek, Yavine Borima. Photograph courtesy of Shuguang Zhang, MIT (Massachusetts Institute of Technology).

Carleton and secondly about his conviction for sexual molestation.

Carleton's sexual orientation was undoubtedly towards males and in particular young men and boys. He declared this explicitly in the privacy of his diaries, but for most of his adult life his sexual orientation was strictly a private matter, as it is with most people. However, it was not fixed or confined and Carleton was able to build good relationships with people of both sexes and all ages, and of widely differing sexual orientations. He lived with men. He lived with women, by one of whom he had a son. He was most happy with children and had a remarkable rapport with them. When he entered a household the adults were overwhelmed by his conversation and the children were charmed by his personality.

Those who met Carleton when they were children have never forgotten him and, if he came back to their home, the rapport was instantly renewed. Carleton always defined 'paedophile' as 'a lover of children', and that is exactly what he was: and children loved him in return. The connotation of 'paedophile' today is inextricably linked to sexual abuse, so we cannot apply it to Carleton. However, we must acknowledge that there was a sexual component to Carleton's love of male children. His principal same-sex orientation was not hidden or denied, and those able to pick up clues to his sexuality could and would do so, but it was not publicly discussed. However, after his arrest and year in gaol he became obsessed with his sexuality and for a time could talk or write of nothing else. This was not his normal behaviour but was a reaction to the deep traumas and torment he

had suffered. Nevertheless, what he thought and talked and wrote about was true and important and raised conflicting moral issues. Everyone has difficulty adjusting their sexual behaviour to their moral values. This is no place for a discourse on psychosexuality or sexual morality, but the dilemmas are clearly more complex for those who are sexually attracted to children – and there is no point in pretending that such people do not exist or that it is all in their imagination. The critical thing is whether the sexuality that one has been given is deployed in an abusive way or not. Love and desire between a man and a woman is a beautiful thing, but raping a woman is universally regarded as criminal abuse. All forms of sexuality can be abused. The important question at issue – at least in most parts of the contemporary world – is whether there has been abuse or not. In Carleton's case the charge is abuse of his children. It is only they who can answer that. From the accounts here by three of his living Melanesian children (39-41) one can make one's own assessment of the truth of this charge.

The other lie that is widely promulgated is that one of Carleton's Micronesian children made a formal complaint that he had been abused by Carleton. There was no formal complaint. The true story goes like this. One of the junior members of Carleton's staff at the National Institutes of Health had felt offended by some action or remark of Carleton's and became embittered and angry. He was determined to get back at Carleton and conducted a sustained and impassioned campaign to discredit him. Eventually he succeeded. It is a sad fact to reflect upon that without the persistence of his nemesis Carleton would be revered today for his love, not denounced for his sexuality. In this story the young man is the elephant in the room that no-one ever mentions in the accounts of Carleton's arrest, charges of sexual abuse, trial and imprisonment. Without his agency nothing of this kind would have happened. He went through Carleton's published journals and private diaries and papers and pulled out what he considered to be incriminating material, which he sent to senior members of the United States Congress. Computer files had to be secured to prevent him gaining access to private and confidential records at night. Carleton was aware of his activities; he was not sacked but allowed to continue since Carleton preferred to consider him harmless. Thus Carleton's combined

generosity and hubris contributed to the disastrous outcome. The young man's first campaign with Congress failed. Then he had a win with the claim that Carleton's laboratory held illegal stocks of smallpox virus. A multimillion-dollar investigation closed the lab for months but failed to find smallpox. Then the composition of Congress changed, with greater representation of the fundamentalist right wing of the political spectrum. The young man's persistence paid off and the Federal Bureau of Investigation (FBI) was called in to take action. They found one of Carleton's Micronesian sons who was failing in college, despite all the help Carleton was giving him, and persuaded him, through monetary and other inducements, to take part in an entrapment: he would call his father and ask him certain questions according to a script prepared by the FBI, and the phone call would be recorded. On the basis of the entrapment transcript the FBI decided to go ahead and press charges. Carleton was arrested outside his home in Frederick County, Maryland after he had returned from a visit to Slovakia. As he was being arrested and roughly taken away, and before charges had been formally laid, television cameras, strategically placed in advance of his arrest, recorded the whole proceedings, which were soon flashed across the nation. In that moment Carleton's reputation was shattered: from honoured Nobel laureate to paedophile laureate, whatever the outcome of any subsequent court proceedings might have been. Carleton's other children and nearly all his friends, some most bravely, supported him vigorously and without question, when he was in turmoil and torment. While he was on bail and awaiting trial, Carleton's children and friends wrote letters of support to the judge presiding over his case. In the meantime the FBI added more charges, of varying degrees of seriousness, to his charge sheet. Finally his lawyer gave Carleton a choice: "Fight every charge, one by one, with an excellent chance of winning them all, and go free, after a cost of many millions of dollars and ten years of your life; or plea bargain, and have all charges dropped forever except for one to which you will plead guilty and for which you will be given a commuted sentence of one year in gaol." For several reasons, not the least of which was the fact that his reputation was already totally destroyed, Carleton chose the latter option. After spending exactly a year in gaol, he came out, got his passport from his lawyer, had a small celebration at Dulles International Airport with close colleagues and

his children who lived in the Washington area, and flew off to Paris, never to return. He lived for another 10 years in Europe, mainly in Amsterdam but also in Paris and Tromsø, travelled to Japan and Singapore and was several times a visiting professor in China, where he was revered like a god, before his heart finally gave out in Tromsø on 11 December 2008.

The eulogy and farewell to Carleton delivered at his funeral in Tromsø by Yavine Borima is reproduced here with Yavine's permission.

We, his friends and family, honour Carleton and express our love and respect for him as we sadly say farewell. Carleton hated long and emotional funeral ceremonies, even for those closest to him, so we should respect his wishes on this occasion, and be brief and calm, despite the sorrow we are feeling.

Carleton was a scientist, a doctor, a thinker, a humanist, an explorer, a warm friend and a loving father. Because of the way he had been persecuted and tormented he became in recent years obsessed with his sexuality. However, that aspect of his life and personality no more represents the man than does the scientific achievement for which he was awarded the Nobel Prize. He was too rich and complex to be confined into any one category. Nor was he a split personality: his different facets all shone as parts of one integrated whole.

To know Carleton was to share his wealth. He was very generous to those he loved. We enjoyed science, literature, food, wine, art, music, travel together – combined in complex and sophisticated ways but never without some moments of simple wonder and delight.

Carleton had so much energy, intellectual and physical. He never stopped – even in sleep he seemed poised for action from the moment he would stir again into waking life.

Carleton was fired by his own enthusiasm, like a Greek god, and with it he captivated others. He enjoyed being alone, addressing his own thoughts in his journal, or reading, but more than anything he loved company, which gave him an audience to enthral.

Carleton was never overawed by important people and treated everyone equally. In a household he would keep the adults silent with his flow of speech and ideas but he took special care to pay attention and listen to the children. He loved children, and showed it in many touching and subtle ways.

When he was a young man Carleton was physically fit, a strong walker and an adventurous explorer. He had an extraordinary ability to make friends with wary and apprehensive people of an unknown culture living in wildly remote communities. Within minutes of his arrival in the community he would have the children romping all over him; some mysterious rapport instantly connected him to children, wherever he was, and this transcended all cultural differences. When the adults came to see what was going on Carleton gradually gathered them too under his spell. It was a rare privilege to share such experiences with him.

Despite the power of his intellect, what was most important to Carleton was love, and he was never afraid to acknowledge it and share it. He loved his family – his mother, his aunt, his brother and everyone in the family of Mikes and Moros that he had created to be his own. He loved his friends and his colleagues and regularly kept in touch with a large number of them. Once, in the early days of the lab at the NIH, he was asked what held his unusual crew of scientists and supporting staff together. His reply was one word: love.

We love you, Carleton. That is uppermost in our thoughts as we say farewell to you. All your family and friends love you and we thank you for enriching our lives.

Goodbye, Carleton. From your heartland of Papua New Guinea we all say goodbye. Yu yet go pinis nau, yu lusim mipela, na mipela no ken lukim yu gen. Tasol mipela olgeta no ken lusim tingting long yu. Nogat tru. Mipela bai tingting long yu moa moa yet, long oltaim.

Stap isi, Kaoten. Rest quietly now. Farewell.

The last great event in Carleton's life was the End of Kuru Conference held at the Royal Society in London in October 2007. He was

quite infirm by then but with the assistance of a friend he managed the flight from Amsterdam, where he was living, to London. There were 15 Papua New Guineans at the conference, including some of his early assistants whom he had not seen for many years. Their reunion was an emotional and physical intermingling that generated a buzz of excitement felt by all of us who were present. Carleton presented a paper at the conference, which came out in the proceedings published in the *Philosophical Transactions of the Royal Society* (36). Carleton enjoyed himself hugely at the meeting and had fun putting together his paper, which connected kuru and the concepts learned from it to a truly fantastic range of contexts. He also praised the cultural achievements of the Palaeo-Melanesians, the early inhabitants of Papua New Guinea, for providing us with an ancient model of a civilized society. It was particularly gratifying to John Collinge and me, as the organizers of the conference, that Carleton received his copy of the *Transactions* about a month before he died. The reminiscences and reflections of the Papua New Guinean participants were also published in the proceedings and most of them mentioned their early memories of working with Carleton (20,42-45). He was indeed a remarkable and unforgettable person. His roving spirit was always firmly linked to Papua New Guinea and has now surely settled in its ground, so much of which he had walked over, and in the hearts of his many Papua New Guinean friends, especially his beloved Moros, his sons and daughters, who were so vital a part of his adopted family and his life.

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OBITUARY

Daniel Carleton Gajdusek, my father

I was on my way home from the States. Carleton and I met in Vanuatu. He drove me to a remote part of the main island of Vanuatu where a rock protruded out over the ocean. The ocean waves would rise higher than the rock point like great mountains and drop suddenly. The water was crashing down and rushing past below us as we stood at the point of the protruding rock. The land behind us shook and tremors went through the trees nearby. A wave of shock, fear and wonder was sent through me. I looked at Carleton with bewilderment. He stood there and gave me a warm smile. He was not scared. I walked off the rock and came to sit on the bonnet of the car. I enjoyed the vibration of the land while Carleton stood for two more wave breaks at the edge of the rock. We sat on top of our rented car for some time and had many talks about everything. He explained to me that he visited this place every time he came this way.

These were moments of great feeling and significance. I know that was his way of initiating me into the challenges of life, as we would not see each other again. I have never forgotten the thrill of that day. It was an initiation process from a father to a son. That was Carleton, my father.

There are no hidden stories to tell about Carleton as he was always open. He talked openly about history and the customary practices among our people of the Anga or Fore. He was very pleased to tell his friends about them. Some of his friends would remark that these practices were intriguing and that would trigger Carleton to elaborate some more. He would mark out his children and tell his friends which one of his children was from the culture with that practice.

I must make it clear here that Carleton was not a guardian, caretaker or adoptive father; he was a true father to all of us. He was our father, as true to us as our genetic parents. The genetic family of each one of Carleton's kids became part of an extended family involving Carleton and all his kids. As well as being the son I was also a grandson of Carleton, because my father Anua was one of Carleton's many sons in the Fore.

Carleton enjoyed walking through the forest. He always said that we were men of the forest. He talked of the qualities of highland men in connection with his life among the Fore in Papua New Guinea. He said this refreshingly – like rain showers in the forest. I think he had fond memories of walkabouts to Agakamatasa, Awarosa, Ilesa and Purosa, to Dunkwi and back, across the Lamari, with leech marks all over his legs. I remember boiling hot water to wash his legs while he and Anua, his son, were talking. They would still be up talking while I fell asleep.

I had security under his fatherhood. He had great love and care attending to every need that all his children had. He gave me freedom to let me ponder and wonder. He was always elaborating history from ancient times to the present, about great thinkers. I listened to his lectures and stories about these great men of history. I never took it all in and after a while I would usually fall asleep.

Carleton knew his children individually. He knew his closest friends individually. He conversed with them with care and passion. These people were important to him: his Micronesian and Papua New Guinean children – the Mikes and the Moros – and his chosen brothers and sisters abroad.

Carleton talked with us and taught us Mikes and Moros to take care of ourselves, to be our own men, to be independent. Some of us took years to understand. I still wrote to him for assistance long after I had left his household.

Carleton loved company and was always ready to give others his time and attention. He was also fair when buying things for his children. He took all of us to the mall if one of his children requested that he or she needed something such as shoes. Girls were taken out to shop separately as they would want more things than us. That was considerate. Carleton helped with the selections at times but mostly stood around and paid for the whole collection at the counter. The trips to the thrift shops were especially nice, where all of us, boys and girls, would go and choose

anything we wanted.

Then Carleton would be excited once more to go on a trip. We went on long trips across the US when we were on holidays and shorter ones on weekends when we were in school. We would enjoy holidays doing things other children did not have the opportunity to do. We visited all the museums in Washington. We would also drive up to Yonkers and visit museums in New York. We went out camping in the mountains of the Adirondacks and Catskills.

We also had trips across the countries of Europe by car. Carleton and I were in Europe on many trips. Carleton was always an historian as well as an adventurer on these trips, and he would tell stories of people, towns, states and mountains. He would sometimes send me out of town to stay with his doctor friends while he was giving his lectures. I would stay with a family belonging to our family of friends until his lectures were over, when he would come and pick me up.

I was the accident-prone one of his children. He called me his accident-prone child ('my Sena'). He would laugh out loud while dressing my wound, whether it was on my face or limb or other part of my body. They were mainly bicycle accidents.

One hot summer I blew up our lawn mower. It was not so funny this time as the explosion threw me a couple of yards. He was more concerned about the mower as it was in flames. I was in fear of what Carleton would say and was on my feet in a second as I saw Carleton walking towards me with a heavy woollen blanket. He quickly threw the woollen blanket over the lawn mower and the flames disappeared. He told me sternly never to put water on a burning machine. Carleton left, and I pushed the burnt lawn mower into the garage.

It was very nice at times when I saw Carleton sleeping, which was rare for him. He just never slept. He spent all the time at his table writing or talking to his little tape recorder about everyone and anything. This was when there was no one around at the dinner table to talk to – and that was rare too. There was nearly always someone at our dinner table.

Carleton lived, or at least knew, multiple lifestyles or cultures. People came and

Carleton knew their language. He spoke with them and they became our friends. They told their stories and all barriers were broken. Very soon I would be entertaining them at our house. Carleton and I would go shopping. I would always be asked to cook as Carleton bragged, "My son can cook." I had learned from my brother John Runman, who called me 'Sena-son'.

Carleton kept a record of every trip, travel or gathering in writing and still films. The mounting of the photographs of all our events was done in strict chronological order by his children; the slide copies were put into slide cases. This library of slides and mounted albums was kept in the living room of our house at Prospect Hill near Frederick, Maryland. Of course copies of pictures were also sent to our families and friends for their files. The photographs were full of interest and I enjoyed just browsing through them.

I do not know what has happened to these archives. They date back to the 40s and 50s. These were some of the activities that Carleton engaged his children in while they were growing up. We were also treated to matinees at Dupont Circle in downtown Washington or at Frederick Town Mall. Carleton preferred that we watch foreign movies so that we could read the English subtitles as well as follow the story. It was always fun.

Carleton was special and I loved him dearly, as his other sons and daughters did. So did his brothers and sisters around the world, his closest friends, and those whom he had touched and influenced, often without knowing. He will never be forgotten. He was loved by many in a special way.

Carleton always had heaps of things to do but he was never disturbed when we interrupted him for something. He did everything together. He was a worker, a father, a mother, a writer, a reader, a giver, a carer and many more under one roof of compassion and love.

