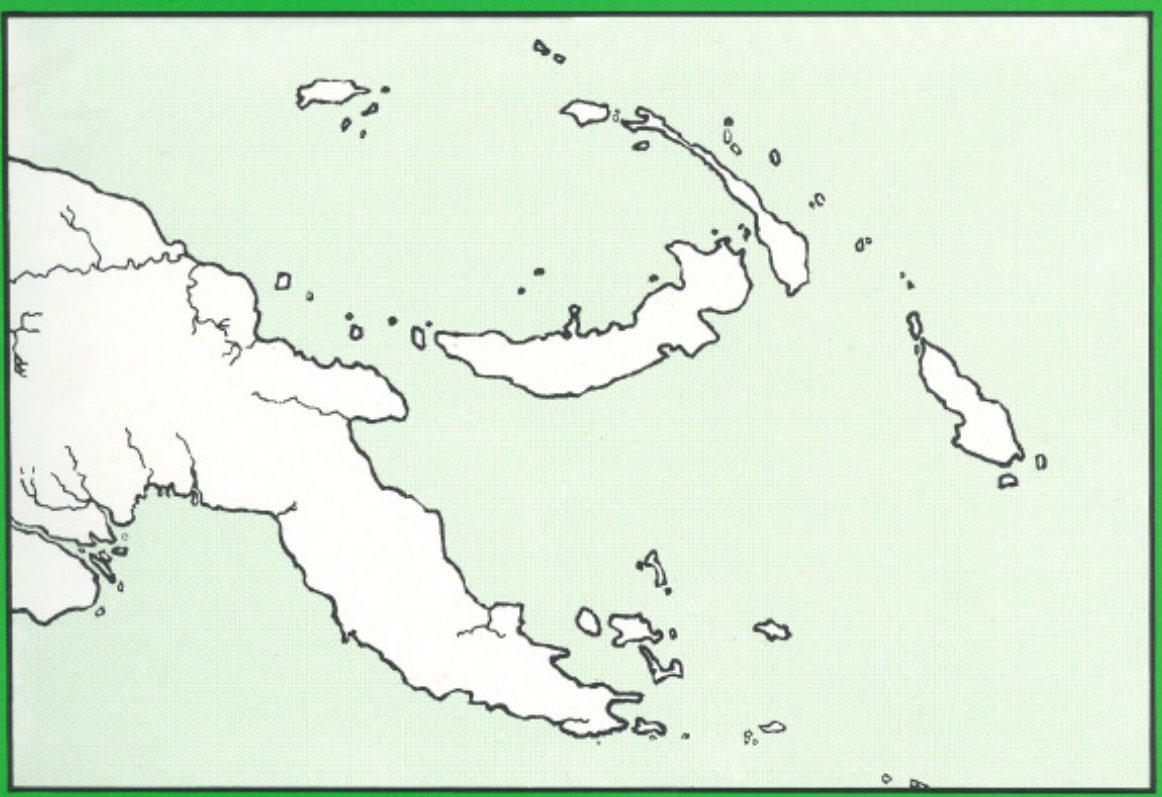
ISSN 0031-1480

PAPUA NEW GUINEA MEDICAL JOURNAL



VOL. 60, NO 1-2, MARCH-JUNE 2017

Medical Society of Papua New Guinea

Executive 2017

President:	Nakapi Tefuarani
Vice-President:	Peter Siba
Secretary:	Lucy John
Treasurer:	Glen Mola
Executive Member:	Evelyn Lavu

Published quarterly by the Medical Society of Papua New Guinea

Papua New Guinea Medical Journal

ISSN 0031-1480

March-June 2017, Volume 60, Number 1-2

Email: pngmedj@pngimr.org.pg
Web page: http://www.pngimr.org.pg

* Registered at GPO, Port Moresby for transmission by Post as a Qualified Publication.

* 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.

CONTENTS

PNG Med J 2017 Mar-Jun;60(1-2):1-4

EDITORIAL

The fight to control tuberculosis in Papua New Guinea – what role does research play?

Papua New Guinea (PNG) is one of the 30 countries with the highest tuberculosis (TB) burden in the world, with an estimated TB incidence rate of 432/100,000 population and a multidrug-resistant TB (MDR-TB) incidence rate of 25/100,000 population in 2015 (1,2). Despite increasing efforts, it remains challenging to sustainably control the spread of the disease, and little is known about the country-wide epidemiology of TB.

Over the past decade, several studies have investigated the presence of drug resistance and determined the genotypes of the circulating *Mycobacterium tuberculosis* (Mtb) strains in different areas of PNG (3-12). These studies revealed that the TB epidemic in PNG varies between provinces and a significant amount of drug resistance was detected in all sites investigated. For example, Ley et al. demonstrated distinct compositions of circulating Mtb populations in different areas of PNG. In Madang, Madang Province the majority of the Mtb strains belonged to lineage 4, whereas in Alotau, Milne Bay Province and Goroka, Eastern Highlands Province lineage 2 (ie, the Beijing family of strains) dominated (5). The Beijing strains were furthermore found to be associated with drug resistance, therefore highlighting Milne Bay Province and Eastern Highlands Province as being at an increased risk of drug-resistant TB. Aia et al. furthermore identified significant differences in the proportion of multidrug-resistant TB – ie, resistant to the major first-line drugs isoniazid and rifampicin – between provinces. Western Province had a significantly higher proportion of MDR-TB cases (34%) than the other provinces included in the study (2.5% in Madang, 3.7% in National Capital District, 8.1% in Morobe) (11).

Such epidemic patterns require adaptive control strategies. In the context of the data described above this means to scale up drug resistance testing and MDR-TB management in high MDR-TB areas, as otherwise inefficient drugs might be used, eventually leading to extensively drug-resistant or even totally resistant TB. Daru Island in the Western Province is an important example of an area with alarmingly high MDR-TB incidence and ongoing transmission (10,12-16). A mathematical model predicted that the MDR-TB incidence in Western Province can only be reduced if programmatical management of MDR-TB is implemented across the entire province (as opposed to only in the provincial capital). Once MDR-TB has reached a significant proportion, the majority of new cases is attributable to transmission rather than to acquisition during treatment (14). The latter was confirmed by a recent whole genome sequencing (WGS) study investigating MDR-TB isolates from the Daru outbreak (12). The Government of PNG has recognized this outbreak as one of the highest priorities in the fight against TB and actions have been taken accordingly; a drug-resistant TB emergency response team was formed in 2014, and in 2016 the Daru Accelerated Response on TB (DART) – establishing decentralized, community-based treatment sites with nutritional support – was implemented. In conjunction with other strategies, such as increasing funding for TB control, earlier diagnosis of drug resistance and improved access to second-line TB treatment, these efforts have led to a significant decrease in 'loss to follow-up' (17,18). In March 2017 the World Bank Emergency Tuberculosis Project was announced; it was established to reduce the incidence and transmission of MDR-TB in Western Province and the National Capital District through improving and expanding the coverage of health services in PNG, eg, by implementing active case detection strategies and expanding the existing DART sites (15,19).

Drug resistance has been identified as the major driver of the TB epidemic in Western Province, but limited country-wide data are available. The MDR-TB outbreak in Western Province has led to increased attention and (inter)national commitment to fight the TB crisis in PNG. This momentum should now be seized to scale up the country-wide response. Routinely performed Gene-Xpert testing in the provincial hospitals – followed by culture

and phenotypic drug susceptibility testing (DST) – indicates the spread of MDR-TB within every province that reported cases in 2016 (unpublished data) but, especially from remote and isolated areas, accurate incidence and prevalence estimates are lacking. Active case detection (ACD) conducted in different regions of PNG exhibited significant differences in the number of undetected positive TB cases found in the community. In the Alotau District of Milne Bay Province ACD found only one additional case that had not been detected through routine procedures. In contrast, in remote areas of Morobe Province 106 additional cases were found – relative to the 24 routinely detected TB cases in the area (20,21). These results reflect the importance of considering site-specific factors in TB control approaches. In areas with high numbers of undiagnosed TB cases, ACD can be a useful tool to increase case detection rates and to reduce the delay in treatment seeking, especially in high-risk groups such as people living with HIV. This in turn improves the probability of cure, reduces the risk of possible transmission and at the same time provides better TB burden estimates. In other areas, however, ACD would contribute only marginally to the current efforts of case detection in the community.

Large-scale epidemiological and operational studies are required to determine site-specific factors driving the epidemiology of TB and to identify the requirements and challenges of individual areas of PNG in the fight against TB. Such studies will enable the identification of shortcomings in the program (coverage and impact) and their reasons, and allow improvement in the implementation of interventions and consequently in the current control efforts. The identification of hotspots of TB transmission and drug resistance allows directing limited resources where they are required the most and where they will have the highest impact. Targeted research can furthermore be used to test the suitability and operational feasibility of interventions complementary to those used in the frame of the current National TB Control Program (eg, ACD). For example, in a setting where many additional cases would be detected through ACD, an already overloaded health centre would not be able to provide the required health service, leading to decreased cure rates and an increase in acquisition and transmission of drug-resistant TB. To avoid this, additional resources would be required and patient management would need to be scaled up (20).

Operational studies could be complemented with molecular epidemiological studies, using comparative WGS approaches. One might argue that PNG has more pressing matters in the fight against TB than to embark on costly genetic research methods. However, the feasibility of such studies in PNG has been proven by Bainomugisa et al. and important insights about the ongoing MDR-TB outbreak have been gained (12). Conducting such research across other areas of PNG would enable us to understand the local epidemiological situation of TB in the country through monitoring spatial and temporal trends of the disease and inferring the relatedness of different strains, and to establish specific control strategies accordingly. Based on the findings of Ley et al. that the Mtb population structure varies significantly between distinct areas of the country, and due to the high human diversity in PNG that could influence host susceptibility, as well as social factors influencing behaviour, it could well be that the proportion of transmitted versus acquired resistance also varies between provinces (5,22).

In addition, WGS allows complementing phenotypic with genotypic DST to obtain detailed drug resistance profiles of the local Mtb strains. If country-wide standardized treatment regimens are not based on such detailed profiles, the risk of using partially ineffective treatment increases, and drug resistance might be further fueled (23-25). This is especially important considering the recently implemented use of new drugs such as bedaquiline and delamanid. If these drugs are used without knowing the detailed resistance profile against all other drugs in the regimen, the acquisition of resistance could also render these drugs inefficient (26). Country-wide access to early and comprehensive DST (ideally point-of-care) is required to avoid increasing drug resistance and its transmission. Apart from effectively diagnosing and treating active disease, preventive treatment of latently infected people and people at increased risk of infection needs to be widely implemented to eventually eliminate TB in the population (27,28).

Considering the geographical difficulties, the cultural differences, the size of the TB

burden and the limited available resources in PNG, conducting large-scale (molecular) epidemiological studies is quite a challenge. On the other hand, PNG also provides a unique opportunity to gain new insights into various aspects of TB and to investigate the drivers of TB epidemiology in a high-burden setting with a highly diverse population incomparable to any other country in the world. With the support of international collaborators and funders and with multi-sectoral approaches involving all stakeholders – including the local community – these challenges can be overcome, and well-planned country-wide research studies can be conducted (27,29). As intensifying research is part of pillar 3 of the END TB strategy, planning detailed and locally adapted research strategies – including additional aspects of TB such as social and cultural determinants – will also be supported by the World Health Organization (27). Understanding the distribution of (drug-resistant) TB will inform policy makers to adapt specific disease control strategies to improve the management of the TB epidemic in the country. A reduced TB burden in PNG would also decrease the risk of the spread of the disease across borders, from which neighbouring countries would directly benefit. Results from molecular epidemiological studies would furthermore contribute to the global collection of data on Mtb and therefore support joint efforts to develop new tools and drugs to prevent TB from becoming an incurable disease in the future, and to reach the Sustainable Development Goal to "ensure healthy lives and promote well-being for all at all ages" (30).

Serej D. Ley

DST/NRF Centre of Excellence for Biomedical Tuberculosis Research
South African Medical Research Council Centre for Tuberculosis Research
Division of Molecular Biology and Human Genetics
Faculty of Medicine and Health Sciences
Tygerberg Campus
Stellenbosch University
PO Box 241
Cape Town 8000
South Africa
serej.ley@gmail.com

Evelyn Lavu

Central Public Health Laboratory
Port Moresby General Hospital
Private Mail Bag 1
Boroko
National Capital District
Papua New Guinea

REFERENCES

1 **World Health Organization.** Global Tuberculosis Report 2016. Geneva: World Health Organization, 2016. www.who.int/tb/publications/global_report/en/
2 **World Health Organization.** Papua New Guinea: tuberculosis profile. Geneva: World Health Organization, 2016.
3 **Ballif M, Harino P, Ley S, Carter R, Coulter C, Niemann S, Borrell S, Fenner L, Siba P, Phuanukoonnon S, Gagneux S, Beck HP.** Genetic diversity of *Mycobacterium tuberculosis* in Madang, Papua New Guinea. *Int J Tuberc Lung Dis* 2012;16:1100-1107.
4 **Ballif M, Harino P, Ley S, Coscolla M, Niemann S, Carter R, Coulter C, Borrell S, Siba P, Phuanukoonnon S, Gagneux S, Beck HP.** Drug resistance-conferring mutations in *Mycobacterium tuberculosis* from Madang, Papua New Guinea. *BMC Microbiol* 2012;12:191.
5 **Ley SD, Harino P, Vanuga K, Kamus R, Carter R, Coulter C, Pandey S, Feldmann J, Ballif M, Siba PM, Phuanukoonnon S, Gagneux S, Beck HP.** Diversity of *Mycobacterium tuberculosis* and drug resistance in different provinces of Papua New Guinea. *BMC Microbiol* 2014;14:307.
6 **Ley SD, Riley I, Beck HP.** Tuberculosis in Papua New Guinea: from yesterday until today. *Microbes Infect* 2014;16:607-614.
7 **Gilpin CM, Simpson G, Vincent S, O'Brien TP, Knight TA, Globan M, Coulter C, Konstantinos A.** Evidence of primary transmission of multidrug-resistant tuberculosis in the Western Province of Papua New Guinea. *Med J Aust* 2008;188:148-152.
8 **Simpson G, Coulter C, Weston J, Knight T, Carter R, Vincent S, Robertus L, Konstantinos A.** Resistance patterns of multidrug-resistant tuberculosis in Western Province, Papua New Guinea [Notes from the field]. *Int J Tuberc Lung Dis* 2011;15:551-552.
9 **Cross GB, Coles K, Nikpour M, Moore OA, Denholm J, McBryde ES, Eisen DP, Warigi B, Carter R, Pandey S, Harino P, Siba P, Coulter C, Mueller I, Phuanukoonnon S, Pellegrini M.** TB incidence and characteristics in the remote Gulf Province of Papua New Guinea: a prospective study. *BMC Infect Dis* 2014;14:93.
10 **McBryde E.** Evaluation of risks of tuberculosis in Western Province Papua New Guinea. Melbourne: Burnet Institute, 2012. www.burnet.edu.au/system/publication/file/3606/2012_Evaluation_of_Risks_of_Tuberculosis_in_Western_Province_PNG.pdf
11 **Aia P, Kal M, Lavu E, John LN, Johnson K, Coulter C, Ershova J, Tosas O, Zignol M, Ahmadova S, Islam T.** The burden of drug-resistant tuberculosis in Papua New Guinea: results of a large population-based survey. *PLoS One* 2016;11:e0149806.
12 **Bainomugisa A, Lavu E, Hiashiri S, Majumdar S, Honjepari A, Moke R, Dakulala P, Hill-Cawthorne GA, Pandey S, Marais BJ, Coulter C, Coin LJM.** Multi-clonal evolution of MDR/XDR *M. tuberculosis* in a high prevalence setting in Papua New Guinea over

three decades. *bioRxiv* 2017. doi: 10.1101/172601. www.biorxiv.org/lookup/doi/10.1101/172601

13 **Hiashiri S, Honjepari A, Aia A, John L, Lavu E, Coulter C, Chan G, Dakulala P.** High levels of primary transmission of drug-resistant tuberculosis in South Fly District, Western Province, Papua New Guinea. Abstract PC-932-05 in Abstract Book of the Forty-sixth World Conference on Lung Health of the International Union Against Tuberculosis and Lung Disease (The Union), Cape Town, South Africa, 2-6 Dec 2015. *Int J Tuberc Lung Dis* 2015;19(Suppl 2):S319-S320.

14 **Furin J, Cox H.** Outbreak of multidrug-resistant tuberculosis on Daru Island. *Lancet Respir Med* 2016;4:347-349.

15 **Kase P, Dakulala P, Bieb S.** Outbreak of multidrug-resistant tuberculosis on Daru Island: an update. *Lancet Respir Med* 2016;4:e40.

16 **Trauer JM, Denholm JT, Waseem S, Ragonnet R, McBryde ES.** Scenario analysis for programmatic tuberculosis control in Western Province, Papua New Guinea. *Am J Epidemiol* 2016;183:1138-1148.

17 **World Health Organization Papua New Guinea.** Joint statement from the World TB Day observation in Daru, South Fly District, Papua New Guinea. Port Moresby: World Health Organization Papua New Guinea, 22-23 Mar 2016. www.facebook.com/permalink.php?story_fbid=1706245659654414&id=1579686252310356

18 **World Health Organization Representative Office Papua New Guinea.** Updates on the situation of drug-resistant tuberculosis in Papua New Guinea, with special emphasis on Daru Island. Port Moresby: World Health Organization Representative Office Papua New Guinea, Apr 2016. www.wpro.who.int/papuanewguinea/areas/tb_leprosy/daru_update/en/

19 **World Bank.** Projects and Operations: Emergency Tuberculosis Project. Washington DC: World Bank, 2017. www.projects.worldbank.org/P160947?lang=en

20 **Ley SD.** Molecular epidemiology of tuberculosis in selected sites across Papua New Guinea. PhD Thesis, University of Basel, Basel, Switzerland, 2014. www.edoc.unibas.ch/33817/

21 **Karki B, Kittel G, Bolokon I Jr, Duke T.** Active community-based case finding for tuberculosis with limited resources: estimating prevalence in a remote area of Papua New Guinea. *Asia Pac J Public Health* 2017;29:17-27.

22 **Kinnear C, Hoal EG, Schurz H, van Helden PD, Möller M.** The role of human host genetics in tuberculosis resistance. *Expert Rev Respir Med* 2017;11:721-737.

23 **Müller B, Chihota VN, Pillay M, Klopper M, Streicher EM, Coetzee G, Trollip A, Hayes C, Bosman ME, Gey van Pittius NC, Victor TC, Gagneux S, van Helden PD, Warren RM.** Programmatically selected multidrug-resistant strains drive the emergence of extensively drug-resistant tuberculosis in South Africa. *PLoS One* 2013;8:e70919.

24 **Streicher EM, Bergval I, Dheda K, Böttger EC, Gey van Pittius NC, Bosman M, Coetzee G, Anthony RM, van Helden PD, Victor TC, Warren RM.** *Mycobacterium tuberculosis* population structure determines the outcome of genetics-based second-line drug resistance testing. *Antimicrob Agents Chemother* 2012;56:2420-2427.

25 **Metcalfe JZ, Streicher E, Theron G, Colman RE, Allender C, Lemmer D, Warren R, Engelthaler DM.** Cryptic micro-heteroresistance explains *M. tuberculosis* phenotypic resistance. *Am J Respir Crit Care Med* 2017 Jun 14. doi: 10.1164/rccm.201703-0556OC

26 **Bloemberg GV, Keller PM, Stucki D, Stuckia D, Trauner A, Borrell S, Latshang T, Coscolla M, Rothe T, Hömke R, Ritter C, Feldmann J, Schulthess B, Gagneux S, Böttger EC.** Acquired resistance to bedaquiline and delamanid in therapy for tuberculosis. *N Engl J Med* 2015;373:1986-1988.

27 **World Health Organization.** WHO end TB strategy: global strategy and targets for tuberculosis prevention, care and control after 2015. Geneva: World Health Organization, 2014. www.who.int/tb/post2015_strategy/en/

28 **Keshavjee S, Dowdy D, Swaminathan S.** Stopping the body count: a comprehensive approach to move towards zero tuberculosis deaths. *Lancet* 2015;386:e46-e47.

29 **Roll Back Malaria Partnership.** Action and investment to defeat malaria 2016-2030: for a malaria-free world. Geneva: World Health Organization, 2015. www.gmap2.org

30 **United Nations Development Programme (UNDP).** Sustainable development goals: 17 goals to transform our world. New York: United Nations Development Programme, 2015. www.un.org/sustainabledevelopment/sustainable-development-goals/

PNG Med J 2017 Mar-Jun;60(1-2):5-14

Scaling up midwifery in Papua New Guinea: how many lives could be saved?

Caroline S.E. Homer[1], Glen Mola[2] and Christine Catling[1,3]

World Health Organization Collaborating Centre for Nursing, Midwifery and Health Development, University of Technology Sydney, Australia and School of Medicine and Health Sciences, University of Papua New Guinea, Port Moresby

SUMMARY

The impact of increasing the midwifery workforce in developing countries has the potential to markedly improve maternal and neonatal outcomes as increased numbers of women have access to essential interventions. We estimated how many women's and babies' lives would be saved in Papua New Guinea if the coverage of midwifery interventions were scaled up.

Introduction

Midwifery and obstetric skills are essential for promoting the health and wellbeing of women and babies, and provide access to quality care throughout the continuum of pregnancy, birth and the postnatal period. Midwives are key members of the maternity care team as are doctors, nurses, community health workers and health extension officers. As well as supporting normal birth, in settings such as Papua New Guinea (PNG) and other low-resource countries midwives have additional skills that include undertaking vacuum extractions and vaginal breech births, manual removal of placentae, administration of medications and administration of injectable family planning methods, among others (1). Midwives also enable transfer of women to obstetric and/or emergency care if necessary and work as part of a multidisciplinary team that in PNG may also include village health volunteers (2).

In 2014, *The Lancet* series on midwifery produced a framework for quality maternal and newborn care developed by synthesizing findings from systematic reviews of women's views and experiences, effective practices and maternal and newborn care providers (1). The framework firmly focused on the care and services that childbearing women and newborn infants need in all settings. The Quality Maternal and Newborn Care Framework of *The Lancet* promotes a "system-level shift from care focused on identification and treatment of pathology for the minority to skilled care for all. This change includes preventive and supportive care that works to strengthen women's capabilities in the context of respectful relationships, is tailored to their needs, focuses on promotion of normal reproductive processes, and in which first-line management of complications and accessible emergency treatment are provided when needed" (1:1129). Quality care requires effective interdisciplinary teamwork and integration across hospital and community settings but, critically, requires women and newborns to have timely access to the essential interventions (3) as well as a philosophy of respectful care and support (4).

The midwifery workforce, therefore, needs examining globally to track the prevalence of midwifery and impact in countries with poor maternal and neonatal outcomes. The impact of increasing the midwifery workforce in 78 developing countries (classified by the Human Development Index [HDI]) has been estimated using the Lives Saved Tool (LiST) by Homer et al. (5). Interventions in

1 World Health Organization Collaborating Centre for Nursing, Midwifery and Health Development, University of Technology Sydney, Level 8, UTS Building 10, Jones St, Broadway, Sydney, New South Wales 2007, Australia

2 Obstetrics and Gynaecology Department, School of Medicine and Health Sciences, University of Papua New Guinea, PO Box 5623, Boroko, National Capital District, Papua New Guinea

3 Corresponding author: christine.catling@uts.edu.au

the LiST were selected that were within the scope of midwifery practice, and used to show that the scaling up of the care given by midwives was linked to lowering maternal and neonatal death rates, including stillbirths, in all countries. The HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living (6).

In 2015, the global maternal mortality ratio (MMR) fell from 385 deaths per 100,000 live births in 1990 to 216 per 100,000, which was a decline of 44% (7). Despite this, many developing countries have made little progress in this area; Papua New Guinea is one of these countries. This paper uses the assumptions from the paper by Homer et al. (5) in *The Lancet* series to show the potential effect of scaling up midwifery and its predicted impact on maternal mortality ratios.

Why Papua New Guinea?

A mostly rural and mountainous country, PNG has a complex cultural population with an estimated 850 languages. It also has high levels of poverty and violence, a low life expectancy and high maternal and infant mortality. In 2015 there was a 1 in 120 lifetime risk of maternal death in PNG (8). Estimates of the rate of maternal deaths in PNG are among the highest in the world at 733 deaths per 100,000 live births in 2006 (9), 545 per 100,000 live births in 2009 (10) and 215 per 100,000 live births in 2015 (8) although discrepancies in data exist (10). Most of these deaths are preventable with access to care (11).

PNG has not met the Millennium Development Goal 5 “improve maternal health” (12). This is due to a multitude of factors, the main ones being high fertility (a total fertility rate of 3.8 in 2012) (13) and a low supervised birth proportion (43% in 2013, which is far below most similar countries) (14). Other important issues are high rates of non-communicable diseases and lack of access to antenatal care, skilled birth attendants, emergency care, family planning services, emergency medicines and consultation and referral systems. Currently in PNG it is estimated that there is one midwife to every 1000 pregnant women, which is well below the recommended level of 6:1000 (15), and most supervised births outside provincial hospitals are by nurses and community health workers, who have varying levels of expertise.

In recent years, the four midwifery schools in PNG have had increased resources and have more students enrolled due to scholarships provided by the Australian Government (16). A fifth midwifery school began training midwives in 2015. Midwifery education has also been enhanced by the Maternal and Child Health Initiative, an Australian Government-funded program (16,17) assisting with overall competency development through intensive mentoring and service delivery. However, there remains a large unmet need for midwifery in PNG.

Currently in PNG there are 723 midwives registered with the PNG Nursing Council. This represents a significant increase over the past four years (Table 1) (18), although the number includes a large proportion of midwives who are not practising or retired. It is clear that the numbers of practising midwives in PNG remain inadequate. Using multi-sourced data, Moores et al. (19) showed that PNG needs to increase the current midwifery workforce by more than 1000 to meet current demands. Other issues within this report highlight the need for a longer midwifery course, an increased quality of clinical practice experience and more clarity regarding the midwives’ scope of practice in PNG.

The Lives Saved Tool

The purpose of the LiST is to determine the number of lives saved when certain interventions are introduced that influence maternal, fetal and neonatal mortality. In particular, the LiST has the ability to estimate cause-specific changes in mortality in relation to distinct midwifery interventions. Beginning with a current health and mortality status and knowledge of health interventions within a given population, LiST links the interventions with effectiveness estimates. This calculates the number of lives saved, and is then able to calculate how many further lives would be saved if those interventions were upscaled. LiST also enables valuable guidance of strategic planning in developing countries (20).

LiST, a Microsoft Windows-based software tool, was first developed by the Child Health Epidemiology Reference Group for the

TABLE 1

MIDWIVES REGISTERED BY THE PAPUA NEW GUINEA NURSING COUNCIL 2009-2014

Institution/Source	2014	2013	2012	2011	2010	2009	Total
University of Papua New Guinea	69	0	0	0	0	0	69
Lutheran School of Nursing, Lae	74	0	0	102	0	0	176
Pacific Adventist University	78	0	0	0	2	0	80
University of Goroka	92	0	0	0	0	(39†)	92
Overseas	2	2	3	0	6	(3†)	13
World Bank report (18)						293	293
Total	315*	2	3	102*	8	293*	723**

†The World Bank report figure of 293 is inclusive of the 39 from the University of Goroka and the 3 from overseas

*These figures represent the number of midwives that registered with the PNG Nursing Council in a particular year; the midwives may have completed their midwifery course in previous years

**A proportion of midwives who registered in 2009 will have now retired from the workforce, hence the total of 723 represents numbers of midwives practising and non-practising/retired

2003 Child Survival Series (21). Since then it has been adapted to estimate the impact of interventions on neonatal survival (22), maternal and child nutrition (23,24), pneumonia and diarrhoea (25) and stillbirth (26). Other comprehensive overviews of the LiST, including training tools, are freely available online (27).

The LiST approach has been used to model a reduction in the causes of maternal mortality using a limited number of interventions such as the use of clean birth kits, promotion of exclusive breastfeeding, vitamin supplementation and skin-to-skin care, among others (28). This showed reductions in maternal and child mortality, in particular when interventions were included within clinics, the community and outreach areas. All of the interventions analysed in this study were within midwives' scope of practice, and hence the focus was to examine all the interventions within midwifery practice and relate them to maternal and neonatal mortality in PNG.

Most recently, in *The Lancet* series on midwifery, LiST was used to model the effects of increasing the coverage of midwifery interventions on maternal and newborn deaths and stillbirths. Homer et al. found a 27% reduction in maternal and neonatal deaths and a 26% reduction in stillbirths in low HDI countries when a modest increase in midwifery coverage was demonstrated (5). Higher percentage reductions were used for significant scale-up of midwifery and universal coverage. There were also deaths calculated for a modelled decrease in midwifery coverage which was based on a 2% decrease in coverage every 5 years.

The midwifery interventions used spanned practices from preconception, conception (early pregnancy care such as folic acid supplementation), antenatal care (eg, vitamin and nutrient supplementation, screening for fetal growth, disease treatment and management), pregnancy and birth (eg, clean birth practices, neonatal resuscitation, medication administration) and postnatal and newborn care (eg, skin-to-skin care, breastfeeding promotion) (Table 2).

The aim of this paper therefore was to estimate the number of maternal and newborn lives that could be saved in PNG if these midwifery interventions were scaled up and available to more women over a 15-year period.

TABLE 2

HEALTH INDICATORS MODELLED AND PROXIES USED FOR ESTIMATING BASELINE COVERAGE OF HEALTH INTERVENTIONS

Delivery point	Intervention	Indicator or proxy indicator and translation formula if no standard indicator is available
Family planning	Contraceptive prevalence rate	% of women at risk of getting pregnant using any method of contraception
Around the time of conception	Folic acid supplementation	Proxy: ANC4+; Formula: 5% of women who have ANC4+ receive folic acid (ie, assumes that 5% of women receiving 4 antenatal visits will receive folic acid supplementation)
	Ectopic pregnancy case management	*Proxy: Access to EmONC; Formula: if facility delivery >50%, 0.75 facility delivery; if facility delivery is between 30 and 50%, 0.50 facility delivery; if facility delivery is <30%, 0.10 facility delivery
	Safe abortion services	% of women getting an abortion who have a safe abortion (ie, medical, surgical)
	Post-abortion care	Proxy: Access to EmONC; Formula: if facility delivery >50%, 75% facility delivery; if facility delivery is between 30 and 50%, 50% facility delivery; if facility delivery is <30%, 10% facility delivery
Antenatal care	Tetanus toxoid	Protected by tetanus toxoid at birth
	IPTp	% of pregnant women protected against malaria with 2+ doses of SP (Fansidar)
	Multiple micronutrient supplementation	% receiving 90+ days of iron-folate during pregnancy
	Calcium supplementation	Proxy: ANC4+; Formula: 5% of ANC4+
	Balanced energy supplementation	Proxy: ANC4+; Formula: ANC4+ the proportion of children 6-23 months appropriately fed (included as impacts on prematurity and neonatal death)
	Syphilis detection and treatment if needed	Proxy: ANC4+; Formula: if ANC4+ is greater than 75%, 70% ANC4+; if ANC is between 40 and 75%, 50% ANC4+; if ANC4+ is less than 40%, 20% ANC4+
	Diabetes case management	Proxy: ANC4+; Formula: 5% of ANC4+
	Screening for and management of pre-eclampsia with $MgSO_4$	Proxy: ANC4+; Formula: 5% of ANC4+
	Case management of malaria in pregnancy	Proxy: ANC4+; Formula: 5% of ANC4+
	Screening and management of fetal growth restriction	Proxy: ANC4+; Formula: 5% of ANC4+
	PMTCT	% of pregnant HIV+ women receiving option A

Care during labour and birth	Clean birth practices	Formula: 50% SBA at home; 60% essential care; 85% BEmONC; 95% CEmONC
	Immediate assessment and stimulation	Formula: 25% SBA at home; 50% essential care; 80% BEmONC; 90% CEmONC
	Skilled attendant at birth	Formula: 100% of skilled attendance
	Neonatal resuscitation	Formula: 20% BEmONC; 70% CEmONC
	Antenatal corticosteroids	Formula: 20% essential care; 85% BEmONC; 95% CEmONC
	Antibiotics for pPRoM	Formula: 20% essential care; 85% BEmONC; 95% CEmONC
	$MgSO_4$ for eclampsia	Formula: 20% essential care; 85% BEmONC; 95% CEmONC
	AMTSL	Formula: 20% essential care; 85% BEmONC; 95% CEmONC
	Induction of post-term labour	Formula: 20% CEmONC
Postpartum and newborn care	Thermal care and clean postnatal practices	Proxy: 100% of a postnatal visit within 48 hours of birth
	Kangaroo mother care	Proxy: facility delivery; Formula: 5% of facility delivery
	Maternal sepsis case management	Proxy: facility delivery; Formula: if facility delivery is greater than 50%, 50% facility delivery; if facility delivery is between 30 and 50%, 20% facility delivery; if facility delivery is less than 30%, 10% facility delivery
	Breastfeeding promotion	Proxy: % of newborns being breastfed exclusively, predominantly, partially or not at all
	Hospital-based care for severe newborn infections	Proxy: facility delivery; Formula: if facility delivery is greater than 50%, 50% facility delivery; if facility delivery is between 30 and 50%, 20% facility delivery; if facility delivery is less than 30%, 10% facility delivery

ANC4+ = 4 or more antenatal care visits
*In the absence of data, formulae are used to estimate the proportion of the indicated cases that receive management: for example, estimating the proportion of ectopic pregnancy cases that obtain treatment is done by making an assumption that when facility-based deliveries are >50%, 75% of those women who give birth in a facility who need the intervention receive ectopic management or post-abortion care if required
EmONC = emergency obstetrics and newborn care
IPTp = intermittent preventive treatment of malaria in pregnancy
SP = sulfadoxine-pyrimethamine
$MgSO_4$ = magnesium sulphate
PMTCT = prevention of mother-to-child transmission of HIV
SBA = skilled birth attendance
BEmONC = basic emergency obstetrics and newborn care
CEmONC = comprehensive emergency obstetrics and newborn care
pPRoM = premature pre-labour rupture of membranes
AMTSL = active management of the third stage of labour

Methods

Assumptions from *The Lancet* series on midwifery (5) were used to calculate the reduction in maternal deaths when there was modestly and substantially increasing midwifery coverage, when there was universal coverage of midwifery, and when there was a decrease in coverage. These were calculated for PNG, which was defined as a low HDI country (29).

We used baseline estimates of maternal deaths, stillbirths and neonatal deaths in PNG per year. These were calculated from United Nations Children's Fund (UNICEF), United Nations (UN) and World Health Organization (WHO) documents that state demographic and epidemiological information about PNG (30,31). The reductions in deaths from *The Lancet* series on midwifery were then superimposed on these data to estimate the lives potentially saved under the three scenarios that were designed to show the possible changes in coverage – from attrition to universal coverage (Table 3).

Results

In a modest scale-up of midwifery (an increase of 10% every 5 years), we found a 27% reduction of maternal deaths from 2000 to 1452 per year, 1052 fewer stillbirths and 1608 fewer neonatal deaths (Table 4). Calculations for a significant scale-up of midwifery resulted in halving the numbers of maternal deaths, stillbirths and neonatal deaths. When scaling up midwifery to provide universal (95%) coverage, maternal deaths reduced 81% to 370 per year, stillbirths reduced from 4000 to 964 and neonatal deaths from 6000 to 582. Reductions in absolute numbers were all largest in the significant and universal scale-up scenarios. In contrast, when there was a 2% decrease in midwifery coverage every 5 years, maternal deaths increased to 2046 and neonatal deaths rose to 6240 (Table 4).

Discussion

The State of the World's Midwifery Report (15) recognized that PNG had a severe midwifery shortage and needed to quadruple the workforce in order to work towards reducing poor maternal and neonatal outcomes. In order to achieve the Sustainable Development Goal of a global MMR below 70, it has been estimated that PNG will need to reduce its MMR by 7.5% each year between 2016 and 2030. Between 1990 and 2015, the average annual percentage change in MMR in Oceania, which comprises Fiji, Kiribati, Federated States of Micronesia, PNG, Samoa, Solomon Islands, Tonga and Vanuatu, was 3% (8). One of the ways to do this is to substantially increase the midwifery workforce. This paper has used the assumptions from *The Lancet* series on midwifery to show how increasing midwifery will positively impact on maternal and neonatal mortality rates.

TABLE 3

SCENARIOS USED IN MODELLING OF IMPACT OF MIDWIFERY OVER A 15-YEAR PERIOD

Scenario	Description	% change
0	No change from current	No changes in current coverage rates
1	Modest scale-up in coverage	10% increase in each of three five-year periods
2	Significant scale-up in coverage	25% increase in each of three five-year periods
3	Universal coverage of all interventions	Achieved 95% coverage of each intervention
4	Attrition back from current status	2% reduction in each of three five-year periods

TABLE 4

Reductions of maternal, fetal and neonatal deaths by 2025 in four midwifery scale-up scenarios

		Scenario 1 Modest scale-up*		Scenario 2 Significant scale-up**		Scenario 3 Universal coverage***		Scenario 4 Attrition†	
	Baseline Deaths (N)	Deaths (N)	Percent reduction	Deaths (N)	Percent reduction	Deaths (N)	Percent reduction	Deaths (N)	Percent reduction
Maternal deaths	2000	1452	27.4	1006	49.7	370	81.5	2046	−2.3
Stillbirths	4000	2948	26.3	2012	49.7	964	75.9	4096	−2.4
Neonatal deaths	6000	4392	26.8	2844	52.6	582	90.3	6240	−4.0

*10% increase in 5-year period
**25% increase in 5-year period
***95% coverage of each intervention
†2% reduction in 5-year period

Family planning interventions are a critical additional component in the reduction of maternal and newborn deaths. A number of family planning interventions were included in Byrne et al. (28), who used LiST to estimate benefits from increasing community and outreach health interventions in PNG. This study showed that the promotion of contraceptive methods could help reduce the maternal mortality ratio in PNG by 31%. Our study differs by showing benefits to the MMR from increases in midwifery interventions before family planning was specifically included. We estimated that with a significant scale-up of midwives in PNG (25% increase in a 5-year period), there would be a 50% reduction in maternal mortality. Given that the WHO estimates that by eliminating unplanned pregnancies around 25-40% of maternal deaths could be prevented (32), it is likely that significant scale-up of midwifery care with family planning could avert even more maternal and neonatal deaths and stillbirths.

This study focuses on the skill set of midwives, and we included a comprehensive list of midwifery interventions that are available within LiST. Byrne et al. (28) included three levels of health interventions at different health care points: the community level, outreach clinics and facility based. Similar to this study, Byrne et al. did find that scaling up the implementation of interventions led to accelerated health gains for women and infants; however, our study showed that scaling up midwifery care raised these gains again. Educated, regulated and professionally supported midwives working as part of an integrated team are the most cost-effective health workers, who can deliver 87% of midwifery interventions (1,15). Countries like PNG, however, will take a considerable length of time to train the number of midwives needed, even with the current scaling up process (15). Therefore, in the meantime, other cadres, including nurses and community health workers, need to be supported and educated to provide quality care. However, nurses and community health workers need to be supported and supervised by qualified midwives. A career development pathway should also be considered to enable some of these nurses and community health workers to train to become midwives in the future.

This study did not include a cost-effectiveness analysis; however, the benefits of educating midwives have been studied in an analysis undertaken for the State of the World's Midwifery Report (15). A value for money assessment was conducted on the Community-based Midwifery Diploma Programme (CMDP) in Bangladesh which takes a systems approach, with a 'hub and spoke' education model. The analysis showed that the hub and spoke model ranked positively for economy, efficiency and effectiveness; the impact in terms of lives and life years saved was similar to that of child immunization; and, finally, investing in midwives could yield a 16.2 return on investment. The conclusion was that educating midwives results in good value for money, especially in low- to middle-income countries (15).

In PNG, focus needs to continue on increasing the quantity of midwifery graduates and also on strengthening education programs to ensure that quality graduates are produced. Quality graduates will only be achieved by meeting competency standards, providing effective clinical experiences, promoting regulation and registration processes and instilling a sense of a distinct midwifery profession. Midwives need to be supported through a strong professional association that can advocate for the provision of high-quality sexual, reproductive, maternal and newborn health care to women, including adolescents. Having an effective midwifery workforce and a functional health system with access to consultation and referral, commodities and drugs and clean water will reduce maternal and neonatal mortality rates in PNG. A commitment to strengthening midwifery in PNG and other countries in the region is critical for addressing health inequalities, especially for women and girls.

Conclusion

A modest scale-up of midwifery (an increase of 10% every 5 years) would reduce maternal deaths by 27%, stillbirths by 26% and neonatal deaths by 27%. Immediate and focused action to build on existing health system resources is necessary in order to combat the high maternal and neonatal death rates in PNG. More midwives are needed to ensure that these gains can be achieved and then sustained. This paper provides support for the education and production of midwives and offers guidance for strategic planning in PNG for improved maternal and child health and reductions in mortality.

CONFLICTS OF INTEREST

CSEH was the Director of the Maternal and Child Health Initiative (MCHI), funded by the Australian Department of Foreign Affairs and Trade and led by the PNG Department of Health (2012-2015). GM was the Obstetric Mentor on the MCHI (2012-2015). CC was a Post-Doctoral Research Fellow funded through the MCHI (2015).

ACKNOWLEDGEMENTS

We acknowledge and thank Australian Aid, which funded the MCHI, and the PNG Department of Health, who led the initiative. Neither organization had a role in the interpretation of data or in the writing and editing of this article.

REFERENCES

1 **Renfrew MJ, McFadden A, Bastos MH, Campbell J, Channon AA, Cheung NF, Silva DRAD, Downe S, Kennedy HP, Malata A, McCormick F, Wick L, Declercq E.** Midwifery and quality care: findings from a new evidence-informed framework for maternal and newborn care. *Lancet* 2014;384:1129-1145.

2 **Au N, Hollingsworth B, Spinks J.** Measuring the efficiency of health services in lower-income countries: the case of Papua New Guinea. *Dev Policy Rev* 2014;32:259-272.

3 **World Health Organization, The Aga Khan University, The Partnership for Maternal, Newborn and Child Health.** Essential interventions, commodities and guidelines for reproductive, maternal, newborn and child health. A global review of the key interventions related to reproductive, maternal, newborn and child health (RMNCH). Geneva: Partnership for Maternal, Newborn and Child Health, 2011.

4 **de Kok B.** Global maternal health: from women's survival to respectful care. *BJOG* 2015;122:248.

5 **Homer CSE, Friberg IK, Dias MAB, ten Hoope-Bender P, Sandall J, Speciale AM, Bartlett LA.** The projected effect of scaling up midwifery. *Lancet* 2014;384:1146-1157.

6 **United Nations Development Programme (UNDP).** Human Development Report 2015. New York: UNDP, 2015. www.hdr.undp.org/en/countries.

7 **Alkema L, Chou D, Hogan D, Zhang S, Moller A, Gemmill A, Fat DM, Boerma T, Temmerman M, Mathers C, Say L; United Nations Maternal Mortality Estimation Inter-Agency Group Collaborators and Technical Advisory Group.** Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. *Lancet* 2016;387:462-474.

8 **World Health Organization, United Nations Children's Fund, United Nations Population Fund, World Bank Group, United Nations.** Trends in maternal mortality: 1990 to 2015. Estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. Geneva: World Health Organization, 2015. www.who.int/reproductivehealth/publications/monitoring/maternal-mortality-2015/en/

9 **National Statistics Office of Papua New Guinea.** Demographic Health Survey of Papua New Guinea 2006. Port Moresby: Population and Social Statistics Division, National Statistics Office, 2009. www.phtpacific.org/sites/default/files/surveys_dev_reports/90/files/PNG_DemographicHealthSurvey-2006_2009-07_GoPNG.pdf

10 **Mola G, Kirby B.** Discrepancies between national maternal mortality data and international estimates: the experience of Papua New Guinea. *Reprod Health Matters* 2013;21:191-202.

11 **Bolnga JW, Hamura NN, Umbers AJ, Rogerson SJ, Unger HW.** Insights into maternal mortality in Madang Province, Papua New Guinea. *Int J Gynaecol Obstet* 2014;124:123-127.

12 **United Nations Global Development Network.** Improve Maternal Health. Geneva: World Health Organization, 2015. www.pg.undp.org/content/papua_new_guinea/en/home/mdgoverview/overview/mdg5/

13 **United Nations Children's Fund (UNICEF).** At a glance: Papua New Guinea 2013. New York: UNICEF, 2013. www.unicef.org/infobycountry/papuang_statistics.html

14 **Papua New Guinea National Department of Health.** 2014 Sector Performance Annual Review. Port Moresby: NDoH, 2014.

15 **United Nations Population Fund (UNFPA), International Confederation of Midwives (ICM), World Health Organization.** The state of the world's midwifery 2014. A universal pathway: a woman's right to health. New York: UNFPA, 2014. www.unfpa.org/sowmy

16 **Dawson A, Kililo M, Geita L, Mola G, Brodie PM, Rumsey M, Copeland F, Neill A, Homer CSE.** Midwifery capacity building in Papua New Guinea: key achievements and ways forward. *Women Birth* 2016;29:180-188.

17 **World Health Organization Collaborating Centre for Nursing, Midwifery and Health Development.** Maternal and child health initiative Papua New Guinea. Sydney: University of Technology Sydney, 2015. www.uts.edu.au/research-and-teaching/our-research/who-collaborating-centre/key-strength-areas/primary-health-care-3

18 **World Bank.** Papua New Guinea health workforce crisis: a call to action. Washington: World Bank, 2011.

19 **Moores A, Puawe P, Buasi N, West F, Samor MK, Joseph N, Rumsey M, Dawson A, Homer CSE.** Midwifery graduates in Papua New Guinea (2012-2013). Sydney: World Health Organization Collaborating Centre for Nursing, Midwifery and Health Development, University of Technology Sydney, 2015.

20 **Bryce J, Friberg IK, Kraushaar D, Nsona H, Afenyadu GY, Nare N, Kyei-Faried S, Walker N.** LiST as a catalyst in program planning: experiences from Burkina Faso, Ghana and Malawi. *Int J Epidemiol* 2010;39(Suppl 1):i40-i47.

21 **Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS; Bellagio Child Survival Study Group.** How many child deaths can we prevent this year? *Lancet* 2003;362:65-71.

22 **Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L; Lancet Neonatal Survival Steering Team.** Evidence-based, cost-effective interventions: how many newborn babies can we save? *Lancet* 2005;365:977-988.

23 **Bhutta ZA, Ahmed T, Black RE, Cousens S, Dewey K, Giugliani E, Haider BA, Kirkwood B, Morris SS, Sachdev HPS, Shekar M; Maternal and Child Undernutrition Study Group.** What works? Interventions for maternal and child undernutrition and survival. *Lancet* 2008;371:417-440.

24 **Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, Webb P, Lartey A, Black RE; Lancet Nutrition Interventions Review Group; Maternal and Child Nutrition Study Group.** Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet* 2013;382:452-477.

25 **Bhutta ZA, Das JK, Walker N, Rizvi A, Campbell H, Rudan I, Black RE; Lancet Diarrhoea and Pneumonia Interventions Study Group.** Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? *Lancet* 2013;381:1417-1429.

26 **Pattinson R, Kerber K, Buchmann E, Friberg IK, Belizan M, Lansky S, Weissman E, Mathai M, Rudan I, Walker N, Lawn JE; Lancet's Stillbirths Series Steering Committee.** Stillbirths: how can health systems deliver for mothers and babies? *Lancet* 2011;377:1610-1623.

