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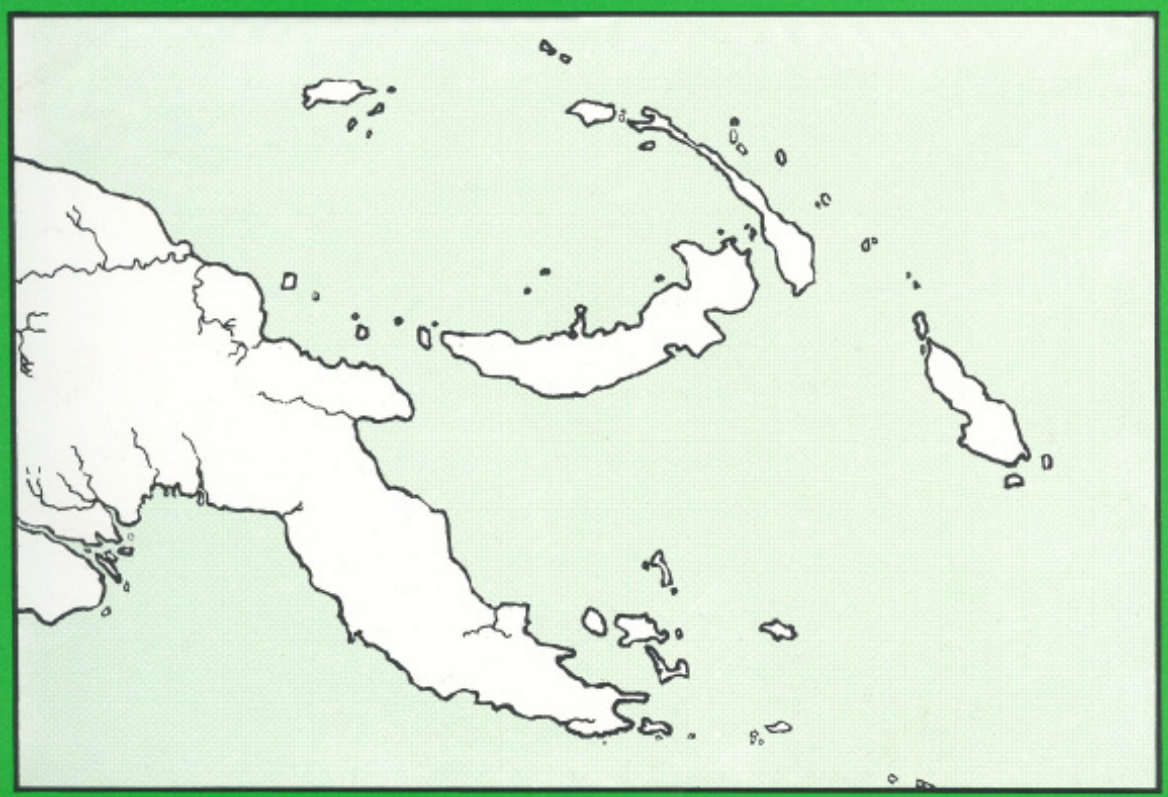

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EDITORIAL

Unintended pregnancy and unsupervised births in Papua New Guinea: can greater access to misoprostol improve maternal health outcomes?

Introduction

Despite a reduction in the global maternal mortality ratio (MMR) there remains a wide discrepancy in the MMR between different regions of the world, and maternal deaths remain unacceptably high in many low-resource settings (1). Countries with the highest levels of maternal mortality have made virtually no progress in reducing maternal deaths over the past two to three decades (2). The majority of maternal deaths (99%) occur in low-resource settings, primarily in remote and rural communities (3). Haemorrhage (primarily postpartum); hypertensive disorders; sepsis; and abortion are responsible for up to 60% of all maternal deaths (4). Many maternal deaths occur suddenly and unpredictably (1) and many could be avoided if preventive and adequate care were available (5). Key factors associated with maternal deaths are: the absence of skilled health professionals during childbirth, lack of services to provide emergency obstetric care and deal with complications of unsafe abortion, ineffective referral systems and lack of access to effective modern family planning methods for many women (5).

Reflecting on current global evidence and recent work undertaken in Papua New Guinea (PNG) this editorial will focus on two key areas of maternal health: unsafe abortion and unsupervised births. We describe the potential role of misoprostol to improve outcomes for women through the prevention of postpartum haemorrhage (PPH) and through the management of induced, unsafe abortion.

Maternal health in Papua New Guinea

In 1990, in an effort to stimulate discussion relating to maternal health in PNG, Joy Gillett (6) published the first report to specifically focus on health issues facing women in PNG. The report provides a broad overview of women's health relating to health and disease; the impact of social and cultural circumstances; nutrition; malaria; sexually transmitted infections; the high risk of childbirth; and family planning. Almost three decades later, many of the issues and problems described remain unchanged and maternal health indicators in PNG are among the poorest in the world (2,7).

The current, high total fertility rate of 4.4 children per woman is little changed from 1985, when the figure was 5.4 children per woman (8). The contraceptive prevalence rate for modern methods of family planning is low at 24%; the unmet need for family planning is 27.4% (8,9). Uptake of antenatal care and health facility births remained virtually unchanged between 1987 and 2017 and remains low with 66% of women attending for any antenatal care and only 44% of women giving birth in a health facility (10).

The MMR in PNG is one of the highest in the world with 594-733 maternal deaths per 100,000 live births (1,2) and is attributable to deteriorating health services and poor access to and uptake of health services (11). One of the key factors associated with maternal deaths is the lack of supervised care during childbirth (12). As in other low-resource countries, the leading causes of maternal mortality in PNG are postpartum haemorrhage and sepsis, due to childbirth and unsafe abortion (11,13).

In response to the maternal health crisis, in 2009 the Minister for Health and HIV convened a Maternal Health Taskforce, to explore the reasons for the deterioration in maternal health and to help establish a way forward to protect the future health of women in PNG (11). Key recommendations were outlined, reflecting a comprehensive approach to improving maternal health. The building of leadership at the Government and local level and recognition of promoting free primary education for girls were outlined alongside the urgent need for provision and access to family planning services and supervised births for all women (11). Importantly was the recognition that the high and rising MMR is a reflection of a poor and dysfunctional health system (11).

The commitment to maternal health was further endorsed through the PNG Development Strategic Plan (2010-2030) (14) and the development of the National Health and HIV Research Agenda in 2013, recognizing maternal health as a priority research area (15). Other Government-led initiatives over the past five years have included a revision of the midwifery training program in PNG (16), an initiative funded by Australian Aid, in collaboration with the World Health Organization PNG, and supported by the University of Technology Sydney, Australia. Through this initiative international midwives and obstetricians have worked alongside local counterparts in four universities to invigorate midwifery practice through training and provision of essential teaching resources. Professional registration of nurses and midwives was also supported and led to the recent launch of a professional registration system for nurses and midwives in PNG (17). Within the National Department of Health, the Reproductive Health Training Unit was established to undertake training of nurses, midwives and doctors in essential and emergency obstetric care (18). At the community level, health care has been re-invigorated with the development and staffing of newly established community health posts in some regions and the development of a six-month in-service program to upskill selected rural-facility-based community health workers (CHWs) in advanced maternity care skills. Although each and all of these strategies are crucial to improving maternal health, and reducing maternal mortality, while women continue to have unplanned and unwanted pregnancies, seek unsafe, induced abortions and give birth in the community without skilled birth attendants they remain at risk. Even with training, upskilling and deployment of trained health professionals skilled in midwifery and emergency obstetric care, women need access to health facilities, with staff able to practise within an enabling environment, that is, with the necessary knowledge, equipment, supplies and mechanisms to manage emergency situations.

Unintended pregnancy

Family planning is about choice, deciding how many children to have and when to have them; it is not solely about preventing unwanted pregnancies. Every individual has the right to determine the number and timing of their children and the right to access reproductive health services, free of discrimination, coercion and violence (19). Fewer births and unwanted pregnancies and a lower proportion of high-risk births contribute towards improved maternal health outcomes and lower maternal mortality and morbidity (20). Recent, global estimates indicate that meeting the unmet need for family planning could avert 29% of maternal deaths annually (21) mainly through reducing the exposure to pregnancy and the associated complications. Access to contraception lowers the risk of having an unsafe abortion (21). However, women may still seek an abortion due to contraceptive failure, poor access to contraception, a mistimed pregnancy, a health risk, rape or incest, or due to socioeconomic reasons (22). Performed correctly by qualified health workers, an induced abortion is a relatively safe procedure (23); however, in unsafe conditions death and disability may occur (24).

A recent study among women attending an antenatal clinic in Port Moresby indicated that half of all pregnancies among the 1198 women participating in the study were unintended (25). The majority of these women were aged under 20 years, unmarried and had either used no contraceptive or used it inconsistently (25). Earlier work undertaken in the Eastern Highlands Province (EHP) identified that the majority of women admitted to hospital following a self-induced abortion had not previously used contraceptives (26). A recent report by Alkema et al. (27) described an increase in the contraceptive prevalence among women in PNG, from 24.5% in 1990 to 36.5% in 2010; however, the unmet need for contraception fell by only 3.4%, from 28.6% to 25.2%, for the same time period (27).

Unsafe abortion

Induced abortion in PNG is restricted under the Criminal Code Act (28). Due in part to this legislation, but also to the religious convictions of many Papua New Guinean health care workers, virtually no abortions take place within public health facilities in PNG (13). However, unsafe abortions are known to be widely practised and sepsis due to unsafe abortion is a leading cause of maternal mortality and morbidity (21).

Traditional herbal abortifacients and physical and mechanical means to end an unwanted pregnancy are reported from many

societies in PNG (6,29). The 1994 national study of sexual and reproductive knowledge in PNG (29) describes a number of women who discussed induced abortion. Reports of self-starvation, self-poisoning, avoidance of antenatal care and direct attempts at induced abortion through natural chemicals or mechanical means and the use of contraceptives, including the 'morning after pill', to terminate an unwanted pregnancy are all described (29).

More recently, work undertaken in Port Moresby in 2011 funded by the United States Agency for International Development (USAID) and the National AIDS Council reported on women who had an induced abortion, which was frequently carried out without the assistance of medically trained staff. Herbal medicine and the taking of 'tablets' (the name or exact nature of the tablets was not reported) were frequently used to end an unwanted pregnancy (30). Two studies undertaken at the Eastern Highlands Provincial Hospital in 2011 and 2012 identified that the majority of women presenting for post-abortion care had used misoprostol to end unwanted pregnancies (26,31-33). The majority of women presenting following an induced abortion were unmarried, students and primigravid (26,32).

In a country with a low contraceptive prevalence rate and high unmet need for family planning, all women of reproductive age need access to contraceptive information and services to avoid, postpone or space pregnancies. In the absence of this, women are resorting to unsafe means to end an unwanted pregnancy, putting their lives at risk and putting an increased strain on an already struggling health system. In PNG an estimated 47% of maternal deaths could be averted through the use of modern contraceptive methods (21). Along with improved access to family planning, improved access to safe abortion services, together with a review of post-abortion care services in PNG, could help in reducing the burden of maternal mortality and morbidity from unsafe, induced abortions.