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OBITUARY

How I knew Dr Carleton Gajdusek, and remembering life with Carleton

How did I know Dr Carleton Gajdusek? Well, the truth of the matter is that he knew my father, Ivan Mbaginta'o, before me. So, because of my father, Dr Carleton Gajdusek knew me first as Ivan's daughter.

Now to begin my story! When I was a kid, I can remember meeting Carleton Gajdusek in the middle of 1982 – or maybe it was 1983: one of those years. I thought that Carleton was a nice person. He asked my father about his family life, about his job, about his children, and so on. My father replied that everything was just fine. Carleton also asked my father whether he was interested in sending one of his children to stay with him in the United States. My father said, "Let me think about it first, then later I will let you know if I am interested or not."

Carleton was in Papua New Guinea for a week or so before he returned to the United States. I really did not know him well at that time because I did not talk to him. I only watched him from a distance talking to my father and discussing everyday things. After Carleton went back to the United States my father gradually prepared for my departure. He arranged my passport, visa and ticket for me to travel to the US to stay with Carleton. The arrangement of my travel was a secret just between Carleton and my father, and I did not know about it.

Anyway, in June 1984 I travelled from Goroka to Port Moresby with a friend of Carleton's and his children. We stayed for a week in Port Moresby and then flew to Australia ... and then to Washington, DC. At Dulles International Airport one of Carleton's colleagues, Dorrie Runman, picked us up and drove us home to Carleton's beautiful 'castle' (an old Maryland mansion) near Frederick town on the top of Prospect Hill. It was a lovely, peaceful place, isolated in the woods, with no near neighbours and no noise of cars; the only noises we could hear were from the birds in the woods. Around the house we had a nice swimming pool, gazebo area, volleyball court, soccer place, a big parking lot, a sweeping driveway and lots of cherry trees in

the orchard garden.

Carleton was a beautiful person and I loved him with all my heart. When Carleton first saw me at his home he gave me a nice welcome-home smile. Carleton was wonderful because he could talk endlessly with his doctor friends about science. Carleton loved science but he had other interests as well, and at the dinner table we always had discussions about things that had happened in school, events in other countries, the books we had read and so forth. Life with Carleton was flexible, easy-going and enjoyable, and as well we had lots of exciting opportunities for doing interesting things. There was one thing that was very important to me and Carleton's other kids, which was that Carleton gave each of us freedom with our own life. He never intervened in our private lives. Carleton wanted us to have freedom, so he gave it to us, and from him it was always and forever.

Carleton was my life. He gave all he had to me, as a father, a friend, a guardian and a mother. Well, he was never much of a mother figure, but he was everything in a father that a child would want. Anything that I asked him for, such as money, shoes and clothes, he always agreed to. He clothed me from head to toe. He had trust in me in my education and loved me like his own daughter. I love my father Carleton for ever because he is my 'never-ending story book'. I say that because in college I was always receiving letters from him telling me a story about his trips to other countries, or what was going on in the house in Middletown, which was our second home after we left our beautiful Prospect Hill home. When I returned to Papua New Guinea in 1995 to be in my own country, I still received letters from him, though less frequently; his last letter to me, before he died in December 2008, was dated 25 April 2008.

Life was never boring when we were with Carleton. He loved all his children from Micronesia and Papua New Guinea. He also had friends among children from all over the world. It was exciting and enjoyable being

around him because he was a wonderful story-teller. His scientist friends liked to invite him to give lectures all over the world, at conferences or in their own departments. He enjoyed that but he never neglected the children who were his friends or part of his family. He always played with children and joked with them about all the things in life.

Sometimes he travelled alone, like an eagle that flies from tree to tree or high in the sky, while his children waited in their nest for his

return home. He was that eagle and we were the children of the famous eagle scientist.

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OBITUARY

Carleton: the champion hero

It was as early as my childhood days that I knew Carleton. In fact he was there even before I was born at Waieti hamlet of Agakamatasa village. He had settled there in order to study the deadly kuru epidemic and its expansion in our area. We called him Kaoten or just Kao.

He lived in a big round house made of bush materials in the centre of the village. The house boasted an upper floor used as a sleeping room, while on the ground floor there were two rooms. One of the rooms was the store room while the other served as an all-purpose room – the living, dining, study and working room.

All day long we would be around Carleton, not even thinking of where and what our parents were up to. For those of us who did not have much of a family because of the curse of kuru Carleton was a perfect alternative caretaker. He gave us marbles and tennis balls and even a soccer ball to play with. He wanted us to be nearby him playing marbles at the front of the house or viewing photographs and magazines or just drawing at his makeshift tables over galvanized patrol boxes in his house. Carleton had a devoted interest in the company of children.

When it came time for shooting pictures we would all follow him, each of us carrying something, either the tripod, an extra camera, camera cases, lenses or rolls of film. We were a noisy bunch from the beginning as we set out from the house, whether we went up the trail or down the road or just around the village, with a lot of giggling, laughing, shouting and chasing as we excitedly followed and watched every move Carleton made.

Most frequently it was at the edge of the village that we stopped, looking over the Lamari River and beyond to Dunkwi and the Anga territory. Carleton would be here for hours pointing his camera and swinging it in a 360 degree circle. He would point to and ask for the names of anything he wanted to know. He learned from us the names of

places, plants, birds, animals and even parts of the human body, as well as the basics of our language, such as salutations and the foods we ate.

Through these interactions he gained much knowledge of our language and culture, in order to understand us, as we learned Pidgin, the lingua franca, from him. This made it easier for us to communicate with a common tongue and understand each other better, thus cultivating a relationship that was very much attached to and dependent on Carleton.

Through his eyes we were able to see far beyond the limits of our local community. Unfortunately not everyone would get to see where Carleton came from, but a lucky handful, including myself, had the privilege of living with him in the United States. The man we called Kaoten in Waieti hamlet was really a global giant in the field of science working for the benefit of mankind. He was a caring man for all ages, regardless of class, gender or colour. Carleton openly boasted of the multicultural kids he had under his care, which he called his family. He was a humble father, a great teacher and undoubtedly a champion hero for those of us in his family.

Carleton/Kaoten is a household name in Agakamatasa village, where he spent a good part of his life working on kuru. He will be forever remembered through the local school, which we have decided to dedicate as a memorial to Carleton, naming it the Gajdusek Memorial Community School (GMCS).

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PUBLICATIONS OF RELEVANCE TO PAPUA NEW GUINEA AND MELANESIA

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- 1 **Anga G, Barnabas R, Kaminiei O, Tefuarani N, Vince J, Ripa P, Riddell M, Duke T.**

The aetiology, clinical presentations and outcome of febrile encephalopathy in children in Papua New Guinea.

Ann Trop Paediatr 2010;30(2):109-118.

BACKGROUND: Febrile encephalopathy, defined as fever, seizures and/or altered consciousness, is a common presentation in children in tropical developing countries. Outcomes range from complete recovery through varying degrees of neurological disability which slowly resolve or remain permanent to death from either the acute illness or complications. Whilst bacterial meningitis accounts for a proportion of children affected, the aetiology in many remains unclear but includes malaria and probably viral encephalitis. **AIM:** To understand the aetiology, presentation and outcome of febrile encephalopathy in children in Papua New Guinea. **METHODS:** Children aged between 1 month and 12 years presenting to Port Moresby General Hospital with febrile encephalopathy were studied prospectively. A detailed history and examination and the following laboratory investigations were undertaken as appropriate: cerebrospinal fluid (CSF) microscopy and bacterial culture, gram stain, measurement of protein and glucose and latex agglutination testing for *Haemophilus influenzae*, *Streptococcus pneumoniae* and *Neisseria meningitidis*; Ziehl-Neelsen staining and india ink examination on selected samples; IgM for Japanese encephalitis, dengue, rubella and measles; PCR testing and mycobacterial culture for *Mycobacterium tuberculosis*. Blood was tested for flavivirus, measles and rubella IgM and IgG. **RESULTS:** 149 children were enrolled in the study. 129 had a lumbar puncture and CSF examination; 66 had a normal CSF white cell count. A clinical or laboratory-based diagnosis was possible for 140 children, but a definite pathogen was identifiable for only 55 (37%). The diagnoses included bacterial meningitis in 33 (*S. pneumoniae* 16, *H. influenzae* 13 and *N. meningitidis* 4), tuberculous meningitis (5), probable tuberculous meningitis (18), malaria (10), cryptococcal meningitis (1), flavivirus encephalitis (5), rubella encephalitis (1), hepatic encephalopathy (1) and HIV encephalopathy (1). There were 28 cases of meningitis of unspecified aetiology. Of the five children with IgM-confirmed flavivirus encephalitis, one had dengue serotype 1 and two had Japanese encephalitis. Twenty-five children (including three of the five children with CSF flavivirus IgM) had serological IgG evidence of previous flavivirus infection. A history of multiple convulsions, the presence of neck stiffness and use of the Glasgow coma score (GCS) and TB score chart helped to identify children with bacterial meningitis and an adverse outcome and those with febrile convulsions. **CONCLUSION:** The study confirms the importance of *S. pneumoniae* and *H.*

influenzae as major causes of febrile encephalopathy in children in Papua New Guinea. Flaviviruses including Japanese encephalitis are a cause of the febrile encephalopathy syndrome, as is *Mycobacterium tuberculosis*. All children with febrile encephalopathy should have their GCS and TB scores recorded and should be examined for neck stiffness, and a history of the frequency of convulsions should be recorded. These basic clinical data can help to discriminate aetiology, to guide treatment and monitoring and to identify the children at highest risk of adverse outcome.

- 2 **Ashwell H, Barclay L.**

Challenges to achieving sustainable community health development within a donor aid business model.

Aust NZ J Public Health 2010 Jun;34(3):320-325.

OBJECTIVE: This paper explores the paradox of donor aid being delivered through a business model through a case study in Papua New Guinea. **METHODS:** A retrospective review of project implementation and an outcome evaluation provided an opportunity to examine the long-term results and sustainability of a large project. Analysis was informed by data collected from 175 interviews (national, provincial, district and village), 93 community discussions and observations across 10 provinces. **RESULTS:** Problems with the business model of delivering aid were evident from implementation data and in an evaluation conducted two years after project completion (2006). Compounding the business model effect were challenges of over-ambitious project goals with limited flexibility to adapt to changing circumstances, a donor payment system requiring short-term productivity and excessive reporting requirements. **CONCLUSION:** An overly ambitious project design, donor dominance within the business model and limited local counterpart capacity created problems in the community initiatives component of the project. Contractual pressures can negatively influence long-term outcomes that require development of local leadership and capacity. Future planning for donor project designs needs to be flexible, smaller in scope and have a longer timeframe of seven to 10 years. **IMPLICATIONS:** Donor-funded projects need to be sufficiently flexible to apply proven principles of community development, build local ownership and allow adequate time to build counterpart knowledge and skills.

- 3 **Atagazli L, Greenhill AR, Melrose W, Pue AG, Warner JM.**

Is *Penicillium citrinum* implicated in sago hemolytic disease?

Southeast Asian J Trop Med Public Health 2010 May;41(3):641-646.

Sago hemolytic disease (SHD) is an acute hemolytic syndrome affecting rural Papua New

Guineans who depend on the starch of *Metroxylon sagu* as a staple carbohydrate. It is a suspected mycotoxicosis associated with fungal succession in stored and perhaps poorly fermented sago. Despite a mortality rate of approximately 25%, little is known about the disease. Recent studies have identified *Penicillium citrinum* as a possible candidate in the etiology of SHD. This is based on the frequency of isolation from sago starch and the hemolytic nature of the organism as demonstrated when cultured on sheep and human blood agar. A highly non-polar lipophilic *P. citrinum* fraction from C18 solid phase extraction demonstrated high hemolytic activity in a semi-quantitative assay using both mouse and human erythrocytes. When the red cell membrane proteins were subjected to sodium dodecyl-sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) separation, cleavage of protein band 3 and spectrin was demonstrated. This breach of major structural red cell proteins is consistent with the severe hemolysis found in vivo. Our findings warrant further investigation into the hemolytic activity of *P. citrinum* and its role as the etiological agent of SHD.

- 4 **Atkinson JA, Fitzgerald L, Toaliu H, Taleo G, Tynan A, Whittaker M, Riley I, Valley A.** Community participation for malaria elimination in Tafea Province, Vanuatu: Part I. Maintaining motivation for prevention practices in the context of disappearing disease. *Malar J* 2010 Apr 12;9:93.

BACKGROUND: In the 1990s, the experience of eliminating malaria from Aneityum Island, Vanuatu is often given as evidence for the potential to eliminate malaria in the south-west Pacific. This experience, however, cannot provide a blueprint for larger islands that represent more complex social and environmental contexts. Community support was a key contributor to success in Aneityum. In the context of disappearing disease, obtaining and maintaining community participation in strategies to eliminate malaria in the rest of Tafea Province, Vanuatu will be significantly more challenging. **METHOD:** Nine focus group discussions (FGDs), 12 key informant interviews (KIIs), three transect walks and seven participatory workshops were carried out in three villages across Tanna Island to investigate community perceptions and practices relating to malaria prevention (particularly relating to bed nets); influences on these practices including how malaria is contextualized within community health and disease priorities; and effective avenues for channelling health information. **RESULTS:** The primary protection method identified by participants was the use of bed nets; however, the frequency and motivation for their use differed between study villages on the basis of the perceived presence of malaria. Village, household and personal cleanliness were identified by participants as important for protection against malaria. Barriers and influences on bed net use included cultural beliefs and practices, travel, gender roles, seasonality of mosquito nuisance and risk perception. Health care workers and church leaders were reported to have greatest influence on malaria prevention practices. Participants preferred receiving health information through visiting community health promotion teams, health workers, church leaders and village chiefs. **CONCLUSION:** In low malaria transmission settings, a package for augmenting social capital and sustaining community participation for elimination will be essential and

includes: 'sentinel sites' for qualitative monitoring of evolving local socio-cultural, behavioural and practical issues that impact malaria prevention and treatment; mobilizing social networks; intersectoral collaboration; integration of malaria interventions with activities addressing other community health and disease priorities; and targeted implementation of locally appropriate, multi-level, media campaigns that sustain motivation for community participation in malaria elimination.

- 5 **Epidemiological Task Group for Overseas French Territories of the Pacific, Barboza P, Baudon C, Chérié-Challine L, Gastellu-Etchegorry M, Gueguen J, La Ruche G, Grangeon JP, Laumond-Barney S, Noël M, Pfannstiel A, Chee-Ayee A, Daudens E, Frogier E, Le B, Mallet HP, Pescheux JP, Vergeaud H, Lastère S, Dutaut E, Yvon JF.**

Influenza A(H1N1)2009 in the French Pacific territories: assessment of the epidemic wave during the austral winter.

Clin Microbiol Infect 2010 Apr;16(4):304-308. Epub 2010 Jan 28.

The three French territories in the Pacific (New Caledonia [NC], French Polynesia [FP] and Wallis and Futuna [WF]) have been affected by an outbreak of influenza A(H1N1)2009 during the austral winter of 2009. This wave of influenza-like illness was characterized by a short duration (approximately 8 weeks) and high attack rates: 16-18% in NC and FP, 28% in Wallis and 38% in Futuna. The number of infected patients requiring hospitalization in critical care services and the number of deaths were, respectively, 21 and 10 in NC and 13 and 7 in FP (none in WF). Diabetes, cardiac and pulmonary diseases, obesity in adults, neuromuscular diseases in children, and Oceanic origin were frequently observed among severe cases and deaths. A significant proportion of the population remains susceptible to A(H1N1)2009, making the occurrence of a second wave likely. A state of preparedness and control efforts must be implemented, based on preventive measures (immunization), as well as combined clinical and virological surveillance and health organization.

- 6 **Becker AE, Roberts AL, Perloe A, Bainivualiku A, Richards LK, Gilman SE, Striegel-Moore RH.** Youth health-risk behavior assessment in Fiji: the reliability of Global School-based Student Health Survey content adapted for ethnic Fijian girls. *Ethn Health* 2010 Apr;15(2):181-197.