27 **Johns Hopkins Bloomberg School of Public Health. The Lives Saved Tool (LiST).** Baltimore: Johns Hopkins Bloomberg School of Public Health, 2015. www.jhsph.edu/research/centers-and-institutes/institute-for-international-programs/current-projects/lives-saved-tool/

28 **Byrne A, Hodge A, Jimenez-Soto E.** Accelerating maternal and child health gains in Papua New Guinea: modelled predictions from closing the equity gap using LiST. *Matern Child Health J* 2015;19:2429-2437.

29 **United Nations Development Programme (UNDP).** Sustaining human progress: reducing vulnerabilities and building resilience. Explanatory note on the 2014 Human Development Report composite indices: Papua New Guinea. New York: UNDP, 2014. http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/PNG.pdf

30 **United Nations Children's Fund, World Health Organization, World Bank, United Nations Department of Economic and Social Affairs, Population Division.** Levels and trends in child mortality 2013. New York: United Nations Inter-agency Group for Child Mortality Estimation, 2013.

31 **United Nations Department of Economic and Social Affairs, Population Division.** World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No ESA/P/WP.241. New York: United Nations Department of Economic and Social Affairs, Population Division, 2015.

32 **World Health Organization Regional Office for the Western Pacific.** Regional framework for reproductive health in the Western Pacific Region. Manila: World Health Organization Regional Office for the Western Pacific, 2013.

Women's recall of provision of antenatal care in Papua New Guinea: findings of a maternal and infant health survey conducted in three provinces

R. Emori[1], A.J. Vallely[1,2,3], H. Gouda[4], P. Siba[1], S. Phuanukoonnon[3], G. Mola[5], C.S.E. Homer[6] and L.M. Vallely[2,3,7]

Papua New Guinea Institute of Medical Research, Goroka, Kirby Institute, University of New South Wales, Sydney, Australia, Australian Institute of Tropical Health and Medicine, James Cook University, Townsville, School of Population Health, University of Queensland, Brisbane, Australia, School of Medicine and Health Sciences, University of Papua New Guinea, Port Moresby and Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Australia

SUMMARY

Antenatal care from a trained health care worker provides the opportunity to promote favourable outcomes for both the woman and her unborn infant. The greatest benefit of antenatal care is seen when the first visit is initiated early in the pregnancy and continued with at least four antenatal visits throughout the pregnancy. In Papua New Guinea (PNG), 66% of women attend for antenatal care at least once during their pregnancy and 51% attend four antenatal visits. We conducted a maternal and infant health survey among 482 women in three sites in PNG, Hiri, Karkar and Asaro, to explore uptake and provision of antenatal care from women's perspectives. Most women attended for antenatal care (95%; 459/482) at least once and 73% (313/431) attended the recommended minimum four antenatal visits. Women in Hiri (77%) and Asaro (78%) were more likely to attend four or more antenatal visits than women in Karkar (66%). No woman in any site reported receiving the full range of antenatal care, as indicated in the PNG national guidelines. Coverage for tetanus toxoid, malaria prophylaxis and provision of iron supplements were similar in all sites. Women in Asaro were more likely to report being advised about a supervised birth (91%) than women in Karkar (86%) or Hiri (68%). Our findings suggest that the opportunity to monitor for risk factors in pregnancy were missed, including the opportunity to provide messages relating to the importance of supervised, health facility births. There is a need for renewed commitment and resources to enable optimal antenatal care to be provided in accordance with established guidelines if PNG is to make significant improvements in maternal and newborn health.

Introduction

Antenatal care from a trained health care worker provides the opportunity to promote favourable outcomes for both the woman and her unborn infant through provision of effective and appropriate screening and preventive and treatment interventions (1). Such interventions

1 Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea

2 Kirby Institute, University of New South Wales, Wallace Wurth Building, Sydney, New South Wales 2052, Australia

3 Australian Institute for Tropical Health and Medicine, James Cook University, Townsville, Queensland 4811, Australia

4 School of Population Health, University of Queensland, Herston Road, Herston, Queensland 4006, Australia

5 School of Medicine and Health Sciences, University of Papua New Guinea, PO Box 5623, Boroko, National Capital District, Papua New Guinea

6 Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, 235 Jones St, Ultimo, New South Wales 2007, Australia

7 Corresponding author: lvallely@kirby.unsw.edu.au

include: iron supplementation; tetanus toxoid immunization; prevention and management of malaria and HIV (human immunodeficiency virus) infection; prevention of mother-to-child transmission of HIV; and management of hypertension and pre-eclampsia (1-5). In addition, antenatal care provides the opportunity to offer advice and information relating to danger signs in pregnancy, and to emphasize the importance of a supervised birth, with a skilled birth attendant (4).

The greatest benefit of antenatal care is seen when the first visit is initiated early in the pregnancy, before the twelfth week of pregnancy, and continues throughout the pregnancy with a minimum of four antenatal visits (6,7). Globally, 82% of women attend for antenatal care at least once during a pregnancy and 51% attend for the recommended four visits (8). In low- and middle-income countries (LMICs) many women attend late for their first antenatal visit, in the second or third trimester, and many do not receive the recommended four visits (8). Likewise, although globally 68% of births are attended by a skilled birth attendant, in the least developed countries only 47% are supervised by a skilled attendant (8). The poor uptake of antenatal care and supervised births is reflected in the high maternal mortality ratios (MMRs) seen in many low-resource settings. While the global MMR is 210 maternal deaths per 100,000 live births, in many low-resource settings it is much higher. In the least developed countries, the MMR is 440 maternal deaths per 100,000 live births; Sub-Saharan Africa has the highest regional ratio with 590 maternal deaths per 100,000 live births (8).

In Papua New Guinea (PNG), 66% of women attend for antenatal care at least once during pregnancy and just over half (51%) attend four antenatal visits (9). Only 44% of women attend for a supervised, health facility birth (9). PNG has one of the highest MMRs in the world with estimates of between 594 and 733 maternal deaths per 100,000 live births (10,11). This high and increasing MMR is likely due to deteriorating rural health services, poor uptake of available health services and significant workforce shortages (11). Cultural and geographical diversity are additional barriers to the availability, access and uptake of professional skilled care during pregnancy and childbirth (11).

The Exxon-Mobil PNG Liquid Natural Gas (LNG) Partnership in Health Project (PiHP) was coordinated by the PNG Institute of Medical Research (IMR) between 2010 and 2016. One of the overarching aims of the program was to monitor the impact of the PNG LNG project on the health of the population by establishing demographic and health surveillance sites in four locations: two 'LNG impact sites' in Hiri District (Central Province) and Hides (Hela Province); and two 'comparator sites' in Karkar (Madang Province) and Asaro (Eastern Highlands Province). An integrated Health and Demographic Surveillance System (iHDSS) conducted in each site provided the ideal platform to identify all pregnant women, or those who had recently given birth, in each of the four sites. A maternal and infant health (MIH) survey was conducted to identify barriers in accessing maternal and child health services and to provide insight into cultural beliefs, practices and experiences surrounding pregnancy, childbirth and the early postnatal period. In this paper we present findings on the uptake and provision of antenatal care, from the women's perspective, in three of the four iHDDS sites.

Methods

A cross-sectional maternal and infant health survey was conducted with 482 women aged 15-44 years in three PiHP demographic surveillance sites: Hiri District (Central), Karkar (Madang) and Asaro (Eastern Highlands). A fourth site (Hides, Hela Province) was excluded from the MIH survey due to security concerns at the time the study was conducted. Women were purposively recruited based on self-report of pregnancy at the most recent demographic update (2012-2013), or if they reported that they had given birth since 2010. Data collection took place between September 2013 and May 2014.

Women willing to participate in the survey were visited in the community by a member of the IMR research team who obtained consent following completion of study-specific informed consent procedures. Participants were interviewed in Tok Pisin using a piloted, study-specific semi-structured questionnaire. Interviews took place in the woman's own home, unless requested that it be undertaken elsewhere. Each interview took between 20 and 40 minutes to complete.

All survey forms were completed using the

iHDSS assigned identity number. All data were entered into an MS (Microsoft) Access database by trained members of the PiHP data entry team. Data were cleaned by the data manager and data queries resolved before data extraction into an MS Excel spreadsheet.

Data were summarized as frequencies and percentages. Chi-squared tests of significance were used to investigate associations between antenatal clinic attendance and key variables of interest, including parity, age and education level. Odds ratios were estimated with 95% confidence intervals. Analyses were conducted using Stata IC v14.0 (StataCorp LP, Texas, USA). Due to the high proportion of women reporting at least one antenatal clinic visit, it was not possible to conduct multivariate analysis to examine independent risk factors associated with attendance.

This study was approved by the Medical Research Advisory Committee (MRAC10.17) of the National Department of Health in Papua New Guinea.

Results

A total of 541 women were identified in three sites: Hiri (200), Karkar (216) and Asaro (125), of whom 482 (89%; 482/541) participated in the MIH survey (Hiri = 173; Karkar = 204; Asaro = 105). 59 women were excluded due to refusal to participate, lack of health and demographic health survey identity number or incomplete data collection.

Sociodemographic characteristics

Around two-thirds of women (64%; 297/465) were aged 15-29 years. Women in Hiri were more likely to be aged 29 years or below (70%) when compared with women in Asaro (55%; OR 1.90, 95% CI: 1.12-3.22; p = 0.020) but not with women in Karkar (63%; p = 0.155) (Table 1). Most women were married/living as married (93%; 447/482) (Table 1). Women in Hiri were more likely to report being married (95%) when compared with women in Karkar (89%; OR 2.49, 95% CI: 1.08-5.73; p = 0.044) but not with women in Asaro (95%). The majority of women (89%; 428/482) reported their occupation as housewife/carrying out household duties; only 5% (24/482) were in paid employment – most (92%; 22/24) from Hiri. Overall, 96% (465/482) of women had received any education; 64% (307/482) received primary level education only and 30% (146/482) attended secondary level education. Women living in Hiri were more likely to report having attended secondary education (54%) than women in Karkar (19%; OR 5.10, 95% CI: 3.25-8.02; p <0.001) or in Asaro (12%; OR 8.53, 95% CI: 4.47-16.5; p <0.001) (Table 1).

Obstetric history

27% (131/482) of all women had given birth once (primiparous) (Table 2). The majority of women (74%; 355/482) last gave birth within two years of the survey (Table 2). Almost two-thirds of women (65%; 312/482) gave birth in either a health centre, hospital or aid post. Women in Asaro were more likely to report a facility birth (72%) than women in Karkar (58%; OR 1.91, 95% CI: 1.14-3.18; p = 0.012) but not in Hiri (68%; p = 0.46) (Table 2). 4 women (1%; 4/482) reported either a stillbirth (1 in Hiri, 1 in Karkar) or a neonatal death (2 in Asaro) in their most recent pregnancy. 9 women (2%; 9/482) reported giving birth to twins, 1 in Hiri, 5 in Karkar and 3 in Asaro (Table 2).

Frequency, timing and quality of antenatal care

Overall, 95% (459/482) of women attended antenatal care at least once during their last pregnancy (Table 2). Most women (96%; 440/459) could recall their gestation at their first antenatal clinic attendance, of whom 74% (327/440) attended for the first time in the second trimester (3-<6 months). Women in Karkar were more likely to present for antenatal care in the third trimester (32%) than women in Asaro (13%; OR 3.07, 95% CI: 1.55-6.09; p = 0.001) or in Hiri (17%; OR 2.27, 95% CI: 1.36-3.77; p = 0.001) (Table 3).

Among those who could recall the total number of antenatal visits they attended (94%; 431/459), 73% (313/431) attended the recommended minimum four antenatal visits. Women in Hiri (77%) and Asaro (78%) were more likely to attend four or more antenatal visits than women in Karkar (66%) (Table 3).

None of the women at any of the three sites reported receiving the full range of antenatal care, as outlined in the PNG Manual of Standard Managements in Obstetrics (12). Most women reported having had their blood pressure checked (89%; 408/459), abdominal palpation (95%; 436/459) and auscultation

TABLE 1

SOCIODEMOGRAPHIC CHARACTERISTICS OF ALL WOMEN IN THE STUDY (N = 482)

		Hiri N = 173		Karkar N = 204		Asaro N = 105		All sites N = 482	
		n	%	n	%	n	%	n	%
Age				N = 201		N = 91		N = 465	
	Not known			(3)		(14)		(17)	
	15-19	12	6.9	14	7.0	0	-	26	5.6
	20-24	49	28.3	54	26.9	29	31.9	132	28.4
	25-29	60	34.7	58	28.9	21	23.1	139	29.9
	30-34	32	18.5	38	18.9	27	29.7	97	20.9
	35-39	16	9.2	25	12.4	6	6.6	47	10.1
	40+	4	2.3	12	6.0	8	8.8	24	5.2
Marital status	Married	165	95.4	182	89.2	100	95.2	447	92.7
	Single	7	4.0	4	2.0	0	-	11	2.3
	Separated	1	0.6	16	7.8	4	3.8	21	4.4
	Widow	0	0	2	1.0	1	1.0	3	0.6
Employment	No paid job	6	3.5	1	0.5	0	-	7	1.5
	Subsistence farmer	0	-	21	10.3	2	1.9	23	4.8
	Household duties/ housewife	145	83.8	181	88.7	102	97.1	428	88.8
	Teacher	1	0.6	1	0.5	0	-	2	0.4
	Security guard	1	0.6	0	-	0	-	1	0.2
	Health care worker	0	-	0	-	1	1.0	1	0.2
	Other paid employment	20	11.6	0	-	0	-	20	4.1
Educational level	No formal education	1	0.6	2	1.0	14	13.3	17	3.5
	Primary school only	71	41.0	158	77.5	78	74.3	307	63.7
	Grade 1-4	*5*	*7.0*	*23*	*14.6*	*34*	*43.6*	*62*	*20.2*
	Grade 5-8	*66*	*93.0*	*135*	*85.4*	*44*	*56.4*	*245*	*79.8*
	Secondary school	94	54.3	39	19.1	13	12.4	146	30.3
	Grade 9-10	*76*	*80.9*	*37*	*94.9*	*13*	*100*	*126*	*86.3*
	Grade 11-12	*18*	*19.1*	*2*	*5.1*	*0*	*-*	*20*	*13.7*
	Technical/vocational college	4	2.3	5	2.5	0	-	9	1.9
	University	3	1.7	0	-	0	-	3	0.6

Religion	Baptist	0	-	1	0.5	23	21.9	24	5.0
	Catholic	1	0.6	40	19.6	5	4.8	46	9.5
	Lutheran	0	-	129	63.2	10	9.5	139	28.8
	Seventh Day Adventist	5	2.9	4	2.0	29	27.6	38	7.9
	United	150	86.7	0	-	0	-	150	31.1
	Pentecostal	2	1.2	14	6.9	1	1.0	17	3.5
	Other	15	8.7	16	7.8	37	35.2	68	14.1

of the fetal heart (94%;430/459), with similar rates seen in all three sites (Table 3). Only half of all women (51%; 233/459) reported having any blood test (Table 3). Women in Asaro were more likely to report having a blood test (79%) than women in Hiri (53%; OR 3.3, 95% CI: 1.87-5.83; p <0.001) or Karkar (34%; OR 7.4, 95%CI: 4.22-13.1; p <0.001) (Table 3). Among all women who had any blood test, 39% (91/233) reported that they did not know what the blood test was for. Women in Karkar were more likely to report not knowing what the blood test was for (57%) than women in Asaro (37%; OR 2.71, 95% CI: 1.39-5.29; p <0.004) or Hiri (29%; OR 3.33, 95%CI: 1.69-6.54; p <0.0004) (Table 4).

Coverage for tetanus toxoid, malaria prophylaxis and provision of iron supplements were similar in all sites (Table 3). Overall, 83% (380/459) of women reported that they had received tetanus toxoid, with women in Hiri more likely to report having done so (88%) than women in Asaro (84%, p = 0.35) or Karkar (77%; OR 2.23, 95% CI: 1.26-3.99; p = 0.005) (Table 3). In all sites, 81% (370/459) of women reported receiving malaria prophylaxis. Iron supplementation tablets were the most frequently provided medication, reported by 85% (388/459) of women (Table 3).

Most women (80%; 366/459) reported being asked about their general health and well-being during their antenatal visit, with 81% (370/459) being advised about having a health facility birth (Table 3). Women in Asaro were more likely to report being asked about their general health (93%) than women in Hiri (79%; OR 3.54, 95% CI: 1.51-8.30; p <0.001) or Karkar (73%; OR 4.81, 95% CI: 2.09-11.67; p <0.001) (Table 3). Women in Asaro were also more likely to report being advised about a supervised birth (91%) than women in Karkar (86%; p = 0.26) or Hiri (68%; OR 4.66, 95% CI: 2.18-9.95; p <0.001) (Table 3).

Education level, age and parity associated with antenatal clinic attendance

Of the women who attended antenatal clinic, 78% (120/154) of those with secondary or tertiary education and 70% (184/263) of those with primary education attended 4 or more times (Table 5). However, there was no significant association between education level, age or parity and frequency of antenatal attendance (Table 5). Parity was not significantly associated with gestation at first antenatal visit (Table 6).

Discussion

The majority of women attended for antenatal care at least once during their most recent pregnancy and more than two-thirds attended for the recommended minimum of four visits. There was a significant association between higher education level and four or more attendances at antenatal clinic; and women in Hiri (located close to the nation's capital, Port Moresby) were more likely to report education beyond grade nine than women in Karkar and Asaro. The highest proportion of women presenting late for antenatal care was seen in Karkar, with one-third of women attending in the third trimester. These women were least likely to receive adequate care during pregnancy, due to their late presentation at antenatal clinic, the reduced number of antenatal visits or to a lack of resources at the health facility providing antenatal care.

Education beyond primary level has been associated with an increase in uptake of antenatal care and with women attending the recommended number of antenatal visits, as was found in a number of low-resource settings (13,14) and, to a limited extent, among women in our study. In 2011, Maraga et al. identified that both primary level education

TABLE 2

OBSTETRIC HISTORY (N = 482 WOMEN)

	Hiri N = 173		Karkar N = 204		Asaro N = 105		All sites N = 482	
	n	%	n	%	n	%	n	%
Previous pregnancies								
1	51	29.5	59	28.9	21	20.0	131	27.2
2	49	28.3	48	23.5	20	19.0	117	24.3
3	30	17.3	35	17.2	22	21.0	87	18.0
4	18	10.4	28	13.7	18	17.1	64	13.3
≥5	25	14.5	34	16.7	24	22.9	83	17.2
Attended antenatal clinic last pregnancy	171	98.8	188	92.2	100	95.2	459	95.2
Year of most recent birth								
2014	0	-	0	-	7	6.7	7	1.5
2013	74	42.8	88	43.1	37	35.2	199	41.3
2012	53	30.6	53	26.0	43	41.0	149	30.9
2011	44	25.4	50	24.5	16	15.2	110	22.8
2010	2	1.2	13	6.4	2	1.9	17	3.5
Location of most recent birth								
Health centre/hospital	118	68.2	118	57.8	76	72.4	312	64.7
Village	55	31.8	86	42.2	29	27.6	170	35.3
Type of birth								
Normal/vaginal	167	96.5	202	99.0	105	100	474	98.3
Caesarean section	5	2.9	1	0.5	0	-	6	1.2
Other – vacuum extraction	1	0.6	1	0.5	0	-	2	0.4
Outcome of infant								
Live births	173*	-	208*	-	108*	-	489*	-
Still births	1	0.6	1	0.5	0	-	2	0.4
Neonatal deaths	0	-	0	-	2	1.9	2	0.4

*Twin births – Hiri 1 set; Karkar 5 sets; Asaro 3 sets

and marriage were significantly associated with the uptake of antenatal care (15). In other settings in PNG, economic, geographical and cultural factors, and previous experience with antenatal services have been identified as barriers to women attending for antenatal care (15-20). Although we identified rates of attendance for both one and four visits that were higher than the national average for PNG, and those reported globally (8,9), these women remained potentially at risk of a poor pregnancy outcome due to incomplete

TABLE 3

SELF-REPORTS OF ANTENATAL CLINIC ATTENDANCE AND CARE RECEIVED DURING LAST PREGNANCY (N = 459)

	Hiri N = 171		Karkar N = 188		Asaro N = 100		All sites N = 459	
	n	%	n	%	n	%	n	%
Gestation at first antenatal clinic visit	**N = 170**		**N = 179**		**N = 91**		**N = 440**	
<3 months	5	2.9	1	0.6	9	9.9	15	3.4
3-<6 months	136	80.0	121	67.6	70	76.9	327	74.3
6-9 months	29	17.1	57	31.8	12	13.2	98	22.3
Don't know	(1)		(9)		(9)		(19)	
Antenatal visits attended	**N = 167**		**N =178**		**N = 86**		**N = 431**	
1	6	3.6	8	4.5	2	2.3	16	3.7
2	10	6.0	17	9.6	5	5.8	32	7.4
3	22	13.2	36	20.2	12	14.0	70	16.2
4	29	17.4	58	32.6	13	15.1	100	23.2
>4	100	59.9	59	33.1	54	62.8	213	49.4
Don't know	(4)		(10)		(14)		(28)	
Care received at antenatal clinic								
Blood pressure checked	156	91.2	162	86.2	90	90.0	408	88.9
Urine test	37	21.6	24	12.8	8	8.0	69	15.0
Any blood test	91	53.2	63	33.5	79	79.0	233	50.8
Palpation	162	94.7	181	96.3	93	93.0	436	95.0
Auscultation of fetal heart	161	94.2	176	93.6	93	93.0	430	93.7
Checked for oedema	109	63.7	133	70.7	86	86.0	328	71.5
Asked about general health	135	78.9	138	73.4	93	93.0	366	79.7
Tetanus toxoid given	151	88.3	145	77.1	84	84.0	380	82.8
Malaria prophylaxis	132	77.2	155	82.4	83	83.0	370	80.6
Worm tablets	47	27.5	75	39.9	45	45.0	167	36.4
Iron tablets (Fefol)	142	83.0	154	81.9	92	92.0	388	84.5
Mosquito net provided	109	63.7	89	47.3	46	46.0	244	53.2
Advised where to give birth	117	68.4	162	86.2	91	91.0	370	80.6

antenatal care (21).

The recommended standard of antenatal care is clearly described within PNG national policy and clinical guidelines (12). However, none of the women who participated in our survey reported receiving the full range of antenatal care, as indicated by these guidelines. The opportunity to monitor for risk factors in pregnancy, including pre-eclampsia, anaemia, and HIV and syphilis screening, were squandered. In addition, there was a missed opportunity to provide women with valuable safe motherhood education about the importance of supervised, health facility births, a key recommendation both globally

TABLE 4

Blood tests at antenatal clinic (N = 233)

	Hiri N = 91		Karkar N = 63		Asaro N = 79		All sites N = 233*	
	n	%	n	%	n	%	n	%
Hb	24	26.4	3	4.8	29	36.7	56	24.0
HIV	60	65.9	26	41.3	46	58.2	132	56.7
Syphilis	45	49.5	4	6.3	40	50.6	89	38.2
Did not know what blood test was for	26	28.6	36	57.1	29	36.7	91	39.1

*Total exceeds 233 as some women reported having more than one test
Hb = haemoglobin
HIV = human immunodeficiency virus

TABLE 5

Sociodemographic factors and parity associated with antenatal attendance, all sites (N = 431)

	Antenatal attendance						
	1-3 visits (N = 118)		4 or more visits (N = 313)		Total (N = 431)		Odds ratio p value
	n	%	n	%	n	%	
Education level							
No education	5	4.2	9	2.9	14	3.2	
Grade 1-8	79	66.9	184	58.8	263	61.0	OR 1.53 (0.97-2.43); p = 0.071
Grade 9-12, university/tertiary level	34	28.8	120	38.3	154	35.7	
Age	N = 115		N = 313		N = 428		
15-24 years	40	34.8	106	33.9	146	34.1	OR 1.04 (0.66-1.63); p = 0.908
25+ years	75	65.2	207	66.1	282	65.9	
Don't know	(3)				(3)		
Parity							
Primiparous	38	32.2	85	27.2	123	28.5	OR 1.27 (0.80-2.01); p = 0.179
Multiparous	80	67.8	228	72.8	308	71.5	

TABLE 6

Parity and gestation at first antenatal clinic visit, all sites (N = 440)

	Gestation at first antenatal clinic visit				Odds ratio p value
	<6 months N = 342		≥6 months N = 98		
	n	%	n	%	
Primiparous (N = 126)	100	79.4	26	20.6	OR 1.14 (0.69-1.89); p = 0.709
Multiparous (N = 314)	242	77.1	72	22.9	

and in national guidelines (3,12).

Malaria, anaemia, syphilis and HIV are all associated with poor maternal and newborn health outcomes (1,22). Malaria prophylaxis and the prevention and treatment of anaemia through iron and folate supplements can effectively reduce morbidity and mortality, including anaemia at term among women and prematurity and low birthweight among infants (1). In our survey, among women who had any blood test, only 24% reported having a haemoglobin estimation, although most women did report receiving iron supplementation and malaria prophylaxis. Such findings are similar to those reported from other settings (23). While some women may have forgotten what type of blood test they had, for example HIV or syphilis, it is concerning that, overall, only 51% reported having had any blood test. Detection and treatment of syphilis during pregnancy is one of the most effective interventions to prevent perinatal mortality and morbidity, including stillbirth (24,25). Among our study participants only 38% of women reported being tested for syphilis, with a very low rate seen in Karkar. It is unclear why these tests were not undertaken. This highlights an area of concern, particularly given that PNG is among 12 high-burden countries selected by the World Health Organization (WHO) for intensified support for the elimination of mother-to-child transmission of syphilis (24). In a recent cross-sectional survey among antenatal attenders in three sites in PNG (n = 765), including Asaro and Hiri, the prevalence of active syphilis was 2% (Hiri = 2%; Asaro = 4%) (26). In the same sites, HIV prevalence was 1% (26). In our survey, women were more likely to report being screened for HIV – an essential intervention to ensure that women are linked to prevention of mother-to-child transmission services – than syphilis.

In low-resource settings, neonatal tetanus remains a significant risk to newborns (1) and is best prevented through maternal tetanus immunization and through the promotion of clean and hygienic births and clean newborn cord-care practices (27). As with provision of iron supplementation and antimalarial drugs, most women reported receiving tetanus toxoid vaccine, with rates similar to those highlighted from other settings (23). While 83% of women reported receiving at least one dose of tetanus toxoid vaccine, we did not collect data relating to further doses of tetanus vaccine, and thus we are unable to ascertain whether women had complete coverage for the prevention of maternal/neonatal tetanus. As with many aspects of antenatal care, women in Karkar were less likely to report receiving tetanus vaccine than women from Hiri and Asaro. Women in Karkar were also more likely to give birth in the community, placing their newborn infants at increased risk of tetanus.

A supervised birth at a health facility can determine the survival and health of both mothers and their newborn infants (4). In our study, as in other settings in PNG and elsewhere (8,19), more women attended for antenatal care than for a supervised, health facility birth. Attendance at an antenatal clinic provides the prime opportunity to offer education relating to the importance of supervised births at a health facility.

As with the uptake of antenatal care, uptake of a supervised, health facility birth at 65% was also higher than the national average. Although this rate is similar to the 63% global estimate of institutional births (8), it remains less than ideal, with more than one-third of women giving birth without adequate supervision. Of interest within our study was that health facility births were noted to be slightly higher in Asaro, the site with the highest proportion of women reporting that they received advice about having a supervised, health facility birth, a finding that is in line with global evidence for birth preparedness counselling and a supervised birth (28).

In view of the poor maternal and newborn health indicators in PNG, the National Health Plan (2010) commits to: (i) Improve maternal health services and supervised births; (ii) Increase tetanus toxoid vaccine coverage among antenatal women; and (iii) Ensure every health facility is capable of providing quality services and support before, during and after pregnancy (29). These key areas are further supported by the recent release of the national public health policies (30). It was outside the scope of this survey to identify constraints at the antenatal clinic level to ascertain why the full range of antenatal care was not provided. However, a number of recommendations are worthy of consideration if improvement in the key areas outlined in the National Health Plan are to be achieved, including community mobilization to change attitudes towards early presentation for antenatal care, staff numbers and staff training in all aspects of antenatal care, including the importance of birth preparedness and the importance of a health facility birth, and review of the supply chain for basic commodities required to provide optimal standard antenatal care.

While this paper reports important findings relating to the completeness and quality of antenatal care, limitations warrant consideration. This was a cross-sectional survey that collected self-reported data on antenatal clinic attendance and care. We did not undertake corroboration between women's self-reports and review of their hand-held antenatal cards. We tried to limit recall bias from self-reports by interviewing women who had given birth recently (which we defined as within the previous two years). It is possible that women did not accurately remember the number of antenatal visits they attended, or the services they had received, which may have led to over- or under-estimation of antenatal attendance and care in these settings. While half of the women could recall having had a blood test, many could not recall what the test was for, but this does not necessarily mean they were not advised at the time blood was collected – it may simply indicate that they have subsequently forgotten.

Conclusion

The majority of women in this study attended for antenatal care during their most recent pregnancy, but many received incomplete care based on established guidance contained in PNG national standards (12). Despite the availability of standard management guidelines, health care workers are not providing the full range of antenatal services, including education relating to supervised health facility births. There is a need for renewed commitment and resources to enable optimal antenatal care to be provided in accordance with established guidelines if PNG is to make significant improvements in maternal and newborn health.

ACKNOWLEDGEMENTS

We acknowledge all the women who willingly shared their time and personal stories. We thank Mrs Nita Otoa, Mrs Jenny Timaus and members of the Partnership in Health Project Demographic Surveillance team for their support in data collection at the field sites, Mrs Yalum Siba for assistance in reviewing survey forms in Karkar and data entry staff from the Partnership in Health Program team. This study was funded by a Partnership in Health Program grant from Esso Highlands Limited, which is an ExxonMobil subsidiary.

REFERENCES

1 **Lassi ZS, Mansoor T, Salam RA, Das JK, Bhutta ZA.** Essential pre-pregnancy and pregnancy interventions for improved maternal, newborn and child health. *Reprod Health* 2014;11(Suppl 1):S2.

2 **Lassi ZS, Kumar R, Mansoor T, Salam RA, Das JK, Bhutta ZA.** Essential interventions: implementation strategies and proposed packages of care. *Reprod Health* 2014;11(Suppl 1):S5.

3 **World Health Organization.** The World Health Report 2005. Make every mother and child count. Geneva: World Health Organization, 2005.

4 **Kerber KJ, de Graft-Johnson JE, Bhutta ZA, Okong P, Starrs A, Lawn JE.** Continuum of care for maternal, newborn, and child health: from slogan to service delivery. *Lancet* 2007;370:1358-1369.

5 **Lawn JE, Zupan J, Begkoyian G, Knippenberg**

R. Newborn survival. In: Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M, Evans DB, Jha P, Mills A, Musgrove P, eds. Disease Control Priorities in Developing Countries. Second edition. Washington DC: Oxford University Press and World Bank, 2006.

6 **World Health Organization.** Making pregnancy safer: the critical role of the skilled attendant. A joint statement by WHO, International Confederation of Midwives (ICM) and International Federation of Gynecology and Obstetrics (FIGO). Geneva: World Health Organization, 2004.

7 **United States Agency for International Development.** Focused antenatal care: providing integrated, individualized care during pregnancy. Washington DC: USAID, 2011. www.accesstohealth.org/toolres/pdfs/

8 **United Nations Children's Fund.** The State of the World's Children 2015. Reimagine the future: innovation for every child. New York: UNICEF, 2014.

9 **Papua New Guinea Department of Health.** 2013 Sector performance annual review. Assessment of sector performance 2008-2012. Port Moresby: National Department of Health, Jul 2013.

10 **Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, Shackelford KA, Steiner C, Heuton KR, Gonzalez-Medina D, Barber R, Huynh C, Dicker D, Templin T, Wolock TM, Ozgoren AA, Abd-Allah F, Abera SF, Abubakar I, Achoki T, Adelekan A, Ademi Z, Adou AK, Adsuar JC, Agardh EE, Akena D, Alasfoor D, Alemu ZA, Alfonso-Cristancho R, Alhabib S, Ali R, Al Kahbouri MJ, Alla F, Allen PJ, AlMazroa MA, Alsharif U, Alvarez E, Alvis-Guzmán N, Amankwaa AA, Amare AT, Amini H, Ammar W, Antonio CA, Anwari P, Arnlöv J, Arsenijevic VS, Artaman A, Asad MM, Asghar RJ, Assadi R, Atkins LS, Badawi A, Balakrishnan K, Basu A, Basu S, Beardsley J, Bedi N, Bekele T, Bell ML, Bernabe E, Beyene TJ, Bhutta Z, Bin Abdulhak A, Blore JD, Basara BB, Bose D, Breitborde N, Cárdenas R, Castañeda-Orjuela CA, Castro RE, Catalá-López F, Cavlin A, Chang JC, Che X, Christophi CA, Chugh SS, Cirillo M, Colquhoun SM, Cooper LT, Cooper C, da Costa Leite I, Dandona L, Dandona R, Davis A, Dayama A, Degenhardt L, De Leo D, del Pozo-Cruz B, Deribe K, Dessalegn M, deVeber GA, Dharmaratne SD, Dilmen U, Ding EL, Dorrington RE, Driscoll TR, Ermakov SP, Esteghamati A, Faraon EJ, Farzadfar F, Felicio MM, Fereshtehnejad SM, de Lima GM, Forouzanfar MH, França EB, Gaffikin L, Gambashidze K, Gankpé FG, Garcia AC, Geleijnse JM, Gibney KB, Giroud M, Glaser EL, Goginashvili K, Gona P, González-Castell D, Goto A, Gouda HN, Gugnani HC, Gupta R, Gupta R, Hafezi-Nejad N, Hamadeh RR, Hammami M, Hankey GJ, Harb HL, Havmoeller R, Hay SI, Pi IB, Hoek HW, Hosgood HD, Hoy DG, Husseini A, Idrisov BT, Innos K, Inoue M, Jacobsen KH, Jahangir E, Jee SH, Jensen PN, Jha V, Jiang G, Jonas JB, Juel K, Kabagambe EK, Kan H, Karam NE, Karch A, Karema CK, Kaul A, Kawakami N, Kazanjan K, Kazi DS, Kemp AH, Kengne AP, Kereselidze M, Khader YS, Khalifa SE, Khan EA, Khang YH, Knibbs L, Kokubo Y, Kosen S, Defo BK, Kulkarni C, Kulkarni VS, Kumar GA, Kumar K, Kumar RB, Kwan G, Lai T, Lalloo R, Lam H, Lansingh VC, Larsson A, Lee JT, Leigh J, Leinsalu M, Leung R, Li X, Li Y, Li Y, Liang J, Liang X, Lim SS, Lin HH, Lipshultz SE, Liu S, Liu Y, Lloyd BK, London SJ, Lotufo PA, Ma J, Ma S, Machado VM, Mainoo NK, Majdan M, Mapoma CC, Marcenes W, Marzan MB, Mason-Jones AJ, Mehndiratta MM, Mejia-Rodriguez F, Memish ZA, Mendoza W, Miller TR, Mills EJ, Mokdad AH, Mola GL, Monasta L, de la Cruz Monis J, Hernandez JC, Moore AR, Moradi-Lakeh M, Mori R, Mueller UO, Mukaigawara M, Naheed A, Naidoo KS, Nand D, Nangia V, Nash D, Nejjari C, Nelson RG, Neupane SP, Newton CR, Ng M, Nieuwenhuijsen MJ, Nisar MI, Nolte S, Norheim OF, Nyakarahuka L, Oh IH, Ohkubo T, Olusanya BO, Omer SB, Opio JN, Orisakwe OE, Pandian JD, Papachristou C, Park JH, Caicedo AJ, Patten SB, Paul VK, Pavlin BI, Pearce N, Pereira DM, Pesudovs K, Petzold M, Poenaru D, Polanczyk GV, Polinder S, Pope D, Pourmalek F, Qato D, Quistberg DA, Rafay A, Rahimi K, Rahimi-Movaghar V, ur Rahman S, Raju M, Rana SM, Refaat A, Ronfani L, Roy N, Pimienta TG, Sahraian MA, Salomon JA, Sampson U, Santos IS, Sawhney M, Sayinzoga F, Schneider IJ, Schumacher A, Schwebel DC, Seedat S, Sepanlou SG, Servan-Mori EE, Shakh-Nazarova M, Sheikhbahaei S, Shibuya K, Shin HH, Shiue I, Sigfusdottir ID, Silberberg DH, Silva AP, Singh JA, Skirbekk V, Sliwa K, Soshnikov SS, Sposato LA, Sreeramareddy CT, Stroumpoulis K, Sturua L, Sykes BL, Tabb KM, Talongwa RT, Tan F, Teixeira CM, Tenkorang EY, Terkawi AS, Thorne-Lyman AL, Tirschwell DL, Towbin JA, Tran BX, Tsilimbaris M, Uchendu US, Ukwaja KN, Undurraga EA, Uzun SB, Vallely AJ, van Gool CH, Vasankari TJ, Vavilala MS, Venketasubramanian N, Villalpando S, Violante FS, Vlassov VV, Vos T, Waller S, Wang H, Wang L, Wang X, Wang Y, Weichenthal S, Weiderpass E, Weintraub RG, Westerman R, Wilkinson JD, Woldeyohannes SM, Wong JQ, Wordofa MA, Xu G, Yang YC, Yano Y, Yentur GK, Yip P, Yonemoto N, Yoon SJ, Younis MZ, Yu C, Jin KY, El Sayed Zaki M, Zhao Y, Zheng Y, Zhou M, Zhu J, Zou XN, Lopez AD, Naghavi M, Murray CJ, Lozano R.** Global, regional, and national levels and causes of maternal mortality during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014;384:980-1004.

11 **Papua New Guinea Department of Health.** Ministerial taskforce on maternal health in Papua New Guinea. Port Moresby: National Department of Health, May 2009.

12 **Mola G, ed.** Manual of standard managements in obstetrics and gynaecology for doctors, HEOs and nurses in Papua New Guinea. Sixth Edition. Port Moresby: National Department of Health, 2010.

13 **Nielsen BB, Liljestrand J, Thilsted SH, Joseph A, Hedegaard M.** Characteristics of antenatal care attenders in a rural population in Tamil Nadu, South India: a community-based cross-sectional study. *Health Soc Care Community* 2001;9:327-333.

14 **Simkhada B, Teijlingen ER, Porter M, Simkhada P.** Factors affecting the utilization of antenatal care in developing countries: systematic review of the literature. *J Adv Nurs* 2008;61:244-260.

15 **Maraga S, Namosha E, Gouda H, Vallely L, Rare L, Phuanukoonnon S.** Sociodemographic factors associated with maternal health care utilization in Wosera, East Sepik Province, Papua New Guinea. *PNG Med J* 2011;54:154-163.

16 **Klufio CA, Kariwiga G.** A comparison of unbooked mothers delivering at Port Moresby General Hospital with mothers seen antenatally: socioeconomic and reproductive characteristics. *PNG Med J* 1992;35:3-9.

17 **Garner P, Lai D, Baea M.** Childbirth in rural areas: maternal deaths, village deliveries and obstetric

service use. *PNG Med J* 1994;37:166-172.
18 **Duke T.** Decline in child health in rural Papua New Guinea. *Lancet* 1999;354:1291-1294.
19 **Vallely LM, Homiehombo P, Kelly A, Vallely A, Homer CSE, Whittaker A.** Exploring women's perspectives of access to care during pregnancy and childbirth: a qualitative study from rural Papua New Guinea. *Midwifery* 2013;29:1222-1229.
20 **Andrew EV, Pell C, Angwin A, Auwun A, Daniels J, Mueller I, Phuanukoonnon S, Pool R.** Factors affecting attendance at and timing of formal antenatal care: results from a qualitative study in Madang, Papua New Guinea. *PLoS One* 2014;9:e93025.
21 **Dowswell T, Carroli G, Duley L, Gates S, Gülmezoglu AM, Khan-Neelofur D, Piaggio G.** Alternative versus standard packages of antenatal care for low-risk pregnancy. *Cochrane Database Syst Rev* 2015;7:Cd000934.
22 **Ouédraogo S, Koura GK, Accrombessi MM, Bodeau-Livinec F, Massougbodji A, Cot M.** Maternal anemia at first antenatal visit: prevalence and risk factors in a malaria-endemic area in Benin. *Am J Trop Med Hyg* 2012;87:418-424.
23 **Bucher S, Marete I, Tenge C, Liechty EA, Esamai F, Patel A, Goudar SS, Kodkany B, Garces A, Chomba E, Althabe F, Barreuta M, Pasha O, Hibberd P, Derman RJ, Otieno K, Hambidge K, Krebs NF, Carlo WA, Chemweno C, Goldenberg RL, McClure EM, Moore JL, Wallace DD, Saleem S, Koso-Thomas M.** A prospective observational description of frequency and timing of antenatal care attendance and coverage of selected interventions from sites in Argentina, Guatemala, India, Kenya, Pakistan and Zambia. *Reprod Health* 2015;12(Suppl 2):S12.
24 **World Health Organization, Centers for Disease Control and Prevention, University College London.** Investment case for eliminating mother-to-child transmission of syphilis: promoting better maternal and child health and stronger health systems. Geneva: World Health Organization, 2012.
25 **Goldenberg RL, McClure EM, Saleem S, Reddy UM.** Infection-related stillbirths. *Lancet* 2010;375:1482-1490.
26 **Vallely LM, Toliman P, Ryan C, Rai G, Wapling J, Tomado C, Huliafi S, Munnull G, Rarau P, Phuanukoonnon S, Wand H, Siba P, Mola GD, Kaldor JM, Vallely AJ.** Prevalence and risk factors of *Chlamydia trachomatis*, *Neisseria gonorrhoeae*, *Trichomonas vaginalis* and other sexually transmissible infections among women attending antenatal clinics in three provinces in Papua New Guinea: a cross-sectional survey. *Sex Health* 2016;13:420-427.
27 **Khan AA, Zahidie A, Rabbani F.** Interventions to reduce neonatal mortality from neonatal tetanus in low and middle income countries – a systematic review. *BMC Public Health* 2013;13:322.
28 **Tura G, Afework MF, Yalew AW.** The effect of birth preparedness and complication readiness on skilled care use: a prospective follow-up study in Southwest Ethiopia. *Reprod Health* 2014;11:60.
29 **Papua New Guinea Department of Health.** Papua New Guinea National Health Plan 2011-2020. Port Moresby: Department of Health, Jun 2010.
30 **Papua New Guinea Department of Health.** Newborn Health Policy. Port Moresby: Department of Health, Jun 2014.

PNG Med J 2017 Mar-Jun;60(1-2):27-40

Supervised and unsupervised birth and early newborn care practices in Papua New Guinea: findings of a maternal and infant health survey conducted in three provinces

R. Emori[1], A.J. Vallely[1,2,3], H. Gouda[4], P. Siba[1], S. Phuanukoonnon[3], G. Mola[5], C.S.E. Homer[6] and L.M. Vallely[2,3,7]

Papua New Guinea Institute of Medical Research, Goroka, Kirby Institute, University of New South Wales, Sydney, Australia, Australian Institute of Tropical Health and Medicine, James Cook University, Townsville, School of Population Health, University of Queensland, Brisbane, Australia, School of Medicine and Health Sciences, University of Papua New Guinea, Port Moresby and Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Australia

SUMMARY

Poor women in remote areas in many countries remain the least likely to receive adequate health care during pregnancy and childbirth for various reasons. In Papua New Guinea (PNG) there is some documentation regarding why women do not attend for supervised births, but less is known about women's perceptions and experiences of childbirth in the community or about newborn care practices in the first few hours following childbirth. As part of a wider maternal and infant health survey among 482 women in three sites in PNG, in this paper we describe women's experiences relating to supervised and unsupervised births and newborn care practices. Among respondents, the majority (95%) reported attending for antenatal care at least once during their most recent pregnancy and almost two-thirds (65%) gave birth in a health facility. Among the health facility births, 88% were assisted by a trained health care worker. Among the women who gave birth in the community, 44% chose to do so. Primiparous women, those aged 15-24 years and women with secondary or tertiary education were significantly more likely to give birth in a health facility than multiparous women, those aged more than 24 years and women with none or only primary education. There were 489 live births, 93% of whom were breastfed. Overall 60% of women knew any danger signs in a newborn infant. Fever was the most frequently mentioned danger sign (81%). Knowledge of danger signs was significantly associated with giving birth in a health facility, being multiparous and having secondary education, compared with village birth, being primiparous and having none or only primary education. Our findings highlight the importance of using the opportunity at antenatal clinic to provide women with information and knowledge, not only on the importance of attending for a health facility birth, but also on the importance of planning and seeking transfer to the health facility early.

Introduction

Despite a global reduction in maternal mortality, poor women and those in remote areas in many countries remain the least likely to receive adequate health care during

1 Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea

2 Kirby Institute, University of New South Wales, Wallace Wurth Building, Sydney, New South Wales 2052, Australia

3 Australian Institute for Tropical Health and Medicine, James Cook University, Townsville, Queensland 4811, Australia

4 School of Population Health, University of Queensland, Herston Road, Herston, Queensland 4006, Australia

5 School of Medicine and Health Sciences, University of Papua New Guinea, PO Box 5623, Boroko, National Capital District, Papua New Guinea

6 Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, 235 Jones St, Ultimo, New South Wales 2007, Australia

7 Corresponding author: lvallely@kirby.unsw.edu.au

pregnancy and childbirth, have limited access to care and have the highest maternal and neonatal mortality rates (1). This is especially true for regions with low numbers of skilled health workers. Globally, 68% of women give birth with a skilled attendant; in the least developed countries the rate is 47%, compared to 99% in most developed countries (2). The importance of giving birth supervised by a skilled birth attendant for all women is key to reducing maternal mortality (3,4). However, a range of reasons make this difficult, particularly in low-resource settings, when delays can occur when seeking health care during pregnancy and childbirth.

Described by Thaddeus and Maine in 1995 the 'three delay framework' classifies common delays in seeking, reaching and receiving appropriate care (5). In many resource-poor settings, the decision to seek and access care frequently rests with family members and, in some situations, traditional birth attendants and village-based health care providers (6-12). Cultural and customary beliefs, geographical, structural and health facility barriers, and economic and social constraints are also reported as barriers to accessing timely care (11).

In many low-resource settings, one in four women give birth alone or with assistance from a relative or friend, a figure unchanged since the early 1990s (13). These unsupervised births, which often take place in rural settings, create a huge challenge in the effort to reduce maternal mortality (14). Significant delays can occur between the onset of a complication, such as postpartum haemorrhage (PPH), and the decision to seek emergency obstetric care. Delays may be due to lack of knowledge or will, lack of access to transport, or barriers relating to appropriate treatment at the facility level (5,15).

In Papua New Guinea (PNG), 64% of pregnant women attend antenatal clinic, at least for one visit, but only 43% have a supervised birth in a health facility (16). PNG has one of the highest maternal mortality ratios (MMRs) in the world, with an estimated 585-733 maternal deaths per 100,000 live births (17,18), and the low uptake of supervised health facility births contributes to this high MMR. While there is some documentation regarding why women do not attend for supervised births in PNG (19-22), findings which tend to reflect those from the international literature, there is little documentation about women's perceptions and experiences of childbirth in the community, and about newborn care practices in the first few hours following childbirth.