Unsupervised births

Poor attendances for antenatal care and for a supervised, health facility birth in PNG are due to many, inter-related factors relating to access, economics, cultural beliefs, social support, knowledge, staff attitude and previous experience as well as decision making (34-40). Although the importance of health facility births is recognized by many women, the reality of reaching a health facility to give birth can be problematic in both urban and rural settings in PNG (34,38,41). Even with the best of intentions to attend a health facility to give birth, poor weather, coupled with difficult terrain, lack of transport and poorly maintained roads, can make access to a health facility challenging (38,41,42). Other reasons stated for not attending for a health facility birth include fear of health facility staff (38,42): fear for not attending antenatal clinic; for losing their antenatal clinic books; or because they have not prepared stipulated items for their newborn baby; or because they do not have money for bed fees (38,42). Some women reported not attending the health facility because they were afraid of being left alone, or not being able to have a family member (mother, aunty) with them (42). Although the importance of health facility births must be encouraged for all women, the reality of giving birth at home, either through choice or circumstances, cannot be ignored. In such circumstances community-based strategies and interventions could provide short-term benefit, while the wider issue of supervised births for all remains out of reach.

Misoprostol: the way forward?

Misoprostol is effective in preventing two of the main causes of maternal mortality – unsafe abortion and postpartum haemorrhage (43,44). An inexpensive, heat-stable tablet available in more than 80 countries across the globe (43), it is particularly useful in resource-poor settings. Guidelines are available to support its use in the induction of labour, prevention and treatment of postpartum haemorrhage, and management of spontaneous and induced abortion (43,45). Since its addition to the World Health Organization's Essential Medicines List in 2011 (46), misoprostol has been available in all hospitals and health centres in PNG with standard guidelines describing its use in managing incomplete abortions, induction of labour and prevention and treatment of postpartum haemorrhage (47).

Misoprostol and management of abortion

The use of misoprostol in managing unwanted pregnancies was first discovered

in the 1980s (44). Since then it has been increasingly used across the globe, particularly in settings with restrictive abortion law, with women gaining access to it without the need to seek care or advice from a health care provider (24,26,48-50). While it is suggested that induced abortion is safer with misoprostol than other unsafe methods to end an unwanted pregnancy, appropriate administration and gestation are important (49) and second trimester unsafe abortions frequently result in more serious complications, including maternal deaths (51), than first trimester abortions.

Following an incomplete abortion, the World Health Organization and the International Federation of Gynaecology and Obstetrics (FIGO) recommend management with the use of misoprostol or manual vacuum aspiration (MVA), rather than sharp curettage. However, evidence-based guidelines for the management with these two approaches typically only include women up to the end of the first trimester (23,52). In settings with restrictive abortion law, women frequently present or access care later in the pregnancy, often in the second trimester (53). In the light of the limited evidence base for post-abortion care in the second trimester, a recent systematic review was undertaken, and concluded that misoprostol is effective in managing women presenting for second trimester post-abortion care (53).

In PNG national standard guidelines indicate the use of MVA or misoprostol to manage incomplete abortion (47). However, while the training and use of MVA techniques is underway for many obstetricians in PNG, dilatation and curettage continue to be more widely practised in some settings (32). Dilatation and curettage requires trained, skilled health personnel and management that may consequently place an increased burden on an already over-stretched health system. MVA, when undertaken in the first trimester, is quicker and associated with less blood loss than dilatation and curettage (54). In addition, it may be carried out successfully by specifically trained nurses and midwives (55,56), thus reducing the clinical workload for doctors. Given the safety and effectiveness of both MVA and misoprostol in the first trimester (57,58) it is possible that some women presenting for post-abortion care could be managed without the need of senior medical staff.

Misoprostol for preventing postpartum haemorrhage

While the importance of supervised births for all women continues to be supported and promoted in PNG, given the geographical and social constraints under which many people live in PNG, community-based interventions as an interim strategy to reduce the risk of maternal death from postpartum haemorrhage is a recently explored option. With the growing body of evidence demonstrating the effectiveness of misoprostol for prevention of postpartum haemorrhage in community settings (59-66), a pilot intervention study (the Safer Childbirth Study) in a remote, rural district in the EHP demonstrated a novel, woman-centred intervention providing women with misoprostol, for prevention of PPH, during a non-facility birth (67). In the absence of community-based health care providers, and with poor access to health facilities, a community-based package of interventions was provided to both men and women with key health education messages relating to birth preparedness. While essential information was included, such as the importance of supervised births, women were also provided with an independent means to protect themselves and their newborn infant from adverse outcomes through the use of clean birth kits and self-administered misoprostol. The intervention was highly acceptable to women, with some women using the clean birth kit and administering the misoprostol during a health-facility birth (67).

The use of misoprostol to prevent and treat PPH is included in national standard guidelines in PNG (47). However, the actual use of misoprostol is limited, with many health care workers believing it can only be used by doctors and health extension officers. Despite this belief, misoprostol is available at all hospitals and health centres throughout PNG. Efforts need to be made to ensure appropriate access to this life-saving commodity, particularly in the rural setting. During the design stage for the Safer Childbirth Study, in which misoprostol is provided directly to women (67), a number of stakeholders in PNG, including nurses, midwives, doctors and members of the ethics committee, expressed concern about distributing misoprostol in the community. Their primary concern was that it could be used by other members of the community to end an unwanted pregnancy, rather than for its intended purpose of

preventing PPH. However, as described above, research had already been completed in PNG (32,33) demonstrating that misoprostol was already being used by women seeking to end an unwanted pregnancy.

Given the high number of unsupervised births and the high MMR in PNG, the potential to extend the use of misoprostol, through community-based initiatives, including women self-administering these life-saving tablets in the absence of a health facility birth, warrants further exploration in PNG. Moreover, through locally appropriate interventions supervised births may be increased while also providing women with a safer childbirth experience through the use of clean birth kits and prevention of PPH with self-administered misoprostol.

Conclusion

Maternal health in Papua New Guinea is in crisis. Unwanted pregnancies and unsupervised births place a huge burden not only on the health of women in PNG but also on an already struggling health system (13,25,26,32,68). There is a need to harness what is known and move forward with health facility and community-based interventions to improve maternal health.

The high MMR is not only an indicator of poor access to essential health services at a critical time in a woman's life, but a violation of women's rights. Despite the numerous sociocultural and geographical barriers and a deteriorating and poorly functioning health system, evidence is becoming increasingly available to support improved outcomes for women and their newborn infants in PNG. Locally appropriate programs and strategies can be used to address two key causes of maternal mortality in PNG. Community-based strategies and interventions may provide a short-term solution to improve maternal health outcomes while wider issues of health system strengthening, including developing a health workforce that includes midwives, abortion law reforms and the revitalization of essential maternal health services, are addressed.

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A review of immunization services in Papua New Guinea, 2017

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SUMMARY

The Expanded Programme on Immunization (EPI) in Papua New Guinea (PNG) was launched in 1977. Subsequently, it has been extremely difficult to reach every child with all scheduled vaccines for a number of reasons. Even when the reasons have been identified (such as difficult terrain making access difficult), it has proved difficult to overcome these roadblocks. Indeed, the overall vaccine coverage has remained stagnant for over a decade. PNG is not reaching its immunization goals and is one of the poorest-performing countries in the South Pacific. Nonetheless, some provinces are able to achieve high coverage, even in the current environment. One of the reasons seems to be the quality of leadership at provincial and district levels. The emergence of successful public health authorities is a real light at the end of a dark tunnel. Low coverage, particularly relating to polio vaccine and measles-containing vaccine, continues to be a risk for large outbreaks, potentially causing high numbers of death and illness. This risk is not uniform throughout the country, but is especially severe in areas and communities with low coverage. In the 2013 measles outbreak, there may have been as many as 75,000 cases, placing other Pacific island countries at potential risk. Encouragingly, donors are looking to invest large amounts of capital into refurbishing the cold chain. Although funds are not plentiful in PNG and will not be for the foreseeable future, money in itself is not the constraint. The fundamental systems in place to run the health services are not yet running smoothly. Until these are sorted out, more cash will not fix it.

Introduction

The Expanded Programme on Immunization (EPI) in Papua New Guinea (PNG) was launched in 1977. It initially targeted six vaccine-preventable diseases: tuberculosis, polio, diphtheria, pertussis and tetanus. This was followed by the introduction of single and combined vaccines: measles, hepatitis B (HepB), diphtheria, tetanus toxoid, pertussis vaccines-HepB (DTP-HepB), *Haemophilus influenzae* type b (Hib), and DTP-Hep B-Hib (pentavalent) vaccines. Additional vaccines recently implemented include bivalent oral polio vaccine (bOPV 1+3), injectable polio vaccine (IPV), 13-valent pneumococcal vaccine (PCV13) and measles/rubella (MR) vaccine. It has been difficult to reach every child with these vaccines for a number of reasons, and even when the reasons have been identified (eg, difficult terrain making access difficult, financing of outreach), it has proved difficult to overcome these roadblocks. Indeed, the overall vaccine coverage has remained stagnant for over a decade. There have been a number of evaluations conducted

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in the past (1,2) with similar findings to this review.

Method

As a first step to writing a proposal for funding to the Government of Papua New Guinea (GPNG) in support of immunization, GAVI (the Global Alliance for Vaccines and Immunization) requested that a desk review of all available relevant, recent literature be carried out. In total, 76 documents were located and reviewed – most were dated 2016 or 2017, with the remainder being from as early as 2001. These included journal-published articles and reports compiled by a wide variety of personnel from non-government organizations (NGOs) and other immunization partners as well as from the National Department of Health (NDoH) and other government agencies. This evaluation summarizes the findings from the desk review.

Results

Coverage

While administrative estimates of coverage (number of vaccine doses administered divided by the estimated target population) have been available for some years, the first coverage survey using a World Health Organization (WHO)-approved methodology was not conducted until 2005 (Table 1) (3). This showed coverage for the third dose of DTP (DTP-3) to be 66% (95% CI 58.8-73.4%), not too discordant from reported data. But nation-wide coverage for most antigens fell below the national target of 80%, although there were regional differences, with some island provinces performing the best. Late doses were a major concern: just 4% were fully immunized with valid ('on time') doses by 1 year of age.

Since that time, coverage for the third dose of DTP has remained largely stagnant in the low 60s (Figure 1).

The 2005 survey found that coverage was low in both rural and hard-to-reach communities: at 6 months 48% of children from urban units had received three valid doses of DTP but only 16% in rural areas and 13% in hard-to-reach communities. The 2016 administrative national coverage of 61% concealed a wide variation within the provinces (Figure 2). For instance, the National Capital District (118%), Manus (93%) and Milne Bay (84%) were high performers, while East Sepik (31%), Gulf (29%) and Jiwaka (22%) were at the bottom of the table. There are no data to suggest gender bias in immunization (4).

Measles virus continues to circulate – there were 2,299 laboratory-confirmed cases reported in 2014 and 38 cases in 2015. In the 2013-2015 outbreak, more than 70,000 compatible cases were reported and there were more than 350 measles-related deaths. Latest figures from WHO/UNICEF (United Nations Children's Fund) report coverage of only around 60% for measles-containing vaccine (MCV)-1 and less than that for MCV-2.

Access to services

Access to services is limited in rural communities, which represent around 87% of the population, as well as in urban poor areas; this has a major effect on coverage. The elements most affected are outreach services, suffering from delayed and/or lack of funding, non-availability of robust micro-plans and non-availability of transport, compounded by staffing difficulties. The disparities can be attributed in large part to the country's rugged terrain, quality and attendance of staff and indirect costs. Poor service management at various levels underlies some of these issues. Rural health services have deteriorated significantly over recent years, with closure of health facilities affecting performance in the districts. Persistent and serious law-and-order problems have resulted in marked regional differences affecting access to health facilities and staff supervision. In addition, there are shortages of medical doctors, nurses and community health workers.