OBJECTIVE: The Global School-based Student Health Survey (GSHS) is an assessment for adolescent health-risk behaviors and exposures, supported by the World Health Organization. Although already widely implemented – and intended for youth assessment across diverse ethnic and national contexts – no reliability data have yet been reported for GSHS-based assessment in any ethnicity or country-specific population. This study reports test-retest reliability for GSHS content adapted for a female adolescent ethnic Fijian study sample in Fiji. **DESIGN:** We adapted and translated GSHS content to assess health-risk behaviors as part of a larger study investigating the impact of social transition on ethnic Fijian secondary schoolgirls in Fiji. In order to evaluate the performance of this measure for our ethnic Fijian study sample (n=523), we examined its test-retest reliability with kappa coefficients, % agreement, and

prevalence estimates in a sub-sample (n=81). Reliability among strata defined by topic, age, and language was also examined. **RESULTS:** Average agreement between test and retest was 77%, and average Cohen's kappa was 0.47. Mean kappas for questions from core modules about alcohol use, tobacco use, and sexual behavior were substantial, and higher than those for modules relating to other risk behaviors. **CONCLUSIONS:** Although test-retest reliability of responses within this country-specific version of GSHS content was substantial in several topical domains for this ethnic Fijian sample, only fair reliability for the module assessing dietary behaviors and other individual items suggests that population-specific psychometric evaluation is essential to interpreting language and country-specific GSHS data.

- 7 **Becker AE, Thomas JJ, Bainivualiku A, Richards L, Navara K, Roberts AL, Gilman SE, Striegel-Moore RH; HEALTHY Fiji Study Group. Collaborators: Aalbersberg B, Khan N, Taganesia A, Masei L, Bainivualiku A, Khan PW, Sarai F.** Validity and reliability of a Fijian translation and adaptation of the Eating Disorder Examination Questionnaire.

Int J Eat Disord 2010 Mar;43(2):171-178.

OBJECTIVE: Assessment of disordered eating has uncertain validity across culturally diverse populations. This study evaluated Eating Disorder Examination Questionnaire (EDE-Q) performance in an ethnic Fijian study population. **METHOD:** The EDE-Q was translated, adapted, and administered to school-going Fijian adolescent females (N = 523). A subsample (n = 81) completed it again within approximately 1 week. We assessed feasibility, internal consistency, and test-retest reliability; evaluated construct validity through factor analysis and correlation with similar constructs; and examined the marginal utility of an additional question on traditional purgative use. **RESULTS:** Internal consistency reliability was adequate for the global scale and subscales (Cronbach's alpha = 0.66-0.91); retest reliability was adequate for both the languages (range of ICCs, 0.50-0.79, and of kappas, 0.46-0.81, excluding purging items). Construct validity was supported by significant correlations with measures of similar constructs. Factor analysis confirms multiple dimensions of eating disorder symptoms but suggests possible culture-specific variation in this population. The majority of respondents endorsing traditional purgative use (58%) did not endorse conventional EDE-Q items assessing purging. **DISCUSSION:** The EDE-Q is a valid measure of eating disorder pathology for ethnic Fijian adolescent females and measures a unitary underlying construct.

- 8 **Becker AE, Thomas JJ, Bainivualiku A, Richards L, Navara K, Roberts AL, Gilman SE, Striegel-Moore RH; HEALTHY Fiji Study Group. Collaborators: Aalbersberg B, Khan N, Taganesia A, Masei L, Bainivualiku A, Khan PW, Sarai F.** Adaptation and evaluation of the Clinical Impairment Assessment to assess disordered-eating-related distress in an adolescent female ethnic Fijian population.

Int J Eat Disord 2010 Mar;43(2):179-186.

OBJECTIVE: Measurement of disease-related impairment and distress is central to diagnostic, therapeutic, and health policy considerations for eating disorders across diverse populations. This

study evaluates psychometric properties of a translated and adapted version of the Clinical Impairment Assessment (CIA) in an ethnic Fijian population. **METHOD:** The adapted CIA was administered to ethnic Fijian adolescent schoolgirls (N = 215). We calculated Cronbach's alpha to assess the internal consistency, examined the association between indicators of eating disorder symptom severity and the CIA to assess construct and criterion validity, and compared the strength of relation between the CIA and measures of disordered eating versus with measures of generalized distress. **RESULTS:** The Fijian version of the CIA is feasible to administer as an investigator-based interview. It has excellent internal consistency (alpha = 0.93). Both construct and criterion validity were supported by the data, and regression models indicated that the CIA predicts eating disorder severity, even when controlling for generalized distress and psychopathology. **DISCUSSION:** The adapted CIA has excellent psychometric properties in this Fijian study population. Findings suggest that the CIA can be successfully adapted for use in a non-Western study population and that at least some associated distress and impairment transcends cultural differences.

- 9 **Blacklow B, Konstantakopoulos N, Hodgson WC, Nicholson GM.**

Presence of presynaptic neurotoxin complexes in the venoms of Australo-Papuan death adders (*Acanthophis* spp.).

Toxicon 2010 Jun 1;55(6):1171-1180. Epub 2010 Jan 11.

Australo-Papuan death adders (*Acanthophis* spp.) are a cause of serious envenomations in Papua New Guinea and northern Australia often resulting in neurotoxic paralysis. Furthermore, victims occasionally present with delayed-onset neurotoxicity that sometimes responds poorly to antivenom or anticholinesterase treatment. This clinical outcome could be explained by the presence of potent snake presynaptic phospholipase A(2) neurotoxin (SPAN) complexes and monomers, in addition to long- and short-chain postsynaptic alpha-neurotoxins, that bind irreversibly, block neurotransmitter release and result in degeneration of the nerve terminal. The present study therefore aimed to determine within-genus variations in expression of high molecular mass SPAN complexes in the venoms of six major species of *Acanthophis* and four geographic variants of *Acanthophis antarcticus*. Venoms were separated by size-exclusion liquid chromatography under non-denaturing conditions and fractions corresponding to proteins in the range of 22 to >60 kDa were subjected to pharmacological characterization using the isolated chick biventer cervicis nerve-muscle (CBCNM) preparation. All venoms, except *Acanthophis wellsi* and *Acanthophis pyrrhus*, contained high mass fractions with phospholipase A(2) activity that inhibited twitch contractions of the CBCNM preparation. This inhibition was of slow onset, and responses to exogenous nicotinic agonists were not blocked, consistent with the presence of SPAN complexes. The results of the present study indicate that clinicians may need to be aware of possible prejunctional neurotoxicity following envenomations from *A. antarcticus* (all geographic variants except perhaps South Australia), *Acanthophis praelongus*, *Acanthophis rugosus* and *Acanthophis laevis* species, and that

early antivenom intervention is important in preventing further development of toxicity.

10 **Bradacs G, Maes L, Heilmann J.**

In vitro cytotoxic, antiprotozoal and antimicrobial activities of medicinal plants from Vanuatu. *Phytother Res* 2010 Jun;24(6):800-809.

Sixty-three extracts obtained from 18 plants traditionally used in the South Pacific archipelago Vanuatu for the treatment of infectious diseases were screened for antimicrobial and antiprotozoal activities. In addition, the extracts were subjected to a detailed analysis on cytotoxic effects toward a panel of human cancer cell lines, designed as a smaller version of the NCI60 screen. Intriguingly, 15 plant extracts exhibited strong cytotoxic effects specific for only one cancer cell line. Extracts of the leaves of *Acalypha grandis* Benth. significantly affected *Plasmodium falciparum* without showing obvious effects against the other protozoa tested. The leaves of *Gyrocarpus americanus* Jacq. displayed significant activity against *Trypanosoma b. brucei* and the leaves of *Tabernaemontana pandacaku* Lam. I as well as the stems of *Macropiper latifolium* (L.f.) against *Trypanosoma cruzi*. In contrast none of the extracts showed relevant antibacterial or antifungal activity.

11 **Bruce E, Bauai L, Yeka W, Sapuri M, Keogh L, Kaldor J, Fairley CK.**

Knowledge, attitudes, practices and behaviour of female sex workers in Port Moresby, Papua New Guinea. *Sex Health* 2010 Mar;7(1):85-86.

12 **Bruce E, Bauai L, Masta A, Rooney PJ, Panui M, Sapuri M, Keogh L, Kaldor J, Fairley CK.**

A cross-sectional study of reported symptoms for sexually transmissible infections among female sex workers in Papua New Guinea. *Sex Health* 2010 Mar;7(1):71-76.

BACKGROUND: Sexually transmissible infections (STIs) are common in female sex workers (FSWs), most of which are asymptomatic and therefore under-reported. Our aim was to determine the sensitivity and specificity of reported symptoms obtained via questionnaire augmented with leukocyte esterase (LE) urine dipstick test for the detection of *Chlamydia trachomatis* (Ct), *Neisseria gonorrhoeae* (Ng) and *Trichomonas vaginalis* (Tv) detected using polymerase chain reaction (PCR). **METHODS:** In November 2003, a cohort of FSWs was screened for STIs and completed a questionnaire. **RESULTS:** We enrolled 129 FSWs (90% participation rate) of whom 48 (37%), 30 (23%) and 53 (41%) were diagnosed with Ng, Ct and Tv, respectively, by PCR. Of those diagnosed with any of these infections, 78% reported anogenital symptoms and of those without infections, 28% reported symptoms. Anogenital symptoms were present in over 50% FSWs. Genital odour (present in 26%), lower abdominal pain (present in 29%), dysuria (present in 19%) had a sensitivity around 50%, specificity >80% and all were significantly associated with positive PCR results for individual organisms; however, the sensitivity of these symptoms to detect the presence of any positive PCR result was low (<50%). When LE urine dipstick test result of >1 was combined with the presence of three reported symptoms the sensitivity was 86%, specificity 73% and positive predictive value 72%: a better predictor of infections. **CONCLUSIONS:**

Our findings suggest that an approach that incorporates LE urine dipstick test >1 and multiple symptoms may be a feasible option for screening infections among FSWs in resource-constrained settings.

13 **Bönsch C, Kempf C, Mueller I, Manning L, Laman M, Davis TM, Ros C.**

Chloroquine and its derivatives exacerbate B19V-associated anemia by promoting viral replication. *PLoS Negl Trop Dis* 2010 Apr 27;4(4):e669.

BACKGROUND: An unexpectedly high seroprevalence and pathogenic potential of human parvovirus B19 (B19V) have been observed in certain malaria-endemic countries in parallel with local use of chloroquine (CQ) as first-line treatment for malaria. The aims of this study were to assess the effect of CQ and other common antimalarial drugs on B19V infection in vitro and the possible epidemiological consequences for children from Papua New Guinea (PNG). **METHODOLOGY/PRINCIPAL FINDINGS:** Viral RNA, DNA and proteins were analyzed in different cell types following infection with B19V in the presence of a range of antimalarial drugs. Relationships between B19V infection status, prior 4-aminoquinoline use and anemia were assessed in 200 PNG children <10 years of age participating in a case-control study of severe infections. In CQ-treated cells, the synthesis of viral RNA, DNA and proteins was significantly higher and occurred earlier than in control cells. CQ facilitates B19V infection by minimizing intracellular degradation of incoming particles. Only amodiaquine amongst other antimalarial drugs had a similar effect. B19V IgM seropositivity was more frequent in 111 children with severe anemia (hemoglobin <50 g/L) than in 89 healthy controls (15.3% vs 3.4%; $p = 0.008$). In children who were either B19V IgM or PCR positive, 4-aminoquinoline use was associated with a significantly lower admission hemoglobin concentration. **CONCLUSIONS/SIGNIFICANCE:** Our data strongly suggest that 4-aminoquinoline drugs and their metabolites exacerbate B19V-associated anemia by promoting B19V replication. Consideration should be given for choosing a non-4-aminoquinoline drug to partner artemisinin compounds in combination antimalarial therapy.

14 **Cama AT, Sikivou BT, Keeffe JE.**

Childhood visual impairment in Fiji.

Arch Ophthalmol 2010 May;128(5):608-612.

OBJECTIVE: To establish the prevalence and causes of low vision and blindness in children aged 0 to 15 years in Fiji using existing data and new surveys. **METHOD:** Childhood visual impairment data on both low visual acuity (<20/60-20/400) and blindness (<20/400) were obtained from existing records at hospital clinics, the school, an outreach service for visually impaired children, primary school screening records, and surveys in high schools and schools for children with multiple disabilities. Crude prevalence was derived and, using 5-year age range and age at onset of vision loss, the probable prevalence per 1000 children was calculated. **RESULTS:** A total of 81 children were identified; causes were established for 70 children, showing that 69% had unavoidable causes of vision loss (retinal, 39.7% and cortical, 15.5%), with the avoidable cause of low vision and blindness mainly being cataract (15.5%). Probable prevalence was 1.134 per 1000 children (95% confidence interval

[CI], 1.115-1.153), with low vision 0.774 per 1000 children (95% CI, 0.758-0.790) and blindness 0.36 per 1000 children (95% CI, 0.349-0.371). The rate of severe visual impairment (<20/200) was 0.522 per 1000 children (95% CI, 0.509-0.535), only half of the total vision loss. **CONCLUSIONS:** Both the low to moderate prevalence and mainly unavoidable causes of visual impairment indicated that Fiji, a developing country, has prevalence and causes of visual impairment similar to more resourced, industrialized countries.

15 Chang SP, Kayatani AK, Terrientes ZI, Herrera S, Leke RG, Taylor DW.

Shift in epitope dominance of IgM and IgG responses to *Plasmodium falciparum* MSP1 block 4.

Malar J 2010 Jan 13;9:14.

BACKGROUND: *Plasmodium falciparum* merozoite surface protein-1 (MSP1) has been extensively studied as a blood-stage malaria vaccine candidate, with most work focused on the conserved 19 kDa and semi-conserved 42 kDa C-terminal regions (blocks 16-17) and the hypervariable N-terminal repeat region (block 2). However, recent genotyping studies suggest that additional regions of MSP1 may be under selective pressure, including a locus of intragenic recombination designated as block 4 within the 3' region of the gene. **METHODS:** The current study examined the antibody response to the two parental and two recombinant forms of block 4 and to blocks 16-17 (3D7) in study populations from Colombia, Papua New Guinea and Cameroon that differ in malaria transmission intensity and ethnic composition. **RESULTS:** IgM and IgG antibodies were detected against parental and recombinant MSP1 block 4 peptides in all three populations. Overall, 32-44% of the individuals produced IgM to one or more of the peptides, with most individuals having IgM antibodies reactive with both parental and recombinant forms. In contrast, IgG seropositivity to block 4 varied among populations (range 15-65%), with the majority of antibodies showing specificity for one or a pair of block 4 peptides. The IgG response to block 4 was significantly lower than that to blocks 16-17, indicating block 4 is subdominant. Antibodies to block 4 and blocks 16-17 displayed distinct IgG subclass biases, with block 4 responses biased toward IgG3 and blocks 16-17 toward IgG1. These patterns of responsiveness were consistently observed in the three study populations. **CONCLUSIONS:** Production of antibodies specific for each parental and recombinant MSP1 block 4 allele in different populations exposed to *P. falciparum* is consistent with balancing selection of the MSP1 block 4 region by the immune response of individuals in areas of both low and high malaria transmission. MSP1 block 4 determinants may be important in isolate-specific immunity to *P. falciparum*.

16 Chootong P, Ntumngia FB, VanBuskirk KM, Xainli J, Cole-Tobian JL, Campbell CO, Fraser TS, King CL, Adams JH.

Mapping epitopes of the *Plasmodium vivax* Duffy binding protein with naturally acquired inhibitory antibodies.

Infect Immun 2010 Mar;78(3):1089-1095. Epub 2009 Dec 14.