The Exxon-Mobil PNG Liquefied Natural Gas (LNG) Partnership in Health Project (PiHP) was coordinated by the PNG Institute of Medical Research (IMR) between 2010 and 2016. One of the overarching aims of the program was to monitor the impact of the PNG LNG project on the health of the population by establishing demographic and health surveillance sites in four locations: two 'LNG intervention sites' in Hiri District (Central Province) and Hides (Hela Province); and two 'no intervention sites' in Karkar (Madang Province) and Asaro (Eastern Highlands Province). An Integrated Health and Demographic Surveillance System (iHDSS) conducted in each site (23) provided the ideal platform to identify all pregnant women, or those who had recently given birth, in each of the four sites. A maternal and infant health survey was conducted with the aims of identifying barriers in accessing maternal and child health services and providing insight into cultural beliefs, practices and experiences surrounding pregnancy, childbirth and the early postnatal period. In this paper we describe women's experiences relating to supervised and unsupervised births and newborn care practices in three of the four iHDSS sites.

Methods

A cross-sectional maternal and infant health (MIH) survey was conducted among 482 women aged 15-44 years in three iHDSS sites: Hiri District (Central), Karkar (Madang) and Asaro (Eastern Highlands). A fourth site (Hides, Hela Province) was excluded from the MIH survey due to security concerns at the time the study was conducted. Women were purposively recruited based on self-reported current pregnancy at the most recent demographic update (2012-2013), or if they reported that they had given birth since 2010. Data collection took place between September 2013 and May 2014.

Women willing to participate in the survey were visited in the community by a member of the IMR research team who obtained consent following completion of study-specific informed consent procedures. Participants

were interviewed in Tok Pisin using a piloted, study-specific semi-structured questionnaire. Interviews took place in the women's own home, unless requested that it be undertaken elsewhere. Each interview took between 20 and 40 minutes to complete.

All surveys were completed using the iHDSS assigned identity number. No participant names or other identifiers were recorded or stored in the same database as the completed survey forms. All surveys were entered into a Microsoft (MS) Access database by trained members of the PiHP data entry team. Data were cleaned by the data manager and data queries resolved before data extraction into an MS Excel database.

Data were summarized as frequencies and percentages. Chi-squared tests of significance were used to investigate associations between supervised and unsupervised births and key variables of interest, including parity, age and education level. Odds ratios were estimated with 95% confidence intervals. Data were analysed using Stata IC v14.0 (StataCorp LP, Texas, USA).

This study was approved by the Medical Research Advisory Committee (MRAC10.17) of the National Department of Health in Papua New Guinea.

Results

A total of 541 women were identified across the three sites: Hiri (200), Karkar (216) and Asaro (125), among whom 482 women were surveyed: Hiri (173), Karkar (204) and Asaro (105). 59 women (11%; 59/541) were excluded due to refusal to participate, lack of identity number or incomplete data collection.

Background characteristics

Sociodemographic and pregnancy characteristics are described in our earlier paper (24). In summary, 64% (297/465) of women were aged 15-29 years, 93% (447/482) were married and 89% (428/482) reported their occupation as housewife/carrying out household duties. Although most women had received some education (96%; 465/482), two-thirds (64%; 307/482) had received only primary level education.

Most women (95%; 459/482) had attended antenatal care at least once during their pregnancy. Three-quarters of women (74%; 355/482) had last given birth within two years of the survey (2012-2014). Most women (98%; 474/482) reported a normal, vaginal birth (24).

Location of last birth and birth assistant

Almost two-thirds of women (65%; 312/482) gave birth in a health facility (Table 1). In Asaro, 72% of women reported a facility birth, similar to women in Hiri (68%). However, significantly fewer women in Karkar (58%) reported a facility birth than women in Asaro (OR 0.52, 95% CI: 0.33-0.87; p = 0.017) (Table 1). Of those who had delivered in a health facility, women in Hiri were significantly more likely to report a hospital birth (78%) than those in Karkar (51%; OR 3.4, 95% CI: 1.94-6.02; p <0.001) or in Asaro (43%; OR 4.5, 95% CI: 2.45-8.65; p <0.001) (Table 1).

Among all health facility births, 88% (268/306) of women were assisted by a trained health care worker (community health worker, nurse, midwife, health extension officer or doctor). The remaining women (12%; 38/306) were assisted by a relative, friend, their husband or a student nurse or gave birth alone (Table 1). There was no significant difference in the proportion of those who gave birth in a health facility with a health care worker in Hiri (82%) from the proportion in Karkar (91%) or in Asaro (92%).

Among the 170 (35%; 170/482) women who gave birth in the community, 44% (74/170) chose to do so. The remaining women (56%; 96/170) had wanted a health facility birth, but were unable to reach or access a health facility due to various reasons, including lack of transport and money, the poor state of the health facilities and fear of being 'scolded' by the health care workers (Table 2). Among women who gave birth in the community and whose assistance was known, most (74%; 121/163) were assisted by a female family member or a friend; 16 women (10%; 16/163) gave birth alone (Table 3).

Primiparous women were significantly more likely to give birth in a health facility than multiparous women (78%; 102/131 versus 60%; 210/351) (OR 2.36, 95% CI: 1.48-3.76; p <0.001) (Table 4). Women aged 15-24 years were also significantly more likely to have a health facility birth (76%; 117/154) than women aged 25 years and over (60%; 186/311) (OR

TABLE 1

HEALTH FACILITY BIRTHS AND ASSISTANCE DURING CHILDBIRTH

	Hiri N = 173		Karkar N = 204		Asaro N = 105		All sites N = 482	
	n	%	n	%	n	%	n	%
All health facility births	118	68.2	118	57.8	76	72.4	312	64.7
Hospital births	92	78.0	60	50.8	33	43.4	185	59.3
Health centre/aid post births	26	22.0	58	49.2	43*	56.6	127	40.7
Assistant during health facility births	115	97.5	117	99.2	74	97.4	306	98.1
Hospital births	**N = 90**		**N = 60**		**N = 33**		**N = 183**	
Assisted by trained health worker[a]	75	83.3	52	86.7	31	93.9	158	86.3
Assisted by other [b,c]	7 [b,c]	7.8	8[c]	13.3	0	-	15	8.2
Gave birth alone	8	8.9	0	-	2	6.1	10	5.5
Not known	(2)		-	-	-	-	(2)	
Health centre/aid post births	**N = 25**		**N = 57**		**N = 41**		**N = 123**	
Assisted by trained health worker[a]	19	76.0	54	94.7	37	90.2	110	89.4
Assisted by other[b,c]	6	24.0	3	5.3	4	9.8	13	10.6
Gave birth alone	0	-	0	-	0	-	0	-
Not known	(1)		(1)		(2)		(4)	

* Includes 2 births immediately outside the health centre

[a] Includes community health workers, nurses, midwives, health extension officers and doctors

[b] Includes 3 births assisted by student nurses

[c] assisted by husbands, female relatives or village birth attendants

TABLE 2

REASONS FOR HOME BIRTH

Women's reasons for *choosing* to give birth at home:

Choice
"…[with] all my children I've done deliveries myself and I've delivered safely, so I don't need to go to the hospital, I know what to do…"

Fear of health staff
"I was scared that the hospital staff might scold me because no antenatal clinic."

"[I] was scared to deliver at the hospital because the doctor might force me to have tubal ligation."

Money
"[I] prepared to give birth at home… [there is] no cost, I won't spend any money."

Night time/ lack of transport
"It was dark and there was no transport to take me to the hospital."

Support
"The family is at home and they'll give me the best care."

Poor state of facilities
"[There is] no good facility in the health centre – no toilet, shower, light..."

No guardian at the hospital
"[there is] no proper care at the hospital labour ward…….so I am [was] scared to go to the hospital for delivery."

Family commitment
"[I have] a lot of children who are in school so if I go away… no one to look after my children, so I gave birth at home."

Ashamed
"I fear going to the health centre to give birth because I don't want the health workers to see my vagina."

Women's reasons for not having a health facility birth, despite wanting one:

Baby came too quickly
"[I] waited for a vehicle to take me to the health centre but I gave birth early [quickly]."

Fear of health staff
"I was scared to go to the hospital because I didn't attend antenatal clinic for checks…I thought the nurses would get on me."

Money
"I had no money for hospital fees."

Night time/ lack of transport
"…it was in the night and heavy rain…"

Sent home from the hospital
"I went to the hospital but [they told me it was] false labour so I was discharged and came home…I delivered in the night."

"I was on the way to the hospital and gave birth in the truck. At the hospital doctors were on strike so I went back home."

TABLE 3

BIRTHS IN THE COMMUNITY

	Hiri N = 173		Karkar N = 204		Asaro N = 105		All sites N = 482	
	n	%	n	%	n	%	n	%
Births in the community	55	31.8	86	42.2	29	27.6	170	35.3
Location of birth	**n = 53**		**n = 81**		**n = 29**		**n = 163**	
Gave birth in own home	49	92.5	71	87.7	27	93.1	147	90.2
Gave birth in other's home	2	3.8	8	9.9	0	-	10	6.1
Gave birth trying to reach health facility	2*	3.8	2**	2.5	2***	6.9	6	3.7
Not known	(2)		(5)				(7)	
Assistant during birth	**n = 52**		**n = 86**		**n = 25**		**n = 163**	
Female family member/friend	36	69.2	67	77.9	18	72.0	121	74.2
Village birth attendant	12	23.1	7	8.1	0	-	19	11.7
Husband	2	3.8	2	2.3	0	-	4	2.5
Nurse in the community	1	1.9	2	2.3	0	-	3	1.8
Gave birth alone	1	1.9	8	9.3	7	28.0	16	9.8
Not known	(3)				(4)		(7)	

*one gave birth in a truck on the way to the health facility; one gave birth on the beach waiting for transport
**one gave birth outside the house; one gave birth in a truck on the way to the health facility
***gave birth on the roadside on the way to the health centre

2.12, 95% CI: 1.37-3.27; p <0.001). Women who attended secondary or tertiary education were significantly more likely to have a health facility birth (80%; 126/158) than women who had received none or only primary education (57%; 186/324) (OR 2.92, 95% CI: 1.87-4.56; p <0.001) (Table 4).

Neonatal outcome and early infant practices

Among the 482 women, nine women gave birth to twins: one in Hiri, five in Karkar and three in Asaro. Most infants (92%; 439/475) were born at term, at eight or nine months gestation (Table 5). There were 489 live births, two stillbirths (one in Hiri, one in Karkar) and two neonatal deaths (both in Asaro). Both stillbirths occurred following births at home – infants were born at full-term. One neonatal death occurred following a birth at home, and one occurred in hospital following a cord prolapse.

Birthweights were available for 70% (340/489) of all live births. Among these 340 infants, 14% (46/340) were of low birthweight (LBW), weighing less than 2.5 kg at birth. The highest proportion of LBW was seen in Karkar (17%; 20/116) (Table 5). Only one infant was born very prematurely, at less than six months. Born at home, in Hiri, the 1.1 kg infant was transferred to the Special Care Baby Unit at the hospital with fever and breathing difficulties, where he made a good recovery.

TABLE 4

PLACE OF BIRTH AND PARITY/AGE/EDUCATION LEVEL

	Health Facility Births (N = 312)								Home/Community Births (N = 170)								
	Hiri N = 118		Karkar N = 118		Asaro N = 76		All sites N = 312		Hiri N = 55		Karkar N = 86		Asaro N = 29		All sites N = 170		OR (95% CI) p value
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
Parity																	
Primiparous	41	34.7	42	35.6	19	25.0	102	32.7	10	18.2	17	19.8	2	6.9	29	17.1	2.36 (1.48-3.76) p <0.001
Multiparous	77	65.3	76	64.4	57	75.0	210	67.3	45	81.8	69	80.2	27	93.1	141	82.9	
Age					N = 67		N = 303				N = 83		N = 24		N = 162		
15-24 years	45	38.1	47	39.8	25	37.3	117	38.6	15	27.3	18	21.7	4	16.7	37	22.8	2.12 (1.37-3.27) p <0.001
25-34 years	61	51.7	48	40.7	33	49.3	142	46.9	32	58.2	50	60.2	15	62.5	97	59.9	
35+ years	12	10.2	23	19.5	9	13.4	44	14.5	8	14.5	15	18.1	5	20.8	28	17.3	
Not known					(9)		(9)				(3)		(5)		(8)		
Education level																	
No education	1	0.8	1	0.8	8	10.5	10	3.2	0	-	1	1.2	6	20.7	7	4.1	2.92 (1.87-4.56) p <0.001
Grade 1-4	4	3.4	7	5.9	21	27.6	32	10.3	1	1.8	16	18.6	13	44.8	30	17.6	
Grade 5-8	36	30.5	73	61.9	35	46.1	144	46.2	30	54.5	62	72.1	9	31.0	101	59.4	
Grade 9-12	71	60.2	32	27.1	12	15.8	115	36.9	23	41.8	7	8.1	1	3.4	31	18.2	
Tertiary/ University	6	5.1	5	4.2	0	-	11	3.5	1	1.8	0	-	0	-	1	0.6	

TABLE 5

LAST BORN INFANT (N = 489 LIVE BIRTHS)

		Hiri N = 173		Karkar N = 197		Asaro N = 105		All sites N = 475	
		n	%	n	%	n	%	n	%
Gestation at birth (N = 475)	6-8 months[a]	16	9.2	11	5.6	9	8.6	36	7.6
	8-9 months	151	87.3	170	86.3	91	86.7	412	86.7
	>9 months	6	3.5	16	8.1	5	4.8	27	5.7
		Hiri N = 165		**Karkar N = 116**		**Asaro N = 59**		**All sites N = 340**	
		n	%	n	%	n	%	n	%
Birthweight[b] (N = 340)	<2.5 kg	19[c]	11.5	20[c]	17.2	7[c]	11.9	46	13.5
	2.5-3.0 kg	77	46.7	57[c]	49.1	14	23.7	148	43.5
	3.0-3.5 kg	52	31.5	29	25.0	21	35.6	102	30.0
	3.5-4 kg	14	8.5	7	6.0	11	18.6	32	9.4
	>4 kg	3	1.8	3	2.6	6	10.2	12	3.5
		Hiri N = 163		**Karkar N = 191**		**Asaro N = 101**		**All sites N = 455**	
		n	%	n	%	n	%	n	%
Breastfeeding (N = 455)	Immediately	113	69.3	86	45.0	23	22.8	222	48.8
	1-2 hours	14	8.6	66	34.6	53	52.5	133	29.2
	2-6 hours	17	10.4	27	14.1	15	14.9	59	13.0
	6-12 hours	4	2.5	5	2.6	5	4.9	14	3.1
	>12 hours	15	9.2	7	3.7	5	4.9	27	5.9

[a] includes one infant in Hiri born at less than 6 months
[b] birthweight is based on all live births, including twin births
[c] includes one set of twins in each field

The majority of women (93%; 455/489) breastfed their infant, among whom 49% (222/455) breastfed immediately following the birth (Table 5). There was no significant association between immediate breastfeeding and location of birth (health facility compared with home birth; data not shown).

Among all infants born in a health facility, most women (81%; 252/312) could recall either Acriflavin or gentian violet paint being applied to the umbilical stump (data not shown). For infants born at home, women were asked about cord care practices, including cord cutting and care of the umbilical cord stump. The majority of women (83%; 128/155) reported that a clean razor blade was used to cut the cord (Table 6). Only 25% (42/170) of women reported applying anything to the umbilical stump to prevent infection; the majority cleaned the umbilical stump with hot or cold water, or applied breastmilk. Among all infants born in the community, 77% (131/170) were bathed immediately or within two hours following their birth (data not shown).

Danger signs in newborn infants

Among all women, 60% (291/482) stated that they knew any danger signs in a newborn infant, of whom 79% (231/291) knew two or more danger signs (Table 7). Fever/'hot skin' was the most frequently mentioned danger sign (81%; 236/291) followed by 'crying too much' (68%; 199/291) (Figure 1). Knowledge of danger signs in the newborn was significantly associated with women who had given birth in a health facility (67%; 208/312), compared with women who gave birth in the village (49%; 83/170) (OR 2.09, 95% CI: 1.43-3.07; p <0.001); multiparous women (64%; 223/351), compared with primiparous women (52%; 68/131) (OR 1.61, 95% CI: 1.07-2.42; p = 0.026); and women with secondary education (74%; 117/158), compared with women with none or only primary education (54%; 174/324) (OR 2.46, 95% CI: 1.62-3.74; p <0.001) (Table 7).

Discussion

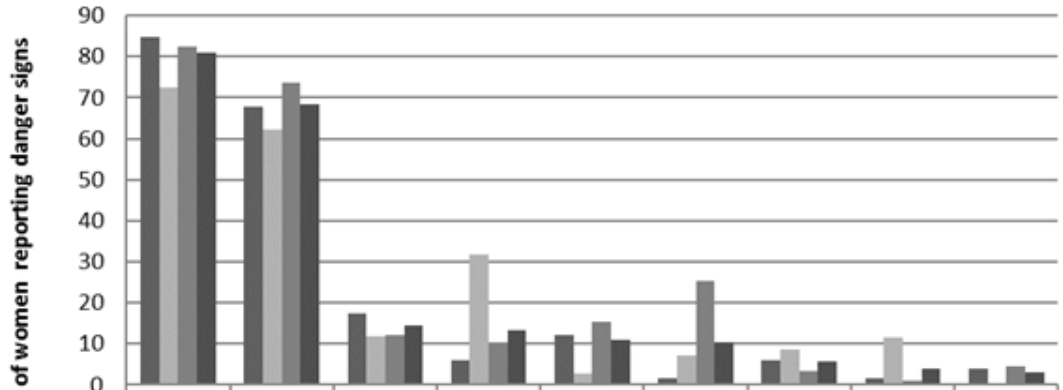
The majority of women who participated in this survey had attended for antenatal care at least once during their pregnancy, but only two-thirds had a health facility birth. Primiparous, younger women (15-24 years) and those with secondary education were significantly more likely to attend for a health facility birth than multiparous women, those aged 25 years and over and women with only primary education. Women who gave birth in a health facility did not always give birth with a trained attendant health care worker. More than half of the women who gave birth in the community did not choose to do so, but were left with no alternative due to lack of money or transport or because labour progressed too quickly to reach a facility in time, or a

TABLE 6

Cord-cutting instrument, home births (N = 170)

	Hiri N = 49		Karkar N = 78		Asaro N = 28		All sites N = 155*	
	n	%	n	%	n	%	n	%
Clean razor blade	41	83.7	68	87.2	19	67.9	128	82.6
Dirty (used) razor blade	1	2.0	3	3.8	0	-	4	2.6
Scissors	5	10.2	3	3.8	5	17.9	13	8.4
Scalpel (surgical) blade	2	4.1	2	2.6	0	-	4	2.6
Knife	0	-	0	-	2	7.1	2	1.3
Sharpened bamboo	0	-	2	2.6	2	7.1	4	2.6

*The instrument used was not known in 15 cases



	Fever	Crying too much	Too sleepy	Not sucking properly	Diarrhoea	Breathing problems	Yellow skin	Born too small	Red umbilicus
Hiri (%)	84.7	67.9	17.5	6.1	12.2	1.5	6.1	1.5	3.8
Karkar (%)	72.4	62.3	11.9	31.9	2.9	7.2	8.7	11.6	0
Asaro (%)	82.4	73.6	12.1	9.9	15.4	25.3	3.3	1.1	4.4
All sites (%)	81.1	68.4	14.4	13.4	11	10.3	5.8	3.8	3.1

Figure 1. Knowledge of newborn danger signs, by site (N = 291).

combination of these reasons.

Of the four women who reported adverse perinatal outcomes, the two stillbirths and one early neonatal death occurred following giving birth in the community. Due to the nature of this survey we were not able to probe as to what may have happened during the labour, or to try and identify a cause for these perinatal deaths. The one infant who died in hospital did so following a complicated birth. Among all live-born infants, most women initiated breastfeeding within the first two hours following birth; the majority of infants born in the community were also bathed within this time frame. While infants born in hospital received management to prevent umbilical cord infection, the majority of infants born in the community received no specific cord care.

Globally, around 82% of women attend antenatal care at least once during each pregnancy and 68% of women give birth with a skilled health worker (2). However, there is variation both within countries and across regions, with rates of 74% and 47% for one antenatal visit and supervised births, respectively, in the least developed countries (2). Similar to other settings, in PNG the proportion of women who attend for antenatal care is typically higher than for a supervised birth (2,16). In 2013, the year this survey was designed, 64% of women in PNG attended antenatal clinic at least once and 43% of women gave birth in a health facility, according to national health information systems data (16). In each of the three provinces where our survey was conducted, a similar trend was noted: uptake of antenatal care was 59%, 61% and 53% in Central, Eastern Highlands and Madang provinces, respectively; and attendance for supervised births was 29%, 33% and 31% respectively (16). In our study we identified much higher rates than either the national or provincial figures, with 95% of women reporting antenatal care and 65% reporting health facility births. Similarly, the PNG 2006 demographic and health survey reports higher rates of women attending for antenatal care (78%) and supervised births (53%) than was recorded in the national health information system at that time (60% and 37%, respectively, for antenatal care and supervised births) (17,18). The high rates reported from the women in our study may be due to recall bias, selection bias, geographical access to a health facility, advice relating to the importance of a health facility birth, as reported by women in Asaro (24), or may be due to ongoing surveillance in the study sites. The higher rates of health facility births in our study may also reflect attendance at antenatal clinic, as described from earlier work in Wosera, East Sepik Province (25),

TABLE 7

KNOWLEDGE OF DANGER SIGNS IN NEWBORNS BY PARITY, LOCATION OF BIRTH AND LEVEL OF EDUCATION

	Hiri N = 173		Karkar N = 204		Asaro N = 105		All sites N = 482		OR (95% CI) p value
	n	%	n	%	n	%	n	%	
Knew any danger signs	**131**	75.7	**69**	33.8	**91**	86.7	**291**	60.4	
Knew two or more danger signs	75	57.3	62	89.9	79	85.9	231	79.4	
Parity:									
Multiparous	95	72.5	56	81.2	72	79.1	223	76.6	1.61 (1.07-2.42) p = 0.026
Primiparous	36	27.5	13	18.8	19	20.9	68	23.4	
Location of birth:									
Health facility birth	91	69.5	52	75.4	65	71.4	208	71.5	2.09 (1.43-3.07) p <0.001
Village birth	40	30.5	17	24.6	26	28.6	83	28.5	
Education level:									
None/primary education (N = 324)	48	36.6	48	69.6	78	85.7	174	59.8	2.46 (1.62-3.74) p <0.001
Secondary or tertiary (N = 158)	83	63.4	21	30.4	13	14.3	117	40.2	

where the importance of antenatal care was identified as a predictor for health facility births. Of concern in our study was that 12% of women who gave birth in a health facility did so without the support of a trained health care worker.

In our earlier work from another setting in PNG, we identified that although women understand the importance of antenatal care and health facility births, accessing these services, particularly during labour and at night, can be problematic (22). Lack of transport, financial constraints, rapid progress of labour, and labour that begins overnight are reported from both PNG and other low-income settings as barriers to a health facility birth (6,22,26-29). Gabrysch and Campbell (30) describe a number of factors associated with health facility births, with primigravid women, those with formal education and women with some health knowledge being more likely to attend for a health facility birth, similar to the findings in our study. Women's reasons for choosing to give birth at home are similar to those reported elsewhere, both in PNG and in other settings (8,22,23,31,32). However, of interest was that women did not report decision-making by a relative as a deterrent to them attending for a health facility birth. The importance of a health facility birth for all women, regardless of their parity, should be emphasized at every opportunity during the antenatal period to promote improved maternal and newborn health outcomes.

Whether a child is born in the community or in a health facility setting, three essential

practices have been identified to reduce newborn morbidity and mortality: thermal care (immediate drying, warming, skin-to-skin contact and delayed bathing); early breastfeeding (within an hour of birth); and clean cord cutting and cord care (33). Such practices are promoted in PNG through the PNG public health policies (34). While the majority of women in our study reported breastfeeding their infants, only 49% did so within the first hour after birth. Those not breastfed within this time frame are at increased risk of all-cause neonatal mortality, especially those born with LBW (35). Furthermore, infants born in the community were placed at further risk due to poor thermal care, with two-thirds of infants bathed within two hours of their birth. By drying babies immediately following the birth and placing the infant in skin-to-skin contact with the mother, promotion of early breastfeeding, together with thermal regulation, may easily be achieved in any setting.

The practice of dry umbilical care (keeping the cord clean and dry, without the application of anything) has been advocated by the World Health Organization for almost two decades (36). However, in unhygienic situations and where infection rates are high, the use of topical antiseptics is recommended (36), with 4% chlorhexidine solution the antiseptic of choice (37). Applied to the umbilical stump within 24 hours following the birth, 4% chlorhexidine has also been shown to reduce all-cause newborn mortality (38), particularly in the community setting (39). However, in this study, 81% of infants born in a health facility had either Acriflavin or gentian violet applied to the umbilical cord, which is still national policy (34). Currently 4% chlorhexidine remains unavailable in PNG. Infants born in the community were left vulnerable to infection not only because of the cord being cut with unclean instruments but also because of the lack of any antibacterial agent being applied to the umbilical stump.

Knowledge of danger signs in newborn infants at the household level is critical to prevent delays in initiating seeking of care at a health facility (40). Among women in our study who knew any danger signs in newborn infants, the majority knew two or more. Women who reported knowing danger signs were more likely to have given birth in a health facility, to have attended secondary school and to be multiparous. These findings are similar to those identified elsewhere, including the recognition of fever as a key danger sign in newborn infants (40). Of interest in our study was that women in Karkar, the setting with the highest proportion of LBW infants, were most likely to report being born too small as a danger sign in newborn infants (Figure 1). Given the high neonatal mortality rate in PNG, with 24 newborn deaths per 1000 live births (2), the promotion of essential newborn care practices, as outlined in national policy, needs to be heeded and extended to the community level, ensuring that all women have the best opportunity to recognize and seek care for sick newborn infants. Given the uptake of antenatal care, this could be an ideal opportunity to promote care of the newborn infant and to educate women of the importance of attending for postnatal care following a birth in the community.

This cross-sectional survey collected self-reported data relating to women's last birth experience. However, we did not review women's hand-held records to corroborate these self-reports. We attempted to limit recall bias from self-reports by interviewing women who had given birth recently (which we defined as within the previous two years).

Conclusion

The majority of women in this study attended for antenatal care during their most recent pregnancy, but uptake of services for a health facility birth was utilized less frequently. There is a need for health care workers to use the opportunity of the antenatal clinic to provide women with information and knowledge not only on the importance of attending for a health facility birth, but also on the importance of planning and seeking transfer to the health facility early. In addition, health care workers need to provide a safe and supportive environment, ensuring that women feel cared for and confident in the care they receive at the health facility. Given the uptake of antenatal care, this could be an ideal opportunity to promote care of the newborn infant and to educate women of the importance of attending for postnatal care following a birth in the community.

ACKNOWLEDGEMENTS

We acknowledge all the women who willingly shared their time and personal stories and, for their support in data collection at the

field sites, Mrs Nita Otoa, Mrs Jenny Timaus, Ms Henny Andaken and members of the Partnership in Health Project Demographic Surveillance Team. We thank Mrs Yalum Siba for assistance in reviewing survey forms in Karkar, Ms Tess Aga, Data Manager, for providing the final dataset, and the data entry and management staff from the Partnership in Health Program team. This study was funded by a Partnership in Health Program grant from Esso Highlands Limited, an ExxonMobil subsidiary.

REFERENCES

1 **Darmstadt GL, Lee AC, Cousens S, Sibley L, Bhutta ZA, Donnay F, Osrin D, Bang A, Kumar V, Wall SN, Baqui A, Lawn JE.** 60 million non-facility births: who can deliver in community settings to reduce intrapartum-related deaths? *Int J Gynaecol Obstet* 2009;107(Suppl 1):S89-S112.

2 **United Nations Children's Fund.** The State of the World's Children 2015. Reimagine the future: innovation for every child. New York: UNICEF, Nov 2014.

3 **World Health Organization, United Nations Population Fund, United Nations Children's Fund, World Bank.** Reduction of maternal mortality. A joint WHO/UNFPA/UNICEF/World Bank statement. Geneva: World Health Organization, 1999.

4 **World Health Organization.** Making pregnancy safer: the critical role of the skilled attendant. A joint statement by WHO, International Confederation of Midwives (ICM) and International Federation of Gynaecology and Obstetrics (FIGO). Geneva: World Health Organization, 2004.

5 **Thaddeus S, Maine D.** Too far to walk: maternal mortality in context. *Soc Sci Med* 1994;38:1091-1110.

6 **Sychareun V, Hansana V, Somphet V, Xayavong S, Phengsavanh A, Popenoe R.** Reasons rural Laotians choose home deliveries over delivery at health facilities: a qualitative study. *BMC Pregnancy Childbirth* 2012;12:86.

7 **Allendorf K.** Couples' reports of women's autonomy and health-care use in Nepal. *Stud Fam Plann* 2007;38:35-46.

8 **Beegle K, Frankenberg E, Thomas D.** Bargaining power within couples and use of prenatal and delivery care in Indonesia. *Stud Fam Plann* 2001;32:130-146.

9 **Mrisho M, Schellenberg JA, Mushi AK, Obrist B, Mshinda H, Tanner M, Schellenberg D.** Factors affecting home delivery in rural Tanzania. *Trop Med Int Health* 2007;12:862-872.

10 **Seljeskog L, Sundby J, Chimango J.** Factors influencing women's choice of place of delivery in rural Malawi – an explorative study. *Afr J Reprod Health* 2006;10:66-75.

11 **Danforth EJ, Kruk ME, Rockers PC, Mbaruku G, Galea S.** Household decision-making about delivery in health facilities: evidence from Tanzania. *J Health Popul Nutr* 2009;27:696-703.

12 **Magoma M, Requejo JH, Campbell OM, Cousens S, Filippi V.** High ANC coverage and low skilled attendance in a rural Tanzanian district: a case for implementing a birth plan intervention. *BMC Pregnancy Childbirth* 2010;10:13.

13 **Koblinsky M, Matthews Z, Hussein J, Mavalankar D, Mridha MK, Anwar I, Achadi E, Adjei S, Padmanabhan P, Marchal B, De Brouwere V, van Lerberghe W; Lancet Maternal Survival Series Steering Group.** Going to scale with professional skilled care. *Lancet* 2006;368:1377-1386.

14 **Miller S, Lester F, Hensleigh P.** Prevention and treatment of postpartum hemorrhage: new advances for low-resource settings. *J Midwifery Womens Health* 2004;49:283-292.

15 **Karoshi M, Keith L.** Challenges in managing postpartum hemorrhage in resource-poor countries. *Clin Obstet Gynecol* 2009;52:285-298.

16 **Papua New Guinea National Department of Health.** National Health Information System: Sector Performance Annual Review 2013. Port Moresby: National Department of Health, 2014.

17 **National Statistics Office of Papua New Guinea.** Demographic Health Survey of Papua New Guinea 2006. Port Moresby: Population and Social Statistics Division, National Statistics Office, 2009.

18 **Papua New Guinea National Department of Health.** Ministerial Taskforce on Maternal Health in Papua New Guinea. Port Moresby: National Department of Health, May 2009.

19 **Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, Shackelford KA, Steiner C, Heuton KR, Gonzalez-Medina D, Barber R, Huynh C, Dicker D, Templin T, Wolock TM, Ozgoren AA, Abd-Allah F, Abera SF, Abubakar I, Achoki T, Adelekan A, Ademi Z, Adou AK, Adsuar JC, Agardh EE, Akena D, Alasfoor D, Alemu ZA, Alfonso-Cristancho R, Alhabib S, Ali R, Al Kahbouri MJ, Alla F, Allen PJ, AlMazroa MA, Alsharif U, Alvarez E, Alvis-Guzmán N, Amankwaa AA, Amare AT, Amini H, Ammar W, Antonio CA, Anwari P, Arnlöv J, Arsenijevic VS, Artaman A, Asad MM, Asghar RJ, Assadi R, Atkins LS, Badawi A, Balakrishnan K, Basu A, Basu S, Beardsley J, Bedi N, Bekele T, Bell ML, Bernabe E, Beyene TJ, Bhutta Z, Bin Abdulhak A, Blore JD, Basara BB, Bose D, Breitborde N, Cárdenas R, Castañeda-Orjuela CA, Castro RE, Catalá-López F, Cavlin A, Chang JC, Che X, Christophi CA, Chugh SS, Cirillo M, Colquhoun SM, Cooper LT, Cooper C, da Costa Leite I, Dandona L, Dandona R, Davis A, Dayama A, Degenhardt L, De Leo D, del Pozo-Cruz B, Deribe K, Dessalegn M, deVeber GA, Dharmaratne SD, Dilmen U, Ding EL, Dorrington RE, Driscoll TR, Ermakov SP, Esteghamati A, Faraon EJ, Farzadfar F, Felicio MM, Fereshtehnejad SM, de Lima GM, Forouzanfar MH, França EB, Gaffikin L, Gambashidze K, Gankpé FG, Garcia AC, Geleijnse JM, Gibney KB, Giroud M, Glaser EL, Goginashvili K, Gona P, González-Castell D, Goto A, Gouda HN, Gugnani HC, Gupta R, Gupta R, Hafezi-Nejad N, Hamadeh RR, Hammami M, Hankey GJ, Harb HL, Havmoeller R, Hay SI, Pi IB, Hoek HW, Hosgood HD, Hoy DG, Husseini A, Idrisov BT, Innos K, Inoue M, Jacobsen KH, Jahangir E, Jee SH, Jensen PN, Jha V, Jiang G, Jonas JB, Juel K, Kabagambe EK, Kan H, Karam NE, Karch A, Karema CK, Kaul A, Kawakami N, Kazanjan K, Kazi DS, Kemp AH, Kengne AP, Kereselidze M, Khader YS, Khalifa SE, Khan EA, Khang YH, Knibbs L, Kokubo Y, Kosen S, Defo BK, Kulkarni C, Kulkarni VS, Kumar GA, Kumar K, Kumar RB, Kwan G, Lai T, Lalloo R, Lam H, Lansingh VC, Larsson A, Lee JT, Leigh J, Leinsalu M, Leung R, Li X, Li Y, Li Y, Liang J, Liang X, Lim SS, Lin HH, Lipshultz SE, Liu S, Liu Y, Lloyd BK, London SJ, Lotufo PA, Ma J, Ma S, Machado VM, Mainoo NK, Majdan M, Mapoma CC, Marcenes W, Marzan MB, Mason-Jones AJ, Mehndiratta MM, Mejia-Rodriguez F, Memish ZA,

Mendoza W, Miller TR, Mills EJ, Mokdad AH, Mola GL, Monasta L, de la Cruz Monis J, Hernandez JC, Moore AR, Moradi-Lakeh M, Mori R, Mueller UO, Mukaigawara M, Naheed A, Naidoo KS, Nand D, Nangia V, Nash D, Nejjari C, Nelson RG, Neupane SP, Newton CR, Ng M, Nieuwenhuijsen MJ, Nisar MI, Nolte S, Norheim OF, Nyakarahuka L, Oh IH, Ohkubo T, Olusanya BO, Omer SB, Opio JN, Orisakwe OE, Pandian JD, Papachristou C, Park JH, Caicedo AJ, Patten SB, Paul VK, Pavlin BI, Pearce N, Pereira DM, Pesudovs K, Petzold M, Poenaru D, Polanczyk GV, Polinder S, Pope D, Pourmalek F, Qato D, Quistberg DA, Rafay A, Rahimi K, Rahimi-Movaghar V, ur Rahman S, Raju M, Rana SM, Refaat A, Ronfani L, Roy N, Pimienta TG, Sahraian MA, Salomon JA, Sampson U, Santos IS, Sawhney M, Sayinzoga F, Schneider IJ, Schumacher A, Schwebel DC, Seedat S, Sepanlou SG, Servan-Mori EE, Shakh-Nazarova M, Sheikhbahaei S, Shibuya K, Shin HH, Shiue I, Sigfusdottir ID, Silberberg DH, Silva AP, Singh JA, Skirbekk V, Sliwa K, Soshnikov SS, Sposato LA, Sreeramareddy CT, Stroumpoulis K, Sturua L, Sykes BL, Tabb KM, Talongwa RT, Tan F, Teixeira CM, Tenkorang EY, Terkawi AS, Thorne-Lyman AL, Tirschwell DL, Towbin JA, Tran BX, Tsilimbaris M, Uchendu US, Ukwaja KN, Undurraga EA, Uzun SB, Vallely AJ, van Gool CH, Vasankari TJ, Vavilala MS, Venketasubramanian N, Villalpando S, Violante FS, Vlassov VV, Vos T, Waller S, Wang H, Wang L, Wang X, Wang Y, Weichenthal S, Weiderpass E, Weintraub RG, Westerman R, Wilkinson JD, Woldeyohannes SM, Wong JQ, Wordofa MA, Xu G, Yang YC, Yano Y, Yentur GK, Yip P, Yonemoto N, Yoon SJ, Younis MZ, Yu C, Jin KY, El Sayed Zaki M, Zhao Y, Zheng Y, Zhou M, Zhu J, Zou XN, Lopez AD, Naghavi M, Murray CJ, Lozano R. Global, regional, and national levels and causes of maternal mortality during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014;384:980-1004.

20 **Whittaker M, Piliwas L, Agale J, Yaipupu J.** Beyond the numbers: Papua New Guinean perspectives on the major health conditions and programs of the country. *PNG Med J* 2009;52:96-113.

21 **Vallely LM, Homiehombo P, Kelly AM, Vallely A, Homer CSE, Whittaker A.** Exploring women's perspectives of access to care during pregnancy and childbirth: a qualitative study from rural Papua New Guinea. *Midwifery* 2013;29:1222-1229.

22 **Andrew EV, Pell C, Angwin A, Auwun A, Daniels J, Mueller I, Phuanukoonnon S, Pool R.** Factors affecting attendance at and timing of formal antenatal care: results from a qualitative study in Madang, Papua New Guinea. *PLoS One* 2014;9:e93025.

23 **Nguyen Pham B, Maraga S, Kumai J, Kue L, Emori R, Boli R, Brown N, Aga T, Jonny R, Degemba B, Sie A, Siba P.** Partnership in Health Project Progress Report. Reporting period: January-June 2015. Goroka: Papua New Guinea Institute of Medical Research, Sep 2015. www.pngimr.org.pg/research%20publications/PNG%20IMR%20PiHP%20September%202015%20Report%20FINAL.pdf

24 **Emori R, Vallely AJ, Gouda H, Siba P, Phuanukoonnon S, Mola G, Homer CSE, Vallely LM.** Women's recall of provision of antenatal care in Papua New Guinea: findings of a maternal and infant health survey conducted in three provinces. *PNG Med J* 2017;60:15-26.

25 **Maraga S, Namosha E, Gouda H, Vallely L, Rare L, Phuanukoonnon S.** Sociodemographic factors associated with maternal health care utilization in Wosera, East Sepik Province, Papua New Guinea. *PNG Med J* 2011;54:154-163.

26 **Shaikh BT, Hatcher J.** Health seeking behaviour and health service utilization in Pakistan: challenging the policy makers. *J Public Health (Oxf)* 2005;27:49-54.

27 **Amooti-Kaguna B, Nuwaha F.** Factors influencing choice of delivery sites in Rakai district of Uganda. *Soc Sci Med* 2000;50:203-213.

28 **Titaley CR, Hunter CL, Dibley MJ, Heywood P.** Why do some women still prefer traditional birth attendants and home delivery?: a qualitative study on delivery care services in West Java Province, Indonesia. *BMC Pregnancy Childbirth* 2010;10:43-61.

29 **Sreeramareddy CT, Joshi HS, Sreekumaran BV, Giri S, Chuni N.** Home delivery and newborn care practices among urban women in western Nepal: a questionnaire survey. *BMC Pregnancy Childbirth* 2006;6:27.

30 **Gabrysch S, Campbell OM.** Still too far to walk: literature review of the determinants of delivery service use. *BMC Pregnancy Childbirth* 2009;9:34.

31 **Gao Y, Barclay L, Kildea S, Hao M, Belton S.** Barriers to increasing hospital birth rates in rural Shanxi Province, China. *Reprod Health Matters* 2010;18:35-45.

32 **Some TD, Sombie I, Meda N.** Women's perceptions of homebirths in two rural medical districts in Burkina Faso: a qualitative study. *Reprod Health* 2011;8:3.

33 **Lassi ZS, Kumar R, Mansoor T, Salam RA, Das JK, Bhutta ZA.** Essential interventions: implementation strategies and proposed packages of care. *Reprod Health* 2014;11(Suppl 1):S5.

34 **Papua New Guinea National Department of Health.** Public Health Policies, Volume 1. Port Moresby: National Department of Health, 2014.

35 **Debes AK, Kohli A, Walker N, Mullany LC.** Time to initiation of breastfeeding and neonatal mortality and morbidity: a systematic review. *BMC Public Health* 2013;13(Suppl 3):S19.

36 **World Health Organization.** Care of the umbilical cord. Maternal and newborn health, safe motherhood. Geneva: World Health Organization, 1998.

37 **Karumbi J, Mulaku M, Aluvaala J, English M, Opiyo N.** Topical umbilical cord care for prevention of infection and neonatal mortality. *Pediatr Infect Dis J* 2013;32:78-83.

38 **Blencowe H, Cousens S, Mullany LC, Lee AC, Kerber K, Wall S, Darmstadt GL, Lawn JE.** Clean birth and postnatal care practices to reduce neonatal deaths from sepsis and tetanus: a systematic review and Delphi estimation of mortality effect. *BMC Public Health* 2011;11(Suppl 3):S11.

39 **Sinha A, Sazawal S, Pradhan A, Ramji S, Opiyo N.** Chlorhexidine skin or cord care for prevention of mortality and infections in neonates. *Cochrane Database Syst Rev* 2015;3:Cd007835.

40 **Ekwochi U, Ndu IK, Osuorah CD, Amadi OF, Okeke IB, Obuoha E, Onah KS, Nwokoye I, Odetunde OI, Obumneme-Anyim NI.** Knowledge of danger signs in newborns and health seeking practices of mothers and care givers in Enugu state, South-East Nigeria. *Ital J Pediatr* 2015;41:18.

PNG Med J 2017 Mar-Jun;60(1-2):41-50

Forty years of postgraduate medical training at the University of Papua New Guinea

John D. Vince[1]

School of Medicine and Health Sciences, University of Papua New Guinea, Port Moresby

SUMMARY

BACKGROUND: Forty years after the first postgraduate diplomates (in child health and obstetrics & gynaecology) graduated in 1976 it is appropriate to track the development of postgraduate training and to assess training outcomes. METHODOLOGY: Data were extracted from graduation documents from 1976 and were checked with senior academic staff and with the current postgraduate lists. RESULTS: Postgraduate diploma programs in anaesthesiology, ophthalmology and otorhinolaryngology followed those in child health and obstetrics & gynaecology. The first home-grown specialists in surgery and child health graduated in 1979 and the MMed program is now offered across the spectrum of medical disciplines with the exception of cancer medicine. Of the 344 postgraduate diplomates, a third have been females and 41 (12%) have been Pacific islanders. 166 (48%) have completed MMed and 56 (16%) are currently in the MMed programs. Since 1979, 378 specialists have graduated with the MMed and 3 with the MDS, of whom 21 (6%) have died and 2 have retired on medical grounds. 74 (19%) of the specialists are female and 40 (10%) are Pacific islanders. Of the 322 living Papua New Guinean (PNG) national specialists currently working 70 (22%) are female, 23 (7%) are currently based overseas, 30 (9%) are working in the private sector and 9 (3%) are no longer working in the medical arena. 260 (81%) are in the public sector, 240 (75%) in the clinical area and 20 (6%) in the administrative area. 22 surgical specialists and 1 anaesthesiologist have completed subspecialty training through the Higher Postgraduate Diploma programs. Other disciplines will follow suit. 12 PNG doctors have obtained overseas Fellowships or Membership of their specialty Royal College. Only 3 are currently based in Papua New Guinea. Master's programs in community health and public health (27 graduates) were introduced in 1987, medical science (16 graduates) in 2006 and pharmacy (3 graduates) in 2012. CONCLUSION: The postgraduate programs at the School of Medicine and Health Sciences of the University of Papua New Guinea have been highly successful in training clinical specialists for Papua New Guinea and Pacific island countries, and in producing a core of the health workforce with Master's degrees in public health, medical sciences and pharmacy. Loss of the specialist workforce overseas has been relatively small.

Introduction

2016 is the 40th anniversary of the first candidates' graduation from a University of Papua New Guinea (UPNG) postgraduate program and provides an opportunity for an assessment of the outcome of the postgraduate programs.

The first Papua New Guinean medical officers graduated from the University of the South Pacific in Fiji between 1951 and 1963. The first intake of medical students to the Papua New Guinea (PNG) Medical College was in 1960 and, by 1970, 36 national doctors had graduated (1). Several of these graduates spent time overseas and at least two obtained diplomas from the London School of Hygiene and Tropical Medicine. The University of Papua New Guinea established

1 School of Medicine and Health Sciences, University of Papua New Guinea, PO Box 5623, Boroko, National Capital District, Papua New Guinea
johndvince@gmail.com

degree courses in 1967 with the first intake of medical students in 1969 (2). Between 1973 and 1989, 224 Papua New Guinean doctors graduated from the then Faculty of Medicine (3). The need for specialist training was recognized at an early stage but opinions as to how this should be done varied. One view was that "a fixed proportion of the graduates from each year must as a matter of urgency be sent abroad for training, and as soon after qualification as possible" (4). Aware of the likelihood of a 'brain drain' with this approach (as had happened in Fiji and some of the African and Asian countries), others in the Faculty of Medicine felt that the best way to train specialists and to retain them in Papua New Guinea was to introduce postgraduate training programs based in the country. The University of Singapore had established its own MMed, which at the time was gaining credibility, and Prof Ian Maddocks, Foundation Dean of the Faculty of Medicine, first proposed the idea of establishing an MMed at UPNG in the early 1970s. He was supported in this by Dr Michael Price (Internal Medicine), Dr John Biddulph (Paediatrics), Dr Ken Clezy (Surgery) and others. The topic was included in the focus issue of the Papua New Guinea Medical Journal in 1979 dealing with the delivery of health care in Papua New Guinea and was hotly debated at the Medical Symposium of 1980. Proponents included Prof. Biddulph: "…there were no mental hang ups that the postgraduate should waste his time pursuing a membership examination. Time wasting because the examination was geared to the needs of an entirely different society and heavily weighted towards the adult hospital medicine of affluent countries" (5). Proponents with provisos included Dr John Garap: "Training of candidates should include time (at least 2 years) outside of Papua New Guinea" and "Candidates completing the M.M. should be provided the opportunity to gain the equivalent or better foreign qualification in the specialty after a period of service" (6). Opponents included Prof. Gordon Cook: "The M.Med. programme has been introduced far too early in PNG; only when there is a nucleus of well trained doctors in the various disciplines and specialties will it be possible to successfully mount such a programme" (4) and "Without an apex to the pyramid in the medical profession there will inevitably be country-wide mediocrity, clinical medicine will degenerate still further, the masses will be poorly treated because no one will be adequately trained to treat them from either preventive or curative viewpoints and PNG will inevitably continue to employ expensive expatriates and/or send patients overseas for treatment." (7).

The diplomas in obstetrics & gynaecology and in child health were the first UPNG postgraduate programs to be established, with the first graduates in 1976. Diplomas in ophthalmology, anaesthesiology and otorhinolaryngology were introduced in the next 15 years. In these disciplines success in the diploma was a requisite to continue into the MMed program. The first Master of Medicine (MMed) candidates – in surgery and child health – graduated in 1979. By 1983 there were 3 UPNG MBBS graduates who had qualified with MMed, with 27 in the various postgraduate training programs (8). MMed programs in internal medicine, ophthalmology, obstetrics and gynaecology, pathology and dermatology and the Master in Dental Surgery (MDS) had produced specialists by 1990, and over the next 20 years MMed programs were introduced in almost all the clinical disciplines, including emergency medicine and, most recently, rural health. An attempt to establish an MMed in radiation oncology was unsuccessful. The need for subspecialization was first proposed in the surgical division and plans initiated by Prof. Sankar Sinha, and subsequently championed and developed by Prof. David Watters, resulted in the introduction in 1994 of the Higher Postgraduate Diploma in clinical and laboratory subspecialties (9).