Cold chain

Much of the cold chain equipment is old, needs replacement or is missing. There is a lack of continuous training and development of staff in vaccine and cold chain management. Cold chain problems include maintenance of equipment, lack of understanding of temperature-monitoring processes, a lack of qualified maintenance personnel, and deficiencies in knowledge on vaccine management at provincial, district and health centre level. The most recent management evaluation (5) highlighted management as the common weakness at all levels, especially in

TABLE 1

National immunization coverage: survey data and administrative reports

Method	Year	National immunization coverage*						
		BCG (%)	DTP-1 (%)	DTP-3 (%)	OPV-3 (%)	HBV-3 (%)	MCV6 (%)	MCV9 (%)
Demographic and health survey[a]	1995	91	79	47	47	57	Introduced in 1996	76
Administrative reports from health facilities	2002	74	81	61	47	60	61	63
	2003	76	88	68	53	67	63	53
	2004	74	81	62	49	60	60	50
	2005	73	80	61	50	63	Not reported	49
Cluster survey[b] (95% confidence interval)	2005	81 (75.5-87.1)	82 (76.2-87.5)	66 (58.8-73.4)	63 (55.9-70.8)	68 (61.0-75.1)	72 (64.1-78.2)	55 (47.9-62.1)

*Comparison of survey data with historical reports, 1995-2005 (3)
BCG = Bacillus Calmette-Guérin (tuberculosis vaccine)
DTP = diphtheria, tetanus toxoid, pertussis
OPV = oral polio vaccine
HBV = hepatitis B virus
MCV = measles-containing vaccine, MCV6 given at 6 months, MCV9 at 9 months of age
[a]Reported in WHO/UNICEF review of national immunization coverage (August 2008) without confidence intervals; the target population was aged 12-23 months
[b]Weighted national averages of card-confirmed doses

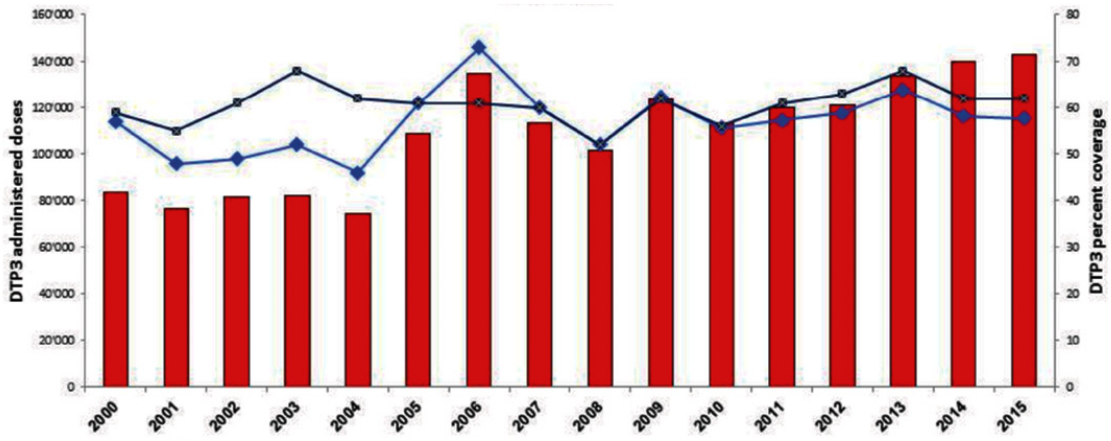

Figure 1. DTP-3 coverage for Papua New Guinea, 2000-2015.
Key:

Doses

Administrative coverage

World Health Organization/United Nations Children's Fund estimate of national immunization coverage (WUENIC)

Sources: World Health Organization, Department of Immunization, Vaccines and Biologicals (IVB) database, as reported to WHO by member states as of 18 November 2016, and WUENIC data as of 15 July 2016

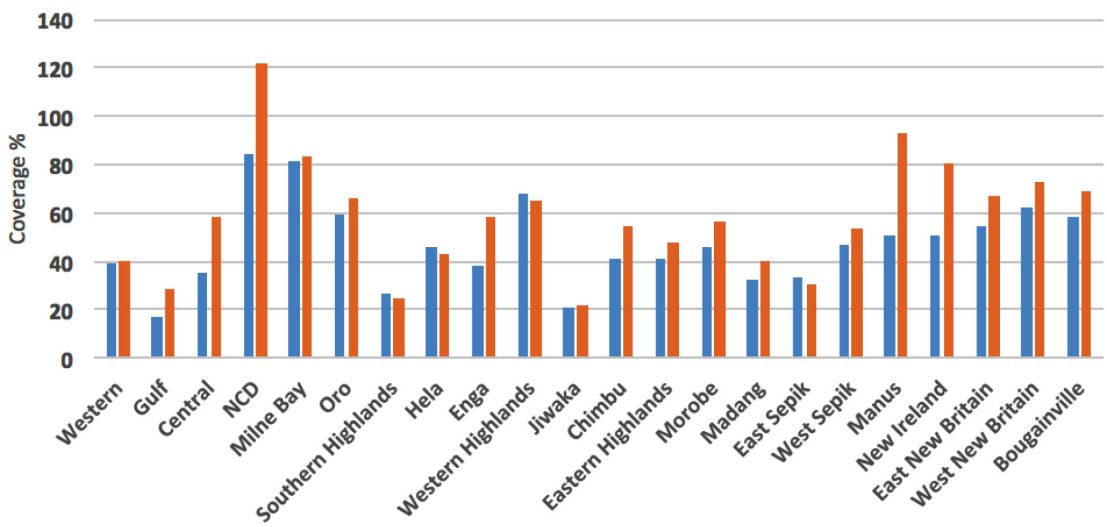

Figure 2. DTP-3 coverage by province 2015-2016. For each province 2015 coverage is on the left, 2016 on the right.
Source: Papua New Guinea National Department of Health

vaccine and stock management. With support from its technical partners, the government has developed a cold chain expansion and rehabilitation plan based on the findings of the 2016 Effective Vaccine Management (EVM) assessment and the 2016 cold chain inventory assessment. The plan is to replace all equipment older than 5 years with new equipment. Much of the older equipment will be replaced with Solar Disks Drive (SDD) refrigerators.

Organic law and decentralization

Provincial leaders are largely autonomous regarding immunization. Provinces and districts have the sole responsibility for service delivery and any related activities concerning program functioning (such as health worker and manager training, and subnational supply chain). The Organic Law is the basis of provincial health service delivery and is poorly understood and hence poorly implemented (6). A lack of clarity exists around program management roles and responsibilities at the province, district and health centre levels, as well as a lack of leadership at all levels. Provincial Authorities receive Health Functional Grants (HFGs) envisioned for health-related expenditures as well as Provincial and District Support Improvement Program funding (PSIP and DSIP) that are discretionary development funds to be spent based on the provincial and district needs. These funds flow to the provincial and district administrations. The Provincial Governors as well as Members of Parliament representing the districts and provinces have discretionary power to allocate the budget to the local priorities, and health is often not prioritized adequately. Despite the fact that the Provincial Health Authorities (PHAs) (already established in 5 provinces, 7 expected in 2017, full roll-out expected by the end of 2018) should be managing the allocation of the HFG, there are often delays in transfer of those funds to where they are needed.

Rural health services

Many rural health facilities receive no or insufficient funding, with serious effects on service delivery (7). In 2015, 29% of health centres and 54% of aid posts did not receive any external support (neither in cash nor in kind), relying on user fees, or simply not providing services. This has been caused by cash flow delays starting at the central level and extending to districts. These issues are likely to have worsened in 2016-2017, making them one of the main impediments to providing full health care services to the whole population of PNG.

Staffing

Staffing is a major issue, with a desperate lack of trained staff, especially in rural settings. There has been a slow implementation of the Health Sector Human Resource Policy Review 2012 and Enhancement Plan 2013-2016. There are insufficient positions, budget and training. Poor staff housing and lack of schools for staff children contribute to the gravitation of staff to urban practice. Low morale reduces productivity and makes recruitment difficult. There are no incentive schemes or hardship allowances to favour rural postings, added to which is a difficult work environment. As a result, it is hard to maintain good staff in post.

Public demand for services

The 2005 coverage survey revealed that the reasons for failure to immunize varied: 21% of mothers said their child was not immunized because distance, travel conditions or cost of transportation prevented access to local health centres; 27% cited a lack of knowledge or misconceptions about immunization; while 29% believed it was because of an issue with the health system. The public is often not aware of the possibility of services being provided, and therefore does not seek them out. There is a lack of communication planning and involvement of communities.

Finances

Health financing, public financial management and specifically immunization financing constitute profound challenges affecting the regular functioning of immunization service delivery (8). As PNG has been experiencing a slow-down in its economy, the government budget has faced increased pressure resulting in significant cuts between 2016 and 2017 in most of the sectors except administration (due to elections in 2017 and the APEC meeting in 2018). The health sector experienced a reduction of 20% in financing. In the future, moderate growth is expected and revenues are anticipated to pick up slowly starting from 2019; however, this will

not translate in the medium term into more resources for health, as the government is maintaining a path to fiscal consolidation. In real terms the reduction in the health sector will amount to 42% between 2016 and 2020. The share of health in the total government budget for 2017 is 9% and is expected to decline to approximately 8% by 2020. Regarding the management of donor funds, the 2016 GAVI Audit of the PNG program (9) declared: "The Audit Team assessed the NDoH management of Gavi funds as unsatisfactory, which means that internal controls and risk management practices were either not established or not functioning well. The majority of issues identified were critical risk. Hence, the overall entity's immunization programme objectives are not likely to be achieved and risks were not appropriately mitigated or managed."

While the health budget has been experiencing significant cuts, immunization has been affected disproportionately. The NDoH budget was reduced by 16% between 2016 and 2017 (this budget only funds activities carried out by the NDoH and does not include provincial services); at the same time the immunization program budget was halved (from K110,000 to K58,800, approximately US$18,500). This has affected immunization's ability to perform routine activities such as supportive supervision, training, annual meetings with provinces and districts, and cold chain procurement at the central level. Both immunization and the medical supplies (vaccine procurement) budget lines are projected to remain flat over the coming 3 years.

Management

Largely due to the decentralized model of its health system, management at all levels (national, provincial, district and health facility) is a challenge. A disconnect exists between defined roles and actual responsibilities between all levels of functionaries. There is a major disconnect between planning at the national level and program implementation at the provincial and facility levels.

Immunization leadership at national level is currently weak but there are plans to strengthen it soon. Provincial management rests with the Provincial Health Authority, particularly the Chief Executive Officer (CEO) and the Provincial Governor. Until recently, this management too has been weak, but with the start of the PHA roll-out, this situation is improving as evidenced by improved performance of these provinces.

Discussion

PNG is not reaching its immunization goals and is one of the poorest-performing countries in the South Pacific. Nonetheless, the latest data tell us that some provinces are able to achieve high coverage, even in the current environment. There is a variety of reasons why some provinces are able to achieve much higher coverage than others. Geography plays an important role, some areas of the country presenting almost insurmountable obstacles to easy access for health services. But the outstanding reason seems to be the quality of leadership at provincial and district levels. The independent review of Provincial Health Authorities in 2015 (6) identified some reasons why Milne Bay Province was one of the most successful. The reasons included the presence of a hard-working Board and CEO; strong political support from the Governor; the purchase of a medical ship in partnership with Youth with a Mission (YWAM); forming strong partnerships including with the private sector; and securing Asian Development Bank (ADB) support for community health post projects and refurbishment of health centres.