Plasmodium vivax Duffy binding protein (DBP) is a merozoite microneme ligand vital for blood-stage

infection, which makes it an important candidate vaccine for antibody-mediated immunity against vivax malaria. A differential screen with a linear peptide array compared the reactivities of noninhibitory and inhibitory high-titer human immune sera to identify target epitopes associated with protective immunity. Naturally acquired anti-DBP-specific serologic responses observed in the residents of a region of Papua New Guinea where *P. vivax* is highly endemic exhibited significant changes in DBP-specific titers over time. The anti-DBP functional inhibition for each serum ranged from complete inhibition to no inhibition even for high-titer responders to the DBP, indicating that epitope specificity is important. Inhibitory immune human antibodies identified specific B-cell linear epitopes on the DBP (Sall) ligand domain that showed significant correlations with inhibitory responses. Affinity-purified naturally acquired antibodies on these epitopes inhibited the DBP erythrocyte binding function greatly, confirming the protective value of specific epitopes. These results represent an important advance in our understanding of part of blood-stage immunity to *P. vivax* and some of the specific targets for vaccine-elicited antibody protection.

17 Cook J, Reid H, Iavro J, Kuwahata M, Taleo G, Clements A, McCarthy J, Valley A, Drakeley C.

Using serological measures to monitor changes in malaria transmission in Vanuatu.

Malar J 2010 Jun 16;9:169.

BACKGROUND: With renewed interest in malaria elimination, island environments present unique opportunities to achieve this goal. However, as transmission decreases, monitoring and evaluation programmes need increasingly sensitive tools to assess *Plasmodium falciparum* and *Plasmodium vivax* exposure. In 2009, to assess the role of serological markers in evaluating malaria transmission, a cross-sectional seroprevalence study was carried out in Tanna and Aneityum, two of the southernmost islands of the Vanuatu archipelago, areas where malaria transmission has been variably reduced over the past few decades. **METHODS:** Malaria transmission was assessed using serological markers for exposure to *P. falciparum* and *P. vivax*. Filter blood spot papers were collected from 1,249 people from Tanna, and 517 people from Aneityum to assess the prevalence of antibodies to two *P. falciparum* antigens (MSP-119 and AMA-1) and two *P. vivax* antigens (MSP-119 and AMA-1). Age-specific prevalence was modelled using a simple catalytic conversion model based on maximum likelihood to generate a community seroconversion rate (SCR). **RESULTS:** Overall seropositivity in Tanna was 9.4%, 12.4% and 16.6% to *P. falciparum* MSP-119, AMA-1 and Schizont Extract respectively and 12.6% and 15.0% to *P. vivax* MSP-119 and AMA-1 respectively. Serological results distinguished between areas of differential dominance of either *P. vivax* or *P. falciparum* and analysis of age-stratified results showed a step in seroprevalence occurring approximately 30 years ago on both islands, indicative of a change in transmission intensity at this time. Results from Aneityum suggest that several children may have been exposed to malaria since the 2002 *P. vivax* epidemic. **CONCLUSION:** Seroepidemiology can provide key information on malaria transmission for control programmes, when parasite rates are low. As Vanuatu moves closer to

malaria elimination, monitoring changes in transmission intensity and identification of residual malaria foci is paramount in order to concentrate intervention efforts.

- 18 **Dancause KN, Vilar M, Dehuff C, Wilson M, Soloway LE, Chan C, Lum JK, Garruto RM.**

Relationships between body size and percent body fat among Melanesians in Vanuatu.

Asia Pac J Clin Nutr 2010;19(3):425-431.

Obesity is a global epidemic, and measures to define it must be appropriate for diverse populations for accurate assessment of worldwide risk. Obesity refers to excess body fatness, but is more commonly defined by body mass index (BMI). Body composition varies among populations: Asians have higher percent body fat (%BF), and Pacific Islanders lower %BF at a given BMI compared to Europeans. Many researchers thus propose higher BMI cut-off points for obesity among Pacific Islanders and lower cut-offs for Asians. Because of the great genetic diversity in the Asia-Pacific region, more studies analyzing associations between BMI and %BF among diverse populations remain necessary. We measured height; weight; triceps, subscapular, and suprailiac skinfolds; waist and hip circumference; and %BF by bioelectrical impedance among 546 adult Melanesians from Vanuatu in the South Pacific. We analyzed relationships among anthropometric measurements and compared them to measurements from other populations in the Asia-Pacific region. BMI was a relatively good predictor of %BF among our sample. Based on regression analyses, the BMI value associated with obesity defined by %BF (>25% for men, >35% for women) at age 40 was 27.9 for men and 27.8 for women. This indicates a need for a more nuanced definition of obesity than provided by the common BMI cut-off value of 30. Rather than using population-specific cut-offs for Pacific Islanders, we suggest the World Health Organization's public health action cut-off points (23, 27.5, 32.5, 37.5), which enhance the precision of assessments of population-wide obesity burdens while still allowing for international comparison.

- 19 **Dayaratne DA.**

Impact of ecology on development of NIDDM.

Med Hypotheses 2010 Jun;74(6):986-988. Epub 2010 Jan 12.

Diabetes has become a global epidemic. The increased incidence of NIDDM is seen all over the world but there is geographical variation. Certain population groups show increased susceptibility to develop diabetes. The prevalence is lowest in Caucasian whites and highest in Pima Indians and Nauruans. Iceland has a particularly low incidence whereas Bahrain is among the countries with highest prevalence. The highest prevalence of diabetes in 2000 was found in Papua New Guinea (15.5%), Mauritius (15%), Bahrain (14.8%), Mexico (14.2%), Trinidad and Tobago (14.1%). Most of the hypotheses developed to explain this trend concerned mainly dietary and nutritional factors. Man had to struggle against harsh climatic conditions for survival. It has been observed that people who have been adapted to a cold environment for generations demonstrate some resistance to develop diabetes. It is hypothesized that presence of thick subcutaneous fat, reactivation of brown adipose tissue in a cold environment and effective mitochondrial enzyme systems for heat

generation act as adaptive mechanisms for survival in a cold environment and retard the development of visceral obesity. Mitochondrial defects have been found in patients with NIDDM and NAFLD. Changes of nuclear genes which encode mitochondrial enzyme systems involved in thermogenesis could be the cause for development of visceral obesity and NIDDM.

- 20 **Dixon BJ, Sagata K, Linklater WL, Dixon AF.**

Male preferences for female waist-to-hip ratio and body mass index in the highlands of Papua New Guinea.

Am J Phys Anthropol 2010 Apr;141(4):620-625.

One hundred men, living in three villages in a remote region of the Eastern Highlands of Papua New Guinea, were asked to judge the attractiveness of photographs of women who had undergone micrograft surgery to reduce their waist-to-hip ratios (WHRs). Micrograft surgery involves harvesting adipose tissue from the waist and reshaping the buttocks to produce a low WHR and an 'hourglass' female figure. Men consistently chose postoperative photographs as being more attractive than preoperative photographs of the same women. Some women gained, and some lost weight, postoperatively, with resultant changes in body mass index (BMI). However, changes in BMI were not related to men's judgments of attractiveness. These results show that the hourglass female figure is rated as attractive by men living in a remote, indigenous community, and that when controlling for BMI, WHR plays a crucial role in their attractiveness judgments.

- 21 **Elsabagh S, Bennett VA, Wylie A.**

Public awareness and prevention of malaria in Vanuatu.

Public Health 2010 May;124(5):295-297. Epub 2010 Mar 31.

- 22 **Falconer DG, Buckley A, Colagiuri R.**

Counting the cost of type 2 diabetes in Vanuatu.

Diabetes Res Clin Pract 2010 Jan;87(1):92-97. Epub 2009 Oct 28.

AIM: To determine the health system costs, cost to people with diabetes and their carers, and impact on quality of life associated with type 2 diabetes in Vanuatu. METHODS: A cross-sectional paper based survey was administered to 199 people with type 2 diabetes as part of a larger diabetes project. RESULTS: There were 172 respondents (86% response rate) with a mean age of 56 years (mean duration of diabetes 8 years, 106 females; 67 unemployed). Over the preceding year there were 2352 outpatient visits for health care totalling 442,400 vatu (\$4020 USD); 140 overnight hospital stays totalling 1,383,620 vatu (\$12,580 USD); and prescription medications costing 3220 vatu/person (\$29.20 USD). Major out-of-pocket costs for individuals were the over-the-counter medications totalling 6600 vatu/person/year (\$60 USD) for 31 people (18%); transport at 1980 vatu/person/year (\$18.00 USD) for 110 people (64%) and special diets for 38 people (22%) costing 36,480 vatu/person (\$332 USD). Quality of life was 91/100 on the EQ-5D visual analogue scale. CONCLUSIONS: Given that diabetes in Vanuatu is likely to be significantly under-diagnosed and under-treated the current costs, while substantial, are artificially low but are set to rise sharply with increased awareness of diabetes and growing rates of obesity.

- 23 **Fegan D, Glennon MJ, Thami Y, Pakoa G.** Resurgence of yaws in Tanna, Vanuatu: time for a new approach? *Trop Doct* 2010 Apr;40(2):68-69.

Recent reports from the island of Tanna in Vanuatu suggest that yaws has resurged. We carried out a serological and clinical survey to determine the prevalence and clinical presentation of yaws on the island. A total of 306 random serum samples were tested for rapid plasma reagin and rapid diagnostic determine syphilis: 31.04% were positive for one or both tests; 39.8% of children surveyed in three schools had skin lesions consistent with yaws; and there were only two cases of secondary yaws osteitis and no cases of tertiary yaws. These results confirm that the disease has resurged but appears to be attenuated. Intramuscular benzathine penicillin is the currently recommended treatment for yaws. We suggest that a stat dose of oral azithromycin would be a more accessible treatment as it could be prescribed by village health workers and therefore enable yaws control to be more easily incorporated into other primary health-care programmes.

- 24 **Fernandez-Becerra C, Sanz S, Brucet M, Stanisic DI, Alves FP, Camargo EP, Alonso PL, Mueller I, del Portillo HA.**

Naturally-acquired humoral immune responses against the N- and C-termini of the *Plasmodium vivax* MSP1 protein in endemic regions of Brazil and Papua New Guinea using a multiplex assay. *Malar J* 2010 Jan 21;9:29.

BACKGROUND: Progress towards the development of a malaria vaccine against *Plasmodium vivax*, the most widely distributed human malaria parasite, will require a better understanding of the immune responses that confer clinical protection to patients in regions where malaria is endemic. **METHODS:** Glutathione S-transferase (GST) and GST-fusion proteins representing the N-terminus of the merozoite surface protein 1 of *P. vivax*, PvMSP1-N, and the C-terminus, PvMSP1-C, were covalently coupled to BioPlex carboxylated beads. Recombinant proteins and coupled beads were used, respectively, in ELISA and Bioplex assays using immune sera of *P. vivax* patients from Brazil and PNG to determine IgG and subclass responses. Concordances between the two methods in the seropositivity responses were evaluated using the Kappa statistic and the Spearman's rank correlation. **RESULTS:** The results using this methodology were compared with the classical microtitre enzyme-linked immunosorbent assay (ELISA), showing that the assay was sensitive, reproducible and had good concordance with ELISA; yet, further research into different statistical analyses seems desirable before claiming conclusive results exclusively based on multiplex assays. As expected, results demonstrated that PvMSP1 was immunogenic in natural infections of patients from different endemic regions of Brazil and Papua New Guinea (PNG), and that age correlated only with antibodies against the C-terminus part of the molecule. Furthermore, the IgG subclass profiles were different in these endemic regions having IgG3 predominantly recognizing PvMSP1 in Brazil and IgG1 predominantly recognizing PvMSP1 in PNG. **CONCLUSIONS:** This study validates the use of the multiplex assay to measure naturally-acquired IgG

antibodies against the merozoite surface protein 1 of *P. vivax*.

- 25 **George K.** Vanuatu: happiest nation on earth, mental health and the Church. *Australas Psychiatry* 2010 Feb;18(1):63-65.

OBJECTIVE: The aim of this paper was to gain an understanding of the mental health needs and services in Vanuatu, and examine the importance of the Church in the lives of the local people and the part that the Church can play in mental health service delivery. **METHOD:** The author visited Vanuatu to gain an understanding of the mental health needs and services in Vanuatu. This was followed by interaction with a number of churches to find out the views of church leaders about mental illness and their interest to learn about mental illness. A questionnaire was completed by 80 individuals who were also involved in some training. **RESULTS:** There was a widely held view that mental illness was due to a weak faith, sin or demon possession. However, there is a desire and an interest among churches to have a better understanding about mental illness. **CONCLUSION:** Churches in Vanuatu can and need to be mobilized to make mental health service delivery successful in the country.

- 26 **Greenhill AR, Blaney BJ, Shipton WA, Pue A, Fletcher MT, Warner JM.**

Haemolytic fungi isolated from sago starch in Papua New Guinea. *Mycopathologia* 2010 Feb;169(2):107-115. Epub 2009 Sep 2.

Sago haemolytic disease (SHD) is a rare but often fatal illness linked to consumption of stale sago starch in Papua New Guinea. Although the aetiology of SHD remains unknown, mycotoxins are suspected. This study investigated whether fungi isolated from Papua New Guinean sago starch were haemolytic. Filamentous fungi and yeasts from sago starch were grown on sheep blood agar and some on human blood agar. Clear haemolytic activity was demonstrated by 55% of filamentous fungal isolates, but not by yeasts. A semi-quantitative bioassay was developed involving incubation of human erythrocytes with fungal extracts. Extracts of cultures of *Penicillium*, *Aspergillus* and *Fusarium* all caused rapid haemolysis in the bioassay. Partial fractionation of extracts suggested that both polar and non-polar haemolytic components had haemolytic activity in vitro. Further work is warranted to identify these metabolites and determine if they play a role in SHD.

- 27 **Heere C, Skeaff CM, Waqatakiwewa L, Vatucaawaqa P, Khan AN, Green TJ.**

Serum 25-hydroxyvitamin D concentration of Indigenous-Fijian and Fijian-Indian women. *Asia Pac J Clin Nutr* 2010;19(1):43-48.

BACKGROUND: Serum 25-hydroxyvitamin D (25OHD) concentrations are lower in Pacific people compared to Caucasians living in New Zealand. However, there are no data on the 25OHD concentrations of Pacific people living in the Pacific Islands. **AIM:** To assess the vitamin D status of indigenous and Indian Fijian women living in Fiji by measuring 25OHD concentrations. **METHODS:** 25OHD concentrations in a national sample of 511 Fijian women (15-44 y). **RESULTS:** The mean 25OHD concentration of Fijian women was 76 nmol/

L (95% CI: 73, 78). 25OHD was lower in Fijian Indian [70 (66, 74) nmol/L; n=205] women compared to indigenous Fijians [80 (76, 84) nmol/L; n=306] ($p<0.0001$). The mean 25OHD was higher in rural [77 (74, 80) nmol/L; n=392] than urban [70 (65, 76) nmol/L; n=119] women ($p<0.0001$). Body mass index (BMI) and age were not predictors of 25OHD concentrations. Of Fijian females, 3%, 11%, and 56% had 25OHD concentrations indicative of 25OHD insufficiency using cut-offs of $< \text{or } =37.5$, $< \text{or } =50$ and $< \text{or } =80$ nmol/L, respectively. CONCLUSION: Mean 25OHD in Fijian women was generally adequate and exceeded concentrations reported in Pacific females living in New Zealand.

28 Hinton R, Earnest J.

Stressors, coping, and social support among women in Papua New Guinea.

Qual Health Res 2010 Feb;20(2):224-238.