Master's programs in community health (1987), public health (1998) and pharmacy (2012) were also established. The Master in Medical Science was established some years before the first graduates in 2007.

This paper aims to analyse the output of the various postgraduate programs, and to put this in the context of the National Department of Health (NDoH) Hospital Standards.

Methodology

Data were extracted from the graduation lists held in the University Library and by the author and entered onto an Excel spreadsheet. Information was checked with senior academic staff and with the postgraduate lists. Current occupation of the specialists in relation to public, private, clinical and administrative areas was determined, and related to the

National Hospital Standards.

Results

The output from the postgraduate clinical diploma programs is shown in Table 1. 344 candidates had graduated up to April 2016, 109 (32%) of whom were women and 41 Pacific islanders. 166 (48%) of these graduates have subsequently succeeded in the MMed program and 56 (16%) are currently continuing their training.

Table 2 shows the output of the MMed and MDS programs from 1979 to the 2016 graduation. 378 MMed candidates and 3 MDS candidates have graduated. 21 have died and 2 retired on medical grounds. 74 (19%) are women and 40 (10%) are Pacific islanders. The outcome for PNG national specialists by discipline is indicated in Table 3 and the overall output of PNG specialists is

TABLE 1

OUTPUT OF POSTGRADUATE CLINICAL DIPLOMA PROGRAMS

Discipline	First graduate	Number of graduates	Female (%)	Pacific islands	Completed MMed	Currently in MMed
Anaesthesiology	1988	66	22 (33)	6	25	9
Child Health	1976	124	53 (43)	17*	65	25
Obstetrics and Gynaecology	1976	119	29 (24)	13**	50	18
Ophthalmology	1982	21	4 (19)	4	14	2
Otorhinolaryngology	1990	14	1 (7)	1	12	2
Total		344	109 (32)	41 (12%)	166 (48%)	56 (16%)

*plus 3 other nationalities
**plus 4 other nationalities

TABLE 2

SPECIALISTS FROM THE MMED AND MDS PROGRAMS SINCE 1979

Total	**381**
MMed	378
MDS	3
Deceased	21 (5.5%)
Retired on medical grounds	2
Females	74 (19.4%)
Pacific islanders	40 (10.5%)
Papua New Guinean national specialists	341

TABLE 3

PAPUA NEW GUINEAN SPECIALISTS IN 2016

Discipline	Year	Graduates/ Females	Died	Public	Clinical	Administration	Private	Overseas	Other
Child Health	1979	58/20	6	44	38	6	3	3	2
Surgery	1979	83/5	6	64	63	1	6	5	2
Internal Medicine	1982	55/5	2	41	37	4	6	4	2
Ophthalmology	1984	13/3	0	10	9	1	3	0	0
Obstetrics and Gynaecology	1987	44/12	2	30	27	3	6	5	1*
Pathology	1988	15/6	1	13	13	0	0	0	1
Dermatology	1990	2	0	2	2	0	0	0	0
Anaesthesiology	1992	23/7	0	19	16	3	2	2	0
Otorhinolaryngology	1993	10/1	1	7	7	0	1	1	0
Psychiatry	1994	9/4	0	8	7	1	0	0	1
Medical Imaging	2003	7/4	0	5	5	0	1	1	0
Emergency Medicine	2007	14/2	0	10	10	0	2	2	0
Rural Health	2015	5/1	0	5	4	1	0	0	0
Dental Surgery	1983	3	1	2	2	0	0	0	0
Total		341/70	19	260	240	20	30	23	9

*retired on medical grounds

shown in Table 4. 22% of the PNG specialists are women, and 81% are currently employed in the public sector (including UPNG and Church health services), 75% in clinical and 6% in administrative positions. 9% of the output is employed in the private sector, 7% are living and working overseas (in a country other than their original nationality) and 3% are not working in the medical arena (Table 4). 23 MMed candidates have subsequently graduated with the Higher Postgraduate Diploma in medical and laboratory subspecialties, 22 in surgical subspecialties and 1 in an anaesthesiology subspecialty (Table 5). The outcome of the non-clinical Master's programs is shown in Table 6. Tables 7 and 8 indicate the hospitals at which there are currently specialists by discipline.

Discussion

The data clearly vindicate the decision to establish postgraduate programs at the School of Medicine and Health Sciences. 81% of specialists trained are currently in the public sector – 75% in the clinical area. Another 9% are practising in the private sector in PNG. There has been relatively small loss to overseas countries. The programs have also contributed significantly to the development of specialist services in the Solomon Islands, Vanuatu and, more recently, East Timor. The proponents of the PNG specialty training programs felt that overseas training was an important part of the MMed (5) and up to the early 2000s the majority of postgraduates were able to spend part of their training in Australian hospitals, sometimes linked to the registrar exchange programs. These programs, which were phased out for a number of reasons, were beneficial to both Australian and PNG trainees. It has unfortunately become increasingly difficult to obtain training positions in Australia. However, there has been, and continues to be, input to postgraduate teaching at Port Moresby General Hospital and other PNG hospitals from academic staff from various hospitals in Australia. Training attachments overseas and the ongoing input from visiting specialists from Australia and other countries have ensured that PNG postgraduates are cogniscent of the practice of their specialty in a resource-rich environment and of a wide spectrum of medical conditions. The programs have been very strongly supported by the Australian Government through AusAID and the Department of Foreign Affairs

TABLE 4

PAPUA NEW GUINEAN MMED/MDS GRADUATES' EMPLOYMENT IN 2016

Graduates*	**322 (%)**
Females	70 (22)
Public	260 (81)
Clinical	240 (75)
Administration	20 (6)
Private	30 (9)
Overseas	23 (7)
Other	9 (3)

*The numbers in Table 3 less those who had died

TABLE 5

Higher Postgraduate Diploma subspecialty graduates

Subspecialty	Number
Head and Neck (Plastic)	3
Orthopaedic Surgery	8*
Urology	3
Paediatric Surgery	4
Neurosurgery	2**
Cardiothoracic Surgery	2**
Cardiothoracic Anaesthesiology	1
Total	23

*1 overseas
**1 deceased

TABLE 6

Outcome of non-clinical Master's programs (year of graduation)

Degree	Year	Graduates	Females	Pacific islands	Deceased
M Community Health	1988	6	3	1	0
M Public Health	2000	21	5	1	2
M Medical Science	2007	16	9	0	1
M Pharmacy	2013	3	3	0	0
MD		6 (2 Hon)	0	0	2
PhD		1	0	0	0

M = Master's
MD = Doctor of Medicine; Hon = Honorary
PhD = Doctor of Philosophy

and Trade (DFAT). Crucial to the credibility of the Master's program, both within PNG and in the wider medical community, is the requirement (specified in the Degree Bylaws) to have external examiners for the MMed and MDS final examinations. These examiners are usually senior members of the various Australian colleges and medical schools, and in addition to their role as examiners, providing quality control for our MMed assessments, they provide advice on the development of the programs in the differing disciplines.

Historically, young doctors from lower- and middle-income countries with fledgling medical training institutions have seen the English (and more recently the Australian and New Zealand) College Membership and Fellowship as the marker of success in postgraduate training. This has led, as noted earlier, to a brain drain from many of these countries. A number of PNG postgraduate students, most having obtained the MMed, have obtained positions in overseas (predominantly Australian) hospitals and have attempted to obtain Fellowships of the Australian or Memberships of the United Kingdom colleges. 12 have been successful – but of these only 3 – the current Professor of Medicine, the Head of the Central Public Health Laboratory and one of the younger physicians – are currently working in PNG.

The value of the MMed and MDS should not be underestimated. The value of a degree is determined by the quality of its graduates. The Singapore MMed is now widely recognized as equivalent to the Fellowship and Membership of the Royal Colleges. It is up to our PNG specialists to prove to the world that the MMed is also a high-quality degree. Many have already done and continue to do so.

In the development of subspecialty training through the Higher Postgraduate Diploma surgery has led the way with 22 successful candidates across a range of surgical subspecialties, and anaesthesiology has followed. Plans are underway to introduce programs across all the disciplines (including intensive care medicine, obstetric and paediatric anaesthesiology, paediatric cardiology, paediatric cancer medicine and neonatal medicine). It is perhaps pertinent to point out that it was never intended that the possession of a Higher Postgraduate Diploma should absolve the holder from responsibilities in the major discipline.

In 2009 there were 145 senior specialist medical officers (SSMOs) and specialist medical officers (SMOs) (10). In the National Health Plan for 2011-2020 projected needs are for 298 although this was based on population data from 2009 (11). Currently there are 240 SSMO/SMOs in the public clinical services (Table 4).

The Hospital Standards indicate that each provincial hospital (Level 5) should have at least a physician, surgeon, obstetrician/ gynaecologist and a paediatrician, and if possible an anaesthetist, pathologist and a medical imaging specialist. Regional hospitals (Level 6) should have the complete range of specialists and the tertiary referral hospital (Level 7) should have subspecialty expertise available.

At the time of writing Port Moresby General Hospital is the only regional (and tertiary) hospital that meets the Hospital Standards (Table 7). None of the 16 public provincial hospitals is fully staffed; two have no specialists, one has one and one has two (Table 8).

Specialist training has until recently been focussed on a specialist workforce for the major hospitals. The reality, of course, is that the majority of the PNG population do not access specialist services at provincial or regional hospitals, and there is a major need to improve the care that sick and injured people receive at district hospitals. The introduction of the MMed in rural health has begun to address this issue. This rigorously assessed program produces doctors highly competent not only in the clinical area, able to deal with clinical emergencies, but also in hospital management, preventive medicine and public health and with the skills necessary to function effectively in a remote district hospital. There is an urgent need for the National Department of Health (NDoH) and the Medical Board to recognize the graduates as specialists and for the provinces to create positions for them. It will obviously not be possible to staff every district hospital with an MMed (Rural Health) specialist in the foreseeable future – but these graduates can set the standards of care for district hospitals and can provide training for junior doctors and other health workers. In relation to improving the standard of care provided in general practice (be it private or public) it is time to consider the introduction of a postgraduate qualification in family medicine

TABLE 7

Specialist staffing at regional and tertiary (Level 6 and 7) hospitals

Specialty	Port Moresby General Hosptial	Angau	Mt Hagen	Rabaul
Physician	7	3	1	1
Surgeon	10	3	3	1
Obstetrician	4	2	2	2
Child Health	7	3	2	1
Anaesthesiology	9	1	-	1
Medical Imaging	4	1	-	-
Pathology	8	1	-	-
Emergency Medicine	5	1	1	-
Psychiatry	4	2	-	-
Ophthalmology	2	1	1	2
Otorhinolaryngology	2	2	1	1
Dermatology	2	-	-	-
Total	64	20	11	9

TABLE 8

Specialist staffing at Level 5 (provincial) hospitals

Specialty	Number of hospitals (total = 16)*
Physician	11
Surgeon	13
Obstetrician	12
Child Health	11
Anaesthesiologist	1
Pathologist	1
Medical Imaging	0

*2 provinces have no specialists; 1 province has 1 specialist; and 1 province has 2 specialists

and general practice.

It is well recognized that skills and knowledge require regular updating. PNG has yet to provide a regulated Continuous Medical Education (CME) pathway, although the Medical Society Symposia and the Specialist Meetings certainly provide an important input, and the Medical Board is considering ways to regulate CME.

The success of the PNG program is mirrored in other 'indigenous' programs. Fiji established a postgraduate training program in 1997 to address the failure of most overseas-trained Pacific island specialists to return to or remain in the Pacific (12). In the first few years of the program retention in the public system in the country was lower than expected as a result of several factors, including political instability, heavy workloads and uncertainty about career benefit. More recently, with political stability and attention to other issues, including career structure and the ability to engage in limited private practice, retention has improved. As of 2010 72% of Fiji Master's graduates were working in the public sectors of their own country with 12% having migrated to a developed country. The availability of a career structure and appropriate financial recompense are key to the success of indigenous training programs. A small study from Ghana found that the presence of a postgraduate program in-country, commitment to serve their own people and a feeling that they can 'make it' financially contributed to the retention of obstetrics and gynaecology specialists (13).

As was the case with PNG, the establishment and maintenance of indigenous programs in other low- and middle-income countries requires the involvement and assistance from institutions and individuals in well-resourced countries, and the political will and support of respective governments (14,15). Collaboration between local institutions and well-resourced partner institutions in research, curriculum development and continuous medical education is important in encouraging successful postgraduate trainees to remain in their own country and for some to follow an academic career pathway (16).

The postgraduate programs in PNG have faced challenges in different disciplines at different times, relating to the availability of supervision for registrar training, but they have been successful in most disciplines for a number of reasons, including:

- the commitment and attention to detail of the instigating expatriate academic and service staff and their belief that service and teaching are both vital in training programs;
- the commitment of PNG postgraduates, particularly those who have been employed as academic staff and have successfully assumed leadership roles, but also those who as specialists have fulfilled their role as trainers in hospitals throughout PNG;
- the support of the National Department of Health;
- the initial and continuing support of overseas colleagues and institutions, particularly in Australia, who have embraced the concept of the MMed training programs and who have provided teaching and service since their inception; and
- the Australian government through its various support programs to the School of Medicine and Health Sciences.

It takes between 13 and 15 years from entry to Science Foundation Year to graduation as a Specialist Medical Officer. This means that those graduating in the 1980s are currently in their mid- to late-50s or 60s. There will therefore be a significant attrition to the specialist workforce over the next 10 years and it will be important to maintain the current output of specialists through the MMed program if the Hospital Standards are to be met. There will also be attrition to the academic staff and it is imperative that those young academics currently employed at the School are encouraged to stay and develop their careers and that recently qualified postgraduates are encouraged to join the School. This requires not only a supportive academic environment, but also conducive terms and conditions of employment.

Conclusion

Whilst it is acknowledged that the data presented in this article may not be absolutely accurate (for example, some clinicians have dual roles as administrators) it does

provide an overall picture of the outcome of the postgraduate training programs. These have been highly successful in training clinical specialists for PNG and Pacific island countries, and in producing a core of the health workforce with Master's degrees in public health, medical sciences and pharmacy. Loss of the specialist workforce overseas has been relatively small. Attrition requires a continuing output of specialists. There is a need for the development of subspecialist programs across the various disciplines, and a need to recognize the importance of specialists in rural health and to introduce a postgraduate program in family health and general practice. It is imperative that conducive terms and conditions of employment are available to recruit and retain PNG national academic staff, and it is recognized that the School will continue to need the support of overseas colleagues and institutions.

ACKNOWLEDGEMENTS

I gratefully acknowledge the help of Mrs Mary Kenpale, the first administrative assistant in the Trauma Postgraduate and Research Centre office, who did most of the initial work of retrieving graduation data. I thank my senior colleagues for checking the data and filling in gaps and Prof. Ian Maddocks for information relating to the introduction of the MMed.

REFERENCES

1 **Biddulph J.** Where have all the doctors gone? An analysis of national medical officers. *PNG Med J* 1979;22:190-199.
2 **Kevau IH, Vince JD, McPherson JV.** Tailoring medical education in Papua New Guinea to the needs of the country. *Med J Aust* 2004;181:608-610.
3 **Biddulph J.** Twenty-five years of medical graduates in Papua New Guinea. *PNG Med J* 1990;33:43-49.
4 **Cook GC.** The training of doctors and the delivery of health care in Papua New Guinea. *PNG Med J* 1979;22:163-165.
5 **Biddulph J.** Postgraduate paediatric education in Papua New Guinea. Abstract in Abstracts and Proceedings of the Sixteenth Annual Symposium of the Medical Society of Papua New Guinea, Madang, 19-21 Sep 1980:63-67.
6 **Garap J.** Medical education: post-graduate or posting graduates. Abstract in Abstracts and Proceedings of the Sixteenth Annual Symposium of the Medical Society of Papua New Guinea, Madang, 19-21 Sep 1980:74-77.
7 **Cook GC.** Post-graduate medical training in Papua New Guinea. Abstract in Abstracts and Proceedings of the Sixteenth Annual Symposium of the Medical Society of Papua New Guinea, Madang, 19-21 Sep 1980:62.
8 **Biddulph J.** Doctors in Papua New Guinea – current and future supply. *PNG Med J* 1983;26:207-211.
9 **Watters DA, Theile DE.** Progress of surgical training in Papua New Guinea to the end of the 20th century. *Aust NZ J Surg* 2000;70:302-307.
10 **Papua New Guinea Department of Health.** Resources for health: total staff by province. In: Papua New Guinea National Health Plan 2001-2010. Volume 3, Part One. Port Moresby: Department of Health, Aug 2000:22.
11 **Papua New Guinea Department of Health.** Resources for health (2001-2008): numbers of staff by province. In: Papua New Guinea National Health Plan 2011-2020. Volume 2, Part A. Port Moresby: Department of Health, Jun 2010:20.
12 **Oman K, Rodgers E, Usher K, Moulds R.** Scaling up specialist training in developing countries: lessons learned from the first 12 years of regional postgraduate training in Fiji – a case study. *Hum Resour Health* 2012;10:48.
13 **Clinton Y, Anderson FW, Kwawukume EY.** Factors related to retention of postgraduate trainees in obstetrics-gynecology at the Korle-Bu Teaching Hospital in Ghana. *Acad Med* 2010;85:1564-1570.
14 **Ganapathi L, Martins Y, Schumann D, Russ C.** Overcoming challenges to develop pediatric postgraduate training programs in low- and middle-income countries. *Educ Health (Abingdon)* 2014;27:277-282.
15 **Kakoma JB.** Postgraduate and research programmes in medicine and public health in Rwanda: an exciting experience about training of human resources for health in a limited resource country. *Pan Afr Med J* 2016;23:171.
16 **Lipnick M, Mijumbi C, Dubowitz G, Kaggwa S, Goetz L, Mabweijano J, Jayaraman S, Kwizera A, Tindimwebwa J, Ozgediz D.** Surgery and anesthesia capacity-building in resource-poor settings: description of an ongoing academic partnership in Uganda. *World J Surg* 2013;37:488-497.

PNG Med J 2017 Mar-Jun;60(1-2):51-59

A preliminary assessment of Toll-like receptor and β-defensin gene polymorphisms in Papua New Guinea – what does it mean for HIV/AIDS?

Barne Willie[1,2,3], Janet Gare[1], Christopher L. King[2], Peter A. Zimmerman[2] and Rajeev K. Mehlotra[2]

Papua New Guinea Institute of Medical Research, Goroka and Center for Global Health and Diseases, Case Western Reserve University School of Medicine, Cleveland, United States of America

SUMMARY

Polymorphisms in Toll-like receptor (*TLR*) and human β-defensin (hBD, encoded by *DEFB*) genes have been evaluated for their associations with HIV (human immunodeficiency virus) infection and disease outcomes. Those studies, conducted in various populations under a variety of study designs, generally revealed that specific single-nucleotide polymorphisms (SNPs) in *TLR1, 2, 3, 4, 6, 7, 8* and *9* genes, and copy number variation (CNV) in *DEFB4* (encoding hBD-2), *DEFB103A* (encoding hBD-3) and *DEFB104A* (encoding hBD-4) genes are among potential genetic factors that can affect susceptibility to HIV infection and/or disease progression. The information regarding their prevalence in Papua New Guinea (PNG) is very limited for *TLR* SNPs and not available for *DEFB* CNV. The present study provides a preliminary assessment of these genetic polymorphisms in samples collected from the Wosera (East Sepik Province, n = 29) and Liksul (Madang Province, n = 23) areas. Wosera samples were analysed for a total of 41 SNPs in 8 *TLR* genes (*TLR1, 2, 3, 4, 6, 7, 8* and *9*) and both sample sets were analysed for CNV in *DEFB4/103A/104A* genes. A number of *TLR* SNPs were not detected and many other SNPs were present at low frequencies (minor allele frequencies ≤0.05) in the Wosera samples. The *DEFB4/103A/104A* copy numbers were significantly different between the two sample sets (p = 0.024). Validation of these results, using larger sample sizes as well as samples from other areas of PNG, is warranted. In addition, genetic association studies are needed to estimate the effects of these polymorphisms on HIV infection and disease progression in PNG.

Introduction

Toll-like receptors (TLRs) play a central role in the immune response by recognizing pathogen-associated molecular patterns from a wide variety of microbes (1,2). Studies evaluating TLR expression and response related to HIV (human immunodeficiency virus) have provided evidence that TLR1,TLR2, TLR3, TLR4, TLR6, TLR7/8 and TLR9 have a functional role in HIV infection and disease, and specific single-nucleotide polymorphisms (SNPs) in these *TLR* genes have been evaluated for their effects on HIV acquisition and disease progression in various populations (3-9). These studies were conducted on European (5,8,9), African (4,6) and North American (3,7) populations, under a variety of study designs. Differences in populations, in the number of SNPs (and/or combinations thereof) and in outcome measures make the comparison of data difficult.

Human β-defensins are small, cationic, amphipathic peptides with antimicrobial and immune regulatory properties. They are released mainly from epithelial cells, although some β-defensins have also been identified in non-epithelial cells (10,11). These antimicrobial peptides can reach biologically relevant concentrations in the systemic

1 Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea

2 Center for Global Health and Diseases, Case Western Reserve University School of Medicine, Biomedical Research Building, Fourth Floor, 2109 Adelbert Road, Cleveland, Ohio 44106-2624, United States of America

3 barne.willie@pngimr.org.pg

circulation (reviewed in 12). The β-defensin gene cluster (*DEFB*) on chromosome 8p23.1 includes *DEFB4*, *DEFB103A* and *DEFB104A* genes, which encode human β-defensin 2 (hBD-2), hBD-3 and hBD-4 peptides, respectively. The approximately 200 kb *DEFB* region containing *DEFB4/103A/104A* varies in its copy number overall from 2 to 12 per diploid genome (PDG); copy numbers of 7 or greater PDG are rare (13,14). β-defensin copy number variation (CNV) is correlated with gene expression (15) and serum peptide concentration (16,17).

Copy number variation of β-defensin genes has been associated with susceptibility to HIV infection (18,19) and disease progression (20). In Brazilian HIV-positive children the median copy number of *DEFB104* was lower than in HIV-exposed uninfected children and healthy controls, suggesting that *DEFB104* may be involved in protection from vertical transmission of HIV (19). It is important to note here that a direct effect of *DEFB104*-encoded hBD-4 peptide on HIV remains to be elucidated. Recently, in a North American, predominantly Caucasian, cohort higher *DEFB4/103A* copy number was associated with slower progression to AIDS (acquired immune deficiency syndrome) (20). On the other hand, in Ethiopian and Tanzanian patients, higher β-defensin cluster CNV was associated with increased HIV viral load before highly active antiretroviral therapy (HAART) and with poor immune reconstitution following initiation of HAART, suggesting that higher β-defensin copy number may be a risk factor (18). Differences in populations, study designs and methodologies to define copy number may have contributed to the lack of a clear relationship between β-defensin CNV and HIV/AIDS. Furthermore, there could be multiple mechanisms that govern the association between β-defensin CNV and HIV/AIDS (reviewed in 12).

Papua New Guinea (PNG), a country in Oceania located approximately 160 km north of the Australian continent, has the greatest burden of HIV in the Asia-Pacific region, with estimates ranging from less than 1% in adults aged 15-49 years to 2.3-19% in the most at-risk populations (references provided in 21). Despite the significance of *TLR* SNPs and β-defensin CNV in HIV/AIDS, data regarding prevalence of *TLR* SNPs in PNG are limited to certain SNPs in *TLR1* (743A>G), *TLR2* (2029C>T, 2178T>A and 2258G>A), *TLR4* (896A>G and 1196C>T) and *TLR9* (−1486C>T, −1237C>T and +1174G>A) (22-24). Of these, *TLR1* 743A>G and *TLR9* −1486C>T and +1174G>A were present at very high frequencies (≥0.3). *TLR2* 2029C>T was rare, and the other SNPs were not detected. No report, to our knowledge, is available regarding the prevalence of β-defensin CNV in PNG. The aim of the present study was to perform a preliminary investigation of these genetic polymorphisms in samples from two areas of PNG. For this aim, a total of 41 SNPs in 8 *TLR* genes (*TLR1, 2, 3, 4, 6, 7, 8* and *9*) were analysed. These SNPs have been evaluated in HIV/AIDS and other infectious diseases as well as inflammatory and immune-mediated non-infectious diseases, and are located in promoter regions, 5'-untranslated regions (UTR), exons, introns and 3'-UTR. A detailed description of how they were selected and their locations has been provided in our previous study (3). Copy number variation in *DEFB4/103A/104A*, located within the β-defensin gene cluster involved in susceptibility to HIV infection and disease progression, was also analysed.

Materials and Methods

Study samples

Samples, previously collected for malaria epidemiological studies conducted by Case Western Reserve University, Cleveland, Ohio, United States of America (USA) and the Papua New Guinea Institute of Medical Research, were utilized. These were blood samples (n = 29) collected from the Wosera area, East Sepik Province (ESP) (25,26), and genomic DNA (deoxyribonucleic acid) samples (n = 23) extracted from blood samples collected from the Liksul area, Madang Province (27,28). No information is available regarding HIV exposure and infection status of the individuals at the time of sampling. Genomic DNA was extracted from all blood samples using the QIAamp® 96 DNA Blood Kit (QIAGEN, Valencia, California (CA), USA). The final concentration of all genomic DNA samples was adjusted to approximately 10 ng/µl. The present genetic analysis study was conducted under the protocol approved by the University Hospitals of Cleveland/Case Institutional Review Board (UHCMC IRB 08-03-33 [An ethnicity-based analysis of genetic polymorphisms and susceptibility to infectious diseases in Papua New Guinea, Principal Investigator PAZ]).

Genetic analysis

A total of 41 SNPs in 8 *TLR* genes (*TLR1, 2, 3, 4, 6, 7, 8* and *9*) were genotyped in the Wosera samples using Illumina's Golden Gate genotyping assay system combined with VeraCode Technology (Illumina Inc., San Diego, CA, USA). Allelic discrimination was performed using a BeadXpress Reader (Illumina Inc., San Diego, CA, USA) according to the manufacturer's instructions. As a control, 30 samples, previously characterized for these *TLR* SNPs using the same genotyping assay (29), were randomly selected and genotyped together with the Wosera samples. These 30 samples belonged to self-identified Caucasians (n = 10) and African-Americans (n = 20) residing in North America. Due to the limited amount of the genomic DNA from the Liksul samples available for this study, *TLR* SNP genotyping of these samples could not be performed.

For the purpose of a generalized comparison of the *TLR* SNP alleles and their frequencies in the Wosera samples with those in the global sample, such data were obtained from the Single Nucleotide Polymorphism database (dbSNP, www.ncbi.nlm.nih.gov/snp/), a public-domain archive for a broad collection of simple genetic polymorphisms. The current global sample comprises 2504 individuals from 26 populations represented in the 1000 Genomes Project (phase 3) (30). These populations do not include PNG or any other population from Oceania, and are divided into 5 super-populations: African, Admixed American, East Asian, European and South Asian.

For the determination of *DEFB4/103A/104A* CNV, the real-time quantitative polymerase chain reaction (PCR) assay was used as described (14), with a slight modification. Reference genes *TBP* (TATA-Box Binding Protein, GenBank accession #AL031259) and *DEFB1*- (encoding hBD-1, GenBank accession #NT_023736), *DEFB4*- and *DEFB103A*-specific primer sets, PCR mix and PCR cycling conditions were used as described (14). In this assay, *DEFB104A*-specific primers, designed based on the chromosome 8 genomic sequence NC_000008.11 (nucleotide coordinates 7836471..7841242), were added. These primer sequences were as follows: exon-1 forward 5'-CTGCTATTAGCCATTTCTCT-3', reverse 5'-GAAGGTTACTCCATCCTTCA-3'; exon-2 forward 5'-CAGCCAAGAATACAGAATTG-3', reverse 5'-GGAAAGCTACTGAGGTCCTA-3'. The StepOne Plus™ Real-Time PCR system (Applied Biosystems, Foster City, CA, USA) was used for the PCR analysis. All *DEFB4*-, *DEFB103A*- and *DEFB104A*-specific primer sets produced only one specific PCR product of approximately 150 base pairs (bp) at 54°C annealing temperature. Each sample was run in triplicate. Genomic DNA samples NA15221 or NA15324 and NA15056 from the Coriell Cell Repositories, already characterized for their *DEFB4/103A* copy numbers (14), were used as controls. Data were analysed by the comparative cycle threshold (Ct) method and the copy numbers were calculated as described (14).

Statistical analysis

By using the genetic analysis program Haploview (version 4.2, Broad Institute, Cambridge, Massachusetts (MA), USA), minor alleles of the *TLR* SNPs were determined and minor allele frequencies (MAF), observed heterozygosity (H_O), predicted heterozygosity (H_P) and Hardy-Weinberg (H-W) equilibrium were calculated. A minor allele is one of the two alleles whose frequency is less than 0.5. The other allele frequencies were simply calculated as 1−MAF. For *DEFB4/103A/104A* copy number data, mean, standard deviation (SD) and median were calculated in Microsoft Excel. To calculate difference in mean copy numbers between the two sample sets, a t-test assuming unequal sample variance, applicable only to independent samples, was used (http://vassarstats.net/tu.html). A two-tailed p value of less than 0.05 was considered significant.

Results

Profile of *TLR* SNPs in the Wosera samples

The profile of 41 *TLR* SNPs, located in 8 *TLR* genes, is presented in Table 1. A number of SNPs were not observed (MAF = 0), and low frequencies (MAF ≤0.05) were observed for many other SNPs in these samples. In order to determine whether the population derived from this set of samples was in H-W equilibrium, SNP-by-SNP analysis of heterozygosity was performed. There was no significant difference between the H_O and H_P values for all SNPs (all p >0.05) except *TLR8* 1A>G (H_O = 0.07, H_P = 0.19, p = 0.03),

TABLE 1

Toll-like receptor (*TLR*) minor alleles and their frequencies in Wosera samples[†]

Gene	rs number	SNP	Amino acid	Minor allele	MAF	Previous studies (f)	NA_30* (f)	Global** (f)
TLR1	rs5743551	−7202G>A		A	0.02		0.35	0.43
	rs5743595	−2192T>C		C	0.00		0.15	0.18
	rs5743611	239G>C	Arg80Thr	C	0.00		0.02	0.02
	rs5743618	1805G>T	Ser602Ile	G	0.02		0.30	0.20
TLR2	rs4696480	−16934T>A		T	0.47		0.42	0.58
	rs1898830	−15607A>G		A	0.48		0.79	0.63
	rs3804099	597T>C	Asn199Asn	C	0.16		0.48	0.41
	rs3804100	1350T>C	Ser450Ser	C	0.16		0.02	0.11
	rs5743708	2258G>A	Arg753Gln	A	0.00	0.00[a,b]	0.02	0.01
TLR3	rs5743303	−8921A>T		T	0.07		0.23	0.17
	rs5743305	−8441T>A		T	0.28		0.30	0.68
	rs3775296	−7C>A		A	0.09		0.17	0.18
	rs3775291	1234C>T	Leu412Phe	C	0.16		0.90	0.77
TLR4	rs2770150	−3612A>G		G	0.00		0.15	0.16
	rs2737190	−2604G>A		G	0.28		0.68	0.49
	rs10759932	−1607T>C		C	0.16		0.28	0.18
	rs4986790	896A>G	Asp299Gly	G	0.00	0.00[a,b]	0.05	0.06
	rs4986791	1196C>T	Thr399Ile	T	0.02	0.00[a,b]	0.00	0.04
	rs11536889	+11381G>C		C	0.00		0.10	0.14
	rs7873784	+12186C>G		G	0.07		0.25	0.14
TLR6	rs5743795	−1401G>A		A	0.00		0.13	0.18
	rs5743806	−673C>T		T	0.05		0.45	0.58
	rs1039559	−502T>C		C	0.05		0.25	0.33
	rs5743810	745T>C	Ser249Pro	T	0.00		0.17	0.12
	rs3821985	1083C>G	Thr361Thr	C	0.05		0.43	0.44
	rs3775073	1263A>G	Lys421Lys	A	0.03		0.45	0.54
	rs5743818	1932T>G	Ala644Ala	G	0.02		0.13	0.09
	rs2381289	4224C>T		C	0.10		0.63	0.63
TLR7	rs2302267	1-120T>G		G	0.02		0.03	0.07
	rs864058	2403G>A	Thr801Thr	A	0.00		0.11	0.11

TLR8	rs3764880	1A>G	Met1Val	A	0.10		0.82	0.54
	rs1548731	+3121T>C		T	0.02		0.47	0.29
	rs5744077	28A>G	Met10Val	G	0.00		0.10	0.04
	rs2159377	354C>T	Asp118Asp	C	0.14		0.77	0.63
	rs5744080	645C>T	His215His	C	0.28		0.48	0.32
	rs2407992	1953G>C	Leu651Leu	C	0.12		0.25	0.72
	rs3747414	2253C>A	Ile751Ile	C	0.12		0.60	0.46
TLR9	rs187084	−1486C>T		T	0.47	0.63[a], 0.5[c]	0.62	0.62
	rs5743836	−1237C>T		C	0.00	0.00[a]	0.28	0.17
	rs352139	+1174G>A		A	0.47	0.62[a]	0.35	0.49
	rs352140	1635G>A	Pro545Pro	G	0.47		0.50	0.58

[†]Allele frequencies from previous studies, North Americans and the global sample are also provided
rs number = SNP accession number (stands for Reference SNP cluster ID)
SNP = single-nucleotide polymorphism
MAF = minor allele frequency
(f) = frequency of the same allele determined as minor allele in the Wosera samples
*NA_30 = 30 North American samples, used as a control, genotyped together with the Wosera samples
**Global = Global sample, comprising 2504 individuals from 26 populations
[a]Reference 22
[b]Reference 23
[c]Reference 24

suggesting that this population was in H-W equilibrium.

TLR2 2258G>A, *TLR4* 896A>G and 1196C>T, and *TLR9* −1486C>T, −1237C>T and +1174G>A from the previous studies conducted in PNG (22-24) were included in the present study. As presented in Table 1, their allele frequencies in our samples were comparable to those previously reported.

The allele frequencies of the 30 control samples, belonging to self-identified Caucasians and African-Americans, are also presented in Table 1. The allele frequencies of these samples were the same as previously reported (29).

In addition, the allele frequencies of the global sample were obtained from the dbSNP database and are presented in Table 1. A generalized comparison between the Wosera samples and the global sample suggests that the *TLR* SNP alleles and their frequencies were markedly different between the two sample sets. Overall, the allelic profiles of the North American samples and the global sample were comparable.

Profile of *DEFB4/103A/104A* CNV in PNG

The distribution of integer *DEFB4/103A/104A* copy numbers in the Wosera and Liksul samples is shown in Figure 1. Copy numbers ranged from 2 to 6 (2.0-6.3) in the Wosera samples and from 2 to 5 (2.1-5.5) in the Liksul samples. A copy number of 3 was predominant in the Wosera samples (38%) and a copy number of 5 was predominant in the Liksul samples (52%). Mean ± SD and median copy numbers were 3.7 ± 1.2 and 3.4, respectively, in the Wosera samples and 4.5 ± 0.9 and 4.8, respectively, in the Liksul samples. Further analysis showed that the mean copy numbers were significantly different between the two sample sets (two-tailed t-test p = 0.024).

Discussion

Previous studies, reporting certain *TLR* allele frequencies in PNG, utilized large sample sizes from two provinces – Dreikikir District, ESP, n = 346 (22), n = 906 (23); Madang Province, n = 1320 (24). Our samples were much smaller in number (n = 29) and were collected from another area in ESP (the

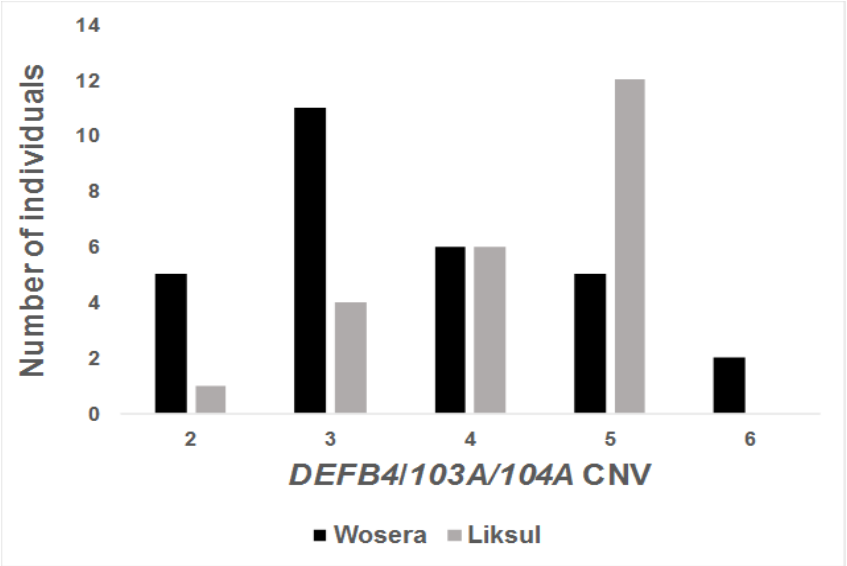


Figure 1. Distribution of *DEFB4/103A/104A* copy number variation (CNV) in the Wosera (n = 29) and Liksul (n = 23) areas.

Wosera). Yet the frequencies of the alleles, as analysed previously and in the present study, were comparable. In addition, the allele frequencies of 30 North American samples, randomly selected from 115 samples analysed in our previous study (29) and included in the present study as a control, were the same as previously reported. Collectively, these observations suggest that, despite the small number of samples, our genotyping results were reliable.

Regarding the comparison of *TLR* allele frequencies in PNG with those in other populations, one of the previous studies (22), conducted in the Dreikikir District (ESP), included samples from Kenya and North America, the latter belonging to Caucasians, African-Americans and Asian-Americans. This study found that the allele frequencies of *TLR2* 22 bp insertion-deletion and GT_n dinucleotide repeat polymorphisms were significantly different between the PNG and Kenyan and between the PNG and Asian-American populations. In addition, the allele frequencies of *TLR9* −1486C>T and +1174G>A were significantly different between the PNG and Kenyan populations. In the present study, statistical comparisons of the allelic profile of the Wosera samples with those of the North American samples and the global sample were not performed. Nevertheless, a generalized comparison suggests that the allelic profile of the Wosera samples was different from those of the other two sample sets.

In our previous study (3), *TLR1* −7202G and 1805T, *TLR4* −1607C, *TLR6* − 673C and 1263G, and *TLR8* 1G and 1953C alleles in North American Caucasian subjects, and the *TLR4* +12186C allele in African-American subjects were associated with 2.0- to 4.2-fold increased odds of being HIV-infected. Thus, these alleles were inferred as susceptible alleles. On the other hand, the *TLR8* 354T allele in African-American subjects was associated with 61% decreased odds of being HIV-infected. Thus, this allele was inferred as a protective allele. In the Wosera samples, the frequencies of the susceptible alleles were high (0.12-0.16) to almost fixed (0.90-0.98) (Table 1). The protective allele was also present at a very high frequency (0.86) (Table 1).

In other studies, other *TLR* SNPs were found to be suggestively or significantly associated with HIV infection/disease outcomes. These were: *TLR2* −16934T>A (protection against rapid progression in North American Caucasians) (7), 597T>C (protection against rapid progression in a Swiss population and lower HIV-1 set-point among seroprevalent Kenyan adults) (5,6), and 1350T>C (increased risk of mortality in

Kenyan children) (4); *TLR3* 1234C>T (higher peak viral load in North American Caucasians) (7); and *TLR9* 1635G>A (lower viral load set-point and slower disease progression in North American Caucasians (7), rapid disease progression in a Swiss population (5), more likely HIV-1 acquisition but lower peak viral load in Kenyan children (4), and reduced HIV-1 acquisition among seronegative Kenyan adults (6)). These *TLR2* −16934T>A, 597T>C and 1350T>C, *TLR3* 1234C>T, and *TLR9* 1635G>A SNPs were also well represented in the Wosera samples (MAF = 0.16-0.47) (Table 1). Thus *TLR* alleles associated with both increased and decreased risk of HIV infection/disease progression elsewhere were observed in the PNG samples examined in this study. Given the restricted sampling in the present study, and the genetic diversity characteristic of PNG populations (31,32), distribution of such alleles in other areas of PNG should be determined.

The *DEFB4/103A/104A* copy numbers were significantly different between the two study areas, with the predominance of a copy number of 3 in the Wosera area and a copy number of 5 in the Liksul area. A mean/median copy number of 4 has been consistently reported in world-wide populations (13,33,34). Furthermore, a world-wide analysis of β-defensin CNV in 68 populations (n = 2015) from America, Europe, Sub-Saharan Africa, Middle East, South Asia, East Asia and Oceania showed that Oceania, represented by Non-Austronesian Melanesians (n = 13) and Papuans (n = 17), had the highest frequency of a copy number of 5 (approximately 35%) (33). Thus our copy number findings for the two areas in PNG are similar to those reported in the literature. Utilizing larger sample sizes, further studies should validate the observation that different copy numbers occur in different populations of PNG, and should investigate whether the predominance of different copy numbers in these populations yield distinct outcomes of HIV infection and/or disease.

It is important to mention that TLRs and hBDs do not work separately from each other – TLRs have been shown to mediate the expression of hBDs in various tissues (35) and therefore the TLR-hBD interplay may be one of the critical determinants of HIV outcomes. Investigating the interactive effect of polymorphisms in *TLR* and *DEFB* on HIV will provide a more comprehensive understanding of how these interrelated innate immune components influence the complex outcomes in HIV and, maybe, other infectious diseases that are also prevalent in PNG (36,37).

It is acknowledged that no HIV/AIDS phenotype data were available pertaining to the samples analysed in the present study. Despite the limited sampling from only two areas in PNG and differences in genotyping methodologies, a positive point of this study was that the *TLR* SNP and *DEFB* CNV genotyping results were comparable to those previously reported. Nevertheless, these preliminary results need to be validated in further studies. In addition, to estimate the effects of these host genetic polymorphisms on HIV infection and disease progression in PNG, large-scale, comprehensive genetic association studies are necessary. The knowledge thus generated may help identify at-risk individuals, design and implement beneficial treatment strategies, and curtail the growth of this epidemic in PNG and the Asia-Pacific region.

ACKNOWLEDGEMENTS

We thank all research participants from the Wosera and Liksul areas. Thanks are due to Alex Barron (from CLK's laboratory) for organizing and providing Madang genomic DNA samples for this study. BW is grateful to Dr Aaron Weinberg (Chair, Department of Biological Sciences, School of Dental Medicine) for permitting him to run *DEFB4/103A/104A* CNV assays in his department, Dr Lance Vernon for including him as a member of his recently published study team and Dr Noemi Hall for her invaluable help with statistical analyses. BW was supported by a training grant from Fogarty International Center, National Institutes of Health (D43TW007377) to PAZ. We sincerely thank Mr Dave McNamara and Dr Carolyn Myers for helpful discussions and critical evaluation of the manuscript.

REFERENCES

1 **Barreiro LB, Ben-Ali M, Quach H, Laval G, Patin E, Pickrell JK, Bouchier C, Tichit M, Neyrolles O, Gicquel B, Kidd JR, Kidd KK, Alcaïs A, Ragimbeau J, Pellegrini S, Abel L, Casanova JL, Quintana-Murci L.** Evolutionary dynamics of human Toll-like receptors and their different contributions to host defense. *PLoS Genet* 2009;5:e1000562.

2 **Misch EA, Hawn TR.** Toll-like receptor polymorphisms and susceptibility to human disease. *Clin Sci (Lond)* 2008;114:347-360.

3 **Willie B, Hall NB, Stein CM, Jurevic RJ, Weinberg A, Mehlotra RK, Zimmerman PA.** Association of

Toll-like receptor polymorphisms with HIV status in North Americans. *Genes Immun* 2014;15:569-577.

4 **Beima-Sofie KM, Bigham AW, Lingappa JR, Wamalwa D, Mackelprang RD, Bamshad MJ, Maleche-Obimbo E, Richardson BA, John-Stewart GC.** Toll-like receptor variants are associated with infant HIV-1 acquisition and peak plasma HIV-1 RNA level. *AIDS* 2013;27:2431-2439.

5 **Bochud PY, Hersberger M, Taffé P, Bochud M, Stein CM, Rodrigues SD, Calandra T, Francioli P, Telenti A, Speck RF, Aderem A; Swiss HIV Cohort Study.** Polymorphisms in Toll-like receptor 9 influence the clinical course of HIV-1 infection. *AIDS* 2007;21:441-446.

6 **Mackelprang RD, Bigham AW, Celum C, de Bruyn G, Beima-Sofie K, John-Stewart G, Ronald A, Mugo NR, Buckingham KJ, Bamshad MJ, Mullins JI, McElrath MJ, Lingappa JR.** Toll-like receptor polymorphism associations with HIV-1 outcomes among sub-Saharan Africans. *J Infect Dis* 2014;209:1623-1627.

7 **Pine SO, McElrath MJ, Bochud PY.** Polymorphisms in toll-like receptor 4 and toll-like receptor 9 influence viral load in a seroincident cohort of HIV-1-infected individuals. *AIDS* 2009;23:2387-2395.

8 **Ricci E, Malacrida S, Zanchetta M, Mosconi I, Montagna M, Giaquinto C, De Rossi A.** Toll-like receptor 9 polymorphisms influence mother-to-child transmission of human immunodeficiency virus type 1. *J Transl Med* 2010;8:49.

9 **Soriano-Sarabia N, Vallejo A, Ramírez-Lorca R, del Mar Rodríguez M, Salinas A, Pulido I, Sáez ME, Leal M.** Influence of the Toll-like receptor 9 1635A/G polymorphism on the CD4 count, HIV viral load, and clinical progression. *J Acquir Immune Defic Syndr* 2008;49:128-135.

10 **Chen H, Xu Z, Peng L, Fang X, Yin X, Xu N, Cen P.** Recent advances in the research and development of human defensins. *Peptides* 2006;27:931-940.

11 **Klotman ME, Chang TL.** Defensins in innate antiviral immunity. *Nat Rev Immunol* 2006;6:447-456.

12 **Mehlotra RK, Zimmerman PA, Weinberg A.** Defensin gene variation and HIV/AIDS: a comprehensive perspective needed. *J Leukoc Biol* 2016;99:687-692.

13 **Groth M, Szafranski K, Taudien S, Huse K, Mueller O, Rosenstiel P, Nygren AO, Schreiber S, Birkenmeier G, Platzer M.** High-resolution mapping of the 8p23.1 beta-defensin cluster reveals strictly concordant copy number variation of all genes. *Hum Mutat* 2008;29:1247-1254.

14 **Linzmeier RM, Ganz T.** Human defensin gene copy number polymorphisms: comprehensive analysis of independent variation in α- and β-defensin regions at 8p22-p23. *Genomics* 2005;86:423-430.

15 **Groth M, Wiegand C, Szafranski K, Huse K, Kramer M, Rosenstiel P, Schreiber S, Norgauer J, Platzer M.** Both copy number and sequence variations affect expression of human *DEFB4*. *Genes Immun* 2010;11:458-466.