Low vaccine coverage can have particularly serious consequences. For instance, the low coverage of measles-containing vaccine continues to be a risk for a large outbreak, potentially causing high numbers of death and illness. This risk is not uniform throughout the country, but is especially severe in areas and communities with low coverage. In the 2013 outbreak, there may have been as many as 75,000 cases, placing other Pacific island countries at potential risk (10,11). A measles outbreak is not a possibility, it is a certainty while coverage remains at its present levels. Decisions are urgently needed at central level and in consultation with partners about how to respond. Should another nation-wide supplementary immunization activity (SIA) be implemented, or is a more focused approach needed targeting communities at highest risk?

In this review, we have identified some of the many reasons why PNG is one of the most difficult countries in the world in which to deliver health services. It is to the immense credit of many hundreds of health care workers that immunization coverage

is as high as it is. Under-staffed clinics are run by individuals who may have minimal training and resources, and who work in harsh conditions to deliver the best service they can. These are the heroes. Despite these efforts, however, many districts are facing very low or stagnant immunization coverage levels.

But not everything is gloom. The performance of some of the provinces is excellent. Donors are looking to invest large amounts of capital into refurbishing the cold chain. Vaccine procurement looks secure for at least the next few years. The emergence of successful PHAs is a real light at the end of a dark tunnel. It is anticipated that this will make a huge difference to the flow of allocated resources right down to the health centre level.

Conclusions

Although funds are not plentiful in PNG and will not be for the foreseeable future, money in itself is not the constraint. The fundamental systems in place to run the health services are not yet running smoothly. Until these are sorted out, more cash will not fix it.

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DISCLAIMER

The views expressed in this article are the views of the authors alone and do not necessarily reflect the views of any individual or organization.

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Rates of receipt of birth dose of hepatitis B immunization in Milne Bay Province, Papua New Guinea

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SUMMARY

Hepatitis B virus (HBV) is an important cause of liver morbidity in Papua New Guinea despite the existence of a national childhood vaccination program. A questionnaire was used to determine current rates of immunization with the HBV vaccine birth dose in children as well as to identify barriers to the receipt of the birth dose in Milne Bay Province. Results suggested that rates of HBV birth dose vaccination were inconsistent between the capital district of Alotau and the 3 rural districts of the province. In this small sample, being from a remote district and being born outside of a hospital setting were significantly associated with lower rates of immunization.

Introduction

Hepatitis B virus (HBV) (family *Hepadnaviridae*, genus *Orthohepadnavirus*) is a partially double-stranded DNA (deoxyribonucleic acid) virus that infects hundreds of millions of people world-wide. Acute HBV infection can cause a self-limiting hepatitis or fulminant liver failure (1). Chronic infection is more likely if transmission occurs within the first 5 years of life and can lead to liver cirrhosis and hepatocellular carcinoma (1,2). In developed countries, transmission of HBV is mainly achieved through sexual contact and intravenous drug use while in developing countries perinatal transmission is more important (3).

Papua New Guinea (PNG), located in the highly endemic Western Pacific region, has an estimated prevalence of chronic HBV infection between 6% and 8% despite the existence of an effective vaccine (4). Prevalence varies considerably between different parts of the country, with some provinces dealing with a more considerable burden of HBV infection than others. In 1989, PNG initiated a 3-dose childhood HBV vaccination program consisting of doses at 1, 2 and 3 months of age and in 1992 a birth dose – defined as a dose of HBV vaccine given within 24 hours of birth – was added to the regimen (2,4,5). Since the implementation of the national vaccination program, a reduction in HBV infection among children in PNG has been reported (5). However, a number of barriers exist in PNG that prevent children from receiving birth doses of HBV vaccine, including home birth (nearly 50% of children born in PNG are born at home and only 21% of these infants receive the HBV birth dose), absence of transportation, lack of vaccine supply (a 2016 study found that 12% of health facilities in PNG were out of stock of HBV vaccine), poor maintenance of a proper cold chain, and false beliefs regarding contraindications to vaccination (6,7).

Materials and Methods

A study was conducted at Alotau General Hospital, a 204-bed provincial reference hospital in the city of Alotau that serves the entirety of Milne Bay Province. Milne Bay is home to 276,000 people of various ethnicities, spread over 160 islands, and comprises part of a region of PNG with a seroprevalence of HBV surface antigen approaching 2.5% (8,9). Milne Bay Province has been divided roughly into quarters by the National Statistical Office of Papua New Guinea to create the capital

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district of Alotau as well as the 3 rural districts of Samarai/Murua, Kiriwina/Goodenough and Esa'ala. Since Alotau District is more developed and also the site of the province's only referral hospital, a questionnaire was used to retrospectively assess any differences in HBV vaccine birth dose status among children of residents of Alotau compared to those from the 3 rural districts.

Demographic and vaccination status data were collected between May and June 2016 via the study questionnaire from parents of paediatric patients that were ≤17 years old at Alotau General Hospital's Outpatient Paediatric Clinic. If there was no record in the child's health book of their child receiving an HBV vaccine birth dose as outlined by national guidelines, parents were asked to identify the reason why from a number of options provided on the questionnaire. Because many residents of rural districts of Milne Bay travel to Alotau District to give birth at the hospital, children's district of birth was not used to assign participants to either the Alotau district group or the rural districts group. Instead, parents' district of residence at the time of their child's birth was used. By distributing participants in this manner, barriers that prevented rural residents from travelling to Alotau for delivery would potentially be identified. All participants received information regarding the public health importance and current status of HBV in PNG. Baseline characteristics of the study population and questionnaire results were analysed (Table 1) using a χ^2 test or Fisher's Exact Test, as appropriate (R for Mac OS X, version 3.2.1, The R Foundation for Statistical Computing).

TABLE 1

Immunization rates and barriers to immunization with hepatitis B vaccine birth dose in residents ≤17 years of age across districts and birth settings in Milne Bay Province, Papua New Guinea, 2016

	Total	Birth dose received[a,b]	Reasons for not receiving the HBV birth dose*				
			Child born at home			Vaccine unavailable	Vaccine not offered
			No clinic access	Chose to give birth at home	Total		
District of residence at birth:							
Alotau	110	94 (85)	2 (13)	2 (13)	4 (25)	1 (6)	11 (69)
Rural[c]	23	14 (61)	5 (56)	2 (22)	7 (78)	0	2 (22)
Birth setting:							
Hospital	99	94 (95)	-	-	-	1 (20)	4 (80)
Health centre	20	11 (55)	-	-	-	0	9 (100)
Home	14	3 (21)	7 (64)	4 (36)	11 (100)	0	0
Total	133	108 (81)	7 (28)	4 (16)	11 (44)	1 (4)	13 (52)

*Number of participants surveyed with indicated response (% of unvaccinated participants from a district or birth setting)
[a]Number of participants surveyed with indicated response (% of total participants from a district or birth setting)
[b]p <0.01 between districts of residence at time of birth and between birth settings: χ^2 test or Fisher's Exact Test
[c]Rural: Esa'ala, Kiriwina/Goodenough and Samarai/Murua districts

Results

A total of 208 children were originally included in the study and the median age was 3.3 years (mean 4.3, standard deviation [SD] 3.7). There was a significant difference between the proportion of children born in hospital and home settings based on whether or not a child was born to residents of Alotau District or one of the 3 rural districts ($p < 0.005$). Most of the children of Alotau residents were born in a hospital (n = 139/176, 79%) while only 50% of the children of residents of the other 3 districts were born in a hospital (n = 16/32). The rate of birth in a health centre was 14% for Alotau residents and 16% for residents of rural districts (n = 25/176 and n = 5/32, respectively). Residents of Alotau had a rate of home birth of 7% while rural districts had a rate of home birth of 34% (n = 12/176 and n = 11/32, respectively; $p < 0.001$).

At this point, 75 of the initial 208 participants were excluded from further analysis of HBV birth dose status for being unable to provide an official health card as proof of immunization. For the 133 remaining participants, birth dose coverage was 81% (n = 108/133) for residents of all 4 districts. Among residents of Alotau, 85% (n = 94/110) received the birth dose while vaccination rates were 61% (n = 14/23) for the rural districts (Fisher's Exact Test, p = 0.015).

Among parents of the 25 participating children who did not receive the birth dose, possible reasons for non-vaccination were offered, including home birth, having poor access to a health facility, and not being offered the vaccination by health workers (doctors, nurses or health extension officers [HEOs]). Birth setting was significantly associated with birth dose coverage, with 95% of hospital births and only 41% of home or health centre births receiving the birth dose (n = 94/99 and n = 14/34, respectively; $p < 0.001$).

Discussion

HBV vaccine birth dose rates from this study were similar to rates published in a previous study (6). This study identifies uneven administration of the birth dose throughout Milne Bay Province. Major barriers included failure of health care providers to offer the birth dose to postpartum mothers in a hospital or health centre and delivery outside of a hospital. Unfortunately, a limitation of this study is that it does not provide information about why there was sometimes a failure to offer the vaccine to newborns of Alotau residents in hospitals and health centres in Alotau District. Further investigation could determine if the underlying causes for the apparent failure of providers to offer the birth dose in Alotau are related to vaccine supply, maintenance of cold chain, medical contraindications, poor data quality, or something else (7).

The exclusion of 75 participants from analysis of HBV birth dose status for being unable to provide an official health card as proof of immunization has the potential to introduce a selection bias to the study. For example, children whose parents were able to furnish a health card may be more likely to have received the birth dose than those who did not have a health card. There are other biases inherent in our study, including referral bias: because research activities took place in a hospital setting, and because parents from remote districts may not travel to Alotau General Hospital unless their child is unwell, a greater proportion of unwell children from remote districts may have been included in the study that were less likely to have been vaccinated at birth. Only a population-based study would minimize these referral biases.

Also, sample sizes from districts other than Alotau were very small and this limits conclusions that can be made regarding the population-based coverage of HBV vaccine birth dose, though it does suggest rural-urban disparity. Data from this study imply that efforts to increase birth dose coverage in Milne Bay could focus on improving the access of pregnant women in remote districts to clinics or increasing the availability of HBV vaccine to those women giving birth outside of a hospital.

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Prevalence of *Leptospira* spp. in rats from Eastern Highlands Province, Papua New Guinea

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SUMMARY

Leptospirosis (Weil's disease) is highly prevalent in the tropics, where conditions for its transmission are favourable. Rodents are the main reservoir in developing nations. Recent studies into leptospirosis in Papua New Guinea have focused on cattle and little to no work has been done to determine the prevalence in humans and rodents. A total of 188 rats were trapped from six different sites in the Eastern Highlands Province during 2014-2015. DNA samples extracted from rat kidneys were screened for *Leptospira* spp. by real-time polymerase chain reaction, with 44/188 (23%) positive. *Leptospira* prevalence by rat species was 8/39 (21%) for *Rattus rattus* and 36/149 (24%) for *Rattus exulans*. This is the first report of the prevalence of *Leptospira* spp. in Papua New Guinean rats.