In this study we used an interpretive, ethnographic, qualitative approach to examine Papua New Guinean women's narratives and perceptions about their health and the ways in which these were linked to coping with personal adversity. Women used a variety of strategies to cope with psychosocial stressors and challenging life circumstances, including both reliance on their own agency and active efforts and the seeking of social and spiritual support. We observed that limited access to social and economic resources, combined with gender constraints, made women socially and culturally vulnerable to social strain that affected their physical and emotional health. A number of women used avoidance strategies that were related to lower levels of self-esteem and life satisfaction and displayed high levels of anxiety. We propose the need to understand the context in which coping takes place and to enhance resilience strategies used by women in developing countries such as Papua New Guinea to manage the multiple stressors associated with confronting life's challenges.

29 Hommel M, Elliott SR, Soma V, Kelly G, Fowkes FJ, Chesson JM, Duffy MF, Bockhorst J, Avril M, Mueller I, Raiko A, Stanisic DI, Rogerson SJ, Smith JD, Beeson JG.

Evaluation of the antigenic diversity of placenta-binding *Plasmodium falciparum* variants and the antibody repertoire among pregnant women.

Infect Immun 2010 May;78(5):1963-1978. Epub 2010 Feb 16.

Pregnant women are infected by specific variants of *Plasmodium falciparum* that adhere and accumulate in the placenta. Using serological and molecular approaches, we assessed the global antigenic diversity of surface antigens expressed by placenta-binding isolates to better understand immunity to malaria in pregnancy and evolution of polymorphisms and to inform vaccine development. We found that placenta-binding isolates originating from all major regions where malaria occurs were commonly recognized by antibodies in different populations of pregnant women. There was substantial antigenic overlap and sharing of epitopes between isolates, including isolates from distant geographic locations, suggesting that there are limitations to antigenic diversity; however, differences between populations and isolates were also seen. Many women had cross-reactive antibodies and/or a broad repertoire of antibodies to different isolates. Studying VAR2CSA as the major antigen expressed by placenta-binding

isolates, we identified antibody epitopes encoded by variable sequence blocks in the DBL3 domain. Analysis of global var2csa DBL3 sequences demonstrated that there was extensive sharing of variable blocks between Africa, Asia, Papua New Guinea, and Latin America, which likely contributes to the high level of antigenic overlap between different isolates. However, there was also evidence of geographic clustering of sequences and differences in VAR2CSA sequences between populations. The results indicate that there is limited antigenic diversity in placenta-binding isolates and may explain why immunity to malaria in pregnancy can be achieved after exposure during one pregnancy. Inclusion of a limited number of variants in a candidate vaccine may be sufficient for broad population coverage, but geographic considerations may also have to be included in vaccine design.

30 Horak HM, Chynoweth JS, Myers WP, Davis J, Fendorf S, Boehm AB.

Microbial and metal water quality in rain catchments compared with traditional drinking water sources in the East Sepik Province, Papua New Guinea.

J Water Health 2010 Mar;8(1):126-138.

In Papua New Guinea, a significant portion of morbidity and mortality is attributed to water-borne diseases. To reduce incidence of disease, communities and non-governmental organizations have installed rain catchments to provide drinking water of improved quality. However, little work has been done to determine whether these rain catchments provide drinking water of better quality than traditional drinking water sources, and if morbidity is decreased in villages with rain catchments. The specific aim of this study was to evaluate the quality of water produced by rain catchments in comparison with traditional drinking water sources in rural villages in the East Sepik Province. Fifty-four water sources in 22 villages were evaluated for enterococci and *Escherichia coli* densities as well as 14 health-relevant metals. In addition, we examined how the prevalence of diarrhoeal illness in villages relates to the type of primary drinking water source. The majority of tested metals were below World Health Organization safety limits. Catchment water sources had lower enterococci and *E. coli* than other water sources. Individuals in villages using Sepik River water as their primary water source had significantly higher incidence of diarrhoea than those primarily using other water sources (streams, dug wells and catchments).

31 Inman WD, Bray WM, Gassner NC, Lokey RS, Tenney K, Shen YY, Tendyke K, Suh T, Crews P.

A beta-carboline alkaloid from the Papua New Guinea marine sponge *Hyrtios reticulatus*.

J Nat Prod 2010 Feb 26;73(2):255-257.

A new 1-imidazolyl-3-carboxy-6-hydroxy-beta-carboline alkaloid, named yrtiocarboline (1), was isolated from a Papua New Guinea marine sponge, *Hyrtios reticulatus*. The structure was elucidated from spectroscopic data, including (1)H-(15)N HMBC NMR experiments, which provided complementary (15)N chemical shift information in support of the structure. This compound showed selective antiproliferative activity against H522-T1 non-small cell lung, MDA-MB-435 melanoma, and U937 lymphoma cancer cell lines.

32 Jorge-Nebert LF, Jiang Z, Chakraborty R, Watson

J, Jin L, McGarvey ST, Deka R, Nebert DW.

Analysis of human *CYP1A1* and *CYP1A2* genes and their shared bidirectional promoter in eight world populations.

Hum Mutat 2010 Jan;31(1):27-40.

The human *CYP1A1*/*CYP1A2* locus comprises the *CYP1A1* (5,988 bp) and *CYP1A2* (7,759 bp) transcribed regions, oriented head-to-head, sharing a bidirectional promoter of 23,306 bp. The older *CYP1A1* gene appears more conserved and responsible for critical life function(s), whereas the younger *CYP1A2* gene might have evolved more rapidly due to environmental (dietary) pressures. A population genetics study might confirm this premise. We combined 60 *CYP1A1*/*CYP1A2* SNPs found in the present study (eight New Guinea Highlanders, eight Samoans, four Dogrib, four Teribe, four Pehuenche, and one Caucasian) with those found in a previous study (six West Africans, four Han Chinese, six Germans, four Samoans, and four Dogrib), yielding a total of 106 SNPs in 106 chromosomes. Resequencing of Oceanians plus Amerindians in the present study yielded 21 New World SNPs (approximately 20%), of which 17 are not previously reported in any SNP database. Various tests revealed selective pressures for both genes and both haploblocks; unfortunately, differences in rates of evolution between the two genes were undetectable. Fay & Wu's H test revealed a 'hitchhiking event' centered around four SNPs in the *CYP1A1* 3'-UTR; a study in silico identified different microRNA-binding patterns in the hitchhiked region when the mutations were present compared with the mutations absent.

33 Kaneko A.

A community-directed strategy for sustainable malaria elimination on islands: short-term MDA integrated with ITNs and robust surveillance. *Acta Trop* 2010 Jun;114(3):177-183. Epub 2010 Feb 2.

In the Asia Pacific sites with low and unstable transmission, elimination should be feasible with existing tools. On Aneityum island, Vanuatu, both *Plasmodium falciparum* and *Plasmodium vivax* malaria were eliminated in 1991 after implementation of a combined intervention package, including mass drug administration (MDA) and insecticide-treated bed nets (ITNs), with high degree of community involvement. Subsequently, community-based surveillance and vector control measures have continued. By reviewing the experiences of the Aneityum project, I intended to examine the roles of the community in malaria elimination. To be successful, the program should transfer major intervention components from the external donor-directed initiative to the community-directed approach. Scaling up of community involvement from simple participation to social participation, where communities are involved in health planning functions, is necessary from malaria control to malaria elimination.

34 Karunajeewa HA, Salman S, Mueller I, Baiwog F, Gomorrai S, Law I, Page-Sharp M, Rogerson S, Siba P, Ilett KF, Davis TM.

Pharmacokinetics of chloroquine and monodesethylchloroquine in pregnancy. *Antimicrob Agents Chemother* 2010 Mar;54(3):1186-1192. Epub 2010 Jan 19.

In order to determine the pharmacokinetic disposition of chloroquine (CQ) and its active

metabolite, desethylchloroquine (DECQ), when administered as intermittent presumptive treatment in pregnancy (IPTp) for malaria, 30 Papua New Guinean women in the second or third trimester of pregnancy and 30 age-matched nonpregnant women were administered three daily doses of 450 mg CQ (8.5 mg/kg of body weight/day) in addition to a single dose of sulfadoxine-pyrimethamine. For all women, blood was taken at baseline; at 1, 2, 4, 6, 12, 18, 24, 30, 48, and 72 h posttreatment; and at 7, 10, 14, 28, and 42 days posttreatment. Plasma was subsequently assayed for CQ and DECQ by high-performance liquid chromatography, and population pharmacokinetic modeling was performed. Pregnant subjects had significantly lower area under the plasma concentration-time curve for both CQ (35,750 versus 47,892 microg.h/liter, $p < 0.001$) and DECQ (23,073 versus 41,584 microg.h/liter, $p < 0.001$), reflecting significant differences in elimination half-lives and in volumes of distribution and clearances relative to bioavailability. Reduced plasma concentrations of both CQ and DECQ could compromise both curative efficacy and posttreatment prophylactic properties in pregnant patients. Higher IPTp CQ doses may be desirable but could increase the risk of adverse hemodynamic effects.

35 Kayser M.

The human genetic history of Oceania: near and remote views of dispersal.

Curr Biol 2010 Feb 23;20(4):R194-R201.

The human history of Oceania is unique in the way that it encompasses both the first out-of-Africa expansion of modern humans to New Guinea and Australia as well as the last regional human occupation of Polynesia. Other anthropological peculiarities of Oceania include features like the extraordinarily rich linguistic diversity especially of New Guinea with about 1,000 often very distinct languages, the independent and early development of agriculture in the highlands of New Guinea about 10,000 years ago, and the long-term isolation of the entire region from the outside world, which lasted as long as until the 1930s for most of the interior of New Guinea. This review will provide an overview on the genetic aspects of human population history of Oceania and how some of the anthropological peculiarities are reflected in human genetic data. Due to current data availability it will mostly focus on insights from sex-specifically inherited mitochondrial DNA and Y-chromosomal DNA, whereas more genome-wide autosomal DNA data are soon expected to add additional details or may correct views obtained from these two, albeit highly complex, genetic loci.

36 Kelly A, Worth H, Akuani F, Kepa B, Kupul M, Walizopa L, Emori R, Cangah B, Mek A, Nosi S, Pirpir L, Keleba K, Siba P.

Gendered talk about sex, sexual relationships and HIV among young people in Papua New Guinea. *Cult Health Sex* 2010 Apr;12(3):221-232.

This paper presents findings from a qualitative study carried out in three secondary schools in Eastern Highlands Province, Papua New Guinea (PNG). Seventy-three Year 12 students took part in eight gender-specific focus group discussions (three female and five male). Irrespective of gender, respondents predominately understood sex as being for the sole purpose of reproduction within marriage. When discussing sex and sexual relationships,

young men used explicit language and referred specifically to sexual organs and activities. Young women did not. Less concerned for privacy, young men talked in public spaces and in groups with same-sex peers about sex and sexual expression, whereas young women discussed such matters one-on-one and in private. These gender differences provide useful entry points for developing appropriate sex and HIV education programmes involving young people in PNG.

- 37 **Kinzer MH, Chand K, Basri H, Lederman ER, Susanti AI, Elyazar I, Taleo G, Rogers WO, Bangs MJ, Maguire JD.**

Active case detection, treatment of falciparum malaria with combined chloroquine and sulphadoxine/pyrimethamine and vivax malaria with chloroquine and molecular markers of anti-malarial resistance in the Republic of Vanuatu.

Malar J 2010 Apr 6;9(1):89.

BACKGROUND: Chloroquine-resistant *Plasmodium falciparum* was first described in the Republic of Vanuatu in the early 1980s. In 1991, the Vanuatu Ministry of Health instituted new treatment guidelines for uncomplicated *P. falciparum* infection consisting of chloroquine/sulphadoxine-pyrimethamine combination therapy. Chloroquine remains the recommended treatment for *Plasmodium vivax*. **METHODS:** In 2005, cross-sectional blood surveys at 45 sites on Malo Island were conducted and 4,060 adults and children screened for malaria. Of those screened, 203 volunteer study subjects without malaria at the time of screening were followed for 13 weeks to observe peak seasonal incidence of infection. Another 54 subjects with malaria were followed over a 28-day period to determine efficacy of anti-malarial therapy; chloroquine alone for *P. vivax* and chloroquine/sulphadoxine-pyrimethamine for *P. falciparum* infections. **RESULTS:** The overall prevalence of parasitaemia by mass blood screening was 6%, equally divided between *P. falciparum* and *P. vivax*. Twenty percent and 23% of participants with patent *P. vivax* and *P. falciparum* parasitaemia, respectively, were febrile at the time of screening. In the incidence study cohort, after 2,303 person-weeks of follow-up, the incidence density of malaria was 1.3 cases per person-year with *P. vivax* predominating. Among individuals participating in the clinical trial, the 28-day chloroquine *P. vivax* cure rate was 100%. The 28-day chloroquine/sulphadoxine-pyrimethamine *P. falciparum* cure rate was 97%. The single treatment failure, confirmed by merozoite surface protein-2 genotyping, was classified as a day 28 late parasitological treatment failure. All *P. falciparum* isolates carried the Thr-76 *pfcr* mutant allele and the double Asn-108 + Arg-59 *dhfr* mutant alleles. *Dhps* mutant alleles were not detected in the study sample. **CONCLUSION:** Peak seasonal malaria prevalence on Malo Island reached hypoendemic levels during the study observation period. The only in vivo malaria drug efficacy trial thus far published from the Republic of Vanuatu showed chloroquine/sulphadoxine-pyrimethamine combination therapy for *P. falciparum* and chloroquine alone for *P. vivax* to be highly efficacious. Although the chloroquine-resistant *pfcr* allele was present in all *P. falciparum* isolates, mutant alleles in the *dhfr* and *dhps* genes do not yet occur to the extent required to confer sulphadoxine-pyrimethamine resistance in this population.

- 38 **Laman M, Hwaihwanje I, Davis TM, Manning L.** Cryptococcal meningitis in immunocompetent Papua New Guinean children.

Trop Doct 2010 Jan;40(1):61-63.

We report three cases of meningo-encephalitis caused by *Cryptococcus neoformans* var. *gattii* in apparently immunocompetent children presenting to a provincial hospital in Papua New Guinea (PNG) over a nine-month period. After a post-mortem diagnosis was made in the first case, a further two were identified quickly using Indian ink staining of cerebrospinal fluid (CSF). The second case had a complicated course and recovered after relapse. The third made a full recovery with appropriate antifungal therapy. Despite the fact that an environmental reservoir has not been established, cryptococcal meningo-encephalitis occurs regularly in PNG. In developing countries such as PNG, a lack of laboratory resources and limited therapeutic options can complicate the management of severe infections such as cryptococcosis. Nevertheless, with inexpensive diagnostic tests (such as Indian ink staining of CSF), a high index of suspicion and a pragmatic approach to antifungal therapy, good therapeutic outcomes can be achieved.

- 39 **Le Hello S, Doloy A, Baumann F, Roques N, Coudene P, Rouchon B, Lacassin F, Bouvet A.** Clinical and microbial characteristics of invasive *Streptococcus pyogenes* disease in New Caledonia, a region in Oceania with a high incidence of acute rheumatic fever.

J Clin Microbiol 2010 Feb;48(2):526-530. Epub 2009 Dec 2.

New Caledonia is an archipelago in the South Pacific with a high prevalence of acute rheumatic fever and rheumatic heart disease. Conducted in 2006, this study aimed at characterizing clinical manifestations and microbial features of isolates obtained from invasive *Streptococcus pyogenes* disease. Clinical and demographic data were collected prospectively. Isolates were biotyped, T typed, emm sequenced, and tested for antibiotic susceptibility. Detection of the *speA*, *speB*, *speC*, and *ssa* genes was also carried out. The estimated annual incidence of invasive *S. pyogenes* disease in 2006 was high at 38 cases/100,000 inhabitants in New Caledonia. Invasive isolates were obtained from 90 patients with necrotizing fasciitis (41 cases), bacteremia with no identified focus (12 cases), myositis (10 cases), septic arthritis (9 cases), erysipelas (8 cases), postpartum infection (4 cases), myelitis and osteomyelitis (3 cases), severe pneumonia (2 cases), and endocarditis (1 case). The most frequent associated comorbidities were skin lesions (71%) and obesity (29%). Thirty-one different emm types were identified, and the following six accounted for 54% of the isolates: emm15 (15.5%), emm92 (12.2%), emm106 (8.9%), emm74 (6.7%), emm89 (5.6%), and emm109 (5.6%). The *speA*, *speC*, and *ssa* genes were expressed at different frequencies in the various emm types. The first epidemiological study of invasive *S. pyogenes* disease in New Caledonia highlights that emm type distribution is particular and should be taken into account in the development of an appropriate vaccine. These findings support the prevention of pyoderma and other cutaneous lesions in order to limit the development of both invasive disease and poststreptococcal sequelae in the South Pacific.