16 **Jansen PA, Rodijk-Olthuis D, Hollox EJ, Kamsteeg M, Tjabringa GS, de Jongh GJ, van Vlijmen-Willems IM, Bergboer JG, van Rossum MM, de Jong EM, den Heijer M, Evers AW, Bergers M, Armour JA, Zeeuwen PL, Schalkwijk J.** β-defensin-2 protein is a serum biomarker for disease activity in psoriasis and reaches biologically relevant concentrations in lesional skin. *PLoS One* 2009;4:e4725.

17 **Jaradat SW, Hoder-Przyrembel C, Cubillos S, Krieg N, Lehmann K, Piehler S, Sigusch BW, Norgauer J.** Beta-defensin-2 genomic copy number variation and chronic periodontitis. *J Dent Res* 2013;92:1035-1040.

18 **Hardwick RJ, Amogne W, Mugusi S, Yimer G, Ngaimisi E, Habtewold A, Minzi O, Makonnen E, Janabi M, Machado LR, Viskaduraki M, Mugusi F, Aderaye G, Lindquist L, Hollox EJ, Aklillu E.** β-defensin genomic copy number is associated with HIV viral load and immune reconstitution in sub-Saharan Africans. *J Infect Dis* 2012;206:1012-1019.

19 **Milanese M, Segat L, Arraes LC, Garzino-Demo A, Crovella S.** Copy number variation of defensin genes and HIV infection in Brazilian children. *J Acquir Immune Defic Syndr* 2009;50:331-333.

20 **Mehlotra RK, Dazard JE, John B, Zimmerman PA, Weinberg A, Jurevic RJ.** Copy number variation within human β-defensin gene cluster influences progression to AIDS in the Multicenter AIDS Cohort Study. *J AIDS Clin Res* 2012;3:3.

21 **Gare J, Kelly-Hanku A, Ryan CE, David M, Kaima P, Imara U, Lote N, Crowe SM, Hearps AC.** Factors influencing antiretroviral adherence and virological outcomes in people living with HIV in the Highlands of Papua New Guinea. *PLoS One* 2015;10:e0134918.

22 **Greene JA, Moormann AM, Vulule J, Bockarie MJ, Zimmerman PA, Kazura JW.** Toll-like receptor polymorphisms in malaria-endemic populations. *Malar J* 2009;8:50.

23 **Hise AG, Hazlett FE, Bockarie MJ, Zimmerman PA, Tisch DJ, Kazura JW.** Polymorphisms of innate immunity genes and susceptibility to lymphatic filariasis. *Genes Immun* 2003;4:524-527.

24 **Manning L, Cutts J, Stanisic DI, Laman M, Carmagnac A, Allen S, O'Donnell A, Karunajeewa H, Rosanas-Urgell A, Siba P, Davis TM, Michon P, Schofield L, Rockett K, Kwiatkowski D, Mueller I.** A Toll-like receptor-1 variant and its characteristic cellular phenotype is associated with severe malaria in Papua New Guinean children. *Genes Immun* 2016;17:52-59.

25 **Kasehagen LJ, Mueller I, Kiniboro B, Bockarie MJ, Reeder JC, Kazura JW, Kastens W, McNamara DT, King CH, Whalen CC, Zimmerman PA.** Reduced *Plasmodium vivax* erythrocyte infection in PNG Duffy-negative heterozygotes. *PLoS One* 2007;2:e336.

26 **Mehlotra RK, Kasehagen LJ, Baisor M, Lorry K, Kazura JW, Bockarie MJ, Zimmerman PA.** Malaria infections are randomly distributed in diverse holoendemic areas of Papua New Guinea. *Am J Trop Med Hyg* 2002;67:555-562.

27 **Mehlotra RK, Fujioka H, Roepe PD, Janneh O, Ursos LM, Jacobs-Lorena V, McNamara DT, Bockarie MJ, Kazura JW, Kyle DE, Fidock DA, Zimmerman PA.** Evolution of a unique *Plasmodium falciparum* chloroquine-resistance phenotype in association with *pfcrt* polymorphism in Papua New Guinea and South America. *Proc Natl Acad Sci USA* 2001;98:12689-12694.

28 **Patel SS, King CL, Mgone CS, Kazura JW, Zimmerman PA.** Glycophorin C (Gerbich antigen blood group) and band 3 polymorphisms in two malaria holoendemic regions of Papua New Guinea. *Am J Hematol* 2004;75:1-5.

29 **Mehlotra RK, Hall NB, Willie B, Stein CM, Weinberg A, Zimmerman PA, Vernon LT.** Associations of Toll-like receptor and β-defensin polymorphisms with measures of periodontal disease (PD) in HIV+ North American adults: an exploratory study. *PLoS One* 2016;11:e0164075.

30 **1000 Genomes Project Consortium, Auton A, Brooks LD, Durbin RM, Garrison EP, Kang HM,**

Korbel JO, Marchini JL, McCarthy S, McVean GA, Abecasis GR. A global reference for human genetic variation. *Nature* 2015;526:68-74.

31 **Lee EJ, Koki G, Merriwether DA.** Characterization of population structure from the mitochondrial DNA vis-à-vis language and geography in Papua New Guinea. *Am J Phys Anthropol* 2010;142:613-624.

32 **Stoneking M, Jorde LB, Bhatia K, Wilson AC.** Geographic variation in human mitochondrial DNA from Papua New Guinea. *Genetics* 1990;124:717-733.

33 **Hardwick RJ, Machado LR, Zuccherato LW, Antolinos S, Xue Y, Shawa N, Gilman RH, Cabrera L, Berg DE, Tyler-Smith C, Kelly P, Tarazona-Santos E, Hollox EJ.** A worldwide analysis of beta-defensin copy number variation suggests recent selection of a high-expressing *DEFB103* gene copy in East Asia. *Hum Mutat* 2011;32:743-750.

34 **Mehlotra RK, Zimmerman PA, Weinberg A, Jurevic RJ.** Variation in human β-defensin genes: new insights from a multi-population study. *Int J Immunogenet* 2013;40:261-269.

35 **Froy O.** Regulation of mammalian defensin expression by Toll-like receptor-dependent and independent signalling pathways. *Cell Microbiol* 2005;7:1387-1397.

36 **Aia P, Kal M, Lavu E, John LN, Johnson K, Coulter C, Ershova J, Tosas O, Zignol M, Ahmadova S, Islam T.** The burden of drug-resistant tuberculosis in Papua New Guinea: results of a large population-based survey. *PLoS One* 2016;11:e0149806.

37 **Vallely LM, Toliman P, Ryan C, Rai G, Wapling J, Tomado C, Huliafi S, Munnull G, Rarau P, Phuanukoonnon S, Wand H, Siba P, Mola GD, Kaldor JM, Vallely AJ.** Prevalence and risk factors of *Chlamydia trachomatis*, *Neisseria gonorrhoeae*, *Trichomonas vaginalis* and other sexually transmissible infections among women attending antenatal clinics in three provinces in Papua New Guinea: a cross-sectional survey. *Sex Health* 2016;13:420-427.

PNG Med J 2017 Mar-Jun;60(1-2):60-61

The use of the back thump as an alternative to the shifting dullness and fluid thrill tests for abdominal ascites

George Gende[1,2]

Port Moresby General Hospital, Papua New Guinea

SUMMARY

This paper describes a clinical test for abdominal ascites that has been found to be reliable and very easy to perform. It is recommended as an alternative to the classical shifting dullness and fluid thrill tests.

The use of the fluid thrill and shifting dullness tests are established in clinical medicine. The transmitted thrill in florid abdominal ascites never fails to awe the medical student. The shifting dullness test, as onerous as it is, is reliable if done correctly. There are now many imaging tests such as ultrasound scan that can make clinical tests seem archaic but the classical clinical tests are the mainstay for diagnosing ascites in many parts of the world.

The back thump test described here as a clinical test for abdominal ascites may well have been first used in Papua New Guinea by Dr S.C.Wigley, who was a tuberculosis (TB) physician in the 1960s. There is, however, no record of its formal documentation in the literature. I heard of the test as a medical student and have used it routinely throughout my practising life.

To perform the test, the clinician stands to the side of the patient with the palm of one hand supporting the abdomen as the patient leans forward and the other hand is fisted and lightly thumps the back in the midline with the hypothenar aspect of the hand. In positive tests the unmistakable thrill is imparted to the waiting hand over the abdomen (Figure 1).

Figure 1. Dr George Gende demonstrating the presence of ascites by percussion from the back in a patient with ascites due to abdominal tuberculosis. Photograph by Professor David Watters.

The classical tests of fluid thrill and shifting dullness are amply described in standard textbooks of medicine and surgery (1,2).

Professor L. Clendening is reported to have said, “Clinical diagnosis is an art, and the mastery of an art has no end: you can always be a better diagnostician.” I share that view as well. I have found this test to be useful. It does not require an assistant as in the fluid thrill test. It can be done quickly without fuss. My observations are that it is negative in normal abdomens, obesity and pregnancy. When ascites is minimal the test may have to be complemented with ultrasound examination. In a female patient with a huge ovarian cyst there will be dullness to percussion centrally and a tympanic percussion note at the flanks. The back thump test feels like a shudder and not quite the thrill as in ascites.

The two classical tests are based on

1 Gerehu Hospital, Port Moresby, PO Box 1630, Boroko, National Capital District, Papua New Guinea
g_gende@yahoo.com

2 Formerly Senior Specialist Surgeon, Port Moresby General Hospital, Private Mail Bag 1, Boroko, National Capital District, Papua New Guinea

the properties of fluids, ie, gravitation and transmission of waves. The back thump test is seen in the light of Huygens' Principle (3), in which a wave form or a disturbance in one corner can go through homogeneous space and every point of contact generates wavelets. The resultant wave form is an expression of the original disturbance which travels in a straight line without interference by the solid, liquid or gaseous state of the intervening space.

There is probably room for refinement, particularly to quantify the ascites and to determine the threshold for a positive test.

I would happily recommend the test to any busy doctor.

REFERENCES

1 **Clain A, ed.** Hamilton Bailey's Demonstrations of Physical Signs in Clinical Surgery. Sixteenth edition. Oxford: Butterworth-Heinemann, 1980:248-249.
2 **Ogilvie C.** Chamberlain's Symptoms and Signs in Clinical Medicine. Tenth edition. Bristol: John Wright & Sons, 1980.
3 **Wikimedia Foundation.** Huygens-Fresnel principle. San Francisco, California: Wikimedia Foundation, 2016. en.widipedia.org/wiki/Huygens%E2%80%93Fresnel_principle

PNG Med J 2017 Mar-Jun;60(1-2):62-69

Prevalence of non-communicable disease in rural Vanuatu

Graeme J. Duke[1], Ann C. Miller[2], Hugo J. Huygens[3], Iain M. Miller[3], Donald Beaumont[4], Douglas Utley[5], Donald L. MacRaild[6] and Richard Tatwin[7]

Intensive Care Department, Eastern Health, Box Hill, Victoria, Australia, Inglis Medical Group, Sale, Victoria, Australia, Central Gippsland Health Service, Sale, Victoria, Australia, Eyelines, Launceston, Tasmania, Australia, Croydon Health Clinic, Croydon, Victoria, Australia, Vanuatu Prevention of Blindness Programme, Valencia Creek, Victoria, Australia and Presbyterian Church of Vanuatu (PCV) Health, Port Vila, Vanuatu

SUMMARY

Objective: **Assess prevalence rates for diabetes, hypertension, obesity and eye disease for adults in Vanuatu, South Pacific.** ***Design:*** **Retrospective observational cohort study from a primary health care program.** ***Setting:*** **Medical and eye care clinics run by Australian-trained health care workers in rural communities on 30 islands from all six provinces of Vanuatu.** ***Participants:*** **6144 clinic attenders over the period July 2009-September 2013.** ***Main outcome measures:*** **Adult prevalence rates for diabetes (random blood glucose >11.1 mmol/l), hypertension (blood pressure >140/90 mmHg), obesity and eye diseases (cataract, pterygium).** ***Results:*** **5424 participants (88%) were adults and 99% were from rural communities. The adult prevalence rates (95% confidence intervals) were as follows: diabetes 6.0% (5.2-6.9%), hypertension 9.3% (8.4-10.1%), obesity 10.7% (8.1-13.9%), cataract 8.3% (7.6-9.2%) and pterygium 10.5% (9.6-11.3%). Most had not received treatment. 3997 adults (74%) had none of these diseases. There were no differences between rates in the six provinces and no temporal trends. These rates are unexpectedly lower than World Health Organization published data and likely to be the result of population differences.** ***Conclusion:*** **The prevalence of non-communicable disease in the rural communities of Vanuatu is lower than expected but remains as a substantial untreated and preventable health risk. Primary health care and education may help minimize further rise in the non-communicable disease burden.**

Introduction

Non-communicable disease (NCD) is a leading cause of preventable mortality in developing nations (1). The South Pacific nation of Vanuatu is one such example (2,3), for which the Australian Government provides financial and human resources to support health care delivery (4).

Vanuatu is an archipelago of 65 inhabited islands stretching over 1300 km, situated 2400 km east of Cairns, with a population of 261,565 (June 2013) (5). Three-quarters of the population live in rural communities structured on traditional customs and subsistence farming with limited access to health care. Average life expectancy in 2010 was 71 years for males and 74 years for females.

The prevalence of NCD in rural Vanuatu is poorly documented, in part due to its geography

1 Intensive Care Department, Eastern Health, 5 Arnold St, Box Hill, Victoria 3128, Australia graeme.duke@easternhealth.com.au

2 Inglis Medical Group, 12 Inglis St, Sale, Victoria 3850, Australia

3 Central Gippsland Health Service, 155 Guthridge Parade, Sale, Victoria 3850, Australia

4 Eyelines, 61 Brisbane St, Launceston, Tasmania 7250, Australia

5 Croydon Health Clinic, 224-238 Mt Dandenong Rd, Croydon, Victoria 3136, Australia

6 Vanuatu Prevention of Blindness Programme, 94 Valencia Creek-Briagolong Rd, Valencia Creek, Victoria 3860, Australia

7 Presbyterian Church of Vanuatu Health, PO Box 150, Port Vila, Shefa Province, Vanuatu

and limited resources for surveillance. A recent World Health Organization (WHO) survey (3) of a mixed urban and rural population reported a high prevalence of hypertension (28.6%), diabetes (21.2%) and obesity (18.8%). Type 2 diabetes mellitus (diabetes) and hypertension are common risk factors for preventable NCD deaths (6,7).

We undertook a retrospective analysis of surveillance data for hypertension, diabetes, obesity and eye disease from rural clinics run by the Vanuatu Prevention of Blindness Programme (VPBP) (8). The purpose of this analysis was to describe the rural burden of NCD and confirm the WHO findings.

Methods

The VPBP is a non-government organization (NGO) providing free primary health care in rural and remote areas where access to health services is limited. This service works in partnership with local health centres to provide free medical and dental examination and eye screening, health education and corrective spectacles at low cost. The VPBP is coordinated and run by indigenous staff with training, administrative and professional support provided by volunteers from Australia. Financial assistance is provided by Uniting World (Australia), Rotary (Sale, Victoria), Vanuatu Ministry of Health, Presbyterian Church of Vanuatu (PCV) Health program and, more recently, a three-year grant from the Australian Department of Foreign Affairs (AusAID). This support has facilitated the collection and storage of surveillance data relating to NCD.

Health care screening was carried out in rural communities by mobile teams of 6-10 health care workers (including at least one qualified Australian doctor and nurse) (8). Communities were notified of scheduled clinic dates, treatment was provided free of charge and attendance was voluntary.

Clinic attenders were offered screening for hypertension, diabetes, obesity and eye disease. Age, sex, home village, medical history, previous medications and fasting status were recorded with the assistance of local interpreters.

Following explanation of the procedure a qualified doctor or nurse measured the upper arm blood pressure (BP) using the auscultation method and Krotokoff sounds with the patient resting in the seated position (7). Elevated pressures were confirmed by a second reading. Automated sphygmomanometers were not used. A blood pressure reading above 140/90 mmHg indicated the presence of hypertension and above 180/110 the hypertension was considered severe.

Random blood glucose levels (BGL) were measured using finger-prick (capillary blood) sampling and an Accu-Chek® Performa (Roche Diagnostics, Hawthorn, Australia) instrument. Battery charge and calibration were checked before each clinic. Abnormal readings were confirmed with a second reading taken, when possible, the following day. Urine or blood 'dipsticks' were not used. A glucose reading above 11.1 mmol/l or current treatment for diabetes were taken as diagnostic of (type 2) diabetes mellitus. Subjects with a BGL reading between 7.0 and 11.1 mmol/l more than 2 hours after food (9) were classified as having 'pre-diabetes'. Insulin therapy and testing of haemoglobin A1c levels were not available in rural communities.

Waist circumference measurements, as a surrogate indicator of obesity, were recorded for adult patients. Body weight was not recorded due to lack of reliable scales. A waist measurement of over 88 cm in women, or 102 cm in men, was indicative of significant obesity (and increased risk of NCD). The normal range for waist measurements in Pacific islanders is unknown (10,11).

Trained optometrists performed visual acuity assessment and fundoscopy. Detailed retinal examination was difficult due to examination conditions and risk of administering mydriatic agents. Where indicated prescription spectacles were provided. Patients with severe cataract or pterygium were offered surgical treatment (with assistance towards medical and travel costs) on the next available surgical list. Those diagnosed with diseases requiring specialist care were commenced on treatment and referred to the appropriate nearest facility.

Statistical analysis

Data were entered onto paper records at the time of consultation and later transferred to a Microsoft Excel® spreadsheet (Microsoft, Redmond, WA, USA) for storage. Records were de-identified before analysis and

approval to publish these results granted by the Vanuatu Ministry of Health. Stata/MP v11 (StataCorp, College Station, Texas) statistical software was used for data analysis.

Patients were classified according to age as paediatric (<17 years), adult (17-64 years) or older adult (≥65 years). The relevant age-matched population estimates were used for calculation of prevalence rates. Continuous data are presented either as median and interquartile range (IQR) or 95% confidence interval (95% CI) using the modified Wald method, where appropriate. Statistical associations between NCD and demographic factors were investigated using logistical regression and reported as an odds ratio (OR), and included adjustment for geographic clustering (by island and province) and secular trends (by year of examination). A p value <0.05 was accepted as significant.

Results

Between July 2009 and September 2013, 6144 patient records were extracted from 125 clinics held on 108 days by eleven medical teams. Patients came from 749 separate towns/villages on 30 (46% of inhabited) islands from all 6 provinces (Figure 1).

The study cohort represents 3.5% of the age-matched national population or 4.8% of the age-matched rural population. Frequency,

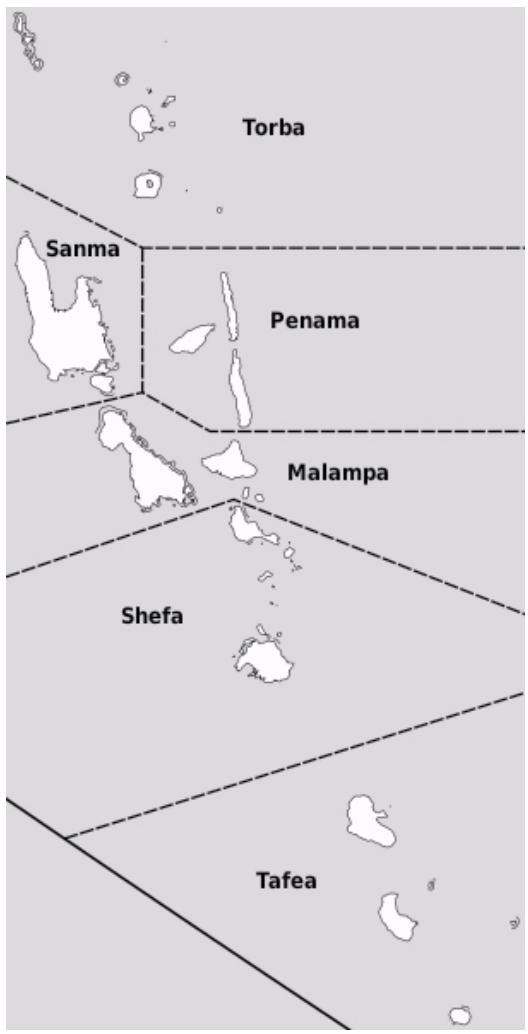


Figure 1. Map of Vanuatu provinces.

age and sex distribution according to province are presented in Table 1. Most subjects (99.3%) were living in rural communities with only 45 (0.7%) classified as urban (eg, Port Vila or Luganville) residents. 720 (11.7%) were children and 61 adults (1.0% of the total) with no recorded age (Table 1) were excluded from the analysis.

Demographic features of the study population and results, according to age group (720 children and 5363 adults), are presented in Table 2. 4403 (72%) clinic attenders underwent blood pressure measurement, 3461 (57%) underwent blood glucose tests and 5139 (84%) underwent ocular examination.

A total of 1081 patients (18%) were referred for specialist opinion and/or treatment not available on the island of residence. 495 (8.1%) were referred for ophthalmic surgery, 96 (1.6%) for other surgical treatment and 436 (7.1%) for follow-up of newly diagnosed hypertension or diabetes. 3997 adults (74%, 3997/5424) did not require treatment but were provided with education regarding lifestyle and dietary risk factors for NCD.

Hypertension

Table 2 shows that 4368 (81%, 4368/5363) of adults had a BP recorded, with a median (IQR) reading of 125/80 mmHg (116/70-140/85). 407 patients (9.3%; 95%CI 8.4-10.1%), with a median age of 56 (47-64) years, were found to be hypertensive and 92 (2.1%; 95%CI 1.7-2.6%) were classified as severely hypertensive (BP >180/110 mmHg). 34 hypertensive patients (8.4%, 34/407) were also found to have diabetes. The majority (93%) of hypertensive patients were either previously undiagnosed (88%) or had discontinued treatment (5%).

Diabetes

Table 2 shows that 3447 (64%, 3447/5363) of adult patients underwent random glucose checks (BGL). The median glucose level was 6.4 mmol/l (95%CI 5.5-7.5 mmol/l). 207 patients (6.0%; 95%CI 5.2-6.9), with a median age of 54 (IQR 45-62) years and a median BGL of 15.9 mmol/l (IQR 12.2–21.8), were classified as having diabetes. Only 23 (11%) were currently receiving hypoglycaemic drug therapy and their median BGL was 18.4 mmol/l (IQR 15.6-22.9 mmol/l).

82 (40%) of the newly diagnosed diabetic patients were also hypertensive, and 7 (3.4%) had severe untreated hypertension. 24 (12%) of the patients with diabetes were found to have cataracts, with a median age of 59 (IQR

TABLE 1

Study population from each province of Vanuatu – child <17 years, adult 17-64 years and older adult ≥65 years

Province	Number	Male	Child	Adult	Older adult	Age not recorded
Malampa	818	47.4%	3.5%	79.1%	16.5%	0.9%
Penama	1205	45.1%	17.2%	67.7%	13.8%	1.3%
Sanma	490	52.4%	11.6%	75.9%	10.8%	1.6%
Shefa	891	47.3%	6.3%	80.8%	11.8%	1.1%
Tafea	1564	52.7%	12.5%	76.2%	10.3%	1.0%
Torba	1176	55.4%	14.9%	74.7%	10.1%	0.3%
Total	6144	50.2%	11.7%	75.3%	12.0%	1.0%

TABLE 2

PREVALENCE OF NON-COMMUNICABLE DISEASE IN STUDY POPULATIONS ACCORDING TO AGE*

Subgroup	Child	Adult	Older adult
Age range	<17 years	17-64 years	≥65 years
Population (national)	109,342	142,875	9,348
Study cohort**	720 (0.7)	4624 (3.2)	739 (7.9)
Male, n (%)	345 (47.9)	2219 (48.0)	487 (65.9)
BP recorded, n (%)	35 (4.9)	3742 (80.9)	626 (84.7)
BP, IQR, mmHg	105/64-125/80	115/70-140/85	125/74-150/90
BP >140/90, mmHg, n (%)	0	306 (8.2)	101 (16.1)
BP >180/110, mmHg, n (%)	0	60 (1.6)	32 (5.1)
BGL test, n (%)	14 (1.9)	2858 (61.8)	589 (79.7)
BGL, median (IQR), mmol/l	6.4 (5.2-7.0)	6.4 (5.5-7.4)	6.5 (5.6-7.8)
Diabetes (>11.1 mmol/l), n (%)	0	165 (5.8)	42 (7.1)
Pre-diabetes (7.0-11.1 mmol/l), n (%)	0	121 (4.2)	66 (11.2)
Visual acuity test, n (%)	321 (44.6)	4125 (89.2)	693 (93.8)
Refraction error, n (%)	27 (8.4)	2634 (63.9)	520 (75.0)
Cataract, n (%)	10 (3.1)	177 (4.3)	241 (34.8)
Pterygium, n (%)	2 (0.6)	473 (11.5)	64 (9.2)

*Data presented as number and percentage of studied population, except for study cohort**, presented as percentage of age-matched national population
BP = blood pressure
IQR = interquartile range
BGL = blood glucose level

53-70) years and blood glucose of 20.1 mmol/l (IQR 12.4-24.8 mmol/l).

187 adults (5.4%), with a median BGL of 7.9 mmol/l (IQR 7.4-8.7 mmol/l), were classified as having 'pre-diabetes'. This group received dietary advice and was encouraged to undergo follow-up and repeat glucose tests.

Obesity

449 adults (8.4%) in 2013 had waist circumference measurements recorded. The median age was 42 (IQR 29-53) years and 42 (10.7%; 95%CI 8.1-13.9%) were classified as obese. The prevalence rate was significantly higher in women (30.5%; 95%CI 24.3-39.7%)

than in men (6.5%; 95%CI 4.0-10.2%; p <0.001).

Eye disease

5139 (84%) of the patients underwent visual assessment (Table 2). 428 (8.3%; 95% CI 7.6-9.2%) patients, with a median age of 67 (IQR 58-74) years, were found to have cataracts in one or both eyes. 304 (5.9%; 95%CI 5.3-6.5%) with dense cataracts were referred for surgical treatment.

Pterygium in one or both eyes was discovered in 539 patients (10.5%; 95% CI 9.6-11.3%), with a median age of 46 (IQR 36-58) years. 149 (2.9%) were referred for surgical treatment to prevent corneal scarring, and the remainder for review. 874 pairs of sunglasses were dispensed for prevention.

3181 patients (61.9%; 95%CI = 59.8-63.6%) were found to have refractive errors and 3694 pairs of prescription spectacles were dispensed, 80% for presbyopia and hypermetropia and 20% for myopia.

Disease associations

The presence of hypertension was found to be associated with increasing age, diabetes and obesity (p <0.001) (Table 3). Diabetes was associated with increasing age, hypertension and obesity (p <0.001), and cataracts were associated with increasing age (p <0.001). NCD rates were higher in the older age group (Table 2). The prevalence rates were similar in each of the six provinces after adjustment for age and nesting of results in different islands. Except for obesity, there were no sex differences in NCD prevalence. No significant prevalence trends were noted across the five-year period.

Discussion

The VPBP undertook a retrospective analysis of NCD in 6144 of the indigenous Vanuatu population, representing 4.8% of the age-matched rural population with broad geographic representation. We found a small but substantial prevalence of untreated diabetes (6.0%), hypertension (9.3%), cataracts (8.3%) and obesity (10.7%). 74% of the adult population was free of these NCDs.

These VPBP NCD rates are higher than those reported 25 years ago (7) but substantially lower than a recent (2013) STEPS (Stepwise approach to surveillance) NCD survey (3) undertaken for the WHO (Table 4). These apparent disparities may be largely explained by known differences between urban and rural populations and, to a lesser extent, the differences in methodology.

The STEPS NCD survey employed a random cluster selection method and validated survey tool (12). VPBP NCD results were based on retrospective analysis of voluntary clinic attenders, spanning several years. NCD surveillance was not the primary role of the VPBP. This may have led to the under-reporting of NCD in this study. There

TABLE 3

Disease associations* between age, diabetes, hypertension, obesity and cataract

Variable	Hypertension	Diabetes	Cataract
Age, per decade	1.52 (1.44-1.61)	1.45 (1.40-1.51)	2.24 (2.09-2.41)
Diabetes	2.45 (1.65-3.65)	na	ns
Hypertension	na	1.54 (1.23-1.92)	ns
Obesity	2.26 (1.28-4.00)	3.10 (2.07-4.64)	ns

*Odds ratio (95% confidence interval); in all the significant associations, p <0.001
na = not applicable
ns = not significant

TABLE 4

Comparative published prevalent rates (percent) for diabetes, hypertension and obesity in Vanuatu

Year	Population type	Number	Diabetes	Hypertension	Obesity	Reference
1985	Rural	746	0.6-2.4	9.3-13.3	3.9-7.2	7
1985	Urban	441	3.6-7.2	16.3-22.4	12.7-18.4	7
2011	Mixed	4224	19.0-23.3	26.5-30.8	16.9-20.8	3
2013	Rural	6144	5.2-6.9	8.4-10.1	8.1-13.9	VPBP

VPBP = Vanuatu Prevention of Blindness Programme

are several major factors, however, that suggest otherwise.

The STEPS NCD study population (n = 4224) was restricted to adults aged 25-64 years. VPBP clinics included older adults so that the age-matched prevalence rates in adults in this study are even lower (Table 2).

The STEPS NCD study included a higher proportion of subjects from urban communities, where higher rates of NCD than in rural villages have been reported (2,7). This geographic or residential bias is supported by the higher rates of treatment reported in the STEPS NCD than in the VPBP population. The proportion of subjects receiving treatment for hypertension (33.6% vs 4.6%; p <0.0001) or diabetes (46.2% vs 11%; p <0.0001), particularly insulin therapy (34% vs <1%; p <0.0001), was significantly higher. Insulin therapy is rarely available in rural communities due to supply and storage problems.

We were forced to rely on random glucose criteria for the diagnosis of diabetes. Yet even if we include those with 'pre-diabetes', the overall rate of hyperglycaemia (11.4%) remains substantially lower than the STEPS NCD reported rate of 21.2%. Furthermore, the majority (60%) of patients classified as having 'pre-diabetes' had a glucose level under 8.0 mmol/l.

The rate of specialist referrals (18%) suggests a substantial disease burden and that the VPBP NCD rates were not based on a select group of healthy subjects.

Whilst the VPBP NCD rates appear to be similar to those in a rural Australian population (13), and lower than those reported in other Pacific nations (14), there are two important differences. In Vanuatu the majority of NCD remains untreated, and the age of onset appears to be younger (15,16). If the observed prevalence rates applied throughout the adult population of Vanuatu we estimate that there may be as many as 10,000 adults with untreated diabetes, 15,000 with untreated hypertension and 16,000 with cataracts. This represents a significant NCD burden.

All data sources indicate a substantial burden of untreated and preventable NCD in Vanuatu. The STEPS NCD survey demonstrated the presence of significant risk factors (obesity, inactivity, alcohol and tobacco consumption, etc) and we confirmed a statistical link between obesity, diabetes and hypertension. Both reports support the hypothesis that education and primary health care may have a substantial benefit in disease prevention (11,12) and future health care costs (14,17).

Despite these limitations the VPBP data set provides useful insights and baseline data where few previously existed. These may be useful in planning future health care interventions (18-20). Continued surveillance is highly desirable and these results demonstrate the potential benefit of collaboration between established high-quality NGOs and government. Surveillance

should be based on internationally accepted criteria (12) and include high-risk subgroups, such as older people and rural communities.

In conclusion, we have identified a lower than expected prevalence of NCD in the rural communities of Vanuatu. Nevertheless this remains a substantial burden of untreated and preventable disease. Available evidence indicates that the higher rates reported in the STEPS NCD reports can be explained by differences between the study populations, and are not incompatible with our findings. Education, screening and primary health care are likely to be important components in NCD prevention.

COMPETING INTERESTS

We have no competing interests. All the research work was performed by volunteers.

ACKNOWLEDGEMENTS

We thank the volunteer nurses, doctors and optometrists who collected the data; Jessy Vatoko for assistance with data entry; the Republic of Vanuatu Ministry of Health for permission to publish these data; Roche Diagnostics Australia for the donation of glucometers; and Aspen Pharmacare, Australia for the donation of antibiotics.

REFERENCES

1 **World Health Organization.** New data highlight increases in hypertension, diabetes incidence. Geneva: World Health Organization, May 2012. www.who.int/mediacentre/news/releases/2012/world_health_statistics_20120516/en/index.html
2 **National Stakeholder Forum.** Building better diabetes care in Vanuatu: Report on the World Diabetes Foundation Project National Stakeholder Forum, 5-6 Jun 2007, Port Vila. Sydney: Diabetes Unit, Australian Health Policy Institute, University of Sydney, 2007.
3 **World Health Organization Western Pacific Region.** Vanuatu NCD Risk Factors STEPS Report. Manila: Western Pacific Region, World Health Organization, May 2013. www.who.int/chp/steps/Vanuatu_STEPS_Report_2013.pdf
4 **Foster M, Condon R, Janovsky K, Slatyer B, Whyatt A.** Working Paper 3: Vanuatu Country Report. Evaluation of Australian Aid to the Health Service Delivery in Papua New Guinea, Solomon Islands and Vanuatu. Canberra: Office of Development Effectiveness, Australian Agency for International Development, Jun 2009. www.dfat.gov.au/aid/how-we-measure.../working-paper-3-vanuatu-country-report.PDF
5 **Index Mundi.** Vanuatu demographics profile 2013. Charlotte, North Carolina: Index Mundi, 2013. www.indexmundi.com/vanuatu/demographics_profile.html
6 **World Life Expectancy.** Country health profiles: Vanuatu. United States of America: LeDuc Media, 2010. www.worldlifeexpectancy.com/country-health-profile/vanuatu
7 **Taylor R, Jalaludin B, Levy S, Montaville B, Gee K, Sladden T.** Prevalence of diabetes, hypertension and obesity at different levels of urbanisation in Vanuatu. *Med J Aust* 1991;155:86-90.
8 **Duke G, MacRaild D, eds.** Vanuatu Prevention of Blindness Project: Handbook for Medical, Nursing and Optometry Team Members. Second edition. Sydney: Uniting World, 2014. Updated at http://pcvhealth.org/eyecare/the-vanuatu-prevention-of-blindness-project
9 **Moebus S, Göres L, Lösch C, Jöckel KH.** Impact of time since last caloric intake on blood glucose levels. *Eur J Epidemiol* 2011;26:719-728.
10 **Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J.** Body mass index, waist circumference and waist:hip ratio as predictors of cardiovascular risk – a review of the literature. *Eur J Clin Nutr* 2009;64:16-22.
11 **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;19:425-431.
12 **World Health Organization.** WHO STEPwise approach to chronic disease risk factor surveillance (STEPS), Version 2.1. Geneva: World Health Organization, 2007. www.who.int/chp/steps/en
13 **Australian Institute of Health and Welfare.** Australia's Health 2010. The Twelfth Biennial Health Report of the Australian Institute of Health and Welfare. Canberra: Australian Institute of Health and Welfare, Jun 2010. www.aihw.gov.au
14 **World Health Organization Western Pacific Region.** Pacific framework for the prevention and control of noncommunicable diseases. Manila: Western Pacific Region, World Health Organization, Aug 2007. www2.wpro.who.int/rcm/en/archives/rc59/rc_resolutions/WPR_RC59_R5.htm
15 **McCarty CA, Mukesh BN, Fu CL, Taylor HR.** The epidemiology of cataract in Australia. *Am J Ophthalmol* 1999;128:446-465.
16 **Smith TST, Szetu J, Bourne RRA.** The prevalence and severity of diabetic retinopathy, associated risk factors and vision loss in patients registered with type 2 diabetes in Luganville, Vanuatu. *Br J Ophthalmol* 2007;91:415-419.
17 **Anderson I, Jarawan E.** The economic costs of non-communicable diseases in the Pacific Islands. A rapid stocktake of the situation in Samoa, Tonga and Vanuatu. Final Report. Washington: World Bank, Nov 2012. www.worldbank.org/content/dam/Worldbank/document/the-economic-costs-of-noncommunicable-diseases-in-the-pacific-islands.pdf
18 **Falconer DG, Buckley A, Colagiuri R.** Counting the cost of type 2 diabetes in Vanuatu. *Diabetes Res Clin Pract* 2010;87:92-97.
19 **Bulletin of the World Health Organization.** Pacific islanders pay heavy price for abandoning traditional diet. *Bull World Health Organ* 2010;88:484-485.
20 **Dancause KN, Vilar M, Wilson M, Soloway LE, DeHuff C, Chan C, Tarivonda L, Regenvanu R, Kaneko A, Lum JK, Garruto RM.** Behavioral risk factors for obesity during health transition in Vanuatu, South Pacific. *Obesity (Silver Spring)* 2013;21:E98-E104.

PNG Med J 2017 Mar-Jun;60(1-2):70-72

CASE REPORT

Congenital diaphragmatic hernia: an experience in general surgery

Jackson Goru Nuli[1,2] and Kevin Lapu[1]

Surgery Department, Nonga General Hospital, Rabaul, Papua New Guinea

SUMMARY

Congenital diaphragmatic hernia (CDH) is a rare condition that occurs in 1:5000 live births. It remains one of the major challenges of perinatal medicine and surgery world-wide. Whilst CDH is managed in western settings by highly specialized surgical, anaesthetic and nursing teams, general surgeons still play a role in the management of CDH in Papua New Guinea and similar countries. We present our surgical experience of a CDH case in a 2-week-old infant.

Case Report

A 2-week-old female was operated on after she had presented to Nonga General Hospital's Paediatric Unit on 17 September 2015, a day after she was born through a normal vaginal delivery at one of the health centres. She weighed 3.7 kg, was irritable and in respiratory distress. Her temperature was 37.6°C, respiratory rate 50 per minute and heart rate 156 per minute. Her oxygen saturation was 79%-85% in room air. She was peripherally cyanosed and was immediately put on oxygen via nasal prongs. There was good air entry on the right chest but minimal air entry on the left with sounds similar to crepitations in the lower left chest. Dual heart sounds were more marked on the right than the left. Her abdomen was soft and not distended and her liver not palpable. There were no other abnormalities detected. She was immediately admitted to the special care nursery. A plain radiograph of the chest and abdomen showed poor outline of the left hemi-diaphragm, bowel shadows in the left chest and the heart deviated to the right. A diagnosis of congenital diaphragmatic hernia (CDH) was established. Surgery was performed 2 weeks after her admission when her cardiorespiratory functions were stable. A subcostal transverse muscle-splitting incision was made on the side of the hernia. The posterolateral defect (Bochdalek) on the left diaphragm was about 4 cm in diameter. The contents of the hernia included the proximal part of the ascending colon, caecum, stomach and all the small bowel. The contents were gently reduced beginning with the ascending colon, followed by the caecum, small bowel and stomach (Figure 1). The anterior rim of the diaphragm was grasped with a Babcock. The posterior rim of the diaphragm was poorly defined and was mobilized by incising the peritoneum. An interrupted mattress non-absorbable suture was employed to close the defect. A continuous vicryl 2/0 suture was used as a second layer (Figure 2). The baby recovered well postoperatively. Her oxygen saturation by day 5 postoperatively was 96%-98% in room air. She was commenced on oral feeds by day 6 postoperatively and subsequently made an uneventful recovery.

Discussion

Congenital diaphragmatic hernia is defined by the presence of an orifice in the diaphragm, usually on the left and posterolateral, that permits the herniation of abdominal contents into the thorax. The mediastinum is displaced to the contralateral side, the lungs are often hypoplastic and their arterioles abnormal causing pulmonary hypertension (1). CDH was described many years ago (1,2) but

1 Surgery Department, Nonga General Hospital, Private Mail Bag 3, Rabaul, East New Britain Province, Papua New Guinea

2 jackson.nuli2@gmail,com

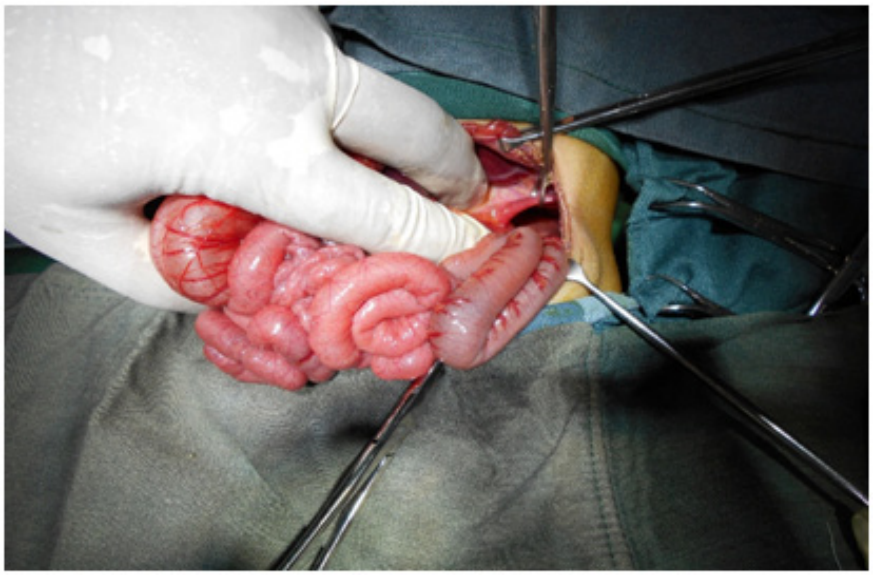


Figure 1. Showing the posterolateral defect in the left diaphragm after the hernial contents have been reduced.

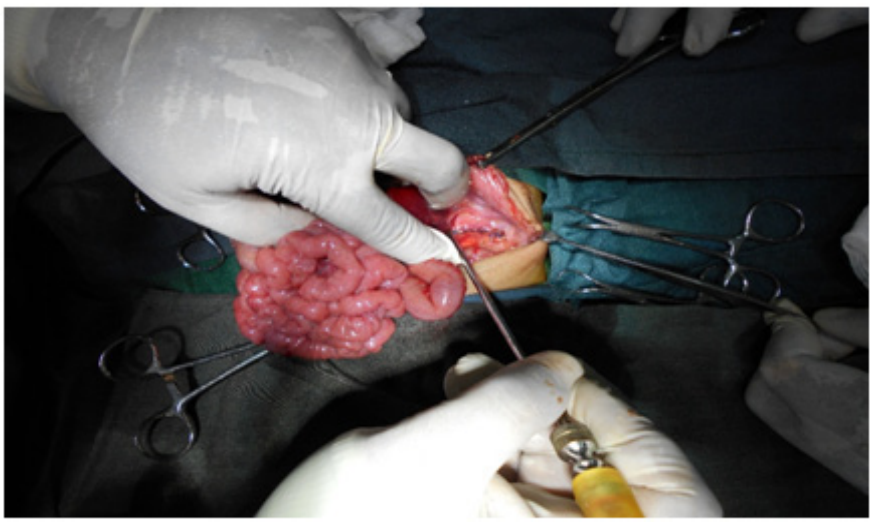


Figure 2. Showing the repair done on the left diaphragm.

survival after repair was not achieved until the 20th century. The incidence is 1 in 5000 live births. It seems to be more frequent in males and less frequent in African-Americans (3,4). The aetiology of CDH remains unclear. The majority are sporadic, with only 2% occurring with a familial association. Approximately 80% are left-sided defects and the majority appear as an isolated anomaly (5). CDH may, however, also occur as part of a syndrome. Survival is poor among infants with associated abnormalities (5).

Diagnosis of CDH is increasingly reported on antenatal ultrasound scans in western countries either by routine anomaly scans at around 20 week's gestation or following clinical suspicion in a case of maternal polyhydramnios (6). CDH is confirmed by visualizing the stomach or loops of bowel within the thoracic cavity – ideally level with the four-chamber view of the fetal heart

– along with mediastinal shift away from the side of the lesion (6). In Papua New Guinea (PNG) sophisticated ultrasonographic antenatal diagnosis is rarely available. The majority of the infants born with a Bochdalek posterolateral hernia become symptomatic at or shortly after birth. Where pulmonary hypoplasia is severe, the infant becomes cyanosed with severe respiratory distress within minutes of birth. In other patients, there is tachypnoea, increased respiratory effort, hyperinflated chest and scaphoid abdomen with heart sounds on the right side (7). A chest X-ray will show loops of bowel within the left chest with the heart deviated to the right. Sometimes the appearance may be difficult to distinguish from basal lung cysts, in which case a repeat chest X-ray is performed after a nasogastric tube is inserted, the tip of which can be seen in the chest (7). Alternatively, a barium study will show bowel within the thoracic cavity when there is a diaphragmatic hernia (7).

Whilst the presence of CDH was previously regarded as a surgical emergency, it is at present accepted that surgery should be undertaken only after cardiorespiratory functions are stable. In a western setting a policy of delayed surgery coupled with gentle ventilation and occasionally extra-corporeal membrane oxygenation (ECMO) support yields the best results recorded (8). Currently the focus of research into CDH management is geared towards improving fetal pulmonary function pre- and post-operatively. The use of nitric oxide to treat pulmonary hypertension (9), high-frequency oscillatory ventilation (10), exogenous surfactant therapy (11), antenatal steroid therapy (12) and fetal lung transplantation (13) are some of the research options being carried out with mixed outcomes.

In PNG, the prognosis of CDH depends on the nature of the defect, associated abnormal pulmonary vasculature and hypertension and the degree of lung hypoplasia, as well as the quality of perinatal care and the surgical expertise. In hospitals where there is no paediatric or cardiothoracic surgeon, general surgery still plays a role in the surgical management of this relatively rare condition.

REFERENCES

1 **Tovar JA.** Congenital diaphragmatic hernia. *Orphanet J Rare Dis* 2012;7:1.
2 **Golombek SG.** The history of congenital diaphragmatic hernia from 1850s to the present. *J Perinatol* 2002;22:242-246.
3 **Harrison MR, Bjordal RI, Langmark F, Knutrud O.** Congenital diaphragmatic hernia: the hidden mortality. *J Pediatr Surg* 1978;13:227-230.
4 **Stege G, Fenton A, Jaffray B.** Nihilism in the 1990s: the true mortality of congenital diaphragmatic hernia. *Pediatrics* 2003;112:532-535.
5 **Skari H, Bjornland K, Haugen G, Egeland T, Emblem R.** Congenital diaphragmatic hernia: a meta-analysis of mortality factors. *J Pediatr Surg* 2000;35:1187-1197.
6 **Adzick NS, Vacanti JP, Lillehei CW, O'Rourke PP, Crone RK, Wilson JM.** Fetal diaphragmatic hernia: ultrasound diagnosis and clinical outcome in 38 cases. *J Pediatr Surg* 1989;24:654-657.
7 **Hutson JM, O'Brien M, Woodward AA, Beasley SW, eds.** Jones' Clinical Paediatric Surgery: Diagnosis and Management. Sixth edition. Oxford: Blackwell Publishing, 2009:26-27.
8 **Moyer V, Moya F, Tibboel R, Losty P, Nagaya M, Lally KP.** Late versus early surgical correction for congenital diaphragmatic hernia in newborn infants. *Cochrane Database Sys Rev* 2002;(3):CD001695.
9 **Bloss RS, Turmen T, Beardmore HE, Aranda JV.** Tolazoline therapy for persistent pulmonary hypertension after congenital diaphragmatic hernia repair. *J Pediatr* 1980;97:984-988.
10 **The HIFI Study Group.** High-frequency oscillatory ventilation compared with conventional mechanical ventilation in the treatment of respiratory failure in preterm infants. *N Engl J Med* 1989;320:88-93.
11 **Jobe AH.** Pulmonary surfactant therapy. *N Engl J Med* 1993;328:861-868.
12 **Crowely PA.** Antenatal corticosteroid therapy: a meta-analysis of the randomized trials, 1972 to 1994. *Am J Obstet Gynecol* 1995;173:322-335.
13 **Parisi F.** Advances in paediatric transplantation: heart and lung. *Transplant Proc* 2001;33:1725-1726.