Introduction

Leptospirosis is one of the world's most widespread zoonoses (1-8), but it is more common in the tropics, where conditions for its transmission are particularly favourable (1,6,9). It is caused by pathogenic species of *Leptospira*, spiral-shaped bacteria of which there are many variants and species, affecting different animals as well as humans (1,4,10-13). *Leptospira* spp. are maintained by chronically infected mammalian hosts (eg, rats, dogs) and are typically transmitted to humans via water contaminated with infected urine or by direct contact with reservoir hosts. Infection can also occur via inhalation or ingestion of infective organisms. Leptospirosis can vary from asymptomatic infection to severe disease ranging from flu-like symptoms to liver and kidney failure, encephalitis and pulmonary involvement (1,3,14). Mild illness, characterized by fever, chills, nausea, malaise and myalgia (3,5,9,14), may be misdiagnosed as other infections such as influenza, dengue and malaria. In the severe state, leptospirosis may appear as meningitis and renal failure, and if left untreated can cause death (14,15). Current treatment guidelines for leptospirosis include the administration of tetracyclines and β-lactam antibiotics/cephalosporins (14). In addition, severe cases of leptospirosis can be treated with high doses of intravenous penicillin, whereas less severe cases can be treated with oral antibiotics such as amoxycillin, ampicillin, doxycycline or erythromycin (14,16). Prevention is largely dependent on sanitation measures that may be difficult to implement in developing countries (14).

Leptospirosis in humans has been recorded in many Pacific island countries. New Caledonia reported 1320 human cases with 39 deaths from 1995 to 2008 and Fiji recorded 142 notified cases with 42 deaths from 1988 to 2000 (17). The recent severe flooding in Fiji in 2012, as a result of two consecutive cyclones,

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resulted in a leptospirosis outbreak with 576 reported cases, and a case fatality rate of 7% (18). Other Pacific island countries have reported yearly outbreaks and notified cases (2,17,19). However, in Papua New Guinea (PNG) leptospirosis has not been widely investigated. Previous investigations into the presence of *Leptospira* spp. (in addition to other zoonoses) were carried out in humans and pigs in the 1950s and 1970s (2,20,21). However, the only recent study, conducted in 2006, investigated the seroprevalence of *Leptospira* spp. in cattle, which confirmed 15 serovars using a microscopic agglutination test (MAT) (22). To date, no studies have found evidence of leptospirosis in rodents in PNG. There have been recent investigations into febrile illness across the border in the northeast of Papua, Indonesia, where 20 patients out of 226 with acute, non-malarial, febrile illness were confirmed to have leptospirosis (23). This highlights the need to investigate and establish the prevalence of leptospirosis and the potential zoonotic transmission risk by rats and to develop strategies to reduce infection rates in affected communities in PNG.

This study aimed to investigate the prevalence of *Leptospira* spp. in its primary vector, in urban and rural communities of PNG where rat infestations are common.

Materials and Methods

Sampling sites

Rodent collections were carried out in six different sites in the Eastern Highlands Province (EHP) of PNG, including Goroka town, Sagifa village, Korofeigu village, Goisipa village, Soyugu village and Hogave village (Figure 1). All of the sites are located between the latitudes of 6° 5' and 6°110' S and at longitude 145°28' E, with an elevation between 1500 and 1600 m and generally characterized by a tropical climate with a mean monthly temperature of 26°C and average monthly rainfall of 250 mm. Selection of the study sites was based on accessibility to the sites and prior known local community contacts from each site. Sample collection was conducted between 2013 and 2015.

Sample size and collection

A total of 188 rats were trapped and collected using cage traps, snap traps, glue traps and local trapping techniques by the villagers from each sampling site. Rats were anaesthetized with chloroform and euthanized by cervical dislocation. Rat kidneys were harvested and

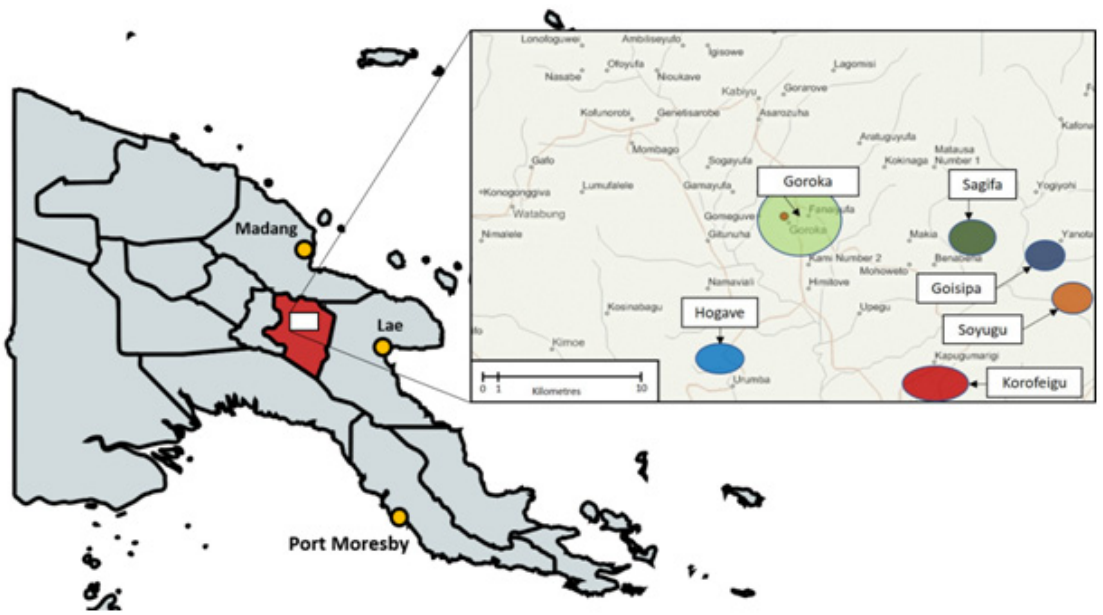

Figure 1. Map of Goroka and surrounding villages and communities with trapping locations shown.

stored in 70% ethanol for later analysis in the laboratory. The research team also recorded morphometric data such as rat species, sex, age phase, fur colour, body weight, body length, tail length and ear length during the field sampling. Even though allowance was made to record pregnancy in the trapped rats, no pregnant rat was observed.

DNA extraction and molecular detection

Nucleic acid extraction was conducted on the rat kidneys using the DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany), according to the manufacturer's instructions.

Molecular detection of *Leptospira* spp. DNA (deoxyribonucleic acid) was conducted using real-time polymerase chain reaction (PCR) with primers and probes as described by Smythe et al. (24). In brief, the primers and probes used were: LeptoForward$^{(15mer)}$ primer (5′ - CCC GCG TCC GAT TAG); LeptoReverse$^{(17mer)}$ primer (5′ - TCC ATT GTG GCC GRA CA); and LeptoProbe$^{(24mer)}$ (5′ - [FAM]CT CAC CAA GGC GAC GAT CGG TAG C[BHQ1]) (24). The reactions were performed in a CFX96 real-time PCR machine (Bio-Rad, USA)

Rat speciation

Speciation of each rat was done using dichotomous keys based on the morphometric data recorded. The key classifies and separates each rat based on different morphological features, which include rat type, sex, age phase, fur colour, body weight, body length, tail length and ear length (25). Due to the absence of available resources to speciate trapped rats conclusively, morphological characteristics of specimens were used to identify them to their closest species. Previous reports have established the difficulties in conclusively identifying *Rattus* species using morphological characteristics (26). However, identification of *Rattus* species based on molecular methods has also been reported as problematic (27). As such, species identification was based on standard methods of morphological characterization and we cannot exclude the possibility that a small number of animals were misidentified and actually belonged to another species within the *Rattus* complex. However, we are confident that this would not influence the main findings and conclusions outlined in this study.

Data analysis

Data were entered into 2007 Microsoft Excel spreadsheets (Microsoft, Redmond, USA) and utilized for calculating *Leptospira* spp. prevalence according to different variables in the rat population (eg, location, sex).

Results

All rats trapped were determined to belong to the *Rattus* complex and were morphologically identified as either *R. rattus* or *R. exulans*. The prevalence of *Leptospira* spp. in the 188 rats was 23% from the six study sites in EHP (Table 1). The prevalence between each site was highly variable, ranging from 7.4% to 33.3%. The prevalence of *Leptospira* spp. was comparable between *R. rattus* and *R. exulans*, with 21% and 24% of animals testing positive, respectively. *Leptospira* was detected in a similar proportion of rodents trapped inside (27%) as outdoors (21%). Adult rats (26%) were positive more frequently than juveniles (14%); and female rats (27%) were more commonly positive for *Leptospira* than males (18%).

Discussion

Although there have been many published papers and reports indicating leptospirosis as a highly prevalent zoonosis world-wide (1-6), there is limited knowledge on leptospirosis in livestock and wildlife in PNG (2,17). This study confirms that rats, common in many communities in PNG, are a significant reservoir of *Leptospira* spp., as has been observed elsewhere. Rats are a major agricultural pest throughout the Pacific and South-East Asia, damaging rice, sugarcane, banana, cocoa, coconut, maize, passion fruit, pawpaw, pineapple, mangoes and root crops (25). The prevalences reported here are similarly reproduced by others in the region, most recently by Guernier et al. in Tahiti, where 20.4% of the rats tested were positive for *Leptospira* (28). 26.5% of farmed pigs were also found to be positive for *Leptospira* in the same study. In another study conducted recently on Christmas Island looking at *Leptospira* in black rats and feral cats, the prevalences observed were 2.9% and 42.4% respectively (29). These recent studies demonstrate that the prevalence of *Leptospira* in a suspected rat reservoir may vary and other animals with shared habitats should be investigated as potential reservoirs

TABLE 1

PREVALENCE OF *LEPTOSPIRA* SPP. IN RATS FROM THE DIFFERENT STUDY SITES AND BY AGE, SEX AND SPECIES

	***Leptospira* spp. positive**		
Characteristic	***Rattus rattus* (%)**	***Rattus exulans* (%)**	**Total (%)**
Sampling sites			
Goroka town (n = 27)	0/10 (0)	2/17 (11.8)	2/27 (7.4)
Sagifa village (n = 32)	2/2 (100)	7/30 (23.3)	9/32 (28.1)
Korofeigu village (n = 76)	5/18 (27.8)	20/58 (34.5)	25/76 (32.9)
Goisipa village (n = 25)	1/9 (11.1)	1/16 (6.3)	2/25 (8.0)
Soyugu village (n = 13)	0/0 (0)	1/13 (7.7)	1/13 (7.7)
Hogave village (n = 15)	0/0 (0)	5/15 (33.3)	5/15 (33.3)
Trapping site			
Indoors (n = 73)	4/24 (16.7)	16/49 (32.7)	20/73 (27.4)
Outside (n = 115)	4/15 (26.7)	20/100 (20.0)	24/115 (20.9)
Age phase			
Adult	8/38 (21.1)	30/108 (27.8)	38/146 (26.0)
Juvenile	0/1 (0)	6/41 (14.6)	6/42 (14.3)
Sex			
Male	2/16 (12.5)	13/66 (19.7)	15/82 (18.3)
Female	6/23 (26.1)	23/83 (27.7)	29/106 (27.4)
Total (n = 188)	8/39 (20.5)	36/149 (24.2)	44/188 (23.4)

or amplifying hosts.

In this study, the *Leptospira* prevalence was highest in Hogave, Korofeigu and Sagifa villages, with 33%, 33% and 28% of rodents testing positive, respectively. The prevalences of *Leptospira* spp. in *R. rattus* (21%) and *R. exulans* (24%) were similar, suggesting that the bacteria do not preferentially infect either species.