40 **Licciardi PV, Balloch A, Russell FM, Mulholland EK, Tang ML.**

Antibodies to serotype 9V exhibit novel serogroup cross-reactivity following infant pneumococcal immunization.

Vaccine 2010 May 14;28(22):3793-3800. Epub 2010 Mar 31.

Cross-reactivity within the pneumococcal immune response was examined in this study. Significant cross-reactivity between serotypes 9V, 15B and 19A was identified in infant post-immunization serum that could not be effectively titrated during specific IgG measurements. Pre-absorption using serotype 9V inhibited this cross-reactivity and normalized titratability in the WHO ELISA for serotypes 15B and 19A. However, this did not affect functional avid IgG and was associated with fewer pneumococcal conjugate vaccine (PCV) doses, suggesting that cross-reactive antibodies were of low avidity. The results in this study have important implications for assessment of vaccine immunogenicity.

41 **Lin E, Kiniboro B, Gray L, Dobbie S, Robinson L, Laumaea A, Schöpflin S, Stanisic D, Betuela I, Blood-Zikursh M, Siba P, Felger I, Schofield L, Zimmerman P, Mueller I.**

Differential patterns of infection and disease with *P. falciparum* and *P. vivax* in young Papua New Guinean children.

PLoS One 2010 Feb 4;5(2):e9047.

BACKGROUND: Where *P. vivax* and *P. falciparum* occur in the same population, the peak burden of *P. vivax* infection and illness is often concentrated in younger age groups. Experiences from malaria therapy patients indicate that immunity is acquired faster to *P. vivax* than to *P. falciparum* challenge. There is, however, little prospective data on the comparative risk of infection and disease from both species in young children living in co-endemic areas. **METHODOLOGY/PRINCIPAL FINDINGS:** A cohort of 264 Papua New Guinean children aged 1-3 years (at enrolment) were actively followed-up for *Plasmodium* infection and febrile illness for 16 months. Infection status was determined by light microscopy and PCR every 8 weeks and at each febrile episode. A generalised estimating equation (GEE) approach was used to analyse both prevalence of infection and incidence of clinical episodes. A more pronounced rise in prevalence of *P. falciparum* compared to *P. vivax* infection was evident with increasing age. Although the overall incidence of clinical episodes was comparable (*P. falciparum*: 2.56, *P. vivax* 2.46 episodes / child / yr), *P. falciparum* and *P. vivax* infectious episodes showed strong but opposing age trends: *P. falciparum* incidence increased until the age of 30 months with little change thereafter, but incidence of *P. vivax* decreased significantly with age throughout the entire age range. For *P. falciparum*, both prevalence and incidence of *P. falciparum* showed marked seasonality, whereas only *P. vivax* incidence but not prevalence decreased in the dry season. **CONCLUSIONS/SIGNIFICANCE:** Under high, perennial exposure, children in PNG begin acquiring significant clinical immunity, characterized by an increasing ability to control parasite densities below the pyrogenic threshold to *P. vivax*, but not to *P. falciparum*, in the 2nd and 3rd year of life. The ability to relapse from long-lasting liver-stages restricts the seasonal variation in prevalence of *P.*

vivax infections.

42 **Maillaud C, Lefebvre S, Sebat C, Barguil Y, Cabalion P, Cheze M, Hnawia E, Nour M, Durand F.**

Double lethal coconut crab (*Birgus latro* L.) poisoning.

Toxicon 2010 Jan;55(1):81-86. Epub 2009 Jul 8.

We report a double lethal coconut crab *Birgus latro* L. poisoning in New Caledonia. Both patients died after showing gastro-intestinal symptoms, major bradycardia with marked low blood pressure, and finally asystolia. Both had significant hyperkalaemia, suggesting a digitaline-like substance intoxication. Traditional knowledge in the Loyalty Islands relates coconut crab toxicity to the consumption of the *Cerbera manghas* fruit by the crustacean. Elsewhere previous descriptions of human poisoning with the kernel of fruits of trees belonging to the genus *Cerbera*, known to contain cardiotoxic cardenolides, appear to be very similar to our cases. Cardenolides assays were performed on patient's serum samples, fruit kernel and on the crustacean guts, which lead us to suppose these two fatal cases were the result of a neriifolin intoxication, this toxin having been transmitted through the coconut crab.

43 **Marfurt J, Smith TA, Hastings IM, Müller I, Sie A, Oa O, Baisor M, Reeder JC, Beck HP, Genton B.**

Plasmodium falciparum resistance to anti-malarial drugs in Papua New Guinea: evaluation of a community-based approach for the molecular monitoring of resistance.

Malar J 2010 Jan 7;9:8.

BACKGROUND: Molecular monitoring of parasite resistance has become an important complementary tool in establishing rational anti-malarial drug policies. Community surveys provide a representative sample of the parasite population and can be carried out more rapidly than accrual of samples from clinical cases, but it is not known whether the frequencies of genetic resistance markers in clinical cases differ from those in the overall population, or whether such community surveys can provide good predictions of treatment failure rates. **METHODS:** Between 2003 and 2005, in vivo drug efficacy of amodiaquine or chloroquine plus sulphadoxine-pyrimethamine was determined at three sites in Papua New Guinea. The genetic drug resistance profile (i.e., 33 single nucleotide polymorphisms in *Plasmodium falciparum crt*, *mdr1*, *dhfr*, *dhps*, and *ATPase6*) was concurrently assessed in 639 community samples collected in the catchment areas of the respective health facilities by using a DNA microarray-based method. Mutant allele and haplotype frequencies were determined and their relationship with treatment failure rates at each site in each year was investigated. **RESULTS:** PCR-corrected in vivo treatment failure rates were between 12% and 28% and varied by site and year with variable longitudinal trends. In the community samples, the frequencies of mutations in *pfprt* and *pfmdr1* were high and did not show significant changes over time. Mutant allele frequencies in *pfdhfr* were moderate and those in *pfdhps* were low. No mutations were detected in *pfATPase6*. There was much more variation between sites than temporal, within-site, variation in allele and haplotype frequencies. This variation did not correlate well with treatment failure rates. Allele and haplotype frequencies were very similar

in clinical and community samples from the same site. **CONCLUSIONS:** The relationship between parasite genetics and in vivo treatment failure rate is not straightforward. The frequencies of genetic anti-malarial resistance markers appear to be very similar in community and clinical samples, but cannot be used to make precise predictions of clinical outcome. Thus, indicators based on molecular data have to be considered with caution and interpreted in the local context, especially with regard to prior drug usage and level of pre-existing immunity. Testing community samples for molecular drug resistance markers is a complementary tool that should help decision-making for the best treatment options and appropriate potential alternatives.

44 Mayer CA, Neilson AA.

Japanese encephalitis - prevention in travellers.
Aust Fam Physician 2010 Jun;39(6):389-394.

This article is the fourth in a series providing a summary of prevention strategies and vaccination for infections that may be acquired by travellers. The series aims to provide practical strategies to assist general practitioners in giving travel advice, as a synthesis of multiple information sources which must otherwise be consulted. Japanese encephalitis (JE) is a potentially fatal arboviral infection prevalent in large parts of Asia, as well as Papua New Guinea and the outer Torres Strait Islands. It is the commonest cause of encephalitis worldwide. Although it seldom affects travellers, its serious consequences and at times unpredictable epidemiology make its prevention an important part of the pre-travel consultation. The phasing out of the previously used mouse brain derived inactivated JE vaccine, and the availability of new, safer vaccines now and in the near future, have prompted a reassessment of vaccination recommendations internationally to include a greater number of travellers.

45 Mercer J, Kelman I, Taranis L, Suchet-Pearson S.

Framework for integrating indigenous and scientific knowledge for disaster risk reduction.
Disasters 2010 Jan;34(1):214-239.

A growing awareness of the value of indigenous knowledge has prompted calls for its use within disaster risk reduction. The use of indigenous knowledge alongside scientific knowledge is increasingly advocated but there is as yet no clearly developed framework demonstrating how the two may be integrated to reduce community vulnerability to environmental hazards. This paper presents such a framework, using a participatory approach in which relevant indigenous and scientific knowledge may be integrated to reduce a community's vulnerability to environmental hazards. Focusing on small island developing states it presents an analysis of the need for such a framework alongside the difficulties of incorporating indigenous knowledge. This is followed by an explanation of the various processes within the framework, drawing on research completed in Papua New Guinea. This framework is an important first step in identifying how indigenous and scientific knowledge may be integrated to reduce community vulnerability to environmental hazards.

46 Mola GD, Kuk JM.

A randomised controlled trial of two instruments for

vacuum-assisted delivery (Vacca Re-Usable Omnicup and the Bird anterior and posterior cups) to compare failure rates, safety and use effectiveness.

Aust NZ J Obstet Gynaecol 2010 Jun;50(3):246-252.

BACKGROUND: Most previous trials of vacuum-assisted delivery have been in settings with high rates of instrumental vaginal delivery (8-12%) and high rates of failure to deliver with the intended instrument (20-30%). Over the past 20 years, vacuum-assisted delivery rates at the Port Moresby General Hospital have been 3-4% with failure rates of <3%. **OBJECTIVE:** The objective is to compare the failure rates of two vacuum extractor instruments, the Vacca Re-Usable Omnicup and the Bird Vacuum delivery system (anterior and posterior cups). **SETTING:** Port Moresby General national referral and teaching Hospital (PMGH), Papua New Guinea. **POPULATION:** Two hundred consecutive women requiring assisted delivery, June-December, 2007. **METHODS:** When a woman required an assisted delivery, she was randomised into either the Vacca Re-Usable Omnicup (Clinical Innovations Inc.) or Bird anterior or posterior metal cup (depending upon the position of the vertex). One hundred women were randomised to each vacuum device. Statistical analysis was on 'an intention-to-treat' basis. **MAIN OUTCOME MEASURES:** The main outcome measure was the successful completion of the delivery with the allocated instrument. Secondary outcomes were maternal trauma (episiotomy and trauma to the maternal genital tract), significant scalp trauma (sub-galeal haemorrhage or serious abrasion) and fetal and neonatal outcomes (Apgar score less than seven at 5 minutes, days spent in the Special Care Nursery and neonatal death). **RESULTS:** Failure rates for both Omnicup (2/100) and Bird metal cups (6/100) were not statistically different (RR 1.05, 95% CI 0.99-1.12; $p = 0.17$). Rates of maternal trauma and fetal scalp trauma were similar in both groups. **CONCLUSION:** Both the Vacca re-useable Omnicup and the Bird metal cups are very effective instruments to achieve successful assisted delivery and equally so. Failures and problems were associated with not applying the vacuum cup to the flexion point on the fetal scalp and the mechanical faults with vacuum equipment devices.

47 Moore MA, Baumann F, Foliaki S, Goodman MT, Haddock R, Maraka R, Koroivueta J, Roder D, Vinit T, Whippy HJ, Sobue T.

Cancer epidemiology in the Pacific islands - past, present and future.

Asian Pac J Cancer Prev 2010;11 Suppl 2:99-106.

The Pacific Ocean contains approximately 25,000 islands, stretching from Papua New Guinea to Easter Island, populated by mixtures of Melanesians, Micronesians and Polynesians, as well as migrant groups from Asia and Europe. The region encompasses a third of the surface of the earth although it is sparsely populated at a total of around 9 million. With the exception of some of the more populated islands, such as New Zealand and Hawaii, few surveys of chronic diseases have been conducted, but it is increasingly recognized that obesity, diabetes and associated conditions are emerging public health problems and clearly there is a need for cooperation to optimize control. Here we focus on cancer registry and epidemiological findings for Papua New Guinea, the Solomons,

Vanuatu, Samoa, New Caledonia, Fiji, Polynesia, French Polynesia, Maori in New Zealand, Native Hawaiians, Micronesia, including Guam, and Aboriginal populations in Australia as assessed by PubMed searches and perusal of the International Agency for Cancer Research descriptive epidemiology database. Overall, the major cancers in males are oral and liver in Papua New Guinea and the Solomon Islands, and lung and prostate elsewhere (Fiji being exceptional in demonstrating a predominance of esophageal cancer), whereas in females it is breast and either cervix or lung, depending largely on whether a cervical cancer screening program is active. In certain locations thyroid cancer is also very prevalent in females. The similarities and variation point to advantages for collaborative research to provide the evidence-base for effective cancer control programs in the region.

- 48 **Mueller I, Genton B, Betuela I, Alpers MP.** Vaccines against malaria: perspectives from Papua New Guinea. *Hum Vaccin* 2010 Jan;6(1):17-20. Epub 2010 Jan 15.

Despite its small population and isolated location Papua New Guinea (PNG) with a malaria burden comparable to sub-Saharan Africa, its intense transmission of all four human *Plasmodium* species and an unrivalled combination of environmental and human variation offers unique perspectives on malaria vaccines. Building on a long history of malaria research, in this article we review past achievements, highlight current research and outline future directions in malaria vaccine research. With intensive transmission of all four species of human malaria, a full range of malaria endemicities, well described epidemiology and a demonstrated capacity to evaluate a malaria vaccine, PNG currently has the only field site that is ready to conduct proof-of-principle studies of currently available *P. vivax* vaccine candidates and future combined *P. falciparum* / *P. vivax* vaccines and also offers unique opportunities for *P. falciparum* vaccine research. PNG is thus ready to contribute significantly in the global malaria vaccine endeavor.

- 49 **Nsanjabana C, Hastings IM, Marfurt J, Müller I, Baea K, Rare L, Schapira A, Felger I, Betschart B, Smith TA, Beck HP, Genton B.**

Quantifying the evolution and impact of antimalarial drug resistance: drug use, spread of resistance, and drug failure over a 12-year period in Papua New Guinea.

J Infect Dis 2010 Feb 1;201(3):435-443.

BACKGROUND. Antimalarial use is a key factor driving drug resistance and reduced treatment effectiveness in *Plasmodium falciparum* malaria, but there are few formal, quantitative analyses of this process. **METHODS.** We analyzed drug usage, drug failure rates, and the frequencies of mutations and haplotypes known to be associated with drug resistance over a 12-year period (1991-2002) in a site in Papua New Guinea. This period included 2 successive treatment policies: amodiaquine (AQ) or chloroquine (CQ) from 1991 through 2000 and their subsequent replacement by sulfadoxine-pyrimethamine (SP) plus AQ or SP plus CQ. **RESULTS.** Drug use approximated 1 treatment per person-year and was associated with increasing frequencies of *pfcr* and *pfmdr1* mutations and of treatment failure. The frequency of *pfdhfr* mutations also increased, especially after the change in

treatment policy. Treatment failure rates multiplied by 3.5 between 1996 and 2000 but then decreased dramatically after treatment policy change. **CONCLUSIONS.** With high levels of resistance to CQ, AQ, and SP, the deployment of the combination of both drugs appears to increase clinical effectiveness but does not decelerate growth of resistance. Our estimates of mutation and haplotype frequencies provide estimates of selection coefficients acting in this environment, which are key parameters for understanding the dynamics of resistance.