MEDLARS BIBLIOGRAPHY

PUBLICATIONS OF RELEVANCE TO PAPUA NEW GUINEA AND MELANESIA

Bibliographic Citation List generated from MEDLARS

1 **Auburn S, Böhme U, Steinbiss S, Trimarsanto H, Hostetler J, Sanders M, Gao Q, Nosten F, Newbold CI, Berriman M, Price RN, Otto TD.**
A new *Plasmodium vivax* reference sequence with improved assembly of the subtelomeres reveals an abundance of *pir* genes.
Wellcome Open Res 2016 Nov 15;1:4.

Plasmodium vivax is now the predominant cause of malaria in the Asia-Pacific, South America and Horn of Africa. Laboratory studies of this species are constrained by the inability to maintain the parasite in continuous ex vivo culture, but genomic approaches provide an alternative and complementary avenue to investigate the parasite's biology and epidemiology. To date, molecular studies of *P. vivax* have relied on the Salvador-I reference genome sequence, derived from a monkey-adapted strain from South America. However, the Salvador-I reference remains highly fragmented with over 2500 unassembled scaffolds. Using high-depth Illumina sequence data, we assembled and annotated a new reference sequence, PvP01, sourced directly from a patient from Papua Indonesia. Draft assemblies of isolates from China (PvC01) and Thailand (PvT01) were also prepared for comparative purposes. The quality of the PvP01 assembly is improved greatly over Salvador-I, with fragmentation reduced to 226 scaffolds. Detailed manual curation has ensured highly comprehensive annotation, with functions attributed to 58% core genes in PvP01 versus 38% in Salvador-I. The assemblies of PvP01, PvC01 and PvT01 are larger than that of Salvador-I (28-30 versus 27 Mb), owing to improved assembly of the subtelomeres. An extensive repertoire of over 1200 *Plasmodium* interspersed repeat (*pir*) genes were identified in PvP01 compared to 346 in Salvador-I, suggesting a vital role in parasite survival or development. The manually curated PvP01 reference and PvC01 and PvT01 draft assemblies are important new resources to study vivax malaria. PvP01 is maintained at GeneDB and ongoing curation will ensure continual improvements in assembly and annotation quality.

2 **Barcham R, Silas E, Irie J.**
Health promotion and empowerment in Henganofi District, Papua New Guinea.
Rural Remote Health 2016 Oct-Dec;16(4):3553.

Evidence shows that the government of Papua New Guinea is failing to provide basic services in health to the majority of its people. Local non-government organisations (NGOs), partnered with international NGOs, are attempting to fill this gap. With limited resources, these small Indigenous organisations must focus much of their effort on training that supports self-reliance as the main strategy for communities to improve their quality of life. This project explored the training content and methodology of Touching The Untouchables (TTU), a small Indigenous NGO based in Goroka, Eastern Highlands Province, that has trained a network of village volunteers in health promotion and safe motherhood. Village life imposes multiple demands, from self-sufficiency in food to maintaining law and order. There are established attitudes about power and dependence, referred to as 'cargo thinking'. Cargo thinking stands as a barrier to the necessity of self-reliance, and requires training strategies that seek to empower participants to create change from their own initiative. Empowerment is understood as oriented towards individual people taking collective action to improve their circumstances by rectifying disparities in social power and control. To achieve self-reliance, empowerment is necessarily operational on the levels of person, community and society. In addition to being operational on all three levels of empowerment, the training content and methodology adopted and developed by TTU demonstrate that empowering practice in training employs approaches to knowledge that are evidence-based, reflexive, contextual and skill-based. Creating knowledge that is reflexive and exploring knowledge about the broader context uses special kinds of communicative tools that facilitate discussion on history, society and political economy. Furthermore, training methodologies that are oriented to empowerment create settings that require the use of all three types of communication required for cooperative action: dramaturgical, normative and teleological communication. The success of TTU's training content and methodology demonstrates that creating the conditions for achieving collective self-reliance through empowerment is a necessary part of primary health promotion in Papua New Guinea, and that underlying the success of empowerment-oriented training are definable types of knowledge and communication.

3 **Barrington DJ, Sridharan S, Saunders SG, Souter RT, Bartram J, Shields KF, Meo S, Kearton A, Hughes RK.**
Improving community health through marketing exchanges: a participatory action research study on water, sanitation, and hygiene in three Melanesian countries.
Soc Sci Med 2016 Dec;171:84-93.

Diseases related to poor water, sanitation and hygiene (WaSH) are major causes of mortality and morbidity. While pursuing marketing approaches to WaSH to improve health outcomes is often narrowly associated with monetary exchange, marketing theory recognises four broad marketing exchange archetypes: market-based, non-market-based, command-based and culturally determined. This diversity reflects the need for parameters broader than monetary exchange when improving WaSH. This study applied a participatory action research process to investigate how impoverished communities in Melanesian urban and peri-urban informal settlements attempt to meet their WaSH needs through marketing exchange. Exchanges of all four archetypes were present, often in combination. Motivations for participating in the marketing exchanges were based on social relationships alongside WaSH needs, health aspirations and financial circumstances. By leveraging these

motivations and pre-existing, self-determined marketing exchanges, WaSH practitioners may be able to foster WaSH marketing exchanges consistent with local context and capabilities, in turn improving community physical, mental and social health.

4 **Bonda DJ, Manjila S, Mehndiratta P, Khan F, Miller BR, Onwuzulike K, Puoti G, Cohen ML, Schonberger LB, Cali I.**
Human prion diseases: surgical lessons learned from iatrogenic prion transmission.
Neurosurg Focus 2016 Jul;41(1):E10.

The human prion diseases, or transmissible spongiform encephalopathies, have captivated our imaginations since their discovery in the Fore linguistic group in Papua New Guinea in the 1950s. The mysterious and poorly understood 'infectious protein' has become somewhat of a household name in many regions across the globe. From bovine spongiform encephalopathy (BSE), commonly identified as mad cow disease, to endocannibalism, media outlets have capitalized on these devastatingly fatal neurological conditions. Interestingly, since their discovery, there have been more than 492 incidents of iatrogenic transmission of prion diseases, largely resulting from prion-contaminated growth hormone and dura mater grafts. Although fewer than 9 cases of probable iatrogenic neurosurgical cases of Creutzfeldt-Jakob disease (CJD) have been reported worldwide, the likelihood of some missed cases and the potential for prion transmission by neurosurgery create considerable concern. Laboratory studies indicate that standard decontamination and sterilization procedures may be insufficient to completely remove infectivity from prion-contaminated instruments. In this unfortunate event, the instruments may transmit the prion disease to others. Much caution therefore should be taken in the absence of strong evidence against the presence of a prion disease in a neurosurgical patient. While the Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) have devised risk assessment and decontamination protocols for the prevention of iatrogenic transmission of the prion diseases, incidents of possible exposure to prions have unfortunately occurred in the United States. In this article, the authors outline the historical discoveries that led from kuru to the identification and isolation of the pathological prion proteins in addition to providing a brief description of human prion diseases and iatrogenic forms of CJD, a brief history of prion disease nosocomial transmission, and a summary of the CDC and WHO guidelines for prevention of prion disease transmission and decontamination of prion-contaminated neurosurgical instruments.

5 **Bong IW, Felker ME, Maryudi A.**
How are local people driving and affected by forest cover change? Opportunities for local participation in REDD+ measurement, reporting and verification.
PLoS One 2016 Nov 2;11(11):e0145330.

Deforestation and forest degradation are complex and dynamic processes that vary from place to place. They are driven by multiple causes. Local communities are, to some extent, driving and also affected by some of these processes. Can their knowledge aid and add to place-specific assessment and monitoring of Deforestation and forest Degradation (DD) drivers? Our research was conducted in seven villages across three provinces of Indonesia (Papua, West Kalimantan and Central Java). Household surveys and focus group discussions were used to investigate how local community knowledge of DD drivers contributes to place-specific assessment and monitoring of DD drivers. We analyzed the link between drivers and local livelihoods to see how attempts to address deforestation and forest degradation might affect local communities and how this link might influence their participation in climate change mitigation measures such as Reducing Emissions from Deforestation and Forest Degradation (REDD+) and Measuring, Reporting and Verifying (MRV) activities. We found that local knowledge is fundamental to capturing the variety of drivers particularly in countries like Indonesia where forest and socio-economic conditions are diverse. Better understanding of drivers and their importance for local livelihoods will not only contribute to a more locally appropriate design of REDD+ and monitoring systems but will also foster local participation.

6 **Burdam FH, Hakimi M, Thio F, Kenangalem E, Indrawanti R, Noviyanti R, Trianty L, Marfurt J, Handayuni I, Soenarto Y, Douglas NM, Anstey NM, Price RN, Poespoprodjo JR.**
Asymptomatic vivax and falciparum parasitaemia with helminth co-infection: major risk factors for anaemia in early life.
PLoS One 2016 Aug 9;11(8):e0160917.

BACKGROUND: Anaemia in children under five years old is associated with poor health, growth and developmental outcomes. In Papua, Indonesia, where the burden of anaemia in infants is high, we conducted a community survey to assess the association between *Plasmodium* infection, helminth carriage and the risk of anaemia. METHODS: A cross sectional household survey was carried out between April and July 2013 in 16 villages in the District of Mimika using a multistage sampling procedure. A total of 629 children aged 1-59 months from 800 households were included in the study. Demographic, symptom and anthropometry data were recorded using a standardized questionnaire. Blood and stool samples were collected for examination. RESULTS: Of the 533 children with blood film examination, 8.8% (47) had *P. vivax* parasitaemia and 3.9% (21) had *P. falciparum*; the majority of children with malaria were asymptomatic (94.4%, 68/72). Soil transmitted helminth (STH) infection was present in 43% (105/269) of children assessed; those with STH were at significantly greater risk of *P. vivax* parasitaemia compared to those without STH (OR = 3.7 [95%CI 1.5-9.2], p = 0.004). Anaemia (Hb<10 g/dl) was present in 24.5% (122/497) of children and associated with *P. vivax* parasitaemia (OR = 2.9 [95%CI, 1.7-4.9], p = 0.001), *P. falciparum* parasitaemia (OR = 4.3 [95%CI, 2.0-9.4], p<0.001), hookworm carriage (OR = 2.6 [95%CI, 1.2-5.8], p = 0.026), *Plasmodium*-helminth coinfection (OR 4.0 [95%CI, 1.4-11.3], p = 0.008) and severe stunting (OR = 1.9 ([95%CI, 1.1-3.3], p = 0.012). CONCLUSIONS: Asymptomatic *P. vivax* and *P. falciparum* infections and hookworm all contribute to risk of paediatric anaemia in coendemic areas and should be targeted with prevention and treatment programs. The relationship between helminth infections and the increased risk of *P. vivax* parasitaemia should be explored prospectively.

7 **Burnett A, Yashadhana A, Cabrera Aguas M,**

Hanni Y, Yu M.
Experiences of vision impairment in Papua New Guinea: implications for blindness prevention programs.
Rural Remote Health 2016 Oct-Dec;16(4):3873.

INTRODUCTION: A person's capability to access services and achieve good eye health is influenced by their behaviours, perceptions, beliefs and experiences. As evidence from Papua New Guinea (PNG) about people's lived experience with vision impairment is limited, the purpose of the present study was to better understand the beliefs, perceptions and emotional responses to vision impairment in PNG. METHODS: A qualitative study, using both purposive and convenience sampling, was undertaken to explore common beliefs and perceptions about vision impairment, as well as the emotional responses to vision impairment. In-depth interviews were undertaken with 51 adults from five provinces representing culturally and geographically diverse regions of PNG. Grounded theory was used to elicit key themes from interview data. RESULTS: Participants described activities of everyday life impacted by vision impairment and the related worry, sadness and social exclusion. Common beliefs about the causes of vision impairment were environmental stressors (sun, dust, dirt and smoke), ageing and sorcery. CONCLUSIONS: Findings provide insight into the unique social context in PNG and identify a number of programmatic and policy implications, such as the need for preventative eye health information and services, addressing persisting beliefs in sorcery when developing health information packages, and the importance of coordinating with counselling and well-being services for people experiencing vision impairment.

8 **Burnett E, Dalipanda T, Ogaoga D, Gaiofa J, Jilini G, Halpin A, Dietz V, Date K, Mintz E, Hyde T, Wannemuehler K, Yen C.**
Knowledge, attitudes, and practices regarding diarrhea and cholera following an oral cholera vaccination campaign in the Solomon Islands.
PLoS Negl Trop Dis 2016 Aug 22;10(8):e0004937.

BACKGROUND: In response to a 2011 cholera outbreak in Papua New Guinea, the Government of the Solomon Islands initiated a cholera prevention program which included cholera disease prevention and treatment messaging, community meetings, and a pre-emptive cholera vaccination campaign targeting 11,000 children aged 1-15 years in selected communities in Choiseul and Western Provinces. METHODOLOGY AND PRINCIPAL FINDINGS: We conducted a post-vaccination campaign, household-level survey about knowledge, attitudes, and practices regarding diarrhea and cholera in areas targeted and not targeted for cholera vaccination. Respondents in vaccinated areas were more likely to have received cholera education in the previous 6 months (33% v. 9%; p = 0.04), to know signs and symptoms (64% vs. 22%; p = 0.02) and treatment (96% vs. 50%; p = 0.02) of cholera, and to be aware of cholera vaccine (48% vs. 14%; p = 0.02). There were no differences in water, sanitation, and hygiene practices. CONCLUSIONS: This pre-emptive OCV campaign in a cholera-naïve community provided a unique opportunity to assess household-level knowledge, attitudes, and practices regarding diarrhea, cholera, and water, sanitation, and hygiene (WASH). Our findings suggest that education provided during the vaccination campaign may have reinforced earlier mass messaging about cholera and diarrheal disease in vaccinated communities.

9 **Butcher RM, Sokana O, Jack K, Macleod CK, Marks ME, Kalae E, Sui L, Russell C, Tutill HJ, Williams RJ, Breuer J, Willis R, Le Mesurier RT, Mabey DC, Solomon AW, Roberts CH.**
Low prevalence of conjunctival infection with *Chlamydia trachomatis* in a treatment-naïve trachoma-endemic region of the Solomon Islands.
PLoS Negl Trop Dis 2016 Sep 7;10(9):e0004863. Correction: *PLoS Negl Trop Dis* 2016 Oct 3;10(10):e0005051.

BACKGROUND: Trachoma is endemic in several Pacific Island states. Recent surveys across the Solomon Islands indicated that whilst trachomatous inflammation-follicular (TF) was present at levels warranting intervention, the prevalence of trachomatous trichiasis (TT) was low. We set out to determine the relationship between chlamydial infection and trachoma in this population. METHODS: We conducted a population-based trachoma prevalence survey of 3674 individuals from two Solomon Islands provinces. Participants were examined for clinical signs of trachoma. Conjunctival swabs were collected from all children aged 1-9 years. We tested swabs for *Chlamydia trachomatis* (Ct) DNA using droplet digital PCR. Chlamydial DNA from positive swabs was enriched and sequenced for use in phylogenetic analysis. RESULTS: We observed a moderate prevalence of TF in children aged 1-9 years (n = 296/1135, 26.1%) but low prevalence of trachomatous inflammation-intense (TI) (n = 2/1135, 0.2%) and current Ct infection (n = 13/1002, 1.3%) in children aged 1-9 years, and TT in those aged 15+ years (n = 2/2061, 0.1%). Ten of 13 (76.9%) cases of infection were in persons with TF or TI (p = 0.0005). Sequence analysis of the Ct-positive samples yielded 5/13 (38%) complete (>95% coverage of reference) genome sequences, and 8/13 complete plasmid sequences. Complete sequences all aligned most closely to ocular serovar reference strains. DISCUSSION: The low prevalence of TT, TI and Ct infection that we observed are incongruent with the high proportion of children exhibiting signs of TF. TF is present at levels that apparently warrant intervention, but the scarcity of other signs of trachoma indicates the phenotype is mild and may not pose a significant public health threat. Our data suggest that, whilst conjunctival Ct infection appears to be present in the region, it is present at levels that are unlikely to be the dominant driving force for TF in the population. This could be one reason for the low prevalence of TT observed during the study.

10 **Chan JA, Howell KB, Langer C, Maier AG, Hasang W, Rogerson SJ, Petter M, Chesson J, Stanisic DI, Duffy MF, Cooke BM, Siba PM, Mueller I, Bull PC, Marsh K, Fowkes FJ, Beeson JG.**
A single point in protein trafficking by *Plasmodium falciparum* determines the expression of major antigens on the surface of infected erythrocytes targeted by human antibodies.
Cell Mol Life Sci 2016 Nov;73(21):4141-4158.

Antibodies to blood-stage antigens of *Plasmodium falciparum* play a pivotal role in human immunity to malaria. During parasite development, multiple proteins are trafficked from the intracellular parasite to the surface of *P. falciparum*-infected erythrocytes (IEs). However, the relative importance of different proteins as

targets of acquired antibodies, and key pathways involved in trafficking major antigens remain to be clearly defined. We quantified antibodies to surface antigens among children, adults, and pregnant women from different malaria-exposed regions. We quantified the importance of antigens as antibody targets using genetically engineered *P. falciparum* with modified surface antigen expression. Genetic deletion of the trafficking protein skeleton-binding protein-1 (SBP1), which is involved in trafficking the surface antigen PfEMP1, led to a dramatic reduction in antibody recognition of IEs and the ability of human antibodies to promote opsonic phagocytosis of IEs, a key mechanism of parasite clearance. The great majority of antibody epitopes on the IE surface were SBP1-dependent. This was demonstrated using parasite isolates with different genetic or phenotypic backgrounds, and among antibodies from children, adults, and pregnant women in different populations. Comparisons of antibody reactivity to parasite isolates with SBP1 deletion or inhibited *PfEMP1* expression suggest that PfEMP1 is the dominant target of acquired human antibodies, and that other *P. falciparum* IE surface proteins are minor targets. These results establish SBP1 as part of a critical pathway for the trafficking of major surface antigens targeted by human immunity, and have key implications for vaccine development, and quantifying immunity in populations.

11 **Chiu CY, White MT, Healer J, Thompson JK, Siba PM, Mueller I, Cowman AF, Hansen DS.**
Different regions of *Plasmodium falciparum* erythrocyte-binding antigen 175 induce antibody responses to infection of varied efficacy.
J Infect Dis 2016 Jul 1;214(1):96-104.

BACKGROUND: Increasing evidence suggests that antibodies against merozoite proteins involved in *Plasmodium falciparum* invasion into the red blood cell play an important role in clinical immunity to malaria. Erythrocyte-binding antigen 175 (EBA-175) is the best-characterized *P. falciparum* invasion ligand, reported to recognize glycophorin A on the surface of erythrocytes. Its protein structure comprises 6 extracellular regions. Whereas region II contains Duffy binding-like domains involved in the binding to glycophorin A, the functional role of regions III-V is less clear. METHODS: We developed a novel cytometric bead array for assessment of antigen-specific antibody concentration in plasma to evaluate the efficacy of immune responses to different regions of EBA-175 and associations between antibody levels with protection from symptomatic malaria in a treatment-reinfection cohort study. RESULTS: We found that while antibodies to region II are highly abundant, circulating levels as low as 5-10 μg/mL of antibodies specific for region III or the highly conserved regions IV-V predict strong protection from clinical malaria. CONCLUSIONS: These results lend support for the development of conserved regions of EBA-175 as components in a combination of a malaria vaccine.

12 **Clegg JM, Legare CH.**
A cross-cultural comparison of children's imitative flexibility.
Dev Psychol 2016 Sep;52(9):1435-1444.

Recent research with Western populations has demonstrated that children use imitation flexibly to engage in both instrumental and conventional learning. Evidence for children's imitative flexibility in non-Western populations is limited, however, and has only assessed imitation of instrumental tasks. This study (N = 142, 6- to 8-year-olds) demonstrates both cultural continuity and cultural variation in imitative flexibility. Children engage in higher imitative fidelity for conventional tasks than for instrumental tasks in both an industrialized, Western culture (United States), and a subsistence-based, non-Western culture (Vanuatu). Children in Vanuatu engage in higher imitative fidelity of instrumental tasks than in the United States, a potential consequence of cultural variation in child socialization for conformity.

13 **Cohen PJ, Lawless S, Dyer M, Morgan M, Saeni E, Teioli H, Kantor P.**
Understanding adaptive capacity and capacity to innovate in social-ecological systems: applying a gender lens.
Ambio 2016 Dec;45(Suppl 3):309-321.

Development policy increasingly focuses on building capacities to respond to change (adaptation), and to drive change (innovation). Few studies, however, focus specifically on the social and gender differentiation of capacities to adapt and innovate. We address this gap using a qualitative study in three communities in Solomon Islands, a developing country, where rural livelihoods and well-being are tightly tied to agriculture and fisheries. We find the five dimensions of capacity to adapt and to innovate (ie, assets, flexibility, learning, social organisation, agency) to be mutually dependent. For example, limits to education, physical mobility and agency meant that women and youth, particularly, felt it was difficult to establish relations with external agencies to access technical support or new information important for innovating or adapting. Willingness to bear risk and to challenge social norms hindered both women's and men's capacity to innovate, albeit to differing degrees. Our findings are of value to those aspiring for equitable improvements to well-being within dynamic and diverse social-ecological systems.

14 **Craig AT, Kama M, Samo M, Vaai S, Matanaicake J, Joshua C, Kolbe A, Durrheim DN, Paterson BJ, Biaukula V, Nilles EJ.**
Early warning epidemic surveillance in the Pacific island nations: an evaluation of the Pacific Syndromic Surveillance System.
Trop Med Int Health 2016 Jul;21(7):917-927.

OBJECTIVE: The Pacific Syndromic Surveillance System (PSSS), launched in 2010, provides a simple mechanism by which 121 sentinel surveillance sites in 21 Pacific island countries and areas perform routine indicator- and event-based surveillance for the early detection of infectious disease outbreaks. This evaluation aims to assess whether the PSSS is meeting its objectives, what progress has been made since a formative evaluation of the system was conducted in 2011, and provides recommendations to enhance the PSSS's performance in the future. METHODS: Twenty-one informant interviews were conducted with national operators of the system and regional public health agencies that use information generated by it. Historic PSSS data were analysed to assess timeliness and completeness of reporting. RESULTS: The system is simple, acceptable and useful for public health decision-makers. The PSSS has greatly enhanced Pacific island countries' ability to undertake early warning surveillance and has contributed to efforts to meet national

surveillance-related International Health Regulation (2005) capacity development obligations. Despite this, issues with timeliness and completeness of reporting, data quality and system stability persist. CONCLUSION: A balance between maintaining the system's simplicity and technical advances will need to be found to ensure its long-term sustainability, given the low-resource context for which it is designed.

15 **Crivelli C, Russell JA, Jarillo S, Fernández-Dols JM.**
The fear gasping face as a threat display in a Melanesian society.
Proc Natl Acad Sci USA 2016 Nov 1;113(44):12403-12407.

Theory and research show that humans attribute both emotions and intentions to others on the basis of facial behavior: a gasping face can be seen as showing 'fear' and intent to submit. The assumption that such interpretations are pancultural derives largely from Western societies. Here, we report two studies conducted in an indigenous, small-scale Melanesian society with considerable cultural and visual isolation from the West: the Trobrianders of Papua New Guinea. Our multidisciplinary research team spoke the vernacular and had extensive prior fieldwork experience. In study 1, Trobriand adolescents were asked to attribute emotions, social motives, or both to a set of facial displays. Trobrianders showed a mixed and variable attribution pattern, although with much lower agreement than studies of Western samples. Remarkably, the gasping face (traditionally considered a display of fear and submission in the West) was consistently matched to two unpredicted categories: anger and threat. In study 2, adolescents were asked to select the face that was threatening; Trobrianders chose the 'fear' gasping face whereas Spaniards chose an 'angry' scowling face. Our findings, consistent with functional approaches to animal communication and observations made on threat displays in small-scale societies, challenge the Western assumption that 'fear' gasping faces uniformly express fear or signal submission across cultures.

16 **Crivelli C, Jarillo S, Russell JA, Fernández-Dols JM.**
Reading emotions from faces in two indigenous societies.
J Exp Psychol Gen 2016 Jul;145(7):830-843.

That all humans recognize certain specific emotions from their facial expression – the Universality Thesis – is a pillar of research, theory, and application in the psychology of emotion. Its most rigorous test occurs in indigenous societies with limited contact with external cultural influences, but such tests are scarce. Here we report 2 such tests. Study 1 was of children and adolescents (N = 68; aged 6-16 years) of the Trobriand Islands (Papua New Guinea, South Pacific) with a Western control group from Spain (N = 113, of similar ages). Study 2 was of children and adolescents (N = 36; same age range) of Matemo Island (Mozambique, Africa). In both studies, participants were shown an array of prototypical facial expressions and asked to point to the person feeling a specific emotion: happiness, fear, anger, disgust, or sadness. The Spanish control group matched faces to emotions as predicted by the Universality Thesis: matching was seen on 83% to 100% of trials. For the indigenous societies, in both studies, the Universality Thesis was moderately supported for happiness: smiles were matched to happiness on 58% and 56% of trials, respectively. For other emotions, however, results were even more modest: 7% to 46% in the Trobriand Islands and 22% to 53% in Matemo Island. These results were robust across age, gender, static versus dynamic display of the facial expressions, and between- versus within-subjects design.

17 **Daufanamae BU, Franklin RC, Eagers J.**
Unintentional injury prevention and the role of occupational therapy in the Solomon Islands: an integrative review.
Rural Remote Health 2016 Oct-Dec;16(4):3810.

INTRODUCTION: Unintentional injuries (injuries for which there is no evidence of a predetermined intent) are one of the leading causes of death worldwide, particularly in low- and middle-income countries (LMICs). Although evidence demonstrates unintentional injuries are preventable it is a public health challenge for many LMICs such as the Solomon Islands. Occupational therapists are well placed to contribute to injury prevention, as they have specialised skills to analyse the accessibility and safety of the environments within which people conduct their daily occupations. While the role of occupational therapy in unintentional injury prevention is well known in high-income countries, it is unfamiliar in LMICs, especially in the Solomon Islands. This integrative review aimed to explore the incidence of common unintentional injuries, and the burden in the Solomon Islands; and explore the potential role of occupational therapy in unintentional injury prevention in the Solomon Islands, based on current activities in LMICs. METHOD: Articles were reviewed from six databases (Medline, CINAHL, OTDBase, OT Seeker, Scopus and PsychInfo). Five articles met the inclusion criteria for the first objective and 15 articles met the inclusion criteria for the second objective. These articles were thematically analysed where themes and codes associated with the research objectives were extracted and analysed. RESULTS: Unintentional injuries in the Solomon Islands reported in the literature included ocular trauma, falls from fruit trees and coconut palms, and road traffic crashes. Burden of injury reported was mostly associated with loss of productivity. Occupational therapists undertook rehabilitative, biomechanical, neurodevelopmental and educational roles in LMIC, focusing on tertiary and secondary injury prevention. CONCLUSIONS: This integrative review suggests that there is limited information regarding injury in the Solomon Islands. However, evidence is available in LMICs to suggest that occupational therapy services can play a potential significant role in unintentional injury prevention, demonstrating a need for establishing injury prevention within the occupational therapy role in the Solomon Islands.

18 **Davis J, Vyankandondera J, Luchters S, Simon D, Holmes W.**
Male involvement in reproductive, maternal and child health: a qualitative study of policymaker and practitioner perspectives in the Pacific.
Reprod Health 2016 Jul 16;13(1):81.

BACKGROUND: The importance of involving men in reproductive, maternal and child health programs is increasingly recognised globally. In the Pacific region, most maternal and child health

services do not actively engage expectant fathers and fathers of young children and few studies have been conducted on the challenges, benefits and opportunities for involving fathers. This study explores the attitudes and beliefs of maternal and child health policymakers and practitioners regarding the benefits, challenges, risks and approaches to increasing men's involvement in maternal and child health education and clinical services in the Pacific. METHODS: In-depth interviews were conducted with 17 senior maternal and child health policymakers and practitioners, including participants from five countries (Cook Islands, Fiji, Papua New Guinea, Solomon Islands, and Vanuatu) and four regional organisations in the Pacific. Qualitative data generated were analysed thematically. RESULTS: Policymakers and practitioners reported that greater men's involvement would result in a range of benefits for maternal and child health, primarily through greater access to services and interventions for women and children. Perceived challenges to greater father involvement included sociocultural norms, difficulty engaging couples before first pregnancy, the physical layout of clinics, and health worker workloads and attitudes. Participants also suggested a range of strategies for increasing men's involvement, including engaging boys and men early in the life-cycle, in community and clinic settings, and making health services more father-friendly through changes to clinic spaces and health worker recruitment and training. CONCLUSIONS: These findings suggest that increasing men's involvement in maternal and child health services in the Pacific will require initiatives to engage men in community and clinic settings, engage boys and men of all ages, and improve health infrastructure and service delivery to include men. Our findings also suggest that while most maternal and child health officials consulted perceived many benefits of engaging fathers, perceived challenges to doing so may prevent the development of policies that explicitly direct health providers to routinely include fathers in maternal and child health services. Pilot studies assessing feasibility and acceptability of context-appropriate strategies for engaging fathers will be useful in addressing concerns regarding challenges to engaging fathers.

19 **Donald W, Pasay C, Guintran JO, Iata H, Anderson K, Nausien J, Gresty KJ, Waters NC, Vestergaard LS, Taleo G, Cheng Q.**
The utility of malaria rapid diagnostic tests as a tool in enhanced surveillance for malaria elimination in Vanuatu.
PLoS One 2016 Nov 30;11(11):e0167136.

BACKGROUND: As part of efforts to eliminate malaria, Vanuatu has piloted the implementation of enhanced malaria surveillance and response strategies since 2011. This involves passive case detection (PCD) in health facilities, proactive case detection (Pro-ACD) and reactive case detection (Re-ACD) in communities using malaria rapid diagnostic tests (RDTs). While RDTs improve case management, their utility for detection of malaria infections in ACDs in this setting is unclear. METHODS: The utility of malaria RDTs as diagnostic tools was evaluated in PCD, in five rounds of Pro-ACDs and five rounds of Re-ACDs conducted in Tafea and Torba Provinces between 2011 and 2014. The number of malaria infections detected by RDTs was compared to that detected by PCR from collected used-RDTs. RESULTS: PCD in Tafea Province (2013) showed a RDT-positive rate of 0.21% (2/939) and a PCR-positive rate of 0.44% (2/453), indicating less than 1% of suspected malaria cases in Tafea Province were due to malaria. In Pro-ACDs conducted in Tafea and Torba Provinces, RDT-positive rates in 2013 and 2014 were 0.14% (3/2145) and 0% (0/2823), respectively, while the corresponding PCR-positive rates were 0.72% (9/1242) and 0.79% (9/1141). PCR identified villages in both provinces appearing to be transmission foci with a small number of low-density infections, mainly *P. falciparum* infections. In five rounds of Re-ACD, RDTs did not identify any additional infections while PCR detected only one among 173 subjects screened. CONCLUSIONS: PCD and Pro-ACDs demonstrate that both Tafea and Torba Provinces in Vanuatu has achieved very low malaria prevalence. In these low-transmission areas, conducting Pro-ACD and Re-ACDs using RDTs appears not cost-effective and may have limited impact on interrupting malaria transmission due to the small number of infections identified by RDTs and considerable operational resources invested. More sensitive, field deployable and affordable diagnostic tools will improve malaria surveillance in malaria elimination settings.

20 **Drew DR, Wilson DW, Elliott SR, Cross N, Terheggen U, Hodder AN, Siba PM, Chelimo K, Dent AE, Kazura JW, Mueller I, Beeson JG.**
A novel approach to identifying patterns of human invasion-inhibitory antibodies guides the design of malaria vaccines incorporating polymorphic antigens.
BMC Med 2016 Sep 23;14(1):144.

BACKGROUND: The polymorphic nature of many malaria vaccine candidates presents major challenges to achieving highly efficacious vaccines. Presently, there is very little knowledge on the prevalence and patterns of functional immune responses to polymorphic vaccine candidates in populations to guide vaccine design. A leading polymorphic vaccine candidate against blood-stage *Plasmodium falciparum* is apical membrane antigen 1 (AMA1), which is essential for erythrocyte invasion. The importance of AMA1 as a target of acquired human inhibitory antibodies, their allele specificity and prevalence in populations is unknown, but crucial for vaccine design. METHODS: *P. falciparum* lines expressing different AMA1 alleles were genetically engineered and used to quantify functional antibodies from two malaria-exposed populations of adults and children. The acquisition of AMA1 antibodies was also detected using enzyme-linked immunosorbent assay (ELISA) and competition ELISA (using different AMA1 alleles) from the same populations. RESULTS: We found that AMA1 was a major target of naturally acquired invasion-inhibitory antibodies that were highly prevalent in malaria-endemic populations and showed a high degree of allele specificity. Significantly, the prevalence of inhibitory antibodies to different alleles varied substantially within populations and between geographic locations. Inhibitory antibodies to three specific alleles were highly prevalent (FVO and W2mef in Papua New Guinea; FVO and XIE in Kenya), identifying them for potential vaccine inclusion. Measurement of antibodies by standard or competition ELISA was not strongly predictive of allele-specific inhibitory antibodies. The patterns

of allele-specific functional antibody responses detected with our novel assays may indicate that acquired immunity is elicited towards serotypes that are prevalent in each geographic location. CONCLUSIONS: These findings provide new insights into the nature and acquisition of functional immunity to a polymorphic vaccine candidate and strategies to quantify functional immunity in populations to guide rational vaccine design.

21 **Duke T.**
Maintenance intravenous fluids for children: enough evidence, now for translation and action.
Paediatr Int Child Health 2016 Aug;36(3):165-167.

22 **França CT, He WQ, Gruszczyk J, Lim NT, Lin E, Kiniboro B, Siba PM, Tham WH, Mueller I.**
Plasmodium vivax reticulocyte binding proteins are key targets of naturally acquired immunity in young Papua New Guinean children.
PLoS Negl Trop Dis 2016 Sep 27;10(9):e0005014.
BACKGROUND: Major gaps in our understanding of *Plasmodium vivax* biology and the acquisition of immunity to this parasite hinder vaccine development. *P. vivax* merozoites exclusively invade reticulocytes, making parasite proteins that mediate reticulocyte binding and/or invasion potential key vaccine or drug targets. While protein interactions that mediate invasion are still poorly understood, the *P. vivax* Reticulocyte-Binding Protein family (PvRBP) is thought to be involved in *P. vivax* restricted host-cell selectivity. METHODOLOGY/PRINCIPAL FINDINGS: We assessed the binding specificity of five members of the PvRBP family (PvRBP1a, PvRBP1b, PvRBP2a, PvRBP2b, PvRBP2-P2 and a non-binding fragment of PvRBP2c) to normocytes or reticulocytes. PvRBP2b was identified as the only reticulocyte-specific binder ($p < 0.001$), whereas the others preferentially bound to normocytes (PvRBP1a/b, $p \leq 0.034$), or showed comparable binding to both (PvRBP2a/2-P2, $p = 0.38$). Furthermore, we measured levels of total and IgG subclasses 1, 2, 3 and 4 to the six PvRBPs in a cohort of young Papua New Guinean children, and assessed their relationship with prospective risk of *P. vivax* malaria. Children had substantial, highly correlated (rho = 0.49-0.82, $p < 0.001$) antibody levels to all six PvRBPs, with dominant IgG1 and IgG3 subclasses. Both total IgG (Incidence Rate Ratio [IRR] 0.63-0.73, $p = 0.008$-0.041) and IgG1 (IRR 0.56-0.69, $p = 0.001$-0.035) to PvRBP2b and PvRBP1a were strongly associated with reduced risk of vivax malaria, independently of age and exposure. CONCLUSION/SIGNIFICANCE: These results demonstrate a diversity of erythrocyte-binding phenotypes of PvRBPs, indicating binding to both reticulocyte-specific and normocyte-specific ligands. Our findings provide further insights into the naturally acquired immunity to *P. vivax* and highlight the importance of PvRBP proteins as targets of naturally acquired humoral immunity. In-depth studies of the role of PvRBPs in *P. vivax* invasion and functional validation of the role of anti-PvRBP antibodies in clinical immunity against *P. vivax* are now required to confirm the potential of the reticulocyte-binding PvRBP2b and PvRBP1a as vaccine candidate antigens.

23 **Gallagher RM.**
Reaching across the strait: a surgical lesson from Papua New Guinea.
ANZ J Surg 2016 Sep;86(9):634.

24 **Gangaiah D, Spinola SM.**
Haemophilus ducreyi cutaneous ulcer strains diverged from both class I and class II genital ulcer strains: implications for epidemiological studies.
PLoS Negl Trop Dis 2016 Dec 27;10(12):e0005259.
BACKGROUND: *Haemophilus ducreyi* has emerged as a major cause of cutaneous ulcers (CU) in yaws-endemic regions of the tropics in the South Pacific, South East Asia and Africa. *H. ducreyi* was once thought only to cause the genital ulcer (GU) disease chancroid; GU strains belong to 2 distinct classes, class I and class II. Using whole-genome sequencing of 4 CU strains from Samoa, 1 from Vanuatu and 1 from Papua New Guinea, we showed that CU strains diverged from the class I strain 35000HP and that one CU strain expressed β-lactamase. Recently, the Centers for Disease Control and Prevention released the genomes of 11 additional CU strains from Vanuatu and Ghana; however, the evolutionary relationship of these CU strains to previously characterized CU and GU strains is unknown. METHODOLOGY/PRINCIPAL FINDINGS: We performed phylogenetic analysis of 17 CU and 10 GU strains. Class I and class II GU strains formed two distinct clades. The class I strains formed two subclades, one containing 35000HP and HD183 and the other containing the remainder of the class I strains. Twelve of the CU strains formed a subclone under the class I 35000HP subclade, while 2 CU strains formed a subclone under the other class I subclade. Unexpectedly, 3 of the CU strains formed a subclone under the class II clade. Phylogenetic analysis of *dsrA-hgbA-ncaA* sequences yielded a tree similar to that of the whole-genome phylogenetic tree. CONCLUSIONS/SIGNIFICANCE: CU strains diverged from multiple lineages within both class I and class II GU strains. Multilocus sequence typing of *dsrA-hgbA-ncaA* could be reliably used for epidemiological investigation of CU and GU strains. As class II strains grow relatively poorly and are relatively more susceptible to vancomycin than class I strains, these findings have implications for methods to recover CU strains. Comparison of contemporary CU and GU isolates would help clarify the relationship between these entities.

25 **Getahun A, Baekalia M, Panda N, Lee A, Puiahi E, Khan S, Tahani D, Manongi D.**
Seroprevalence of hepatitis B surface antigen in pregnant women attending antenatal clinic in Honiara, Solomon Islands, 2015.
World J Hepatol 2016 Dec 8;8(34):1521-1528.
AIM: To determine the seroprevalence of hepatitis B surface antigen (HBsAg) among pregnant women attending antenatal clinic in Honiara, Solomon Islands. METHODS: This descriptive cross-sectional study was carried out in seven area health centers in Honiara. From March to June 2015, identification of eligible pregnant women in each site was conducted using systematic random sampling technique. A total of 243 pregnant women who gave written informed consent were enrolled. Standardized tool was used to record demographics, obstetric history and serology results. HBsAg and hepatitis B e antigen (HBeAg) were tested using point-of-care rapid diagnostic test. All HBsAg positive samples were verified using enzyme-linked immunosorbent assay. RESULTS: The mean age of participants was 26 ± 6 years. The overall hepatitis HBsAg prevalence

was 13.8% with higher rate (22%) reported in women between 30 and 34 years of age. Majority of HBsAg positive participants were Melanesians (29 out of 33). None of the pregnant women in the 15-19 years and ≥40 years tested positive for HBsAg. There was no statistically significant difference in HBsAg prevalence by age, ethnicity, education or residential location. The overall HBeAg seroprevalence was 36.7%. Women between 20 and 24 years of age had the highest rate of 54.5%. Low level of knowledge about hepatitis B vaccination was reported. Overall, 54.6% of participants were not aware of their hepatitis B vaccination status and only 65.2% of mothers reported their child had been vaccinated. CONCLUSION: Hepatitis B is a disease of public health importance in Solomon Islands and this emphasizes the need for integrated preventative interventions for its control.

26 **Gouda HN, Kelly-Hanku A, Wilson L, Maraga S, Riley ID.**
"Whenever they cry, I cry with them": reciprocal relationships and the role of ethics in a verbal autopsy study in Papua New Guinea.
Soc Sci Med 2016 Aug;163:1-9.

Verbal autopsy (VA) methods usually involve an interview with a recently bereaved individual to ascertain the most probable cause of death when a person dies outside of a hospital and/or did not receive a reliable death certificate. A number of concerns have arisen around the ethical and social implications of the use of these methods. In this paper we examine these concerns, looking specifically at the cultural factors surrounding death and mourning in Papua New Guinea, and the potential for VA interviews to cause emotional distress in both the bereaved respondent and the VA fieldworker. Thirty-one semi-structured interviews with VA respondents, the VA team and community relations officers as well as observations in the field and team discussions were conducted between June 2013 and August 2014. While our findings reveal that VA participants were often moved to cry and feel sad, they also expressed a number of ways they benefited from the process, and indeed welcomed longer transactions with the VA interviewers. Significantly, this paper highlights the ways in which VA interviewers, who have hitherto been largely neglected in the literature, navigate transactions with the participants and make everyday decisions about their relationships with them in order to ensure that they and VA interviews are accepted by the community. The role of the VA fieldworker should be more carefully considered, as should the implications for training and institutional support that follow.

27 **Heggen AE, Solomon AW, Courtright P.**
Perspectives of national coordinators and partners on the work of the Global Trachoma Mapping Project.
Ophthalmic Epidemiol 2016 Dec;23(6):366-372.

PURPOSE: Neglected tropical diseases (NTDs) affect people living in the poorest regions of the world and their debilitating effects perpetuate the poverty cycle. Understanding the distribution of NTDs is crucial for effective intervention delivery. In 2012, the Global Trachoma Mapping Project (GTMP) was initiated to map >1800 suspected trachoma endemic districts by March 2015. This research was carried out to better understand the implementation experience and identify lessons which might inform the GTMP and similar initiatives. METHODS: Using grounded theory methodology, semi-structured interviews were conducted with key informants from six countries with 63% of the global mapping backlog (Ethiopia, Malawi, Mozambique, Nigeria, Solomon Islands, and Yemen). Interviews were transcribed, coded, and findings separated into categories. RESULTS: Three themes were identified during the research: planning and operations, technical implementation, and governance. The project was felt to be most successful in countries where the Ministry of Health was actively engaged in setting standards, ensuring capacity building for government staff, and guiding the training, data collection, analysis, and interpretation of data. Standardized tools, training platforms, and the use of electronic data capture increased confidence in the reliability of the survey data, informed quality improvement efforts within survey implementation, and the immediate release of results empowered end-user decision-makers. Regional collaboration between endemic countries bolstered program manager competence and confidence, while reinforcing partnerships essential to the success of the GTMP. CONCLUSIONS: We depict how innovative characteristics of the GTMP, and lessons learned from its implementation, can strengthen similar initiatives to map disease prevalence and risk factors.

28 **Hill DL, Wilson DW, Sampaio NG, Eriksson EM, Ryg-Cornejo V, Harrison GL, Uboldi AD, Robinson LJ, Beeson JG, Siba P, Cowman AF, Hansen DS, Mueller I, Schofield L.**
Merozoite antigens of *Plasmodium falciparum* elicit strain-transcending opsonizing immunity.
Infect Immun 2016 Jul 21;84(8):2175-2184.

It is unclear whether naturally acquired immunity to *Plasmodium falciparum* results from the acquisition of antibodies to multiple, diverse antigens or to fewer, highly conserved antigens. Moreover, the specific antibody functions required for malaria immunity are unknown, and hence informative immunological assays are urgently needed to address these knowledge gaps and guide vaccine development. In this study, we investigated whether merozoite-opsonizing antibodies are associated with protection from malaria in a strain-specific or strain-transcending manner by using a novel field isolate and an immune plasma-matched cohort from Papua New Guinea with our validated assay of merozoite phagocytosis. Highly correlated opsonization responses were observed across the 15 parasite strains tested, as were strong associations with protection (composite phagocytosis score across all strains in children uninfected at baseline: hazard ratio of 0.15, 95% confidence interval of 0.04 to 0.63). Opsonizing antibodies had a strong strain-transcending component, and the opsonization of transgenic parasites deficient for MSP3, MSP6, MSPDBL1, or *P. falciparum* MSP1-19 (PfMSP1-19) was similar to that of wild-type parasites. We have provided the first evidence that merozoite opsonization is predominantly strain transcending, and the highly consistent associations with protection against diverse parasite strains strongly supports the use of merozoite opsonization as a correlate of immunity for field studies and vaccine trials. These results demonstrate that conserved domains within merozoite antigens targeted by opsonization generate strain-transcending immune responses and represent promising vaccine candidates.

29 **Hoy D, Saketa ST, Maraka RR, Sio A, Wanyeki I, Frison P, Ogaoga D, Iniakawala D, Joshua C, Duituturaga S, Lepers C, Roth A, White P, Souares Y.**
Enhanced syndromic surveillance for mass gatherings in the Pacific: a case study of the 11th Festival of Pacific Arts in Solomon Islands, 2012.
Western Pac Surveill Response J 2016 Sep 27;7(3):15-20.

Mass gatherings pose public health challenges to host countries, as they can cause or exacerbate disease outbreaks within the host location or elsewhere. In July 2012, the 11th Festival of Pacific Arts (FOPA), a mass gathering event involving 22 Pacific island states and territories, was hosted by Solomon Islands. An enhanced syndromic surveillance (ESS) system was implemented for the event. Throughout the capital city, Honiara, 15 sentinel sites were established and successfully took part in the ESS system, which commenced one week before the FOPA (25 June) and concluded eight days after the event (22 July). The ESS involved expanding on the existing syndromic surveillance parameters: from one to 15 sentinel sites, from four to eight syndromes, from aggregated to case-based reporting and from weekly to daily reporting. A web-based system was developed to enable data entry, data storage and data analysis. Towards the end of the ESS period, a focus group discussion and series of key informant interviews were conducted. The ESS was considered a success and played an important role in the early detection of possible outbreaks. For the period of the ESS, 1668 patients with syndrome presentations were received across the 15 sentinel sites. There were no major events of public health significance. Several lessons were learnt that are relevant to ESS in mass gathering scenarios, including the importance of having adequate lead-in time for engagement and preparation to ensure appropriate policy and institutional frameworks are put in place.

30 **Hupalo DN, Luo Z, Melnikov A, Sutton PL, Rogov P, Escalante A, Vallejo AF, Herrera S, Arévalo-Herrera M, Fan Q, Wang Y, Cui L, Lucas CM, Durand S, Sanchez JF, Baldeviano GC, Lescano AG, Laman M, Barnadas C, Barry A, Mueller I, Kazura JW, Eapen A, Kanagaraj D, Valecha N, Ferreira MU, Roobsoong W, Nguitragool W, Sattabonkot J, Gamboa D, Kosek M, Vinetz JM, González-Cerón L, Birren BW, Neafsey DE, Carlton JM.**
Population genomics studies identify signatures of global dispersal and drug resistance in *Plasmodium vivax*.
Nat Genet 2016 Aug;48(8):953-958.