Villagers reported that garden rats were one of the most important pests for pineapple, sweet potatoes and other garden crops. Rats were also commonly reported in village houses. Given the high prevalence of *Leptospira*,

indirect environmental transmission of the pathogen by rats through food and water sources are highly likely. Practices such as drinking from open water sources, exposure of uncovered food to rodent excreta and other general unhygienic practices greatly increase transmission and infection risk to humans. To our knowledge, there have been no recent studies to determine the prevalence of *Leptospira* infection in PNG people. The broad spectrum of symptoms attributed to *Leptospira* infection in humans means that clinical diagnosis, without adequate laboratory support, is difficult (1). As noted previously in reference to cholera (30), improved laboratory diagnostics in rural regions of PNG are urgently needed. This is particularly pertinent for bacterial infections that are difficult to diagnose, such as leptospirosis, typhoid and scrub typhus, where effective antimicrobial treatment is available.

Conclusion

This study provides the first report of the general prevalence of *Leptospira* spp. in PNG rodent reservoirs. PNG is located in the tropics with high rainfall year-round, providing a favourable environment for *Leptospira* spp. survival and spread. In addition, unhygienic practices and frequent contact of humans with rat excreta increase the risk of *Leptospira* spp. transmission. Further research is needed to determine the burden of leptospirosis in PNG and public health initiatives may be necessary to reduce rodent prevalence.

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Assessing the changing burden of diseases at the primary health care level in rural Papua New Guinea

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SUMMARY

Introduction **Defining the changing burden of diseases and provision of health services at the primary health care level is important to inform the decision-making processes in health care. The Papua New Guinea Institute of Medical Research established an integrated Health and Demographic Surveillance System (iHDSS) in 2011 to provide morbidity surveillance data on the provision of basic health services, such as immunization, antenatal care and family planning, in primary health facilities in four surveillance sites: Hiri, Karkar, Hides and Asaro. This paper assesses changes in the burden of common illnesses and the utilization of basic health services among the surveillance population at the primary health care level.** ***Methods*** **Morbidity data on common illnesses and information on use of health services were collected on a daily basis by clinical research officers, who were based in primary health facilities, including seven health centres and three community health posts. The total numbers of visits and utilization of health services were collected, using a standard report template for recording and reporting at the end of each month for consolidation and analysis. A total of 81,051 caseloads were recorded from March 2011 to December 2015. In this paper, descriptive statistics such as proportion and frequency distribution were conducted to show changes in morbidity modality and utilization of health services in the surveillance sites over the period 2011-2015.** ***Results*** **Respiratory diseases, skin infections and diarrhoeal disease were the leading causes of visits to the health facilities, with total numbers of 19,462, 7605 and 6030 cases reported respectively. The high burden of infectious diseases has been consistently observed across all surveillance sites over the last 5 years. The access to and utilization of immunization services has been improved, with the number of immunizations increased from 11,183 to 16,927 over the period 2014-2015, when the supplementary immunization program was commenced. Data on family planning services were available for only two years, 2014 and 2015. A total of 3066 visits in all the health facilities was recorded and more follow-up data are needed to identify and report any change in the coming years.** ***Conclusion*** **The iHDSS has provided new data on morbidities in rural areas of Papua New Guinea over the period 2011-2015. Infectious diseases, particularly respiratory diseases, skin infections and diarrhoeal disease, were the most common presentations. The increased tally numbers of visits for immunization, antenatal care and family planning suggest that more resources are needed to effectively respond to the increased demand for health services at the primary health care level.**

Background

Defining the burden of diseases is important for public health interventions in developing countries, particularly in limited-resource settings (1). In Papua New Guinea (PNG), insufficient investment, weak management and leadership and inadequate numbers of health care personnel play a crucial role in the suboptimal performance of the health

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systems, particularly at the primary level (2).

The introduction of short- and medium-term health plans has provided new visions and guidelines in strengthening primary health care facilities and improving basic health services in the rural areas. The National Health Plan 2011-2020 emphasizes strengthening primary health care service delivery and aligns its objectives with the Millennium Development Goals (MDGs) (3-5). The Plan sets out targets for improvement in the areas of child health and maternal health and the reduction of communicable diseases, contributing to achieving MDG 4, 5 and 6, respectively.

According to the World Health Organization (WHO), the Country Cooperation Strategic Agenda 2010-2015 has outlined the key priorities for the health sector, including capacity building to develop and implement cost-effective approaches to reducing the burden of diseases, including tuberculosis (TB), malaria, and respiratory, diarrhoeal and sexually transmitted diseases (6). Other key priority areas included improving maternal and child health programs through a comprehensive package of integrated primary care services, including the immunization services for prevention of common childhood diseases and provision of family planning services (6).

In 2011, the Papua New Guinea Institute of Medical Research (PNGIMR) established and operated an integrated Health and Demographic Surveillance System (iHDSS) under the Partnership in Health Program (PiHP) (7-9). An essential component of the iHDSS is morbidity surveillance at the primary health care level. The morbidity surveillance was established to assess the burden of common illnesses and the provision of basic health services at the primary health care facilities in the surveillance sites.

The iHDSS clinical staff collected morbidity surveillance data and provided clinical services to the communities. The clinical team comprised 1 Medical Doctor (MD), 2 Health Extension Officers (HEOs), 6 Nursing Officers (NOs) and 3 Community Health Workers (CHWs). The doctor provided overall technical and clinical support to the clinical team and verified causes of death. The HEOs conducted quality checks for the morbidity data and provided daily supervision and clinical support to NOs and laboratory technicians. The NOs and CHWs were based in health facilities and were involved in collecting morbidity data and samples for laboratory testing. In addition to data collection, the clinicians were involved in all the activities concerned with the provision of primary health services. They conducted routine clinical work such as patient interrogation, examination and treatment, and provision of immunization and antenatal care, and performed deliveries. Tally numbers were collected by clinical staff and later consolidated by the data analysis team for analysis and reporting.

Previous studies on the burden of diseases in PNG suggest that infectious diseases, including lower respiratory infections, diarrhoeal disease and malaria, are still among the leading causes of death today (10,11). Outbreaks are frequently reported due to the lack of access to primary health services and the ineffective responses of the health system, particularly in remote rural areas, to emerging health issues. These observations were also reported in the PNG Health Service Delivery Profile 2012, in which tuberculosis, diarrhoeal diseases and acute respiratory infections accounted for the heaviest burdens of morbidity and mortality at the primary health care level (5). In addition to that, the maternal mortality ratio remains high in PNG. According to a study on women's perception and utilization of maternal health services conducted by PNGIMR, 44% of pregnant women delivered births at home and over 44% of women experienced complications during or immediately following delivery (12).

As most of the population live in scattered communities in remote rural areas, improving access to and provision of basic health care services remains a major challenge to the health sector. Many health facilities are not fully functioning with adequately trained staff. This, in turn, undermines the health status of people, particularly those living in rural remote areas. The health service charges on patients can further prevent the poorest from enjoying the right of access to primary health care (13).

In August 2013, the PNG Government launched the Free Primary Health Care and Subsidized Specialist Services Policy. The implementation of the policy, which came into effect on 24 February 2014, was outlined in two stages: (i) immediate implementation for health facility levels from one to three, including community health posts and health

centres; and (ii) implementation by December 2014 in levels four to seven, being district, provincial and regional hospitals and the national hospital in Port Moresby (14). For the health facilities at levels from one to three, appropriate funds were made available by the approval of the National Executive Council (NEC) for immediate implementation of the policy, according to which all user fees were abolished in the community health posts and health centres. Such policies are expected to have a positive impact on the local populations, who depend on these primary health facilities for basic health care services. On the other hand, it can have a negative impact on primary health care, for example, through increased demand for rural health services resulting in overcrowding, inadequate supplies and deterioration in quality of services.

Obtaining reliable estimates of disease burden at the primary health care level is challenging in PNG as most of the people live in rural areas, in some of which they have little or no access to basic health facilities. Understanding these challenges is therefore crucial to the determination of public health priorities and resource allocation, and to the development of preventive interventions and treatment guidelines (15,16).

This paper uses morbidity data available from the iHDSS to analyse the burden of diseases and illnesses, and the provision and utilization of health care services at the primary health facilities in the surveillance sites, thereby providing better understanding of public health issues in the rural areas of PNG.

Methods

Surveillance sites

There were four surveillance sites where the morbidity surveillance activities were conducted: Hides, Asaro, Hiri and Karkar. These four sites were selected to monitor the health and demographic impact of the PNG Liquefied Natural Gas (PNG LNG) Project: Hides and Hiri as the impact sites, Asaro and Karkar as the comparison sites.

Table 1 shows the overall description of primary health facilities, health staff and health services available in the four surveillance sites. The morbidity surveillance focuses on basic health care services available at primary health facilities, including community health posts (CHPs) and health centres. The CHP concept was established in February 2013, based on the previous model of level one health facilities, including aid post and health subcentre, to serve the people living within a given geographical boundary. The CHP is staffed by at least three health workers and provides a range of primary health services such as maternal and child health services, midwifery, health promotion and community awareness, family planning, immunization, emergency care and stabilization of patients prior to referral to higher-level health facilities such as health centre or hospital. However, the modality of aid posts and health subcentres is still functioning in the surveillance sites after the introduction of the new CHP concept.

A health centre serves a population of 5000-20,000 and provides management of chronic and acute conditions, performs basic surgical care, birth deliveries, and paediatric and adult outpatient care, and functions as an intermediary referral point to district or provincial hospitals (4). A health centre is often staffed by an HEO, who acts as officer-in-charge of the health facility, 2 NOs and 5 or more CHWs.

All primary health facilities in the surveillance sites were involved in morbidity surveillance and data collection.

Hides site

The Hides surveillance site was designed as an impact area site and located in Hela Province. This site covered three divisions, with a surveillance population coverage of approximately 13,000. The populations in Hides are substantially larger, but many locations are extremely difficult to access (7,17). The two main health facilities are Mananda Health Centre and Para CHP, both of which are run by the Evangelical Church of PNG. Mananda Health Centre has 3 NOs and 6 CHWs. It has the capacity to admit up to 10 inpatients, store vaccines and provide immunization services for children as well as antenatal care and family planning services for women. This health centre has a delivery room, with electricity supplied from a generator set and a solar power system.

Para CHP is staffed by 3 CHWs. It can admit up to 3 patients, mostly postnatal mothers, and provide assistance for birth

deliveries, immunization and family planning services. Para CHP is powered by solar.

The iHDSS HEO based at Mananda Health Centre collected and reported morbidity data in both Mananda Health Centre and Para CHP.

Asaro site

The Asaro surveillance site was set up as a comparison site and is located approximately 45 km northeast from Goroka township in Eastern Highlands Province. The site covered a population of over 10,000, with 3 health centres, namely Asaro, Kwongi and Tafeto. All basic health services are available and provided for local people (17). However, it has been reported that many people bypass these primary health facilities to seek higher-quality health care services at the Goroka Provincial Hospital, which is located in Goroka town. There are 4 iHDSS clinical staff, 1 HEO and 3 NOs, working in the Asaro site. The HEO based at the PNGIMR Goroka office provided technical support to the research team.

Asaro Health Centre is run by the Eastern Highlands Provincial Health Division. The staff include an HEO, 3 NOs and 11 CHWs. It has 3 clinics – for sexually transmitted infections (STIs), antenatal care and family planning services – and a delivery room. The general ward in Asaro Health Centre can admit up to 12 patients, including two postnatal mothers.