- 50 **Peel TN, Bhatti D, De Boer JC, Stratov I, Spelman DW.**

Chronic cutaneous ulcers secondary to *Haemophilus ducreyi* infection.

Med J Aust 2010 Mar 15;192(6):348-350.

Haemophilus ducreyi is a well recognised causative agent of genital ulcers and chancroid. We report two unusual cases of non-sexually transmitted *H. ducreyi* infection leading to chronic lower limb ulcers. Both patients were Australian expatriates visiting Australia from the Pacific Islands – one from Papua New Guinea and the other from Vanuatu.

- 51 **Poespoprodjo JR, Hasanuddin A, Fobia W, Sugiarto P, Kenangalem E, Lampah DA, Tjitra E, Price RN, Anstey NM.**

Severe congenital malaria acquired in utero.

Am J Trop Med Hyg 2010 Apr;82(4):563-565.

Vertical transmission of *Plasmodium falciparum* is under-recognized and usually associated with asymptomatic low-level parasitemia at birth. We report symptomatic congenital malaria presenting as a neonatal sepsis syndrome. The presence at birth of a high asexual parasitemia, gametocytemia, and splenomegaly indicated in utero rather than intrapartum transmission. The neonate was successfully treated with intravenous artesunate followed by oral dihydroartemisinin-piperaquine, without apparent adverse effects.

- 52 **Reid H, Vally A, Taleo G, Tatem AJ, Kelly G, Riley I, Harris I, Henri I, Imahe S, Clements AC.**

Baseline spatial distribution of malaria prior to an elimination programme in Vanuatu.

Malar J 2010 Jun 2;9:150.

BACKGROUND: The Ministry of Health in the Republic of Vanuatu has implemented a malaria elimination programme in Tafea Province, the most southern and eastern limit of malaria transmission in the South West Pacific. Tafea Province is comprised of five islands with malaria elimination achieved on one of these islands (Aneityum) in 1998. The current study aimed to establish the baseline distribution of malaria on the most malarious of the province's islands, Tanna Island, to guide the implementation of elimination activities. **METHODS:** A parasitological survey was conducted in Tafea Province in 2008. On Tanna Island there were 4,716 participants from 220 villages, geo-referenced using a global position system. Spatial autocorrelation in observed prevalence values was assessed using a semivariogram. Backwards step-wise regression analysis was conducted to determine the inclusion of environmental and climatic variables into a prediction model. The Bayesian geostatistical logistic regression model was used to predict malaria risk, and associated uncertainty across the island. **RESULTS:** Overall, prevalence on Tanna was 1.0% for *Plasmodium falciparum* (accounting

for 32% of infections) and 2.2% for *Plasmodium vivax* (accounting for 68% of infections). Regression analysis showed significant association with elevation and distance to coastline for *P. vivax* and *P. falciparum*, but no significant association with NDVI or TIR. Colinearity was observed between elevation and distance to coastline with the later variable included in the final Bayesian geostatistical model for *P. vivax* and the former included in the final model for *P. falciparum*. Model validation statistics revealed that the final Bayesian geostatistical model had good predictive ability. **CONCLUSION:** Malaria in Tanna Island, Vanuatu, has a focal and predominantly coastal distribution. As Vanuatu refines its elimination strategy, malaria risk maps represent an invaluable resource in the strategic planning of all levels of malaria interventions for the island.

- 53 **Russell FM, Carapetis JR, Balloch A, Licciardi PV, Jenney AW, Tikoduadua L, Waqatakirewa L, Pryor J, Nelson J, Byrnes GB, Cheung YB, Tang ML, Mulholland EK.**

Hyporesponsiveness to re-challenge dose following pneumococcal polysaccharide vaccine at 12 months of age, a randomized controlled trial. *Vaccine* 2010 Apr 26;28(19):3341-3349. Epub 2010 Mar 4.

BACKGROUND: To evaluate the immunological impact of the 23-valent pneumococcal polysaccharide vaccine (23vPPS) at 12 months, for children who have received zero to three infant doses of seven-valent pneumococcal conjugate vaccine (PCV), on responses to a subsequent exposure to a small dose of 23vPPS (mPPS). **METHODS:** Five hundred and fifty-two Fijian infants were stratified by ethnicity and randomized into eight groups to receive zero, one, two, or three PCV doses at 14 weeks, six and 14 weeks, or six, ten, and 14 weeks. Within each group, half received 23vPPS at 12 months and all received mPPS at 17 months. Sera were taken prior and one month post-mPPS. **FINDINGS:** By 17 months, geometric mean antibody concentrations (GMC) to all 23 serotypes in 23vPPS were significantly higher in children who had received 23vPPS at 12 months compared to those who had not. Post-mPPS, children who had not received the 12 month 23vPPS had a significantly higher GMC for all PCV serotypes compared with those who had (each $p < 0.02$). For the non-PCV serotypes, children who had not received the 12 month 23vPPS had significantly higher GMC for six of 16 non-PCV serotypes (7F, 9N, 12F, 19A, 22F, 33F) than those who did (each $p < 0.02$). After adjusting for the pre-mPPS level, exposure to 23vPPS was associated with a lower response to mPPS for all serotypes (each $p < 0.001$). **INTERPRETATION:** Despite higher antibody concentrations at 17 months in children who had received 23vPPS at 12 months, the response to a re-challenge was poor for all 23 serotypes compared to children who had not received the 12 month 23vPPS.

- 54 **Salman S, Rogerson SJ, Kose K, Griffin S, Gomorai S, Baiwog F, Winmai J, Kandai J, Karunajeewa HA, O'Halloran SJ, Siba P, Ilett KF, Mueller I, Davis TM.**

Pharmacokinetic properties of azithromycin in pregnancy. *Antimicrob Agents Chemother* 2010 Jan;54(1):360-366. Epub 2009 Oct 26.

Azithromycin (AZI) is an azalide antibiotic with antimalarial activity that is considered safe in pregnancy. To assess its pharmacokinetic properties when administered as intermittent preventive treatment in pregnancy (IPTp), two 2-g doses were given 24 h apart to 31 pregnant and 29 age-matched nonpregnant Papua New Guinean women. All subjects also received single-dose sulfadoxine-pyrimethamine (SP) (1,500 mg and 75 mg) or chloroquine (450-mg base daily for 3 days). Blood samples were taken at 0, 1, 2, 3, 6, 12, 24, 32, 40, 48, and 72 h and on days 4, 5, 7, 10, and 14 for AZI assay by ultra-high-performance liquid chromatography-tandem mass spectrometry. The treatments were well tolerated. Using population pharmacokinetic modeling, a three-compartment model with zero-order followed by first-order absorption and no lag time provided the best fit. The areas under the plasma concentration-time curve (AUC(0-infinity)) (28.7 and 31.8 mg.h/liter for pregnant and nonpregnant subjects, respectively) were consistent with the results of previous studies, but the estimated terminal elimination half-lives (78 and 77 h, respectively) were generally longer. The only significant relationship for a range of potential covariates, including malarial parasitemia, was with pregnancy, which accounted for an 86% increase in the volume of distribution of the central compartment relative to bioavailability without a significant change in the AUC(0-infinity). These data suggest that AZI can be combined with compounds with longer half-lives, such as SP, in combination IPTp without the need for dose adjustment.

- 55 **Sanga K, de Costa C, Mola G.**

A review of maternal deaths at Goroka General Hospital, Papua New Guinea 2005-2008.

Aust NZ J Obstet Gynaecol 2010 Feb;50(1):21-24.

BACKGROUND: Papua New Guinea is a developing country with a population of six million, facing significant geographical, cultural and economic barriers to the provision of antenatal and intrapartum care. The maternal mortality ratio (MMR) is an internationally regarded index of the quality of a country's maternity services; the most recently reported MMR for Papua New Guinea of 773 deaths per 100 000 births is one of the highest in the world. **AIMS:** To review information about women who died from pregnancy-related causes, both direct and indirect, in the Goroka General Hospital (GGH) during the period 1st January 2005 to 31st May 2008. **METHODS:** A retrospective review was undertaken of the charts of women recorded as dying in the Obstetrics and Gynaecology (O&G) ward of GGH in the study period. **RESULTS:** The charts of 21 women who died from pregnancy-related causes were reviewed and information collated. Puerperal sepsis and sepsis complicating unsafe abortion were the most common causes of maternal death accounting for 48% of deaths. Other causes included ectopic pregnancy and postpartum haemorrhage. Contributing factors included residence in a rural area, geographical and transport difficulties accessing care, non-use of family planning services, non-booking for antenatal care and late presentation in pregnancy or labour, and under-resourcing of services at GGH. The socio-economic status of most of the women was low, and where educational attainments were recorded these were also low. 71% of women identified themselves as practising Christians. **CONCLUSIONS:** Better outreach

services to provide health information and antenatal care, with specific counselling about the need for supervised delivery, are urgently required in the Eastern Highlands Province that GGH serves if numbers of maternal deaths are to be reduced. Working through churches in the region may be the most appropriate way to provide information and services to women because a majority of women adhere to Christianity and can be reached in this way.

- 56 **Schoepflin S, Lin E, Kiniboro B, DaRe JT, Mehlotra RK, Zimmerman PA, Mueller I, Felger I**

Treatment with Coartem (artemether-lumefantrine) in Papua New Guinea.

Am J Trop Med Hyg 2010 Apr;82(4):529-534.

A recent drug efficacy trial reported Coartem (artemether-lumefantrine) to be highly effective against *Plasmodium falciparum* in children less than 5 years of age in Papua New Guinea (PNG). In contrast, we have observed high levels of treatment failures in non-trial conditions in a longitudinal cohort study in the same age group in PNG. Recrudescences were confirmed by genotyping of three different marker genes to provide optimal discrimination power between parasite clones. After excluding genetic host factors by genotyping potentially relevant cytochrome P450 loci, the high number of treatment failures in our study is best explained by poor adherence to complex dosing regimens in combination with insufficient fat supplementation, which are both crucial parameters for the outcome of Coartem treatment. In contrast to the situation in classic drug trials with ideal treatment conditions, our field survey highlights potential problems with unsupervised usage of Coartem in routine clinical practice and under program conditions.

- 57 **Seed CR, Coughlin JT, Pickworth AM, Harley RJ, Keller AJ.**

Relapsing vivax malaria despite chemoprophylaxis in two blood donors who had travelled to Papua New Guinea.

Med J Aust 2010 Apr 19;192(8):471-473.

Two Australian blood donors were diagnosed with relapsing *Plasmodium vivax* malaria 5 and 15 months, respectively, after their most recent travel to a malaria-endemic country. Common features included travel to Papua New Guinea (specifically, the Kokoda Trail); full compliance with recommended malaria chemoprophylaxis; and negative results on malaria antibody testing at the time of donation. Although all fresh blood components from the two donors issued on the basis of these negative results were recalled before transfusion, these cases underscore the increased potential for relapse of *P. vivax* in donors returning from malaria-endemic countries, as well as the inability to identify the potential for relapse using current malarial screening tests.

- 58 **Senn N, Maraga S, Sie A, Rogerson SJ, Reeder JC, Siba P, Mueller I.**

Population hemoglobin mean and anemia prevalence in Papua New Guinea: new metrics for defining malaria endemicity?

PLoS One 2010 Feb 24;5(2):e9375.

BACKGROUND: The hypothesis is that hemoglobin-based metrics are useful tools for estimating malaria endemicity and for monitoring

malaria control strategies. The aim of this study is to compare population hemoglobin mean and anemia prevalence to established indicators of malaria endemicity, including parasite rates, rates of enlarged spleens in children, and records of (presumptive) malaria diagnosis among populations living with different levels of malaria transmission. **METHODOLOGY/PRINCIPAL FINDINGS:** Convenience sample, multisite cross-sectional household surveys conducted in Papua New Guinea. Correlations (r^2) between population Hb mean and anemia prevalence and altitude, parasite rate, and spleen rate were investigated in children aged 2 to 10 years, and in the general population; 21,664 individuals from 156 different communities were surveyed. Altitude ranged from 5 to 2120 meters. In young children, correlations between altitude and parasite rate, population Hb mean, anemia prevalence, and spleen rate were high (r^2 : -0.77, 0.73, -0.81, and -0.68; $p < 0.001$). In the general population, correlations between altitude and population Hb mean and anemia prevalence were 0.83 and 0.85, respectively. Among young children, parasite rate correlated highly with anemia prevalence, population Hb mean, and spleen rate (r^2 : 0.81, -0.81, and 0.86; $p < 0.001$). Population Hb mean (corrected for direct altitude effects) increased with altitude, from 10.5 g/dl at <500 m to 12.8 g/dl at >1500 m ($p < 0.001$). **CONCLUSIONS/SIGNIFICANCE:** In PNG, where *Plasmodium vivax* accounts for an important part of all malaria infections, population hemoglobin mean and anemia prevalence correlate well with altitude, parasite, and spleen rates. Hb measurement is simple and affordable, and may be a useful new tool, alone or in association with other metrics, for estimating malaria endemicity and monitoring effectiveness of malaria control programs. Further prospective studies in areas with different malaria epidemiology and different factors contributing to the burden of anemia are warranted to investigate the usefulness of Hb metrics in monitoring malaria transmission intensity.

- 59 **Senn N, Riddell M, Omena M, Siba P, Reeder JC, Clements CJ, Morgan C.**

Measles in Papua New Guinea: an age-specific serological survey.

Vaccine 2010 Feb 17;28(7):1819-1823. Epub 2009 Dec 16.

We aimed to determine the proportion of the population in Madang (Papua New Guinea) immune to measles infection by age groups, with respect to immunization status and study location, using dried blood sampling technology. We performed a prospective cross-sectional sero-survey. Population immunity against measles was sub-optimal (77%) and reported measles vaccine coverage in children <10 years of age was low (41%). The urban population was more susceptible to measles infection, compared with the rural population (66% vs 79% immune, $aOR = 0.6$, $p = 0.05$). Sero-conversion and long term protection rates appeared to be higher when at least one dose of vaccine was provided at or after 12 months of age (84% vs 59%, $aOR = 4.3$, $p = 0.004$). Such a dose is, however, not currently prescribed by the national immunization schedule.

- 60 **Shaukat AM, Breman JG, McKenzie FE.**

Using the entomological inoculation rate to assess the impact of vector control on malaria parasite

transmission and elimination.

Malar J 2010 May 12;9:122.

BACKGROUND: Prior studies have shown that annual entomological inoculation rates (EIRs) must be reduced to less than one to substantially reduce the prevalence of malaria infection. In this study, EIR values were used to quantify the impact of insecticide-treated bed nets (ITNs), indoor residual spraying (IRS), and source reduction (SR) on malaria transmission. The analysis of EIR was extended through determining whether available vector control tools can ultimately eradicate malaria. **METHOD:** The analysis is based primarily on a review of all controlled studies that used ITN, IRS, and/or SR and reported their effects on the EIR. To compare EIRs between studies, the percent difference in EIR between the intervention and control groups was calculated. **RESULTS:** Eight vector control intervention studies that measured EIR were found: four ITN studies, one IRS study, one SR study, and two studies with separate ITN and IRS intervention groups. In both the Tanzania study and the Solomon Islands study, one community received ITNs and one received IRS. In the second year of the Tanzania study, EIR was 90% lower in the ITN community and 93% lower in the IRS community, relative to the community without intervention; the ITN and IRS effects were not significantly different. In contrast, in the Solomon Islands study, EIR was 94% lower in the ITN community and 56% lower in the IRS community. The one SR study, in Dar es Salaam, reported a lower EIR reduction (47%) than the ITN and IRS studies. All of these vector control interventions reduced EIR, but none reduced it to zero. **CONCLUSION:** These studies indicate that current vector control methods alone cannot ultimately eradicate malaria because no intervention sustained an annual EIR less than one. While researchers develop new tools, integrated vector management may make the greatest impact on malaria transmission. There are many gaps in the entomological malaria literature and recommendations for future research are provided.