Plasmodium vivax is a major public health burden, responsible for the majority of malaria infections outside Africa. We explored the impact of demographic history and selective pressures on the *P. vivax* genome by sequencing 182 clinical isolates sampled from 11 countries across the globe, using hybrid selection to overcome human DNA contamination. We confirmed previous reports of high genomic diversity in *P. vivax* relative to the more virulent *Plasmodium falciparum* species; regional populations of *P. vivax* exhibited greater diversity than the global *P. falciparum* population, indicating a large and/or stable population. Signals of natural selection suggest that *P. vivax* is evolving in response to antimalarial drugs and is adapting to regional differences in the human host and the mosquito vector. These findings underline the variable epidemiology of this parasite species and highlight the breadth of approaches that may be required to eliminate *P. vivax* globally.

31 **Igai K, Itakura M, Nishijima S, Tsurumaru H, Suda W, Tsutaya T, Tomitsuka E, Tadokoro K, Baba J, Odani S, Natsuhara K, Morita A, Yoneda M, Greenhill AR, Horwood PF, Inoue J, Ohkuma M, Hongoh Y, Yamamoto T, Siba PM, Hattori M, Minamisawa K, Umezaki M.**
Nitrogen fixation and *nifH* diversity in human gut microbiota.
Sci Rep 2016 Aug 24;6:31942.

It has been hypothesized that nitrogen fixation occurs in the human gut. However, whether the gut microbiota truly has this potential remains unclear. We investigated the nitrogen-fixing activity and diversity of the nitrogenase reductase (NifH) genes in the faecal microbiota of humans, focusing on Papua New Guinean and Japanese individuals with low to high habitual nitrogen intake. A $^{15}N_2$ incorporation assay showed significant enrichment of ^{15}N in all faecal samples, irrespective of the host nitrogen intake, which was also supported by an acetylene reduction assay. The fixed nitrogen corresponded to 0.01% of the standard nitrogen requirement for humans, although our data implied that the contribution in the gut in vivo might be higher than this value. The *nifH* genes recovered in cloning and metagenomic analyses were classified in two clusters: one comprising sequences almost identical to *Klebsiella* sequences and the other related to sequences of *Clostridiales* members. These results are consistent with an analysis of databases of faecal metagenomes from other human populations. Collectively, the human gut microbiota has a potential for nitrogen fixation, which may be attributable to *Klebsiella* and *Clostridiales* strains, although no evidence was found that the nitrogen-fixing activity substantially contributes to the host nitrogen balance.

32 **Imai C, Cheong HK, Kim H, Honda Y, Eum JH, Kim CT, Kim JS, Kim Y, Behera SK, Hassan MN, Nealon J, Chung H, Hashizume M.**
Associations between malaria and local and global climate variability in five regions in Papua New Guinea.
Trop Med Health 2016 Aug 4;44:23.

BACKGROUND: Malaria is a significant public health issue in Papua New Guinea (PNG) as the burden is among the highest in Asia and the Pacific region. Though PNG's vulnerability to climate change and sensitivity of malaria mosquitoes to weather are well-documented, there are few in-depth epidemiological studies conducted on the potential impacts of climate on malaria incidence in the country. METHODS: This study explored what and how local weather and global climate variability impact on malaria incidence in five regions of PNG. Time series methods were applied to evaluate the associations of malaria incidence with weather and climate factors, respectively. Local weather factors including precipitation and temperature and global climate phenomena such as El Niño-Southern Oscillation (ENSO), the ENSO Modoki, the Southern Annular Mode, and the Indian Ocean Dipole were considered in analyses. RESULTS: The results showed that malaria incidence was associated

with local weather factors in most regions but at different lag times and directions. Meanwhile, there were trends in associations with global climate factors by geographical locations of study sites. CONCLUSIONS: Overall heterogeneous associations suggest the importance of location-specific approaches in PNG not only for further investigations but also for public health interventions in response to the potential impacts arising from climate change.

33 **Kapia S, Rao BK, Sakulas H.**
Assessment of heavy metal pollution risks in Yonki Reservoir environmental matrices affected by gold mining activity.
Environ Monit Assess 2016 Oct;188(10):586. Epub 2016 Sep 24.

This study reports the heavy metal (Hg, Cd, Cr, Cu, and Pb) contamination risks to and safety of two species of fresh water fish (tilapia, *Oreochromis mossambicus* and carp, *Cyprinus carpio*) that are farmed in the Yonki Reservoir in the Eastern Highlands of Papua New Guinea (PNG). The upper reaches of the reservoir are affected by alluvial and large-scale gold mining activities. We also assessed heavy metal levels in the surface waters and sediments and in selected aquatic plant species from the reservoir and streams that intersect the gold mining areas. The water quality was acceptable, except for the Cr concentration, which exceeded the World Health Organization (WHO) standard for water contamination. The sediments were contaminated with Cd and Cu in most of the sampling stations along the upstream waters and the reservoir. The Cd concentration in the sediments exceeded the US Environmental Protection Agency's Sediment Quality Guideline (SQG) values, and the geoaccumulation index (Igeo) values indicated heavy to extreme pollution. In addition, the Cd, Cu, and Pb concentrations in aquatic plants exceeded the WHO guidelines for these contaminants. Between the fish species, tilapia accumulated significantly higher ($p < 0.05$) Cu in their organ tissues than carp, confirming the bioaccumulation of some metals in the aquatic fauna. The edible muscles of the fish specimens had metal concentrations below the maximum permissible levels established by statutory guidelines. In addition, a human health risk assessment, performed using the estimated weekly intake (EWI) values, indicated that farmed fish from the Yonki Reservoir are safe for human consumption.

34 **Karl S, White MT, Milne GJ, Gurarie D, Hay SI, Barry AE, Felger I, Mueller I.**
Spatial effects on the multiplicity of *Plasmodium falciparum* infections.
PLoS One 2016 Oct 6;11(10):e0164054.

As malaria is being pushed back on many frontiers and global case numbers are declining, accurate measurement and prediction of transmission becomes increasingly difficult. Low transmission settings are characterised by high levels of spatial heterogeneity, which stands in stark contrast to the widely used assumption of spatially homogeneous transmission used in mathematical transmission models for malaria. In the present study an individual-based mathematical malaria transmission model that incorporates multiple parasite clones, variable human exposure and duration of infection, limited mosquito flight distance and most importantly geographically heterogeneous human and mosquito population densities was used to illustrate the differences between homogeneous and heterogeneous transmission assumptions when aiming to predict surrogate indicators of transmission intensity such as population parasite prevalence or multiplicity of infection (MOI). In traditionally highly malaria endemic regions where most of the population harbours malaria parasites, humans are often infected with multiple parasite clones. However, studies have shown also in areas with low overall parasite prevalence, infection with multiple parasite clones is a common occurrence. Mathematical models assuming homogeneous transmission between humans and mosquitoes cannot explain these observations. Heterogeneity of transmission can arise from many factors including acquired immunity, body size and occupational exposure. In this study, we show that spatial heterogeneity has a profound effect on predictions of MOI and parasite prevalence. We illustrate that models assuming homogeneous transmission underestimate average MOI in low transmission settings when compared to field data and that spatially heterogeneous models predict stable transmission at much lower overall parasite prevalence. Therefore it is very important that models used to guide malaria surveillance and control strategies in low transmission and elimination settings take into account the spatial features of the specific target area, including human and mosquito vector distribution.

35 **Karl S, Laman M, Moore BR, Benjamin JM, Salib M, Lorry L, Maripal S, Siba P, Robinson LJ, Mueller I, Davis TME.**
Risk factors for *Plasmodium falciparum* and *Plasmodium vivax* gametocyte carriage in Papua New Guinean children with uncomplicated malaria.
Acta Trop 2016 Aug;160:1-8.

There are limited data on gametocytaemia risk factors before/after treatment with artemisinin combination therapy in children from areas with transmission of multiple *Plasmodium* species. We utilised data from a randomised trial comparing artemether-lumefantrine (AL) and artemisinin-naphthoquine (AN) in 230 Papua New Guinean children aged 0.5-5 years with uncomplicated malaria in whom determinants of gametocytaemia by light microscopy were assessed at baseline using logistic regression and during follow-up using multilevel mixed effects modelling. Seventy-four (32%) and 18 (8%) children presented with *P. falciparum* and *P. vivax* gametocytaemia, respectively. Baseline *P. falciparum* gametocytaemia was associated with Hackett spleen grade 1 (odds ratio (95% CI) 4.01 (1.60-10.05) vs grade 0; $p < 0.001$) and haemoglobin (0.95 (0.92-0.97) per 1g/L increase; $p < 0.001$), and *P. falciparum* asexual parasitaemia in slide-positive cases (0.36 (0.19-0.68) for a 10-fold increase; $p = 0.002$). Baseline *P. vivax* gametocytaemia was associated with Hackett grade 2 (12.66 (1.31-122.56); $p = 0.028$), mixed *P. falciparum*/*vivax* infection (0.16 (0.03-1.00); $p = 0.050$), *P. vivax* asexual parasitaemia (5.68 (0.98-33.04); $p = 0.053$) and haemoglobin (0.94 (0.88-1.00); $p = 0.056$). For post-treatment *P. falciparum* gametocytaemia, independent predictors were AN vs AL treatment (4.09 (1.43-11.65)), haemoglobin (0.95 (0.93-0.97)), presence/absence of *P. falciparum* asexual forms (3.40 (1.66-6.68)) and day post-treatment (0.86 (0.82-0.90)) ($p < 0.001$). Post-treatment *P. vivax* gametocytaemia was predicted by presence of *P.*

vivax asexual forms (596 (12-28,433); p <0.001). Consistent with slow *P. falciparum* gametocyte maturation, low haemoglobin, low asexual parasite density and higher spleen grading, markers of increased prior infection exposure/immunity, were strong associates of pre-treatment gametocyte positivity. The persistent inverse association between *P. falciparum* gametocytaemia and haemoglobin during follow-up suggests an important role for bone marrow modulation of gametocytogenesis. In *P. vivax* infections, baseline and post-treatment gametocyte carriage was positively related to the acute parasite burden, reflecting the close association between the development of asexual and sexual forms.

36 **Karyana M, Devine A, Kenangalem E, Burdarm L, Poespoprodjo JR, Vemuri R, Anstey NM, Tjitra E, Price RN, Yeung S.**
Treatment-seeking behaviour and associated costs for malaria in Papua, Indonesia.
Malar J 2016 Nov 8;15(1):536.

BACKGROUND: Malaria remains a significant public health issue in Eastern Indonesia, where multidrug resistant *Plasmodium falciparum* and *Plasmodium vivax* are highly prevalent. The objective of this study was to describe treatment-seeking behaviour and household costs prior to a change to a unified treatment policy of dihydroartemisinin-piperaquine in Mimika district, Papua province in 2006. METHODS: In 2005 a randomized cross-sectional household survey was conducted to collect data on demographics, socio-economic status (SES), treatment-seeking, case management, and household costs. Information on the cost of illness was also collected from patients exiting health facilities, in order to compare the cost of episodes diagnosed as *P. vivax* compared with those diagnosed as *P. falciparum*. RESULTS: 825 households were included in the survey. Of the 764 individuals who sought treatment for fever outside the home in the last month, 46% (349/764) went to a public health facility. Of the 894 reported visits to healthcare providers, 48% (433) resulted in a blood test, of which 78% (337) were reportedly positive. Only 10% (17/177) of individuals who reported testing positive for *P. falciparum* or mixed infection received the first-line treatment of chloroquine with SP, and 38% (61/159) of those with a diagnosis of *P. vivax* reportedly received the first-line treatment of chloroquine and primaquine. Overall, public facilities were more likely to prescribe the correct prevailing first-line drug combinations than private providers (OR = 3.77 [95% CI 2.31-6.14], p <0.001). The mean cost to the household of an episode of *P. vivax* was similar to the cost of *P. falciparum* [US$44.50 (SD: 46.23) vs US$48.58 (SD: 64.65)]. CONCLUSIONS: Private providers were a popular source of treatment for malaria, but adherence to the national guidelines was low and the economic burden of malaria for both *P. falciparum* and *P. vivax* infections was substantial. Engagement with the private sector is needed to ensure that patients have access to affordable good-quality, effective diagnostics and anti-malarials for both *P. falciparum* and *P. vivax*.

37 **Kase P, Dakulala P, Bieb S.**
Outbreak of multidrug-resistant tuberculosis on Daru Island: an update.
Lancet Respir Med 2016 Aug;4(8):e40.

38 **Kaspar A, Kei J, Driscoll C, Swanepoel de W, Goulios H.**
Overview of a public health approach to pediatric hearing impairment in the Pacific Islands.
Int J Pediatr Otorhinolaryngol 2016 Jul;86:43-52.

BACKGROUND: Childhood hearing impairment is a significant cause of disability in developing countries. Otitis media and meningitis are leading infectious causes of preventable hearing loss in children. It is estimated that the Pacific Islands have among the greatest global burden of childhood hearing impairment due to infectious causes, and yet there is currently very little in the research literature on pediatric hearing disorders in this region. OBJECTIVES: (1) To review existing research literature on pediatric hearing impairment in the Pacific Islands, and (2) to present a public health approach to the development and improvement of childhood hearing services in the Pacific Islands. DATA: The primary tool was a comprehensive literature review. MEDLINE and ScienceDirect databases were searched for relevant journal articles. There was no limit on the date of publication. Any article reporting on hearing impairment in the Pacific Region was included. RESULTS: A total of 23 journal articles were found that satisfied the above inclusion criteria. The limited information available in the literature suggests that otitis media and vaccine-preventable infections are a significant cause of avoidable childhood hearing impairment in the Pacific Islands. Pediatric audiology services are limited in this region. Further research is required to develop effective public health programs that should reduce the burden of preventable childhood hearing loss in the Pacific Islands. CONCLUSIONS: There is limited information in the research literature on pediatric hearing impairment and audiology services in the Pacific Islands. Epidemiological data based on the WHO Ear and Hearing Disorders Survey Protocol are urgently needed, and the development of audiology services within the existing public and primary health care framework should reduce the burden of preventable hearing loss in the Pacific Islands.

39 **Kelly-Hanku A, Aeno H, Wilson L, Eves R, Mek A, Nake Trumb R, Whittaker M, Fitzgerald L, Kaldor JM, Vallely A.**
Transgressive women don't deserve protection: young men's narratives of sexual violence against women in rural Papua New Guinea.
Cult Health Sex 2016 Nov;18(11):1207-1220.

Sexual violence against women and girls is commonplace in Papua New Guinea (PNG). While the experiences of women are rightly given central place in institutional responses to sexual violence, the men who perpetrate violence are often overlooked, an oversight that undermines the effectiveness of prevention efforts. This paper draws on interviews conducted with young men as part of a qualitative longitudinal study of masculinity and male sexuality in a rural highland area of PNG. It explores one aspect of male sexuality: men's narratives of sexual violence. Most striking from the data is that the collective enactment of sexual violence against women and girls is reported as an everyday and accepted practice amongst young men. However, not all women and girls were described as equally at risk, with those who transgress gender roles and roles inscribed and reinforced by patriarchal structures, at greater risk. To address this situation, efforts to reduce sexual violence against women

and girls require an increased focus on male-centred intervention to critically engage with the forms of patriarchal authority that give license to sexual violence. Understanding the perceptions and experiences of men as perpetrators of sexual violence is a critical first step in the process of changing normative perceptions of gender, a task crucial to reducing sexual violence in countries such as PNG.

40 **Kinaston RL, Roberts GL, Buckley HR, Oxenham M.**
A bioarchaeological analysis of oral and physiological health on the south coast of New Guinea.
Am J Phys Anthropol 2016 Jul;160(3):414-426.

OBJECTIVES: The south coast of New Guinea has a complex prehistory known for its exchange systems that linked distinct cultural groups living along the coast, inland, and on offshore islands. Here we compare the palaeohealth of two relatively contemporaneous skeletal samples from the south coast of New Guinea (850-200 BP) that were from two ecologically different sites (one inland and one offshore island) and likely represent distinct cultural groups. We aim to elucidate health patterns that may provide information about the specific lifeways and quality of life of each community. MATERIALS AND METHODS: Oral conditions (caries, calculus, alveolar lesions, and antemortem tooth loss [AMTL]) were analyzed macroscopically to assess possible intra- and inter-population variation in oral and physiological health. The frequency of linear enamel hypoplasia (LEH) was also used as a nonspecific indicator of stress to assess childhood health at each site. RESULTS: The inhabitants from the small offshore island of Motupore, thought to be associated with Austronesian-speaking Motu tribes, displayed different patterns of oral pathological conditions (more carious lesions on the tooth crown and calculus) and LEH (lower frequencies) compared with inland people residing at the site of Nebira. DISCUSSION: It is suggested that the causes for the variation in oral and physiological health were likely multifactorial and potentially associated with variables such as the ecological and geographical settings of the sites, cultural differences, infectious disease, differential fertility and, potentially, diet. This research provides previously unknown information about possible culturally moderated practices that affected health in the past.

41 **Ko R, Macleod C, Pahau D, Sokana O, Keys D, Burnett A, Willis R, Wabulembo G, Garap J, Solomon AW.**
Population-based trachoma mapping in six evaluation units of Papua New Guinea.
Ophthalmic Epidemiol 2016;23(Suppl 1):22-31.

PURPOSE: We sought to determine the prevalence of trachomatous inflammation-follicular (TF) in children aged 1-9 years, and trachomatous trichiasis (TT) in those aged ≥15 years, in suspected trachoma-endemic areas of Papua New Guinea (PNG). METHODS: We carried out six population-based prevalence surveys using the protocol developed as part of the Global Trachoma Mapping Project. RESULTS: A total of 19,013 individuals were sampled for inclusion, with 15,641 (82.3%) consenting to participate. Four evaluation units had prevalences of TF in children ≥10%, above which threshold the World Health Organization (WHO) recommends mass drug administration (MDA) of azithromycin for at least three years: Western Province (South Fly/Daru) 11.2% (95% confidence interval, CI, 6.9-17.0%), Southern Highlands (East) 12.2% (95% CI 9.6-15.0%), Southern Highlands (West) 11.7% (95% CI 8.5-15.3%), and West New Britain 11.4% (95% CI 8.7-13.9%). TF prevalence was 5.0-9.9% in Madang (9.4%, 95% CI 6.1-13.0%) and National Capital District (6.0%, 95% CI 3.2-9.1%), where consideration of a single round of MDA is warranted. Cases of TT were not found outside West New Britain, in which four cases were seen, generating an estimated population-level prevalence of TT in adults of 0.10% (95% CI 0.00-0.40%) for West New Britain, below the WHO elimination threshold of 0.2% of those aged ≥15 years. CONCLUSION: Trachoma is a public health issue in PNG. However, other than in West New Britain, there are few data to support the idea that trachoma is a cause of blindness in PNG. Further research is needed to understand the stimulus for the active trachoma phenotype in these populations.

42 **Koepfli C, Nguitragool W, Hofmann NE, Robinson LJ, Ome-Kaius M, Sattabongkot J, Felger I, Mueller I.**
Sensitive and accurate quantification of human malaria parasites using droplet digital PCR (ddPCR).
Sci Rep 2016 Dec 16;6:39183.

Accurate quantification of parasite density in the human host is essential for understanding the biology and pathology of malaria. Semi-quantitative molecular methods are widely applied, but the need for an external standard curve makes it difficult to compare parasite density estimates across studies. Droplet digital PCR (ddPCR) allows direct quantification without the need for a standard curve. ddPCR was used to diagnose and quantify *P. falciparum* and *P. vivax* in clinical patients as well as in asymptomatic samples. ddPCR yielded highly reproducible measurements across the range of parasite densities observed in humans, and showed higher sensitivity than qPCR to diagnose *P. falciparum*, and equal sensitivity for *P. vivax*. Correspondence in quantification was very high (>0.95) between qPCR and ddPCR. Quantification between technical replicates by ddPCR differed 1.5-1.7-fold, compared to 2.4-6.2-fold by qPCR. ddPCR facilitates parasite quantification for studies where absolute densities are required, and will increase comparability of results reported from different laboratories.

43 **Larson EC, Pond CD, Rai PP, Matainaho TK, Piskaut P, Franklin MR, Barrows LR.**
Traditional preparations and methanol extracts of medicinal plants from Papua New Guinea exhibit similar cytochrome P450 inhibition.
Evid Based Complement Alternat Med 2016;2016:7869710.

The hypothesis underlying this current work is that fresh juice expressed from Papua New Guinea (PNG) medicinal plants (succus) will inhibit human cytochrome P450s (CYPs). The CYP inhibitory activity identified in fresh material was compared with inhibition in methanol extracts of dried material. Succus is the most common method of traditional medicine (TM) preparation for consumption in PNG. There is increasing concern that TMs might antagonize or complicate drug therapy. We have previously shown that methanol extracts of commonly consumed PNG medicinal plants are

able to induce and/or inhibit human CYPs in vitro. In this current work plant succus was prepared from fresh plant leaves. Inhibition of three major CYPs was determined using human liver microsomes and enzyme-selective model substrates. Of 15 species tested, succus from 6/15 was found to inhibit CYP1A2, 7/15 inhibited CYP3A4, and 4/15 inhibited CYP2D6. Chi-squared tests determined differences in inhibitory activity between succus and methanol preparations. Over 80% agreement was found. Thus, fresh juice from PNG medicinal plants does exhibit the potential to complicate drug therapy in at-risk populations. Further, the general reproducibility of these findings suggests that methanol extraction of dried material is a reasonable surrogate preparation method for fresh plant samples.

44 **Little EE, Carver LJ, Legare CH.**
Cultural variation in triadic infant-caregiver object exploration.
Child Dev 2016 Jul;87(4):1130-1145.

Two studies examined the extent to which the type of triadic interaction pervasive in Western populations (ie, shared visual attention and ostensive pedagogical cues) was representative of infant-caregiver object exploration in a non-Western indigenous community. Caregivers in the United States and Vanuatu interacted with infants and a novel object for 3 minutes. In Study 1 (N = 116, Mage = 29.05), Ni-Van caregivers used more physical triadic engagement and US caregivers used more visual triadic engagement. In Study 2 (N = 80, Mage = 29.91), US caregivers were more likely than Ni-Van caregivers to transmit an action and to use visual cues while interacting with their child. These studies demonstrate that the Western model of early social learning is not universal.

45 **Malaspinas AS, Westaway MC, Muller C, Sousa VC, Lao O, Alves I, Bergström A, Athanasiadis G, Cheng JY, Crawford JE, Heupink TH, Macholdt E, Peischl S, Rasmussen S, Schiffels S, Subramanian S, Wright JL, Albrechtsen A, Barbieri C, Dupanloup I, Eriksson A, Margaryan A, Moltke I, Pugach I, Korneliussen TS, Levkivskyi IP, Moreno-Mayar JV, Ni S, Racimo F, Sikora M, Xue Y, Aghakhanian FA, Brucato N, Brunak S, Campos PF, Clark W, Ellingvåg S, Fourmile G, Gerbault P, Injie D, Koki G, Leavesley M, Logan B, Lynch A, Matisoo-Smith EA, McAllister PJ, Mentzer AJ, Metspalu M, Migliano AB, Murgha L, Phipps ME, Pomat W, Reynolds D, Ricaut FX, Siba P, Thomas MG, Wales T, Wall CM, Oppenheimer SJ, Tyler-Smith C, Durbin R, Dortch J, Manica A, Schierup MH, Foley RA, Lahr MM, Bowern C, Wall JD, Mailund T, Stoneking M, Nielsen R, Sandhu MS, Excoffier L, Lambert DM, Willerslev E.**
A genomic history of Aboriginal Australia.
Nature 2016 Oct 13;538(7624):207-214.

The population history of Aboriginal Australians remains largely uncharacterized. Here we generate high-coverage genomes for 83 Aboriginal Australians (speakers of Pama-Nyungan languages) and 25 Papuans from the New Guinea Highlands. We find that Papuan and Aboriginal Australian ancestors diversified 25-40 thousand years ago (kya), suggesting pre-Holocene population structure in the ancient continent of Sahul (Australia, New Guinea and Tasmania). However, all of the studied Aboriginal Australians descend from a single founding population that differentiated ~10-32 kya. We infer a population expansion in northeast Australia during the Holocene epoch (past 10,000 years) associated with limited gene flow from this region to the rest of Australia, consistent with the spread of the Pama-Nyungan languages. We estimate that Aboriginal Australians and Papuans diverged from Eurasians 51-72 kya, following a single out-of-Africa dispersal, and subsequently admixed with archaic populations. Finally, we report evidence of selection in Aboriginal Australians potentially associated with living in the desert.

46 **Mallick S, Li H, Lipson M, Mathieson I, Gymrek M, Racimo F, Zhao M, Chennagiri N, Nordenfelt S, Tandon A, Skoglund P, Lazaridis I, Sankararaman S, Fu Q, Rohland N, Renaud G, Erlich Y, Willems T, Gallo C, Spence JP, Song YS, Poletti G, Balloux F, van Driem G, de Knijff P, Romero IG, Jha AR, Behar DM, Bravi CM, Capelli C, Hervig T, Moreno-Estrada A, Posukh OL, Balanovska E, Balanovsky O, Karachanak-Yankova S, Sahakyan H, Toncheva D, Yepiskoposyan L, Tyler-Smith C, Xue Y, Abdullah MS, Ruiz-Linares A, Beall CM, Di Rienzo A, Jeong C, Starikovskaya EB, Metspalu E, Parik J, Villems R, Henn BM, Hodoglugil U, Mahley R, Sajantila A, Stamatoyannopoulos G, Wee JT, Khusainova R, Khusnutdinova E, Litvinov S, Ayodo G, Comas D, Hammer MF, Kivisild T, Klitz W, Winkler CA, Labuda D, Bamshad M, Jorde LB, Tishkoff SA, Watkins WS, Metspalu M, Dryomov S, Sukernik R, Singh L, Thangaraj K, Pääbo S, Kelso J, Patterson N, Reich D.**
The Simons Genome Diversity Project: 300 genomes from 142 diverse populations.
Nature 2016 Oct 13;538(7624):201-206.

Here we report the Simons Genome Diversity Project data set: high-quality genomes from 300 individuals from 142 diverse populations. These genomes include at least 5.8 million base pairs that are not present in the human reference genome. Our analysis reveals key features of the landscape of human genome variation, including that the rate of accumulation of mutations has accelerated by about 5% in non-Africans compared to Africans since divergence. We show that the ancestors of some pairs of present-day human populations were substantially separated by 100,000 years ago, well before the archaeologically attested onset of behavioural modernity. We also demonstrate that indigenous Australians, New Guineans and Andamanese do not derive substantial ancestry from an early dispersal of modern humans; instead, their modern human ancestry is consistent with coming from the same source as that of other non-Africans.

47 **Marks M, Yin YP, Chen XS, Castro A, Causer L, Guy R, Wangnapi R, Mitjà O, Aziz A, Castro R, da Luz Martins Pereira F, Taleo F, Guinard J, Bélec L, Tun Y, Bottomley C, Ballard RC, Mabey DC.**
Metaanalysis of the performance of a combined treponemal and nontreponemal rapid diagnostic test for syphilis and yaws.
Clin Infect Dis 2016 Sep 1;63(5):627-633.

BACKGROUND: The human treponematoses are important causes of disease. Mother-to-child transmission of syphilis remains a major cause of stillbirth and neonatal death. There are also almost 100 000 cases of endemic treponemal disease reported annually, predominantly yaws. Rapid diagnostic tests (RDTs) would improve access to

screening for these diseases. Most RDTs cannot distinguish current and previous infection. The Dual Path Platform (DPP) Syphilis Screen & Confirm test includes both a treponemal (T1) and nontreponemal (T2) component and may improve the accuracy of diagnosis. METHODS: We conducted a metaanalysis of published and unpublished evaluations of the DPP-RDT for the diagnosis of syphilis and yaws. We calculated the sensitivity, specificity, and overall agreement of the test compared with reference laboratory tests. RESULTS: Nine evaluations, including 7267 tests, were included. Sensitivity was higher in patients with higher-titer rapid plasma reagin (≥16) for both the T1 (98.2% vs 90.1%, p <0.0001) and the T2 component (98.2% vs 80.6%, p <0.0001). Overall agreement between the DPP test and reference serology was 85.2% (84.4%-86.1%). Agreement was highest for high-titer active infection and lowest for past infection. CONCLUSIONS: The RDT has good sensitivity and specificity of the treponemal and nontreponemal components both in cases of suspected syphilis and yaws, although the sensitivity is decreased at lower antibody titers.

48 **Marks M, Sokana O, Nachamkin E, Puiahi E, Kilua G, Pillay A, Bottomley C, Solomon AW, Mabey DC.**
Prevalence of active and latent yaws in the Solomon Islands 18 months after azithromycin mass drug administration for trachoma.
PLoS Negl Trop Dis 2016 Aug 23;10(8):e0004927.

INTRODUCTION: Both yaws and trachoma are endemic in the Pacific. Mass treatment with azithromycin is the mainstay of the WHO strategy for both the eradication of yaws and the elimination of trachoma as a public health problem, but the dose recommended for trachoma is lower than that for yaws. In countries where both diseases are endemic, there is a potential for synergy between yaws and trachoma control programs if mass treatment with the lower dose of azithromycin was shown to be effective for the treatment of yaws. In an earlier study, we demonstrated a profound reduction in the clinical and serological prevalence of yaws following a single round of mass treatment with azithromycin 20 mg/kg undertaken for the purposes of trachoma elimination. METHODS: This survey was conducted 18 months following a single round of azithromycin mass treatment in the same communities in which we had conducted our previous six-month follow-up survey. We examined children aged 1-14 years and took blood and lesion samples for yaws diagnosis using the *Treponema pallidum* particle agglutination assay (TPPA) and the non-treponemal Rapid Plasma Reagin (RPR) test. RESULTS: A total of 1,284 children were enrolled in the study. Amongst children aged 5-14 years, 223 had a positive TPPA (27.5%, 95% CI 13.6-47.7%). The TPPA seroprevalence amongst this age group did not differ significantly from either our pre-mass treatment survey or our initial follow-up survey. Thirty-five children had positive TPPA and positive RPR (4.3%, 95% CI 2.1-8.7%), and this did not differ significantly from our initial post-mass drug administration (MDA) follow-up survey (4.3% versus 3.5%, p = 0.43) but remained significantly lower than our initial pre-MDA survey (4.3% vs 21.7%, p <0.0001). Village-level MDA coverage was strongly associated with dual-seropositivity (p = 0.005). Amongst children aged 1-4 years, 16 had a positive TPPA (3.5%, 95% CI 1.6-7.1%). This did not differ significantly from the seroprevalence in this age group that had been predicted based on our previous surveys (3.5% vs 5%, p = 0.11). Fourteen children (1.1%) were considered to have a skin lesion clinically consistent with yaws, but none of these individuals was seropositive for yaws. Of nine cases where a swab could be collected for PCR, all were negative for *Treponema pallidum* subsp. *pertenue* DNA. DISCUSSION: In this study we have shown that the benefit of a single round of mass treatment with azithromycin 20mg/kg appears to extend to 18 months without any further intervention. The lack of a significant change in seroprevalence from 6 to 18 months after mass treatment might suggest that interventions could be spaced at yearly intervals without a significant loss of impact, and that this might facilitate integration of yaws eradication with other neglected tropical disease (NTD) control programmes. MDA coverage above 90% was associated with significantly better outcomes than coverages lower than this threshold, and strategies to improve coverage at all stages of yaws eradication efforts should be investigated.

49 **McIver L, Kim R, Woodward A, Hales S, Spickett J, Katscherian D, Hashizume M, Honda Y, Kim H, Iddings S, Naicker J, Bambrick H, McMichael AJ, Ebi KL.**
Health impacts of climate change in Pacific island countries: a regional asesment of vulnerabilities and adaptation priorities.
Environ Health Perspect 2016 Nov;124(11):1707-1714.

BACKGROUND: Between 2010 and 2012, the World Health Organization Division of Pacific Technical Support led a regional climate change and health vulnerability assessment and adaptation planning project, in collaboration with health sector partners, in 13 Pacific island countries – Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. OBJECTIVE: We assessed the vulnerabilities of Pacific island countries to the health impacts of climate change and planned adaptation strategies to minimize such threats to health. METHODS: This assessment involved a combination of quantitative and qualitative techniques. The former included descriptive epidemiology, time series analyses, Poisson regression, and spatial modeling of climate and climate-sensitive disease data, in the few instances where this was possible; the latter included wide stakeholder consultations, iterative consensus building, and expert opinion. Vulnerabilities were ranked using a 'likelihood versus impact' matrix, and adaptation strategies were prioritized and planned accordingly. RESULTS: The highest-priority climate-sensitive health risks in Pacific island countries included trauma from extreme weather events, heat-related illnesses, compromised safety and security of water and food, vector-borne diseases, zoonoses, respiratory illnesses, psychosocial ill-health, non-communicable diseases, population pressures, and health system deficiencies. Adaptation strategies relating to these climate change and health risks could be clustered according to categories common to many countries in the Pacific region. CONCLUSION: Pacific island countries are among the most vulnerable in the world to the health impacts of climate change. This vulnerability is a function of their unique geographic, demographic, and

socioeconomic characteristics combined with their exposure to changing weather patterns associated with climate change, the health risks entailed, and the limited capacity of the countries to manage and adapt in the face of such risks.

50 **Mola G.**
Trials of vacuum extraction.
Eur J Obstet Gynecol Reprod Biol 2016 Aug;203:332.

51 **Molumi CP, Dubey SP.**
Airway scleromas and their extensions.
ANZ J Surg 2016 Sep;86(9):670-674.
BACKGROUND: Scleroma is a rare, chronic, granulomatous infectious disease of the respiratory tract mucosa which begins in the nose and spreads to the respiratory tract and adjoining structures. We report on the extensions and the management of 134 cases of scleroma in the Highlands region of Papua New Guinea. METHODS: The charts and treatment records of 134 scleroma cases were retrospectively reviewed from 1995 to 2013. The staging, extensions, treatment and results of treatment were reviewed and analysed. RESULTS: Of the 134 cases, 72 (53.7%) were females and the age ranged from 6 to 65 years. The disease was confined to the nose and nasopharynx in 71 (53.0%) cases. Extension of the disease from the nose to the Eustachian tube occurred in nine (6.7%) cases and into the middle ear in four (3.0%) cases. Further extensions to the larynx and trachea were seen in 17 (12.7%) cases each and the bronchus in three (2.2%) cases. Primary laryngoscleroma without involvement of the nose and nasopharyngeal stenosis without laryngeal involvement were managed in 11 (8.2%) and nine (6.7%) cases respectively. Others cases treated were ethmoid scleroma with proptosis and scleroma involving the upper lip in one (0.75%) case each. Ninety-nine (74.9%) patients were treated medically while 35 (26.1%) patients required surgery. Cures were achieved in 83 (61.9%) cases treated medically and 26 (19.4%) had successful surgical outcome. CONCLUSION: Scleroma begins in the nose and when not arrested, extends causing obstruction to the airway and cosmetic deformity which requires surgical intervention.

52 **Moore BR, Benjamin JM, Auyeung SO, Salman S, Yadi G, Griffin S, Page-Sharp M, Batty KT, Siba PM, Mueller I, Rogerson SJ, Davis TME.**
Safety, tolerability and pharmacokinetic properties of coadministered azithromycin and piperaquine in pregnant Papua New Guinean women.
Br J Clin Pharmacol 2016 Jul;82(1):199-212.
AIMS: The aim of the present study was to investigate the safety, tolerability and pharmacokinetics of coadministered azithromycin (AZI) and piperaquine (PQ) for treating malaria in pregnant Papua New Guinean women. METHODS: Thirty pregnant women (median age 22 years; 16-32 weeks' gestation) were given three daily doses of 1 g AZI plus 960 mg PQ tetraphosphate with detailed monitoring/blood sampling over 42 days. Plasma AZI and PQ were assayed using liquid chromatography-mass spectrometry and high-performance liquid chromatography, respectively. Pharmacokinetic analysis was by population-based compartmental models. RESULTS: The treatment was well tolerated. The median (interquartile range) increase in the rate-corrected electrocardiographic QT interval 4 hour postdose [12 (6-26) ms(0) (.5)] was similar to that found in previous studies of AZI given in pregnancy with other partner drugs. Six women with asymptomatic malaria cleared their parasitaemias within 72 hours. Two aparasitaemic women developed late uncomplicated *Plasmodium falciparum* infections on Days 42 and 83. Compared with previous pregnancy studies, the area under the concentration-time curve (AUC0-∞) for PQ [38818 (24354-52299) µg h l(-1)] was similar to published values but there was a 52% increase in relative bioavailability with each dose. The AUC0-∞ for AZI [46799 (43526-49462) µg h l(-1)] was at least as high as reported for higher-dose regimens, suggesting saturable absorption and/or concentration-dependent tissue uptake and clearance from the central compartment. CONCLUSIONS: AZI-PQ appears to be well tolerated and safe in pregnancy. Based on the present/other data, total AZI doses higher than 3 g for the treatment and prevention of malaria may be unnecessary in pregnant women, while clearance of parasitaemia could improve the relative bioavailability of PQ.

53 **Moores A, Puawe P, Buasi N, West F, Samor MK, Joseph N, Rumsey M, Dawson A, Homer CSE.**
Education, employment and practice: midwifery graduates in Papua New Guinea.
Midwifery 2016 Oct;41:22-29.
BACKGROUND: Papua New Guinea has a very high maternal mortality rate (773/100,000), low rates of supervised births and a critical shortage of skilled midwives. A midwifery education initiative commenced in 2012, funded by the Australian Government and led by the National Department of Health. One specific objective of the initiative was to improve the standard of clinical teaching and practice in four schools of midwifery. There were 394 midwives educated over the 4-year period (2012-2015) representing half of all midwives in Papua New Guinea. A study was undertaken to describe the educational programme, employment, practices and experiences of graduates who studied midwifery in 2012 and 2013 as part of the initiative. OBJECTIVE: the aim of this paper is to explore the education, employment and practice of newly graduated midwives in Papua New Guinea. DESIGN: a mixed methods descriptive study design was used. Surveys and focus groups were used to gather data. Ethical approval was granted by the relevant Human Research Ethics Committees. SETTING AND PARTICIPANTS: all midwifery graduates in 2012 and 2013 from the four midwifery schools in Papua New Guinea were included in the study and almost 80% were contacted. FINDINGS: nearly 90% of graduates were working as midwives, with an additional 3% working as midwifery or nursing educators. This study discovered that graduates exhibited increased skills acquisition and confidence, leadership in maternal and newborn care services and a marked improvement in the provision of respectful care to women. The graduates faced challenges to implement evidence-based care with barriers including the lack of appropriate resources and differences of opinion with senior staff. CONCLUSIONS: factors affecting the quality of midwifery education will need to be addressed if Papua New Guinea is to continue to improve the status of maternal and newborn health. Specifically, the length of the midwifery education, the quality of clinical practice and the exposure to rural and remote area practice need addressing in many contexts like

Papua New Guinea.

54 **Morita A, Natsuhara K, Vengiau G, Chia-Jung Chen C, Odani S, Inaoka T, Tadokoro K, Suda K, Furusawa T, Siba P, Phuanukoonnon S, Umezaki M.**
Reduced morning cortisol concentration in saliva was associated with obesity: evidence from community-dwelling adults in Papua New Guinea.
Am J Hum Biol 2016 Jul;28(4):587-590.
OBJECTIVES: This study investigated morning salivary cortisol concentration in relation to total body fat composition among community-dwelling Papua New Guinean adults. METHODS: In addition to demographic and anthropometric measurements, saliva was collected in a single morning from 478 residents in Eastern Highlands Province and Madang Province. RESULTS: After adjusting for age, region, and occupation, the morning salivary cortisol concentration was significantly negatively correlated with body mass index among men ($B = -0.01$, $p < 0.05$) and women ($B = -0.013$, $p < 0.05$), and waist circumference ($B = -0.007$, $p < 0.05$), waist-to-hip ratio ($B = -1.214$, $p < 0.05$), and subscapular-to-triceps skinfold-thickness ratio ($B = -0.045$, $p < 0.05$) among men. Men with total or abdominal body fat mass known for elevated risk of non-communicable diseases displayed lower cortisol compared to men without such risk. CONCLUSIONS: Papua New Guinean adults with increased accumulation of body fat showed reduced cortisol concentration in morning saliva.

55 **Natuzzi ES, Joshua C, Shortus M, Reubin R, Dalipanda T, Ferran K, Aumua A, Brodine S.**
Defining population health vulnerability following an extreme weather event in an urban Pacific island environment: Honiara, Solomon Islands.
Am J Trop Med Hyg 2016 Aug 3;95(2):307-314.
Extreme weather events are common and increasing in intensity in the southwestern Pacific region. Health impacts from cyclones and tropical storms cause acute injuries and infectious disease outbreaks. Defining population vulnerability to extreme weather events by examining a recent flood in Honiara, Solomon Islands, can help stakeholders and policymakers adapt development to reduce future threats. The acute and subacute health impacts following the April 2014 floods were defined using data obtained from hospitals and clinics, the Ministry of Health and in-country World Health Organization office in Honiara. Geographical information system (GIS) was used to assess morbidity and mortality, and vulnerability of the health system infrastructure and households in Honiara. The April flash floods were responsible for 21 acute deaths, 33 injuries, and a diarrhea outbreak that affected 8,584 people with 10 pediatric deaths. A GIS vulnerability assessment of the location of the health system infrastructure and households relative to rivers and the coastline identified 75% of the health infrastructure and over 29% of Honiara's population as vulnerable to future hydrological events. Honiara, Solomon Islands, is a rapidly growing, highly vulnerable urban Pacific Island environment. Evaluation of the mortality and morbidity from the April 2014 floods as well as the infectious disease outbreaks that followed allows public health specialists and policymakers to understand the health system's and populations' vulnerability to future shocks. Understanding the negative impacts natural disasters have on people living in urban Pacific environments will help the government as well as development partners in crafting resilient adaptation development.

56 **O'Farrell N, Moi H.**
2016 European guideline on donovanosis.
Int J STD AIDS 2016 Jul;27(8):605-607.
Donovanosis is a rare sexually transmitted infection now mainly seen in sporadic cases in Papua New Guinea, South Africa, India, Brazil and Australia. The causative organism is *Calymmatobacterium granulomatis*, though a proposal has been put forward that the organism be reclassified as *Klebsiella granulomatis* comb nov. The incubation period is approximately 50 days with genital papules developing into ulcers that increase in size. Four types of lesions are described - ulcerogranulomatous, hypertrophic, necrotic and sclerotic. The diagnosis is usually confirmed by microscopic identification of characteristic Donovan bodies on stained tissue smears. More recently, polymerase chain reaction methods have been developed. The recommended treatment is azithromycin 1 g weekly until complete healing is achieved.

57 **Oktavianthi S, Trianty L, Noviyanti R, Trimarsanto H, Sudoyo H, Malik SG.**
Placental weight ratio affects placental mRNA expression of insulin-like growth factor-I and long isoform of the leptin receptor in *Plasmodium falciparum* infected pregnant women.
Asia Pac J Clin Nutr 2016 Dec;25(Suppl 1):S75-S82.
BACKGROUND AND OBJECTIVES: *Plasmodium falciparum* infection during pregnancy is characterised by placental inefficiency caused by infected erythrocyte sequestration. Reduced placental efficiency leads to placental intrauterine adaptation for sustaining fetal growth, which is reflected by changes in the expression of placental genes involved in intrauterine growth regulation. Therefore, we aimed to determine whether the placental weight ratio, an indicator of placental efficiency, affects the placental expression of the components of the insulin-like growth factor axis and leptin signalling pathway in *P. falciparum*-infected pregnant women. METHODS AND STUDY DESIGN: A malaria case-only analysis of 50 *P. falciparum*-infected pregnant women in Timika, Papua, Indonesia, was conducted. The placental mRNA expression of insulin-like growth factor-I, insulin-like growth factor binding protein-1, leptin, and the long and short isoforms of the leptin receptor was measured through quantitative realtime PCR. RESULTS: The placental weight ratio exerted a positive effect on the placental mRNA expression of insulin-like growth factor-I (coefficient = 6.10, $p = 0.002$) and the long isoform of the leptin receptor (coefficient = 4.73, $p = 0.015$) in malaria-infected pregnant women without fever or chill symptoms. CONCLUSION: Our results indicate that placental adaptive responses caused by adverse intrauterine conditions in *P. falciparum* infected pregnant women vary depending on the presence or absence of fever and chill symptoms.

58 **Pagani L, Lawson DJ, Jagoda E, Mörseburg A, Eriksson A, Mitt M, Clemente F, Hudjashov G, DeGiorgio M, Saag L, Wall JD, Cardona A, Mägi R, Sayres MA, Kaewert S, Inchley C, Scheib CL, Järve M, Karmin M, Jacobs GS, Antao T, Iliescu FM, Kushniarevich A, Ayub Q, Tyler-Smith**

C, Xue Y, Yunusbayev B, Tambets K, Mallick CB, Saag L, Pocheshkhova E, Andriadze G, Muller C, Westaway MC, Lambert DM, Zoraqi G, Turdikulova S, Dalimova D, Sabitov Z, Sultana GN, Lachance J, Tishkoff S, Momynaliev K, Isakova J, Damba LD, Gubina M, Nymadawa P, Evseeva I, Atramentova L, Utevska O, Ricaut FX, Brucato N, Sudoyo H, Letellier T, Cox MP, Barashkov NA, Škaro V, Mulahasanovic L, Primorac D, Sahakyan H, Mormina M, Eichstaedt CA, Lichman DV, Abdullah S, Chaubey G, Wee JT, Mihailov E, Karunas A, Litvinov S, Khusainova R, Ekomasova N, Akhmetova V, Khidiyatova I, Marjanović D, Yepiskoposyan L, Behar DM, Balanovska E, Metspalu A, Derenko M, Malyarchuk B, Voevoda M, Fedorova SA, Osipova LP, Lahr MM, Gerbault P, Leavesley M, Migliano AB, Petraglia M, Balanovsky O, Khusnutdinova EK, Metspalu E, Thomas MG, Manica A, Nielsen R, Villems R, Willerslev E, Kivisild T, Metspalu M.
Genomic analyses inform on migration events during the peopling of Eurasia.
Nature 2016 Oct 13;538(7624):238-242.

High-coverage whole-genome sequence studies have so far focused on a limited number of geographically restricted populations, or been targeted at specific diseases, such as cancer. Nevertheless, the availability of high-resolution genomic data has led to the development of new methodologies for inferring population history and refuelled the debate on the mutation rate in humans. Here we present the Estonian Biocentre Human Genome Diversity Panel (EGDP), a dataset of 483 high-coverage human genomes from 148 populations worldwide, including 379 new genomes from 125 populations, which we group into diversity and selection sets. We analyse this dataset to refine estimates of continent-wide patterns of heterozygosity, long- and short-distance gene flow, archaic admixture, and changes in effective population size through time as well as for signals of positive or balancing selection. We find a genetic signature in present-day Papuans that suggests that at least 2% of their genome originates from an early and largely extinct expansion of anatomically modern humans (AMHs) out of Africa. Together with evidence from the western Asian fossil record, and admixture between AMHs and Neanderthals predating the main Eurasian expansion, our results contribute to the mounting evidence for the presence of AMHs out of Africa earlier than 75,000 years ago.

59 **Pava Z, Burdam FH, Handayuni I, Trianty L, Utami RA, Tirta YK, Kenangalem E, Lampah D, Kusuma A, Wirjanata G, Kho S, Simpson JA, Auburn S, Douglas NM, Noviyanti R, Anstey NM, Poespoprodjo JR, Marfurt J, Price RN.**
Submicroscopic and asymptomatic *Plasmodium* parasitaemia associated with significant risk of anaemia in Papua, Indonesia.
PLoS One 2016 Oct 27;11(10):e0165340..