Tafeto Health Centre is run by the Catholic Health Services. It has 3 NOs and 3 CHWs. The facility has a delivery room and provides antenatal and immunization services, with a capacity to admit 10 inpatients. Family planning services are not available in this health centre.

Kwongi Health Centre is run by the Evangelical Brotherhood Church Health Services. The facility admits up to 6 inpatients and provides basic health care services such as family planning, immunization and antenatal care, including birth deliveries. It is staffed by 3 NOs and 3 CHWs.

Hiri site

The Hiri surveillance site is another impact site of the PNG LNG Project and is located to the west of Port Moresby, the national capital of PNG. This site covers four coastal villages, including Porebada, Boera, Papa and Lealea, with a total surveillance population of approximately 12,000 (18,19). There are 3 health facilities in Papa, Boera and Porebada villages that provide basic health services to the population in the site.

Papa Health Centre is staffed by 1 HEO, 3 NOs (one works for the PNGIMR's iHDSS) and 2 CHWs. The facility provides basic outpatient services for common diseases, including STIs and respiratory diseases, immunization, family planning and antenatal care. The facility has a delivery room, but does not have a ward to admit inpatients; rather it has a 'recovery room' to keep patients, mostly postnatal mothers and children, for observation for a few hours or up to 24 hours before they are discharged home or referred. Papa Health Centre is run by the Salvation Army Health Services.

The other health facilities are Boera and Porebada CHPs; both these facilities are operated as aid posts. Boera aid post is staffed by a lone CHW while Porebada is staffed by 2 CHWs, including one employed by PNGIMR. Both health facilities are run by the Central Provincial Health Division. These facilities provide daily outpatient treatment for common illnesses, and limited family planning, antenatal care and immunization services. Both Boera and Porebada have one delivery room each; however, they do not have wards to admit inpatients. Sick patients, including postnatal mothers, are kept in a room and observed for a few hours before being discharged or referred.

Karkar site

Karkar District is a volcanic island located 30 km off the PNG coast in the Bismarck Sea and is part of Madang Province. The Karkar surveillance site covers a population of approximately 18,500 (the total population of Karkar is about 60,000) (18,19) and was selected as another comparison site for the PNG LNG Project; it was active under the iHDSS in the period 2011-2015. The site has 3 health facilities.

Gaubin Hospital is the largest facility and is run by Lutheran Health Services. The hospital has 1 doctor and several NOs and CHWs. Gaubin Hospital is classified as a level four hospital (district hospital) and is the only referral hospital on the entire island.

TABLE 1

Overall description of primary health care facilities in surveillance sites, PNGIMR iHDSS, 2011-2015

iHDSS sites	Health centre (HC)	Community health post (CHP)
Hides	• 1 health centre • Total staff: 10, including 1 HEO (employed by IMR), 3 NOs, 6 CHWs • Provided outpatient services, including diagnosing and treating common diseases • Provided immunization, antenatal and postnatal care, and family planning services • Provided minor surgical, accident and emergency services • Had one general ward that could admit a maximum of 10 inpatients, including children and postnatal mothers	• 1 CHP • Total staff: 3 CHWs • Provided basic outpatient services for common diseases, immunization, antenatal care and family planning services • Had a single delivery room; could admit 3 inpatients, including postnatal mothers and children
Asaro	• 3 health centres • Total staff: 30, including 1 HEO, 12 NOs (3 employed by IMR), 17 CHWs • Provided outpatient services, including diagnosing and treating common diseases • Provided immunization, antenatal and postnatal care, and family planning services • STI clinic in Asaro HC; minor surgical, accident and emergency services • Each HC had a general ward that could admit between 6 and 12 inpatients, including children and postnatal mothers	• No CHP

Hiri	• 1 health centre • Total staff: 6, including 1 HEO, 3 NOs (1 employed by IMR), 2 CHWs • Provided outpatient services, including diagnosing and treating common diseases • Provided immunization, antenatal and postnatal care, STI management and family planning services • Provided minor surgical, accident and emergency services • Had a general room to observe very sick patients, mostly postnatal mothers and children	• 2 CHPs • Total staff: 3 CHWs (one employed by IMR) • Provided diagnosis and treatment services for common illnesses, immunization, antenatal care and family planning services • Had a single delivery room and a general ward to observe very sick patients, mostly children and postnatal mothers
Karkar*	• 2 health centres • Total staff: 8 including 3 NOs (1 research nurse employed by IMR), 5 CHWs (one employed by IMR) • Provided daily outpatient services, including screening, diagnosis and treatment of common diseases, immunization, antenatal and postnatal care, and family planning services • Provided minor surgical, accident and emergency services • Each HC had a delivery room and a general ward that could admit up to 4 inpatients, including children and postnatal mothers	• No CHP

PNGIMR = Papua New Guinea Institute of Medical Research
iHDSS = integrated Health and Demographic Surveillance System
HEO = health extension officer
NO = nursing officer
CHW = community health worker
STI = sexually transmitted infection
*Gaubin District Hospital in the Karkar site is not included in this table, though the medical doctor employed by IMR was based at Gaubin Hospital

The hospital provides nearly all specialist services including surgical, obstetrics and gynaecological, medical, child health and laboratory services. Because the surveillance population in Karkar is substantially larger than the other sites, Gaubin Hospital was included in the morbidity surveillance.

Primary health facilities in the Karkar site are Miak and Mapor Health Centres. The facilities have a general ward to admit patients, mostly postnatal mothers and children, and provide basic health care services such as immunization, antenatal care, family planning, and diagnosis and treatment of common illnesses. These health centres are staffed by 1 nursing officer and 2 CHWs each. The PNGIMR recruited 1 medical doctor, 1 research nurse and 1 CHW for the morbidity data collection and clinical work in the Karkar site.

Surveillance population

The catchment population included patients of all ages and both sexes who were seeking health care services in the four surveillance sites. That included: (i) inpatients and outpatients who visited health facilities; (ii) women who came for family planning and antenatal services; (iii) children who were immunized against common infectious diseases; and (iv) people who sought treatment for minor accidents and injuries. Although these patients were entitled to free health care for basic health services, some with injuries were charged fees. In particular, patients with injuries as a result of domestic and tribal fighting were charged fees.

Data collection tools

There are two data collection tools being used to collect morbidity surveillance data. One is the 'morbidity tally form'. This form has a list of all the common diseases such as respiratory diseases, sexually transmitted infections, skin infections and diarrhoeal disease as well as a list of basic health care services provided for each visit at the health facilities. The numbers of visits for these diseases are referred to as 'caseloads', that is, the total number of diseases diagnosed and recorded for every visit at the health facilities (one patient could have more than one visit for a particular disease episode).

The first page of the form is general information such as health facility name, name of iHDSS site, name and code number of research staff who collected and recorded the tally numbers, and dates (week starting to week ending). The second page is divided into small rows and columns. In the first column are the names of different diseases, both communicable and non-communicable, and accidents and injuries. On the top part of page two, there are more columns to write the days of the week (Monday to Friday), weekend, and the total numbers. The other rows (after disease names) are left blank for the clinical staff to write the tally numbers against the most likely diseases diagnosed each day and weekend. Similar to the second page, the third page is for antenatal care, family planning and immunization services. The three-page tally number form is for recording a one-week tally number collection.

Another data collection tool is the 'morbidity surveillance questionnaire', which was developed to collect comprehensive health data at the individual level, outlined in six research modules. The data collection using this tool is ongoing and is not included in this paper. These morbidity surveillance data will be consolidated for analysis by the end of 2017.

Data collection, recording and reporting

Clinical staff, including NOs, CHWs and HEOs, conducted daily visits to the health facilities and collected morbidity data using the 'morbidity tally form'. One form was used for each week. For every patient that came to the health facility, clinical staff put a mark on the tally form against the most likely disease diagnosed after routine clinical interrogation, examination and treatment and before discharge or referral to another health facility. Similarly, they put a mark against the basic health services provided to the patient. For example, if the patient came to the health facility for measles vaccine, the NOs put a mark on the immunization column on the form.

At the end of each day, NOs kept records of all the tally numbers. NOs collected the morbidity tally numbers until the end of the week. For those patients who visited the health facilities during the weekends, the NOs would review the health facility daily attendance record cards on the following Monday and tally the numbers under 'weekend' on the tally form.

At the end of the week, they added up all the numbers of patients seen and kept the form in a secured filing cabinet. At the end of each month, the completed tally number forms were sent to the Goroka PNGIMR office for data analysis, reporting and archiving.

Morbidity data are consolidated for reporting every six months and then compiled with other iHDSS work for inclusion in the PNGIMR technical reports, which have been published twice a year in March and September. The findings of the morbidity data are then disseminated to the project funders, stakeholders and the communities as part of the iHDSS activities.

Data quality and data analysis

All the morbidity tally forms are first quality checked at the surveillance sites by the medical doctor or HEO based at the sites before being sent to the PNGIMR main office in Goroka for final quality control and entering into the iHDSS database.

This paper analyses morbidity tally numbers collected from March 2011 to December 2015. The paper conducts descriptive analysis of the total number of caseloads, the types of infectious diseases and the types of basic health care services recorded in all health facilities within the four surveillance sites of the iHDSS. The findings are presented by year to show the changes in total numbers of caseloads, reported infectious diseases and provision of basic health care services. Further analysis of morbidity data by surveillance site was conducted to compare the patterns of infectious diseases and utilization of basic health care services across the different surveillance sites.

Results

There was a total of 81,051 caseloads, 69,316 infectious diseases and 44,118 health care services recorded in the four iHDSS sites over the period 2011-2015 (Table 2). The total number of caseloads recorded increased over this period, with the highest number recorded in 2015 (36,562). It was followed by 2014 (18,019), 2012 (13,989) and 2011 (9631). The caseload recorded in 2013 was the lowest with just 2850. Similarly, the trend of increased total numbers of infectious diseases was also clearly shown, with the highest record in 2015 (27,402), followed by 2014 (17,233), 2012 (13,871) and 2011 (8939). Again, the record for 2013 was the lowest, 1871. The data on provision of basic health services (immunization, antenatal and family planning) showed the highest record for 2015 (25,396) followed by 2014 (17,837). However, the records were similarly low for 2011 (301), 2012 (286) and 2013 (298). Overall, increased total numbers of caseloads and infectious diseases were observed over the five years, with the exception of the records in 2013. This observation will be further analysed in the discussion section.