61 Snowdon W, Lawrence M, Schultz J, Vivili P, Swinburn B.

Evidence-informed process to identify policies that will promote a healthy food environment in the Pacific Islands.

Public Health Nutr 2010 Jun;13(6):886-892. Epub 2010 Mar 3.

OBJECTIVE: To implement a systematic evidence-informed process to enable Fiji and Tonga to identify the most feasible and targeted policy interventions which would have most impact on diet-related non-communicable diseases. **DESIGN:** A multisectoral stakeholder group of policy advisers was formed in each country. They used participatory approaches to identify the problem policies and gaps contributing to an unhealthy food environment. Potential solutions to these problems were then identified, and were assessed by them for feasibility, effectiveness, cost-effectiveness and side-effects. Data were gathered on the food and policy environment to support the assessments. A shortlist of preferred policy interventions for action was then developed. **RESULTS:** Sixty to eighty policy problems were identified in each country, affecting areas such as trade, agriculture, fisheries and pricing. Up to 100 specific potential policy solutions were then developed in each country. Assessment

of the policies highlighted relevant problem areas including poor feasibility, limited effectiveness or cost-effectiveness and serious side-effects. A shortlist of twenty to twenty-three preferred new policy options for action in each country was identified. **CONCLUSIONS:** Policy environments in these two countries were not conducive to supporting healthy eating. Substantial areas of potential action are possible, but some represent better choices. It is important for countries to consider the impact of non-health policies on diets.

62 Snowdon W, Potter JL, Swinburn B, Schultz J, Lawrence M.

Prioritizing policy interventions to improve diets? Will it work, can it happen, will it do harm?

Health Promot Int 2010 Mar;25(1):123-133.

Policies from non-health sectors have considerable impacts on the food environment and in turn on population nutrition. Health impact assessment (HIA) methods have been developed to identify the potential health effects of non-health policies; however, they are underused both within and outside the health sector. HIA and other assessment methods and tools can be used more extensively in health promotion to assist with the identification of the best policy options to pursue to improve and protect health. A participatory process is presented in this paper which combines HIAs with feasibility and effectiveness assessments. The intention is to enable health promoters to more accurately identify which policy change options would be most likely to improve diets, considering both impact and likelihood of implementation. The process was successfully used in Fiji and Tonga and provided a more systematic way of understanding which policy interventions showed the most promise.

63 Soeksmanto A, Subroto MA, Wijaya H, Simanjuntak P.

Anticancer activity test for extracts of Sarang semut plant (*Myrmecodya pendens*) to HeLa and MCM-B2 cells.

Pak J Biol Sci 2010 Feb 1;13(3):148-151.

The aim of this study is to investigate anticancer activity of methanol extract (ethylacetate, n-butanol and water partitions) and water extract from Sarang semut (local name), *Myrmecodya pendens*, which is one of Rubiaceae family. Within Papua area (Indonesia), this medicinal plant has been used traditionally as alternative treatment for ulcer, tumor and cancer. In this study, the extracts of this plant were tested for their activities in some cancer cells (HeLa and MCM-B2 cell). The result showed that water extract of this plant has better anticancer activity compared to other extracts. The IC50 value of water extract A is 27.61 ppm (HeLa) and 54.57 ppm (MCM-B2), while water extract B is 29.36 ppm (HeLa) and 74.20 ppm (MCM-B2). Our study concluded that polar extract (water) exhibited higher anticancer activity than non-polar extracts (ethylacetate and n-butanol).

64 Toikilik S, Tuges G, Lagani J, Wafiware E, Posanai E, Coghlan B, Morgan C, Sweeney R, Miller N, Abramov A, Stewart A, Clements CJ.

Are hard-to-reach populations being reached with immunization services? Findings from the 2005 Papua New Guinea national immunization coverage survey.

Vaccine 2010 Jun 23;28(29):4673-4679. Epub 2010

May 6.

OBJECTIVE: To measure immunization coverage among children aged 12-23 months in Papua New Guinea (PNG) and to assess if and why there are differences between hard-to-reach and more accessible communities. **METHODS:** WHO cluster sampling methodology was employed to measure immunization coverage in PNG's four regions. Survey data were re-analyzed according to a local assessment of geographical accessibility indicated by census unit type: urban, rural and hard-to-reach. Census units were designated as hard-to-reach if they were five or more km from a health centre. **FINDINGS:** Nationwide coverage for most antigens falls below the national target of 80% although there are regional differences with Islands performing the best. Late doses are a major concern: just 4% were fully immunized with valid ("on time") doses by 1 year of age. Coverage was lower in both rural and remote communities: at 6 months 48% of children from urban units had received three valid doses of DTP-3 but only 16% in rural areas and 13% in hard-to-reach communities. Reasons for failure to immunize varied: 21% of mothers said their child was not immunized because distance, travel conditions or cost of transportation prevented access to local health centres; 27% cited a lack of knowledge or misconceptions about immunization; while 29% believed it was because of an issue with the health system. **CONCLUSIONS:** Throughout PNG there is an urgent need to increase immunization coverage and to ensure that children are immunized on time according to the schedule. Both coverage and timeliness of doses are worse for children living in hard-to-reach and rural areas. Achieving national immunization targets requires improvements in health service delivery, including outreach, especially for remote and rural communities, as well as greater community education and social mobilisation in support of immunization services.

65 **Tu HP, Chen CJ, Tovosia S, Ko AM, Lee CH, Ou TT, Lin GT, Chang SJ, Chiang SL, Chiang HC, Chen PH, Wang SJ, Lai HM, Ko YC.**

Associations of a non-synonymous variant in *SLC2A9* with gouty arthritis and uric acid levels in Han Chinese subjects and Solomon Islanders. *Ann Rheum Dis* 2010 May;69(5):887-890. Epub 2009 Aug 31.

OBJECTIVE: To study the associations of gout, tophi and uric acid levels with the gout-related *SLC2A9* (solute carrier family 2, member 9) single nucleotide polymorphisms (SNPs) between two different racial groups. **METHODS:** Eight *SLC2A9* SNPs were genotyped in 109 subjects with gout and 191 control subjects from Han Chinese men in Taiwan and 69 subjects with gout and 168 control subjects from the Solomon Islands. **RESULTS:** Non-synonymous *SLC2A9* rs3733591 Arg265His was associated with risk for gout and tophaceous gout in Han Chinese subjects ($p=0.0012$ and $p=0.0044$). The genetic effect of this SNP on tophaceous gout was replicated in Solomon Islanders ($p=0.0184$). Patients with *SLC2A9* Arg265His risk C-allele consistently had a higher risk for tophi (OR 2.05-2.15) than non-tophi (OR 0.91-1.62). SNP rs3733591 described 3.68% and 5.98% of the total variability in uric acid levels for Chinese and Solomon Island subjects, respectively. **CONCLUSION:** Non-synonymous SNP rs3733591 variant within the *SLC2A9* gene from two

geographically diverse populations served as an important genetic checkpoint for tophaceous gout and increased uric acid levels.

66 **van den Biggelaar AH, Holt PG.**

99th Dahlem conference on infection, inflammation and chronic inflammatory disorders: neonatal immune function and vaccine responses in children born in low-income versus high-income countries. *Clin Exp Immunol* 2010 Apr;160(1):42-47.

There is increasing evidence that the functional state of the immune system at birth is predictive of the kinetics of immune maturation in early infancy. Moreover, this maturation process can have a major impact on early vaccine responses and can be a key determinant of risk for communicable and non-communicable diseases in later life. We hypothesize that environmental and genetic factors that are often typical for poor-resource countries may have an important impact on prenatal immune development and predispose populations in low-income settings to different vaccine responses and disease risks, compared to those living in high-income countries. In this paper we aimed to summarize the major differences between neonatal and adult immune function and describe what is known so far about discrepancies in immune function between newborns in high- and low-income settings. Further, we discuss the need to test the immunological feasibility of accelerated vaccination schedules in high-risk populations and the potential of variation in disease-specific and non-specific vaccine effects.

67 **van Maaren PJ.**

Fighting the tuberculosis epidemic in the Western Pacific region: current situation and challenges ahead.

Kekkaku 2010 Jan;85(1):9-16.

INTRODUCTION: Tuberculosis (TB) remains a major public health problem in the Western Pacific Region. More than 20% of the global burden of TB is found in the Region. In 2007, the latest year for which data are available, there were an estimated 1.9 million incident cases (109 per 100,000 population). Four countries (Cambodia, China, the Philippines and Vietnam) account for 93% of the total estimated incident cases in the Region. Every year an estimated 300 thousand persons die due to TB. The Region is host to an estimated 135,000 multi-drug resistant TB cases, most of which can be found in China. **TB PREVALENCE AND TB MORTALITY:** The Regional Stop TB strategy aims to halve the prevalence and mortality rates of 2000 by 2010. Based on current estimates, the TB prevalence declined by 24% between 2000 and 2007, while TB mortality declined by 19% in the same period. Given the current annual decrease in TB prevalence and mortality, it is unlikely that the Region will achieve the 50% reduction by 2010. **CASE FINDING:** Approximately 1.4 million new TB cases were notified in the Region in 2007, of which there were close to 0.7 million smear-positive cases. Cases from China accounted for 70% of the total notified smear-positive cases. The Regional case detection rate was sustained at 78%. Case detection rates in China, the Lao People's Democratic Republic, Mongolia, the Philippines and Vietnam exceeded the 70% target. **TREATMENT OUTCOMES:** A total of 92% of the 0.7 million new pulmonary smear-positive cases registered for treatment in 2006 were successfully treated. The

treatment success rates exceed the 85% target in all countries with a high burden of TB, except Papua New Guinea where it was reported at 73%. **MULTIDRUG-RESISTANT TB:** In 2007, the proportion of MDR-TB in new TB cases was estimated to be 4%. A total of 135,411 MDR-TB cases was estimated to have occurred in 2007. Based on the overall case management data, 10,231 new patients and 1,596 re-treatment patients were reported with available drug susceptibility testing (DST) results in the Region. Of these, 1% (89/10,231) and 29% (468/1,596) had MDR-TB, respectively. Capacity to detect and treat MDR-TB cases is still very limited in most countries in the Region. Eighteen countries and areas in the Region have conducted drug resistance surveillance (DRS) since 2000, according to the Global Project on Anti-tuberculosis Drug Resistance Surveillance. Among new TB cases, the prevalence of multidrug-resistant TB (MDR-TB) ranged from 0% in Cambodia to 11.1% in the Commonwealth of the Northern Mariana Islands. MDR-TB prevalence among re-treatment cases ranged from 3.1% in Cambodia to 27.5% in Mongolia. In the five countries with a high burden of TB with available data from surveys (Cambodia, China, Mongolia, the Philippines, and Vietnam), MDR-TB prevalence in new cases and re-treatment cases ranged from 0% in Cambodia to 4.9% in China and from 3.1% in Cambodia to 27.5% in Mongolia, respectively. Notably, there were alarming rates of MDR-TB in several provinces in China among both new and retreatment cases. Increasing numbers of MDR-TB cases are reported from Papua New Guinea. **TB-HIV CO-INFECTION:** The overall estimated prevalence of HIV in new TB cases in 2007 was 2.7%. With 8.0% in 2008 compared to 11.8% in 2003, Cambodia shows a declining prevalence of HIV in new TB cases. There was a significant increase in the use of anti-retroviral therapy (ART) in the Region. However, detailed and complete data as well as strong collaboration in HIV and TB management are needed to be able to closely monitor the use of ART and its impact on TB-HIV co-infection in the Region. **CONCLUSION:** In spite of the substantial progress made in most countries with a high burden of TB, substantial challenges remain in the Region. The rate of decline in TB prevalence and mortality is too low to reach the 50% reduction goal in 2010. It will be necessary to further increase TB case detection and address the emerging spread of drug-resistant TB. The slow response in the most affected countries in the

Region is a cause for concern. Strong commitment by national governments and their partners is needed to sustain and further strengthen the current TB control efforts.

- 68 **Wong RP, Lautu D, Tavul L, Hackett SL, Siba P, Karunajeewa HA, Ilett KF, Mueller I, Davis TM.**

In vitro sensitivity of *Plasmodium falciparum* to conventional and novel antimalarial drugs in Papua New Guinea.

Trop Med Int Health 2010 Mar;15(3):342-349. Epub 2010 Jan 11.

OBJECTIVE: Recent clinical studies have shown high rates of malaria treatment failure in endemic areas of Papua New Guinea (PNG), necessitating a change of treatment from chloroquine (CQ) or amodiaquine (AQ) plus sulphadoxine-pyrimethamine to the artemisinin combination therapy (ACT) artemether plus lumefantrine (LM). To facilitate the monitoring of antimalarial drug resistance in this setting, we assessed the in vitro sensitivity of *Plasmodium falciparum* isolates from Madang Province. **METHODS:** A validated colorimetric lactate dehydrogenase assay was used to assess growth inhibition of 64 *P. falciparum* isolates in the presence of nine conventional or novel antimalarial drugs [CQ, AQ, monodesethyl-amodiaquine (DAQ), piperazine (PQ), naphthoquine (NQ), mefloquine (MQ), LM, dihydroartemisinin and azithromycin (AZ)]. **RESULTS:** The geometric mean (95% confidence interval) concentration required to inhibit parasite growth by 50% (IC₅₀) was 167 (141-197) nM for CQ, and 82% of strains were resistant (threshold 100 nM), consistent with near-fixation of the CQ resistance-associated *pfcr* allele in PNG. Except for AZ [8.351 (5.418-12.871) nM], the geometric mean IC₅₀ for the other drugs was <20 nM. There were strong associations between the IC₅₀s of 4-aminoquinoline (CQ, AQ, DAQ and NQ), bisquinoline (PQ) and aryl aminoalcohol (MQ) compounds suggesting cross-resistance, but LM IC₅₀ only correlated with that of MQ. **CONCLUSIONS:** Most PNG isolates are resistant to CQ in vitro but not to other ACT partner drugs. The non-isotopic semi-automated high-throughput nature of the *Plasmodium* lactate dehydrogenase assay facilitates the convenient serial assessment of local parasite sensitivity, so that emerging resistance can be identified with relative confidence at an early stage.

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Manuscripts are accepted for publication only with the understanding that they have not been published nor submitted for publication elsewhere. All manuscripts will be sent out for referees' comments as part of the peer review process.

Original Articles: Reports of original and new investigations or contributions.

Brief Communications and Case Reports: Contents similar to that of original articles but text should be no more than a total of 4 Journal pages including all figures and tables.

Reviews: Critical analysis of previously collected and published information.

Letters: Short reports of clinical experience or topics of interest. Text should not exceed 2 pages of the Journal.

Other types of manuscript may also be accepted for publication at the Editor's discretion.

Submitted manuscripts should conform to the instructions set out below. Manuscripts not conforming to these instructions will be returned.

MANUSCRIPTS

Submit the original with a virus-free electronic copy on disk as a word document or send by email to the Editorial Office. All sections including text, references, tables and legends should be in double spacing. Manuscripts should not be right justified. Each paper should include an informative Summary, Introduction, Patients/Materials and Methods, Results, Discussion and References. The title page should include the title, full names of all authors, names and addresses of institutions where the work has been done and full present address of the first or corresponding author.

References should be in the Vancouver style and include all authors. All references should be checked against the original source. Sample references are shown below.

- 3 **Garner PA, Hill G.** Brainwashing in tuberculosis management. *PNG Med J* 1985;28:291-293.
- 4 **Cochrane RG.** A critical appraisal of the present position of leprosy. In: Lincicome DP, ed. *International Review of Tropical Medicine*. New York: Academic Press, 1961:1-42.

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Abbreviations: Standard abbreviations and units should be used.

Drug Names: Generic names of drugs should be used.

Orthography: The Shorter Oxford English Dictionary is followed.

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