Submicroscopic *Plasmodium* infections are an important parasite reservoir, but their clinical relevance is poorly defined. A cross-sectional household survey was conducted in southern Papua, Indonesia, using cluster random sampling. Data were recorded using a standardized questionnaire. Blood samples were collected for haemoglobin measurement. *Plasmodium* parasitaemia was determined by blood film microscopy and PCR. Between April and July 2013, 800 households and 2,830 individuals were surveyed. Peripheral parasitaemia was detected in 37.7% (968/2,567) of individuals, 36.8% (357) of whom were identified by blood film examination. Overall the prevalence of *P. falciparum* parasitaemia was 15.4% (396/2567) and that of *P. vivax* 18.3% (471/2567). In parasitaemic individuals, submicroscopic infection was significantly more likely in adults (adjusted odds ratio (AOR): 3.82 [95%CI: 2.49-5.86], p <0.001) compared to children, females (AOR = 1.41 [1.07-1.86], p = 0.013), individuals not sleeping under a bednet (AOR = 1.4 [1.0-1.8], p = 0.035), and being afebrile (AOR = 3.2 [1.49-6.93], p = 0.003). The risk of anaemia (according to WHO guidelines) was 32.8% and significantly increased in those with asymptomatic parasitaemia (AOR 2.9 [95% 2.1-4.0], p = 0.007), and submicroscopic *P. falciparum* infections (AOR 2.5 [95% 1.7-3.6], p = 0.002). Asymptomatic and submicroscopic infections in this area co-endemic for *P. falciparum* and *P. vivax* constitute two-thirds of detectable parasitaemia and are associated with a high risk of anaemia. Novel public health strategies are needed to detect and eliminate these parasite reservoirs, for the benefit both of the patient and the community.

60 **Pearson RD, Amato R, Auburn S, Miotto O, Almagro-Garcia J, Amaratunga C, Suon S, Mao S, Noviyanti R, Trimarsanto H, Marfurt J, Anstey NM, William T, Boni MF, Dolecek C, Tran HT, White NJ, Michon P, Siba P, Tavul L, Harrison G, Barry A, Mueller I, Ferreira MU, Karunaweera N, Randrianarivelojosia M, Gao Q, Hubbart C, Hart L, Jeffery B, Drury E, Mead D, Kekre M, Campino S, Manske M, Cornelius VJ, MacInnis B, Rockett KA, Miles A, Rayner JC, Fairhurst RM, Nosten F, Price RN, Kwiatkowski DP.**
Genomic analysis of local variation and recent evolution in *Plasmodium vivax*.
Nat Genet 2016 Aug;48(8):959-964.

The widespread distribution and relapsing nature of *Plasmodium vivax* infection present major challenges for the elimination of malaria. To characterize the genetic diversity of this parasite in individual infections and across the population, we performed deep genome sequencing of >200 clinical samples collected across the Asia-Pacific region and analyzed data on >300,000 SNPs and nine regions of the genome with large copy number variations. Individual infections showed complex patterns of genetic structure, with variation not only in the number of dominant clones but also in their level of relatedness and inbreeding. At the population level, we observed strong signals of recent evolutionary selection both in known drug resistance genes and at new loci, and these varied markedly between geographical locations. These findings demonstrate a dynamic landscape of local evolutionary adaptation in the parasite population and provide a foundation for genomic surveillance to guide effective strategies for control and elimination of *P. vivax*.

61 **Peltzer K, Pengpid S.**
Risk and protective factors affecting sexual risk behavior among school-aged adolescents in Fiji, Kiribati, Samoa, and Vanuatu.
Asia Pac J Public Health 2016 Jul;28(5):404-415.

There are limited studies on the prevalence and correlates of sexual risk behavior among adolescents in Pacific Island countries. In order to inform public sexual and reproductive health interventions, the

aim of this study was to assess the prevalence and correlates of various sexual risk behaviors among in-school adolescents in 4 Pacific Island countries using data from the Global School-Based Health Survey. In a cross-sectional study, 6792 school-going adolescents (49.7% boys and 50.3% girls; 13-16 years old) from Fiji, Kiribati, Samoa, and Vanuatu were surveyed with a self-administered questionnaire. Overall, 18.9% of students reported to ever had sex (ranging from 12.9% in Vanuatu to 57.5% in Samoa), and of those sexually active, 38.0% had an early sexual debut (<14 years), 38.1% had 2 or more sexual partners during their lifetime, 39.5% had not used a condom at last sex, 50.9% had not used birth control at last sex, and 77.8% engaged in sexually risky behavior using a composite measure. Multivariate logistic regression found that male sex, older age, tobacco use, alcohol use, mental distress, having no close friends, and truancy were associated with several of 5 or all 5 sexual risk behaviors. Sexual and reproductive health promotion programs are indicated to address the high risk of sexually transmitted infection, HIV, and pregnancy in this adolescent population.

62 **Pillay A, Katz SS, Abrams AJ, Ballard RC, Simpson SV, Taleo F, Lahra MM, Batra D, Rowe L, Trees DL, Asiedu K, Chen CY.**
Complete genome sequences of 11 *Haemophilus ducreyi* isolates from children with cutaneous lesions in Vanuatu and Ghana.
Genome Announc 2016 Jul 7;4(4). pii: e00459-16.

Haemophilus ducreyi causes chancroid and has recently been shown to be a significant cause of cutaneous lesions in tropical or subtropical regions where yaws is endemic. Here, we report the draft genome assemblies for 11 cutaneous strains of *Haemophilus ducreyi*, isolated from children in Vanuatu and Ghana.

63 **Poletti AM, Dubey SP, Colombo G, Cugini G, Mazzoni A.**
Treatment of endolymphatic sac tumour (papillary adenocarcinoma) of the temporal bone.
Rep Pract Oncol Radiother 2016 Jul-Aug;21(4):391-394.

AIM: To define a better treatment of sporadic endolymphatic sac tumours (ELST) analysing our experience and literature available data. BACKGROUND: ELST can arise as a sporadic case (rare) or as a part of von Hippel-Lindau (VHL) disease. It is a low grade malignancy with local spread by continuity. MATERIALS AND METHODS: we described our experience with 7 cases with up to date follow up. RESULTS: Five cases were free of disease after the first surgical procedure. One case had recurrence in the temporal lobe after 12 years. One case had two surgical procedures followed by irradiation and died five years after radiotherapy with a slow disease progression. CONCLUSION: With increasing expertise in the skull base surgery, complete tumour excisions are achieved in the majority of the more recent cases and appear to be the treatment of choice. External irradiation is also used as palliative measures with doubtful effectiveness. Some recent reports showed encouraging results with gamma knife radiosurgery.

64 **Pulford J, Smith I, Mueller I, Siba PM, Hetzel MW.**
Health worker compliance with a 'test and treat' malaria case management protocol in Papua New Guinea.
PLoS One 2016 Jul 8;11(7):e0158780.

The Papua New Guinea (PNG) Department of Health introduced a 'test and treat' malaria case management protocol in 2011. This study assesses health worker compliance with the test and treat protocol on a wide range of measures, examines self-reported barriers to health worker compliance as well as health worker attitudes towards the test and treat protocol. Data were collected by cross-sectional survey conducted in randomly selected primary health care facilities in 2012 and repeated in 2014. The combined survey data included passive observation of current or recently febrile patients (N = 771) and interviewer administered questionnaires completed with health workers (N = 265). Across the two surveys, 77.6% of patients were tested for malaria infection by rapid diagnostic test (RDT) or microscopy, 65.6% of confirmed malaria cases were prescribed the correct antimalarials and 15.3% of febrile patients who tested negative for malaria infection were incorrectly prescribed an antimalarial. Overall compliance with a strictly defined test and treat protocol was 62.8%. A reluctance to test current/recently febrile patients for malaria infection by RDT or microscopy in the absence of acute malaria symptoms, reserving recommended antimalarials for confirmed malaria cases only and choosing to clinically diagnose a malaria infection despite a negative RDT result were the most frequently reported barriers to protocol compliance. Attitudinal support for the test and treat protocol, as assessed by a nine-item measure, improved across time. In conclusion, health worker compliance with the full test and treat malaria protocol requires improvement in PNG and additional health worker support will likely be required to achieve this. The broader evidence base would suggest any such support should be delivered over a longer period of time, be multi-dimensional and multi-modal.

65 **Reid MJ, Switzer WM, Schillaci MA, Ragonnet-Cronin M, Joanisse I, Caminiti K, Lowenberger CA, Galdikas BM, Sandstrom PA, Brooks JI.**
Detailed phylogenetic analysis of primate T-lymphotropic virus type 1 (PTLV-1) sequences from orangutans (*Pongo pygmaeus*) reveals new insights into the evolutionary history of PTLV-1 in Asia.
Infect Genet Evol 2016 Sep;43:434-450.

While human T-lymphotropic virus type 1 (HTLV-1) originates from ancient cross-species transmission of simian T-lymphotropic virus type 1 (STLV-1) from infected nonhuman primates, much debate exists on whether the first HTLV-1 occurred in Africa, or in Asia during early human evolution and migration. This topic is complicated by a lack of representative Asian STLV-1 to infer PTLV-1 evolutionary histories. In this study we obtained new STLV-1 LTR and tax sequences from a wild-born Bornean orangutan (*Pongo pygmaeus*) and performed detailed phylogenetic analyses using both maximum likelihood and Bayesian inference of available Asian PTLV-1 and African STLV-1 sequences. Phylogenies, divergence dates and nucleotide substitution rates were co-inferred and compared using six different molecular clock calibrations in a Bayesian framework, including both archaeological and/or nucleotide substitution rate calibrations. We then combined our molecular

results with paleobiogeographical and ecological data to infer the most likely evolutionary history of PTLV-1. Based on the preferred models our analyses robustly inferred an Asian source for PTLV-1 with cross-species transmission of STLV-1 likely from a macaque (*Macaca* sp.) to an orangutan about 37.9-48.9kya, and to humans between 20.3 and 25.5kya. An orangutan diversification of STLV-1 commenced approximately 6.4-7.3kya. Our analyses also inferred that HTLV-1 was first introduced into Australia ~3.1-3.7kya, corresponding to both genetic and archaeological changes occurring in Australia at that time. Finally, HTLV-1 appears in Melanesia at ~2.3-2.7kya corresponding to the migration of the Lapita peoples into the region. Our results also provide an important future reference for calibrating information essential for PTLV evolutionary timescale inference. Longer sequence data, or full genomes from a greater representation of Asian primates, including gibbons, leaf monkeys and Sumatran orangutans, are needed to fully elucidate these evolutionary dates and relationships using the model criteria suggested herein.

66 **Requena P, Rui E, Padilla N, Martínez-Espinosa FE, Castellanos ME, Bôtto-Menezes C, Malheiro A, Arévalo-Herrera M, Kochar S, Kochar SK, Kochar DK, Umbers AJ, Ome-Kaius M, Wangnapi R, Hans D, Menegon M, Mateo F, Sanz S, Desai M, Mayor A, Chitnis CC, Bardají A, Mueller I, Rogerson S, Severini C, Fernández-Becerra C, Menéndez C, Del Portillo H, Dobaño C.**
Plasmodium vivax VIR proteins are targets of naturally-acquired antibody and T cell immune responses to malaria in pregnant women.
PLoS Negl Trop Dis 2016 Oct 6;10(10):e0005009.

P. vivax infection during pregnancy has been associated with poor outcomes such as anemia, low birth weight and congenital malaria, thus representing an important global health problem. However, no vaccine is currently available for its prevention. *Vir* genes were the first putative virulent factors associated with *P. vivax* infections, yet very few studies have examined their potential role as targets of immunity. We investigated the immunogenic properties of five VIR proteins and two long synthetic peptides containing conserved VIR sequences (PvLP1 and PvLP2) in the context of the PregVax cohort study including women from five malaria endemic countries: Brazil, Colombia, Guatemala, India and Papua New Guinea (PNG) at different timepoints during and after pregnancy. Antibody responses against all antigens were detected in all populations, with PNG women presenting the highest levels overall. *P. vivax* infection at sample collection time was positively associated with antibody levels against PvLP1 (fold-increase: 1.60 at recruitment-first antenatal visit) and PvLP2 (fold-increase: 1.63 at delivery), and *P. falciparum* co-infection was found to increase those responses (for PvLP1 at recruitment, fold-increase: 2.25). Levels of IgG against two VIR proteins at delivery were associated with higher birth weight (27 g increase per duplicating antibody levels, $p < 0.05$). Peripheral blood mononuclear cells from PNG uninfected pregnant women had significantly higher antigen-specific IFN-γ TH1 responses ($p = 0.006$) and secreted less pro-inflammatory cytokines TNF and IL-6 after PvLP2 stimulation than *P. vivax*-infected women ($p < 0.05$). These data demonstrate that VIR antigens induce the natural acquisition of antibody and T cell memory responses that might be important in immunity to *P. vivax* during pregnancy in very diverse geographical settings.

67 **Rero A, Aipit J, Yarong-Kote T, Watch V, Bolnga JW, Vei R, Morris M, Lufele E, Laman M.**
The burden of child maltreatment leading to hospitalization in a provincial setting in Papua New Guinea.
J Trop Pediatr 2016 Aug;62(4):282-287.

INTRODUCTION: Child maltreatment is prevalent globally. In Papua New Guinea (PNG), child maltreatment remains an under-reported problem. METHODS: As part of a 10 month prospective observational study conducted at Modilon Hospital in PNG, we investigated the burden of child maltreatment in the form of sexual abuse, physical abuse and neglect, leading to hospitalization in children ≤14 years. RESULTS: Of 1061 screened admissions, 107 (10%) fulfilled the definition of child maltreatment. The in-hospital admission prevalence of sexual abuse was 5.7% [60 of 1061; 95% confidence interval (CI): 4.4-7.3]. Neglect accounted for 3.4% (36 of 1061; 95% CI: 2.4-4.7) of admissions, while physical abuse accounted for 1.0% (11 of 1061; 95% CI: 0.6-1.9). Mortality was highest in the neglected group, with severe acute malnutrition accounting for 89% of deaths. CONCLUSION: Improved awareness, establishment of appropriate channels for addressing child maltreatment and enforcement of child protection laws in PNG and other epidemiologically similar settings are urgently needed.

68 **Rodriguez-Fernandez R, Ng N, Susilo D, Prawira J, Bangs MJ, Amiya RM.**
The double burden of disease among mining workers in Papua, Indonesia: at the crossroads between old and new health paradigms.
BMC Public Health 2016 Sep 8;16:951.

BACKGROUND: As the global shift toward non-communicable diseases overlaps with the unfinished agenda of confronting infectious diseases in low- and middle-income countries, epidemiological links across both burdens must be recognized. This study examined the non-communicable disease-infectious disease overlap in the specific comorbidity rates for key diseases in an occupational cohort in Papua, Indonesia. METHODS: Diagnosed cases of ischaemic heart disease, stroke, hypertension, diabetes (types 1 and 2), chronic obstructive pulmonary disease, asthma, cancer, HIV and AIDS, tuberculosis, and malaria were extracted from 22,550 patient records (21,513 men, 1037 women) stored in identical electronic health information systems from two clinic sites in Papua, Indonesia. Data were collected as International Classification of Diseases, 10th Revision, entries from records spanning January-December 2013. A novel application of Circos software was used to visualize the interconnectedness between the disease burdens as overlapping prevalence estimates representing comorbidities. RESULTS: Overall, NCDs represented 38% of all disease cases, primarily in the form of type 2 diabetes (n = 1440) and hypertension (n = 1398). Malaria cases represented the largest single portion of the disease burden with 5310 recorded cases, followed by type 2 diabetes with 1440 cases. Tuberculosis occurred most frequently alongside malaria (29%), followed by chronic obstructive pulmonary disease (19%),

asthma (17%), and stroke (12%). Hypertension-tuberculosis (4%), tuberculosis-cancer (4%), and asthma-tuberculosis (2%) comorbidities were also observed. CONCLUSIONS: The high prevalence of multimorbidity, preponderance of non-communicable diseases, and extensive interweaving of non-communicable and infectious disease comorbidities highlighted in this cohort of mining workers in Papua, Indonesia reflect the markedly double disease burden increasingly plaguing Indonesia and other similar low- and middle-income countries – a challenge with which their over-stretched, under-resourced health systems are ill-equipped to cope. Integrated, person-centered treatment and control strategies rooted in the primary healthcare sector will be critical to reverse this trend.

69 **Rosenthal VD, Al-Abdely HM, El-Kholy AA, Al Khawaja SA, Leblebicioglu H, Mehta Y, Rai V, Hung NV, Kanj SS, Salama MF, Salgado-Yepez E, Elahi N, Morfin Otero R, Apisarnthanarak A, De Carvalho BM, Ider BE, Fisher D, Buenaflor MC, Petrov MM, Quesada-Mora AM, Zand F, Gurskis V, Anguseva T, Ikram A, Aguilar de Moros D, Duszynska W, Mejia N, Horhat FG, Belskiy V, Mioljevic V, Di Silvestre G, Furova K, Ramos-Ortiz GY, Gamar Elanbya MO, Satari HI, Gupta U, Dendane T, Raka L, Guanche-Garcell H, Hu B, Padgett D, Jayatilleke K, Ben Jaballah N, Apostolopoulou E, Prudencio Leon WE, Sepulveda-Chavez A, Telechea HM, Trotter A, Alvarez-Moreno C, Kushner-Davalos L.**
International nosocomial infection control consortium report, data summary of 50 countries for 2010-2015: device-associated module.
Am J Infect Control 2016 Dec 1;44(12):1495-1504.

BACKGROUND: We report the results of the International Nosocomial Infection Control Consortium (INICC) surveillance study from January 2010-December 2015 in 703 intensive care units (ICUs) in Latin America, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific. METHODS: During the 6-year study period, using Centers for Disease Control and Prevention National Healthcare Safety Network (CDC-NHSN) definitions for device-associated health care-associated infection (DA-HAI), we collected prospective data from 861,284 patients hospitalized in INICC hospital ICUs for an aggregate of 3,506,562 days. RESULTS: Although device use in INICC ICUs was similar to that reported from CDC-NHSN ICUs, DA-HAI rates were higher in the INICC ICUs: in the INICC medical-surgical ICUs, the pooled rate of central line-associated bloodstream infection, 4.1 per 1,000 central line-days, was nearly 5-fold higher than the 0.8 per 1,000 central line-days reported from comparable US ICUs; the overall rate of ventilator-associated pneumonia was also higher, 13.1 versus 0.9 per 1,000 ventilator-days, as was the rate of catheter-associated urinary tract infection, 5.07 versus 1.7 per 1,000 catheter-days. From blood culture samples, frequencies of resistance of *Pseudomonas* isolates to amikacin (29.87% vs 10%) and to imipenem (44.3% vs 26.1%), and of *Klebsiella pneumoniae* isolates to ceftazidime (73.2% vs 28.8%) and to imipenem (43.27% vs 12.8%) were also higher in the INICC ICUs compared with CDC-NHSN ICUs. CONCLUSIONS: Although DA-HAIs in INICC ICU patients continue to be higher than the rates reported in CDC-NSHN ICUs representing the developed world, we have observed a significant trend toward the reduction of DA-HAI rates in INICC ICUs as shown in each international report. It is INICC's main goal to continue facilitating education, training, and basic and cost-effective tools and resources, such as standardized forms and an online platform, to tackle this problem effectively and systematically.

70 **Self L.**
Controlling malaria in Western Pacific with mosquito nets treated with pyrethroids in village communities, 1979-1999.
Am J Trop Med Hyg 2016 Jul 6;95(1):10-14.

Insecticide-treated mosquito nets were first put to practical use in the Western Pacific Region. Less than a decade after conducting workshops and other promotional activities, millions of people were protected by 1989. This occurred before the availability of commercially produced pretreated nets and before global funding for mass net distribution. This paper describes the sequence of steps leading to regional control success. The beginning stages in 1979 recognized that treating torn mosquito nets was a viable control option. Basic net treatment procedures were established by 1983 and workshops were held the next 2 years in China, Cambodia, Laos, Malaysia, Papua New Guinea, Philippines, Solomon Islands, Vanuatu, and Vietnam. Malaria staff became convinced of net benefits and were motivated to impart their knowledge to others. Village inhabitants soaked the nets in washbasins containing permethrin or deltamethrin solution, then dried them horizontally on mats. By the 1990s, the population protected by nets had appreciably increased, and regional malaria cases confirmed by microscopy were markedly reduced. This coincided with commercial interest to mass-produce pretreated mosquito nets for worldwide use.

71 **Skoglund P, Posth C, Sirak K, Spriggs M, Valentin F, Bedford S, Clark GR, Reepmeyer C, Petchey F, Fernandes D, Fu Q, Harney E, Lipson M, Mallick S, Novak M, Rohland N, Stewardson K, Abdullah S, Cox MP, Friedlaender FR, Friedlaender JS, Kivisild T, Koki G, Kusuma P, Merriwether DA, Ricaut FX, Wee JT, Patterson N, Krause J, Pinhasi R, Reich D.**
Genomic insights into the peopling of the Southwest Pacific.
Nature 2016 Oct 27;538(7626):510-513.

The appearance of people associated with the Lapita culture in the South Pacific around 3,000 years ago marked the beginning of the last major human dispersal to unpopulated lands. However, the relationship of these pioneers to the long-established Papuan people of the New Guinea region is unclear. Here we present genome-wide ancient DNA data from three individuals from Vanuatu (about 3,100-2,700 years before present) and one from Tonga (about 2,700-2,300 years before present), and analyse them with data from 778 present-day East Asians and Oceanians. Today, indigenous people of the South Pacific harbour a mixture of ancestry from Papuans and a population of East Asian origin that no longer exists in unmixed form, but is a match to the ancient individuals. Most analyses have interpreted the minimum of twenty-five per cent Papuan ancestry in the region today as evidence that the first humans to reach remote Oceania, including Polynesia, were derived from population mixtures near New Guinea, before their further expansion into Remote Oceania.

However, our finding that the ancient individuals had little to no Papuan ancestry implies that later human population movements spread Papuan ancestry through the South Pacific after the first peopling of the islands.

72 **Sokana O, Macleod C, Jack K, Butcher R, Marks M, Willis R, Chu BK, Posala C, Solomon AW.**
Mapping trachoma in the Solomon Islands: results of three baseline population-based prevalence surveys conducted with the Global Trachoma Mapping Project.
Ophthalmic Epidemiol 2016;23(Suppl 1):15-21.

PURPOSE: We sought to complete the baseline trachoma map of the Solomon Islands by establishing prevalences of active trachoma and trichiasis in the provinces of Choiseul, Western, Rennell-Bellona, and Temotu. METHODS: Using the standardized methodology developed for the Global Trachoma Mapping Project, we conducted cross-sectional community-based surveys from September to November 2013. Choiseul and Western provinces were each mapped as separate evaluation units (EUs); Rennell-Bellona and Temotu were combined to form a third EU. RESULTS: A total of 9819 individuals were sampled for inclusion, with 9224 (93.3%) consenting to examination, of whom 4587 (46.3%) were female. Survey teams visited 82 villages, and surveyed 2448 households. Two EUs had prevalences of trachomatous inflammation-follicular (TF) in 1-9-year-olds over the 10% threshold at which WHO recommends mass distribution of azithromycin for at least 3 years (Western 20.4%, 95% confidence interval, CI 15.6-26.3%; Rennell-Bellona/Temotu 22.0%, 95% CI 18.5-26.0%). Choiseul had a TF prevalence of 6.1% (95% CI 4.1-8.6%), and met the criterion for a single round of mass antibiotic distribution before re-survey. The adjusted prevalences of trichiasis in those aged 15+ years were 0.0% (95% CI 0.0-0.2%) in Choiseul, 0.16% (95% CI 0.0-0.5%) in Western, and 0.10% (95% CI 0.0-0.3%) in Rennell-Bellona/Temotu provinces. All three EUs require implementation of the facial cleanliness and environmental improvement components of the trachoma elimination strategy. CONCLUSION: Active trachoma is prevalent in the Solomon Islands. However, there is little evidence of the blinding complications of trachoma being a public health problem there. Further research into the explanation for this phenomenon is warranted.

73 **Speare R, Bradbury RS, Croese J.**
A case of *Ancylostoma ceylanicum* infection occurring in an Australian soldier returned from Solomon Islands.
Korean J Parasitol 2016 Aug;54(4):533-536.

A 26-year-old male member of the Australian Defense Force presented with a history of central abdominal pain of 4 weeks duration and peripheral eosinophilia consistent with eosinophilic enteritis. Acute hookworm disease was diagnosed as the cause. Adult worms recovered from feces after therapy with albendazole were morphologically consistent with *Ancylostoma ceylanicum*. As the patient had been deployed with the Regional Assistance Mission to Solomon Islands for 6 months prior to this presentation, it is very likely that the *A. ceylanicum* was acquired in Solomon Islands. Until now, it has been assumed that any *Ancylostoma* spp. recovered from humans in Solomon Islands is *A. duodenale*. However, this case demonstrates that human hookworm infection acquired in the Solomon Islands could be caused *by A. ceylanicum*.

74 **Spencer PS, Palmer VS, Kisby GE.**
Seeking environmental causes of neurodegenerative disease and envisioning primary prevention.
Neurotoxicology 2016 Sep;56:269-283.

Pathological changes of the aging brain are expressed in a range of neurodegenerative disorders that will impact increasing numbers of people across the globe. Research on the causes of these disorders has focused heavily on genetics, and strategies for prevention envision drug-induced slowing or arresting disease advance before its clinical appearance. We discuss a strategic shift that seeks to identify the environmental causes or contributions to neurodegeneration, and the vision of primary disease prevention by removing or controlling exposure to culpable agents. The plausibility of this approach is illustrated by the prototypical neurodegenerative disease amyotrophic lateral sclerosis and parkinsonism-dementia complex (ALS-PDC). This often-familial long-latency disease, once thought to be an inherited genetic disorder but now known to have a predominant or exclusive environmental origin, is in the process of disappearing from the three heavily affected populations, namely Chamorros of Guam and Rota, Japanese residents of Kii Peninsula, Honshu, and Auyu and Jaqai linguistic groups on the island of New Guinea in West Papua, Indonesia. Exposure via traditional food and/or medicine (the only common exposure in all three geographic isolates) to one or more neurotoxins in seed of cycad plants is the most plausible if yet unproven etiology. Neurotoxin dosage and/or subject age at exposure might explain the stratified epidemic of neurodegenerative disease on Guam in which high-incidence ALS peaked and declined before that of PD, only to be replaced today by a dementing disorder comparable to Alzheimer's disease. Exposure to the Guam environment is also linked to the delayed development of ALS among a subset of Chamorro and non-Chamorro Gulf War/Era veterans, a summary of which is reported here for the first time. Lessons learned from this study and from 65 years of research on ALS-PDC include the exceptional value of initial, field-based informal investigation of disease-affected individuals and communities, the results of which can provide an invaluable guide to steer cogent epidemiological and laboratory-based research.

75 **Stucki D, Brites D, Jeljeli L, Coscolla M, Liu Q, Trauner A, Fenner L, Rutaihwa L, Borrell S, Luo T, Gao Q, Kato-Maeda M, Ballif M, Egger M, Macedo R, Mardassi H, Moreno M, Vilanova GT, Fyfe J, Globan M, Thomas J, Jamieson F, Guthrie JL, Asante-Poku A, Yeboah-Manu D, Wampande E, Ssengooba W, Joloba M, Boom WH, Basu I, Bower J, Saraiva M, Vasconcellos SE, Suffys P, Koch A, Wilkinson R, Gail-Bekker L, Malla B, Ley SD, Beck HP, de Jong BC, Toit K, Sanchez-Padilla E, Bonnet M, Gil-Brusola A, Frank M, Penlap Beng VN, Eisenach K, Alani I, Ndung'u PW, Revathi G, Gehre F, Akter S, Ntoumi F, Stewart-Isherwood L, Ntinginya NE, Rachow A, Hoelscher M, Cirillo DM, Skenders G, Hoffner S, Bakonyte D, Stakenas P, Diel R, Crudu V, Moldovan O, Al-Hajoj S, Otero L, Barletta F, Carter EJ, Diero L, Supply P, Comas I, Niemann S, Gagneux S.**
Mycobacterium tuberculosis lineage 4 comprises

globally distributed and geographically restricted sublineages.
Nat Genet 2016 Dec;48(12):1535-1543.

Generalist and specialist species differ in the breadth of their ecological niches. Little is known about the niche width of obligate human pathogens. Here we analyzed a global collection of *Mycobacterium tuberculosis* lineage 4 clinical isolates, the most geographically widespread cause of human tuberculosis. We show that lineage 4 comprises globally distributed and geographically restricted sublineages, suggesting a distinction between generalists and specialists. Population genomic analyses showed that, whereas the majority of human T cell epitopes were conserved in all sublineages, the proportion of variable epitopes was higher in generalists. Our data further support a European origin for the most common generalist sublineage. Hence, the global success of lineage 4 reflects distinct strategies adopted by different sublineages and the influence of human migration.

76 **Toliman P, Badman SG, Gabuzzi J, Silim S, Forereme L, Kumbia A, Kombuk B, Kombati Z, Allan J, Munnull G, Ryan C, Vallely LM, Kelly-Hanku A, Wand H, Mola GD, Guy R, Siba P, Kaldor JM, Tabrizi SN, Vallely AJ.**
Field evaluation of Xpert HPV point-of-care test for detection of human papillomavirus infection by use of self-collected vaginal and clinician-collected cervical specimens.
J Clin Microbiol 2016 Jul;54(7):1734-1737.

The World Health Organization has recommended that testing for high-risk human papillomavirus (HPV) (hrHPV) infection be incorporated into cervical screening programs in all settings worldwide. In many high-burden, low-income countries, it will not be feasible to achieve high cervical screening coverage using hrHPV assays that require clinician-collected samples. We conducted the first evaluation of self-collected vaginal specimens compared with clinician-collected cervical specimens for the detection of hrHPV infection using the Xpert HPV test. Women aged 30 to 54 years attending two well-woman clinics in Papua New Guinea were invited to participate and provided self-collected vaginal and clinician-collected cervical cytobrush specimens. Both specimen types were tested at the point of care by using the Xpert HPV test. Women were given their cervical test result the same day. Those with a positive hrHPV test and positive examination upon visual inspection of the cervix with acetic acid were offered same-day cervical cryotherapy. A total of 1,005 women were enrolled, with 124 (12.3%; 95% confidence interval [CI], 10.3%-14.4%) being positive for any hrHPV infection. There was a 99.4% overall percent agreement (OPA) between vaginal and cervical tests for HPV-16 (95% CI, 98.9%-99.9%), a 98.5% OPA for HPV-18/45 (95% CI, 97.7%-99.3%), a 94.4% OPA for other hrHPV infections (95% CI, 92.9%-95.9%), and a 93.4% OPA for all hrHPV types combined (95% CI, 91.8%-95.0%). Self-collected vaginal specimens had excellent agreement with clinician-collected cervical specimens for the detection of hrHPV infection using the Xpert HPV test. This approach provides for the first time an opportunity to incorporate point-of-care hrHPV testing into clinical cervical screening algorithms in high-burden, low-income settings.

77 **Unger HW, Wangnapi RA, Ome-Kaius M, Boeuf P, Karl S, Mueller I, Rogerson SJ.**
Azithromycin-containing intermittent preventive treatment in pregnancy affects gestational weight gain, an important predictor of birthweight in Papua New Guinea – an exploratory analysis.
Matern Child Nutr 2016 Oct;12(4):699-712.

In Papua New Guinea, intermittent preventive treatment with sulphadoxine-pyrimethamine and azithromycin (SPAZ-IPTp) increased birthweight despite limited impact on malaria and sexually transmitted infections. To explore possible nutrition-related mechanisms, we evaluated associations between gestational weight gain (GWG), enrolment body mass index (BMI) and mid-upper arm circumference (MUAC), and birthweight. We investigated whether the increase in birthweight associated with SPAZ-IPTp may partly be driven by a treatment effect on GWG. The mean GWG rate was 393 g/week (SD 250; n = 948). A 100 g/week increase in GWG was associated with a 14 g (95% CI 2.6-25.4) increase in birthweight (p = 0.016). Enrolment BMI and MUAC also positively correlated with birthweight. SPAZ-IPTp was associated with increased GWG [58 g/week (26-900), p < 0.001, n = 948] and with increased birthweight [48 g, 95% CI (8-880), p = 0.019] when all eligible women were considered (n = 1947). Inclusion of GWG reduced the birthweight coefficient associated with SPAZ-IPTp by 18% from 44 to 36 g (n = 948), although SPAZ-IPTp was not significantly associated with birthweight among women for whom GWG data were available (p = 0.13, n = 948). One month post-partum, fewer women who had received SPAZ-IPTp had a low post-partum BMI (<18.5 $kg.m^{-2}$) [adjusted risk ratio: 0.55 (95% CI 0.36-0.82), p = 0.004] and their babies had a reduced risk of wasting [risk ratio 0.39 (95% CI 0.21-0.72), p = 0.003]. SPAZ-IPTp increased GWG, which could explain its impact on birthweight and maternal post-partum BMI. Future trials of SPAZ-IPTp must incorporate detailed anthropometric evaluations to investigate mechanisms of effects on maternal and child health.

78 **Unger HW, Cates JE, Gutman J, Briand V, Fievet N, Valea I, Tinto H, d'Alessandro U, Landis SH, Adu-Afarwuah S, Dewey KG, Ter Kuile F, Dellicour S, Ouma P, Slutsker L, Terlouw DJ, Kariuki S, Ayisi J, Nahlen B, Desai M, Madanitsa M, Kalilani-Phiri L, Ashorn P, Maleta K, Mueller I, Stanisic D, Schmiegelow C, Lusingu J, Westreich D, van Eijk AM, Meshnick S, Rogerson S.**
Maternal malaria and malnutrition (M3) initiative, a pooled birth cohort of 13 pregnancy studies in Africa and the Western Pacific.
BMJ Open 2016 Dec 21;6(12):e012697.

PURPOSE: The Maternal Malaria and Malnutrition (M3) initiative has pooled together 13 studies with the hope of improving understanding of malaria-nutrition interactions during pregnancy and to foster collaboration between nutritionists and malariologists. PARTICIPANTS: Data were pooled on 14 635 singleton, live birth pregnancies from women who had participated in 1 of 13 pregnancy studies. The 13 studies cover 8 countries in Africa and Papua New Guinea in the Western Pacific conducted from 1996 to 2015. FINDINGS TO DATE: Data are available at the time of antenatal enrolment of women into their respective parent study and at delivery. The data set comprises essential data such as malaria infection status, anthropometric

assessments of maternal nutritional status, presence of anaemia and birth weight, as well as additional variables such as gestational age at delivery for a subset of women. Participating studies are described in detail with regard to setting and primary outcome measures, and summarised data are available from each contributing cohort. FUTURE PLANS: This pooled birth cohort is the largest pregnancy data set to date to permit a more definite evaluation of the impact of plausible interactions between poor nutritional status and malaria infection in pregnant women on fetal growth and gestational length. Given the current comparative lack of large pregnancy cohorts in malaria-endemic settings, compilation of suitable pregnancy cohorts is likely to provide adequate statistical power to assess malaria-nutrition interactions, and could point towards settings where such interactions are most relevant. The M3 cohort may thus help to identify pregnant women at high risk of adverse outcomes who may benefit from tailored intensive antenatal care including nutritional supplements and alternative or intensified malaria prevention regimens, and the settings in which these interventions would be most effective.

79 **Wallis P, Starr M, Phillips RJ.**
An uncommon cause of erythema nodosum.
J Paediatr Child Health 2016 Oct;52(10):961-963.

80 **Weaver R, Reiling L, Feng G, Drew DR, Mueller I, Siba PM, Tsuboi T, Richards JS, Fowkes FJ, Beeson JG.**
The association between naturally acquired IgG subclass specific antibodies to the PfRH5 invasion complex and protection from *Plasmodium falciparum* malaria.
Sci Rep 2016 Sep 8;6:33094.

Understanding the targets and mechanisms of human immunity to malaria is important for advancing the development of highly efficacious vaccines and serological tools for malaria surveillance. The PfRH5 and PfRipr proteins form a complex on the surface of *P. falciparum* merozoites that is essential for invasion of erythrocytes and are vaccine candidates. We determined IgG subclass responses to these proteins among malaria-exposed individuals in Papua New Guinea and their association with protection from malaria in a longitudinal cohort of children. Cytophilic subclasses, IgG1 and IgG3, were predominant with limited IgG2 and IgG4, and IgG subclass-specific responses were higher in older children and those with active infection. High IgG3 to PfRH5 and PfRipr were significantly and strongly associated with reduced risk of malaria after adjusting for potential confounding factors, whereas associations for IgG1 responses were generally weaker and not statistically significant. Results further indicated that malaria exposure leads to the co-acquisition of IgG1 and IgG3 to PfRH5 and PfRipr, as well as to other PfRH invasion ligands, PfRH2 and PfRH4. These findings suggest that IgG3 responses to PfRH5 and PfRipr may play a significant role in mediating naturally acquired immunity and support their potential as vaccine candidates and their use as antibody biomarkers of immunity.

81 **Wijaya I, Pangestu W.**
Giant scrotal hydrocele and bilateral leg lymphedema as clinical manifestation of chronic lymphatic filariasis.
Acta Med Indones 2016 Jul;48(3):239-241.

A 51-year-old male came with the complaint of recurrent swelling in the scrotum and legs. Swelling of the scrotum first appeared 17 years ago in the left scrotum approximately the same size as an apple and he underwent surgery. However, 2 years after surgery, the swelling reemerged and gradually increased in size in both scrotums. Left leg swelling began to emerge 5 years ago followed by right leg 3 years after. The patient lives in Sarmi regency, Papua province (endemic).

82 **Witaningrum AM, Kotaki T, Khairunisa SQ, Yunifiar MMQ, Indriati DW, Bramanthi R, Nasronudin, Kameoka M.**
Genotypic characterization of human immunodeficiency virus type 1 derived from antiretroviral therapy-naive individuals residing in Sorong, West Papua.
AIDS Res Hum Retroviruses 2016 Aug;32(8):812-817.

Papua and West Papua provinces have the highest prevalence rate of human immunodeficiency virus type 1 (HIV-1) infection in Indonesia; however, data on the molecular epidemiology of HIV-1 are limited. We conducted a genotypic study on HIV-1 genes derived from antiretroviral therapy-naive individuals residing in Sorong, West Papua. HIV-1 genomic fragments were amplified from 43 peripheral blood samples, and sequencing analysis of the genes was carried out. Of the 43 samples, 41 protease (PR), 31 reverse transcriptase (RT), 26 gag, and 25 env genes were sequenced. HIV-1 subtyping revealed that CRF01_AE (48.8%, 21/43) and subtype B (41.9%, 18/43) were the major subtypes prevalent in the region, whereas other recombinant forms were also detected. Major drug resistance-associated mutations for PR inhibitors were not detected; however, mutations for the RT inhibitors, A62V and E138A, appeared in a few samples, indicating the possible emergence of transmitted HIV-1 drug resistance in Sorong, West Papua.

83 **Worwor G, Harries AD, Merilles OE Jr, Viney K, Rory JJ, Taleo G, Guyant P.**
Syndromic surveillance in Vanuatu since Cyclone Pam: a descriptive study.
Western Pac Surveill Response J 2016 Dec 19;7(4):6-11.

In 2012, Vanuatu designed and implemented a syndromic surveillance system based on the guidelines developed by the Pacific Community and the World Health Organization to provide early warning of outbreaks and other important public health events. Four core syndromes were endorsed for surveillance: acute fever and rash, prolonged fever, influenza-like illness and acute watery diarrhoea. In March 2015, Vanuatu was struck by Cyclone Pam, after which several important changes and improvements to the country's syndromic surveillance were made. To date, there has been no formal evaluation of whether regular reports are occurring or that core syndromes are being documented. We therefore carried out a descriptive study in the 11 sentinel sites in Vanuatu conducting syndromic surveillance between July and December 2015. There was a total of 53 822 consultations which were higher in the first 13 weeks (n = 29,622) compared with the last 13 weeks (n = 24,200). During the six months, there were no cases of acute fever and rash or prolonged fever. There were

cases with influenza-like illness from week 27 to 35, but no case was reported after week 35. Acute watery diarrhoea occurred in one or two cases per week during the whole study period. For these two core syndromes, there were generally more females than males, and about one-third were children aged under 5 years. In conclusion, Vanuatu implemented changes to its new syndromic surveillance system from July to December 2015, although laboratory components had not yet been incorporated. The laboratory components are working in 2016 and will be the subject of a further report.

84 **Young S, Perry WR, Leodoro B, Nosa V, Bissett I, Windsor JA, Dare AJ.**
Challenges and opportunities in the provision of surgical care in Vanuatu: a mixed methods analysis. *World J Surg* 2016 Aug;40(8):1865-1873.

BACKGROUND: The Pacific island nation of Vanuatu faces a number of challenges in delivering surgical care to its population. We aimed to understand and document the barriers, opportunities and required actions to improve surgical care in the country using a mixed methods analysis which incorporated the perspectives of local health stakeholders. METHODS: A baseline quantitative assessment of surgical capacity in Vanuatu was carried out using the WHO situational analysis tool. Twenty semi-structured interviews were then conducted on the two main islands (Efate and Espiritu Santo) with surgeons, allied health staff, health managers, policy-makers and other key stakeholders, using a grounded theory qualitative case study methodology. Initial informants were identified by purposive sampling followed by snowball sampling until theoretical saturation was reached. Interviews were open and axially coded with subsequent thematic analysis. RESULTS: Vanuatu faces deficits in surgical infrastructure, equipment and human resources, especially in the rural provinces. Geographic isolation, poverty and culture – including the use of traditional medicine and low health literacy – all act as barriers to patients accessing timely surgical care. Issues with governance, human resourcing and perioperative care were commonly identified by stakeholders as key challenges facing surgical services. Increasing outreach clinics, developing efficient referral systems, building provincial surgical capacity and undertaking locally led research were identified as key actions that can improve surgical care. CONCLUSION: Documenting locally identified challenges and opportunities for surgical care in Vanuatu is an important first step towards developing formal strategies for improving surgical services at the country level.

Papua New Guinea Institute of Medical Research Monograph Series

ISSN 0256 2901

1. Growth and Development in New Guinea. A Study of the Bundi People of the Madang District.
   L.A. Malcolm. ISBN 9980 71 000 4, 1970, 105p.
2. Endemic Cretinism.
   B.S. Hetzel and P.O.D. Pharoah, Editors. ISBN 9980 71 001 2, 1971, 133p.
3. Essays on Kuru.
   R.W. Hornabrook, Editor. ISBN 9980 71 002 0 (also 0 900848 95 2), 1976, 150p.
4. The People of Murapin.
   P.F. Sinnett. ISBN 9980 71 003 9 (also 0 900848 87 1), 1977, 208p.
5. A Bibliography of Medicine and Human Biology of Papua New Guinea.
   R.W. Hornabrook and G.H.F. Skeldon, Editors. ISBN 9980 71 004 7, 1977, 335p. (with 1976 Supplement, 36p.)
6. Pigbel. Necrotising Enteritis in Papua New Guinea.
   M.W. Davis, Editor. ISBN 9980 71 005 5, 1984, 118p.
7. Cigarette Smoking in Papua New Guinea.
   D.E. Smith and M.P. Alpers, Editors. ISBN 9980 71 006 3, 1984, 83p.
8. Village Water Supplies in Papua New Guinea.
   D.E. Smith and M.P. Alpers, Editors. ISBN 9980 71 007 1, 1985, 94p.
9. The Health of Women in Papua New Guinea.
   Joy E. Gillett. ISBN 9980 71 008 X, 1990, 180p.
10. National Study of Sexual and Reproductive Knowledge and Behaviour in Papua New Guinea.
    The National Sex and Reproduction Research Team and Carol Jenkins. ISBN 9980 71 009 8, 1994, 147p.
11. Childhood in Papua New Guinea.
    H. Sheils Fenbury, Editor. ISBN 9980 71 012 8, 2009, 149p.

Monographs 1-5 are case-bound, 6-11 are paperbacks.

Monographs may be obtained from
The Librarian,
Papua New Guinea Institute of Medical Research
PO Box 60, Goroka, EHP 441,
Papua New Guinea

Cost of each Monograph is K20 plus postage.

Applications for free copies of any monograph should be sent to the Director at the above address.

	Postage and Handling (PNG Kina)	
	AIRMAIL	
	Within PNG	International
1,2,10,11	15.00	40.00
3,4,5	40.00	90.00
6,7,8,9	8.00	25.00

K=PGK=Kina. Please make payment in Kina. If payment is made in any other currency, please add sufficient funds to cover all bank charges

THE MEDICAL SOCIETY OF PAPUA NEW GUINEA

Society Membership and Journal Subscription

Membership of the Medical Society of Papua New Guinea is open to all health workers whether resident in Papua New Guinea or overseas. Members of the Society receive four issues of the Papua New Guinea Medical Journal each year. The Society organizes an annual symposium and other activities.

Membership dues are:-

Papua New Guinea residents:
Members – K150
Associate (Student) Members – K20
Overseas residents: K200; AU$120; US$120

I wish to join the Medical Society of Papua New Guinea as a

Full Member ☐

Please indicate your category

Medical Officer	[ ]
Scientific Officer	[ ]
Pharmacist	[ ]
Health Extension Officer	[ ]
Nursing Officer	[ ]
Laboratory Technologist	[ ]
Radiographer	[ ]
Social Health Worker	[ ]
Other (Please specify)	[ ]

OR a Student Member ☐
(for full-time students)

Medical Student	[ ]
Other Student (Please specify)	[ ]

I enclose my membership fee of

K……..for the year(s)…….....

Name: …….....

Title: …….....

Address: …….....

…….....

…….....

Telephone: …….....

Fax: …….....

Email: …….....

(Forward to the Membership Secretary, Medical Society of Papua New Guinea, PO Box 60, Goroka, EHP 441, Papua New Guinea)

INFORMATION FOR AUTHORS

The Papua New Guinea Medical Journal invites submission of original papers and reviews on all aspects of medicine. Priority will be given to articles and subjects relevant to the practice of medicine in Papua New Guinea and other countries in the South Pacific.

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.

Criteria for authorship should follow the principles published by the International Committee of Medical Journal Editors (ICMJE); a brief statement of the role of each author in the study should accompany submission of the manuscript.

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 4 Journal pages including 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

Submit the original with a virus-free electronic copy or send by email to the Editorial Office. All sections of the manuscript, 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.

ILLUSTRATIONS

Tables and figures should be prepared on separate pages. Figures should be sent as separate jpeg or tiff images. Do not paste the images into Word. Photomicrographs should have internal scale markers. Each table should have a heading and footnotes which make it understandable without reference to the text. Each figure should have a legend; figure legends should be typed together on a separate sheet.

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.

EDITORIAL MAIL

Manuscripts and other editorial communications should be forwarded to:

The Editor,
Papua New Guinea Medical Journal,
PO Box 60, Goroka, EHP,
Papua New Guinea
Email: pngmedj@pngimr.org.pg

SUBSCRIPTIONS

Communications about subscriptions should be addressed to the Journal as above. Matters related to the Society should be addressed to the *Medical Society of Papua New Guinea, PO Box 6665, Boroko, NCD, Papua New Guinea.*

Subscriptions: Members of the Medical Society of Papua New Guinea receive the Journal as part of their annual subscription. Others may subscribe and should contact the subscription secretary for a price.

Note: Once an issue of the Journal has been distributed to subscribers its content is placed in open access on the website www.pngimr.org.pg/png_med_journal/index.htm

CONTENTS