Table 3 shows the total and proportion of caseloads recorded by year in each

TABLE 2

TOTAL NUMBERS OF CASELOADS, INFECTIOUS DISEASES AND HEALTH CARE SERVICE PROVISIONS RECORDED IN ALL FOUR SURVEILLANCE SITES, IHDSS, 2011-2015

	2011	2012	2013	2014	2015	Total
Caseloads*	9631	13989	2850	18019	36562	81051
Infectious diseases**	8939	13871	1871	17233	27402	69316
Basic health care services***	301	286	298	17837	25396	44118

iHDSS = integrated Health and Demographic Surveillance System
*Caseloads are total numbers of all diseases diagnosed and recorded at the health clinics
**Infectious diseases include tuberculosis, sexually transmitted infections, skin infections, respiratory diseases, malaria, diarrhoea, meningitis, anaemia, ear and eye infections and suspected measles
***Basic health care services include immunization, antenatal care, family planning and accidents and injuries

TABLE 3

Total numbers of caseloads recorded by year in each surveillance site, iHDSS, 2011-2015

iHDSS site	2011		2012		2013		2014		2015		Total
	N	%	N	%	N	%	N	%	N	%	N (100%)
Hides	1009	4.8	898	4.2	907	4.3	7119	33.5	11306	53.2	21239
Asaro	481	4.0	NA	NA	721	5.9	2748	22.7	8176	67.4	12126
Hiri	8141	23.7	13091	38.1	1222	3.6	5800	16.9	6146	17.9	34400
Karkar	NA	NA	NA	NA	NA	NA	2352	17.7	10934	82.3	13286
All sites	9631	11.9	13989	17.3	2850	3.5	18019	22.2	36562	45.1	81051

iHDSS = integrated Health and Demographic Surveillance System
NA = data not available

surveillance site. Hiri reported the highest number of 34,400 caseloads, of which 38% was recorded in 2012, followed by 24% in 2011, 18% in 2015, 17% in 2014, but only 4% in 2013. Hides reported a total of 21,239 caseloads for the five-year period, with the highest proportion of 53% in 2015 and 34% in 2014. By contrast, low caseloads recorded in 2011, 2012 and 2013 accounted for only 5%, 4% and 4% of the total caseloads, respectively. Asaro site recorded 12,126 caseloads, with a proportion of 67% in 2015, 23% in 2014, 6% in 2013 and 4% in 2011. The Asaro site did not report the caseload for 2012. A total of 13,286 caseloads was recorded in the Karkar site for 2015 and 2014, accounting for 82% and 18% respectively. There were no data recorded for Karkar for the period 2011-2013. Overall, the data showed that there has been a significant increase in the total number of caseloads recorded in the period 2014-2015 compared to the period 2011-2013. This observation will be further analysed in the discussion.

Table 4 shows the burden of infectious diseases by iHDSS site for the period 2011-2015. In Hides, respiratory diseases accounted for the highest proportion of 30%, followed by diarrhoeal disease 12% and skin infections 8%. Similarly in the Asaro site, respiratory diseases accounted for the highest proportion (29%), followed by skin infections (12%) and diarrhoeal disease (9%). The Karkar site also reported respiratory diseases as the most common (26%), then skin infections (11%) and diarrhoeal disease (7%). In the Hiri site, the three leading causes of infections were respiratory diseases (31%), skin infections (18%) and malaria (11%). It was noticeable that STIs were quite significant in the Asaro site (6%) compared to the other sites: Hides (3%), Hiri (1%) and Karkar (1%). The 'other infections' included combinations of many infectious diseases such as meningitis, suspected measles, and eye, ear and dental infections, and accounted for the highest proportions, ranging from 31% to 50% across

TABLE 4

Burden of infectious diseases by iHDSS surveillance site, 2011-2015

Infectious diseases	Hides		Asaro		Karkar		Hiri		All sites	
	N	%	N	%	N	%	N	%	N	%
Respiratory diseases	5382	29.6	4176	28.8	7710	26.0	2194	31.4	19462	28.1
Skin infections	1491	8.2	1735	12.0	3118	10.5	1261	18.0	7605	11.0
Diarrhoea	2123	11.7	1365	9.4	2094	7.1	448	6.4	6030	8.7
Malaria	447	2.5	259	1.8	1440	4.9	779	11.1	2925	4.2
STIs	469	2.6	935	6.4	261	0.9	71	1.0	1736	2.5
TB	0	0.0	32	0.2	42	0.1	71	1.0	145	0.2
Other infections	8298	45.6	6011	41.4	14939	50.5	2165	31.0	31413	45.3
Total	18210	100	14513	100	29604	100	6989	100	69316	100

iHDSS = integrated Health and Demographic Surveillance System
STI = sexually transmitted infection
TB = tuberculosis

the sites. Overall the Karkar site reported the highest burden of infectious diseases, with a record of 29,604 caseloads, followed by Hides 18,210, Asaro 14,513 and Hiri 6989. Respiratory diseases, skin infections and diarrhoea were the three leading causes of all infectious diseases presenting at the primary health facilities across the four surveillance sites.

Table 5 shows the availability and provision of basic health services by iHDSS site over the period 2011-2015. The Asaro site provided a total of 20,944 services, of which 72% were for immunization, 23% for antenatal care, 4% for family planning, and 2% for accidents and injuries. In Hides, 68% of its primary health services were for immunization, 19% for antenatal care, 9% for family planning and 4% for accidents and injuries. Similarly, 60% of the primary health services provided in Hiri were for immunization, compared to 25% for antenatal care, 9% for accidents and injuries and 6% for family planning. By contrast, Karkar recorded 40% for antenatal care, 34% for immunization, 16% for family planning and 10% for accidents and injuries. Obviously, immunization services and antenatal care were most commonly used at primary health facilities across surveillance sites.

Table 6 shows the primary health services provided by year in all four surveillance sites over the period 2011-2015. A total of 28,597 immunization services were provided, with the highest proportion of the services (59%) being provided in 2015, followed by 2014 (39%) and only 2% for the three years 2011, 2012 and 2013 combined. Similarly, the antenatal care provided in 2014 and 2015 accounted for 47% and 50%, respectively, while the accumulated figure for 2011, 2012 and 2013 was just 3%. No record of family planning services were reported in 2011, 2012 and 2013, but 3066 services were reported for 2015 (53%) and 2014 (47%). A total of 1857 accidents and injuries were reported over the five years, mostly in 2015 (80%) and 2014 (14%). Overall, the data on provision and utilization of basic health care services in all surveillance sites showed that the majority of services were reported in 2014 (40%) and 2015 (58%), significantly higher than the period 2011-2013 (2%).

Discussion

These results indicate how the relative burden of diseases and their changing patterns can be assessed in rural health services, which provide primary health care for the majority of Papua New Guinea's population. The results and their deficiencies also indicate the difficulties in establishing and maintaining good surveillance at the primary health care level. Some of these difficulties are pointed out and exemplified in the discussion that follows. Their effects mean that any

TABLE 5

Availability and provision of basic health care services by surveillance site, iHDSS, 2011-2015

Health care services	Asaro		Hides		Hiri		Karkar		All sites	
	N	%	N	%	N	%	N	%	N	%
Immunization	15128	72.2	8339	67.9	3292	60.0	1838	33.9	28597	64.8
Antenatal care	4717	22.5	2311	18.8	1396	25.5	2174	40.1	10598	24.0
Family planning	782	3.7	1108	9.0	309	5.6	867	16.0	3066	6.9
Accidents/injuries	317	1.5	515	4.2	488	8.9	537	9.9	1857	4.2
Total	20944	100	12273	100	5485	100	5416	100	44118	100

iHDSS = integrated Health and Demographic Surveillance System

TABLE 6

AVAILABILITY AND PROVISION OF BASIC HEALTH CARE SERVICES OVER TIME, IHDSS, 2011-2015

Health care services	2011		2012		2013		2014		2015		Total
	N	%	N	%	N	%	N	%	N	%	N (100%)
Immunization	146	0.5	164	0.6	177	0.6	11183	39.1	16927	59.2	28597
Antenatal care	131	1.2	83	0.8	81	0.8	4955	46.8	5348	50.5	10598
Family planning	NA	NA	NA	NA	NA	NA	1437	46.9	1629	53.1	3066
Accidents/injuries	24	1.3	39	2.1	40	2.2	262	14.1	1492	80.3	1857
Total	301	0.7	286	0.6	298	0.7	17837	40.4	25396	57.6	44118

iHDSS = integrated Health and Demographic Surveillance System
NA = data not available

conclusions drawn from the data obtained during the developing stage of this project must be regarded as tentative. However, the benefits of achieving consistently reliable data of this kind would contribute significantly to the sustainable development of PNG.

Increased access and utilization of primary health care services

The iHDSS has outlined the access and utilization of basic health services in the four iHDSS sites. The analysis of morbidity data showed that there was an increase in the number of caseloads recorded in the period 2011-2015: the total caseloads reported in 2014-2015 were two times higher than that reported in 2011-2012. However, the caseload recorded was very low in 2013 (see Table 2). There were potential explanations for these observations.

The increased caseloads recorded in 2014-2015 signify the improvement in the data collection of the iHDSS (see Table 3). Clinical staff, particularly NOs and CHWs, visited the health facilities more constantly than in the previous years. The inclusion of more primary health facilities in the iHDSS has provided more completed morbidity tally numbers. For example, the Asaro site reported tally numbers for three health centres for the period 2014-2015, compared to only one health centre in the previous years, 2011-2013. Another possible explanation for the increased number of caseloads recorded in the Hiri and Hides sites was the influx of people in those sites as a result of the PNG LNG Project activities, whereby more people visited the health facilities to seek health care services. The increased caseloads could also suggest an improvement in access and utilization of the primary health care services in the surveillance sites. The household survey conducted by PNGIMR in early 2015 found that 80% of households reported having access to primary health facilities, 80% of households used outpatient services and 90% of them were satisfied with the services provided in the last visit to a health facility (8).

However, the unavailability or low number of caseloads recorded in Karkar and Asaro over the period 2011-2013 does not necessarily mean that basic health care services were not available in this period. Rather it is an indication that either the research clinicians did not visit the health facility regularly for data collection and/or there were not enough clinical staff to collect and report morbidity data. In addition, many patients could have bypassed the primary health care level to seek higher-quality services at the secondary or tertiary health care facilities. For example, the Hiri site is quite close to Port Moresby and patients may choose to attend clinics and hospitals in the city. Similarly, the population in the Asaro site may also bypass Asaro and Tafeto health centres to use the services at the Goroka Provincial Hospital. About 14% of households in the surveillance sites reported using health care services at a district or provincial hospital, as shown by the data from the household survey (8). As a result, the presented data of the period 2011-2013 are likely to have under-reported the actual burden of diseases in the surveillance sites. The explanation for the decrease in the total number of caseloads recorded in the Hiri site between 2011-2012 and 2013-2015 was because the later tally numbers reported were for only six months, rather than twelve months. Another factor was the shortage of clinical staff working in this site. Some clinical nurses and HEOs who were initially recruited to collect morbidity data left their jobs after they secured another job with better conditions.

Morbidity tally numbers have also some limitations. Firstly, the data do not provide an individual identifier and therefore cannot distinguish between new cases and repeated visits to the health facilities. However, both constitute an added burden on the health care sector. Secondly, while the tally numbers have shown the burden of health care services at the primary level, it is not clear whether or not patients receive proper consultations, treatment or referrals. In other words, the data do not allow conducting further analysis of the quality of services provided at the primary health care level in PNG.

Infectious diseases remain the main challenge at the primary health care level

The data indicated that respiratory infectious diseases are still dominant, accounting for 28% of all infectious diseases presenting at the primary health facilities. Respiratory infectious diseases, including pneumonia and upper respiratory tract infections, were the most common reason for health facility visits in all surveillance sites (Table 4). This observation is confirmed by findings from the data of children under five years of age (CU5)

collected by iHDSS in the period January-June 2016, which reported a pneumonia incidence rate of 33% among children aged 6-11 months (20). The burden of respiratory infections as recorded in Hiri, Hides and Asaro (Table 4) is consistent with the CU5 data, in which the pneumonia incidence was reported as 36% for Hiri, 26% for Hides and 10% for Asaro (20).

Diarrhoeal diseases were among the leading causes of health facility visits in the surveillance sites. Diarrhoeal disease was more common in the highlands areas, in Hides (12%) and Asaro (9%), than the coastal areas, in Karkar (7%) and Hiri (6%) (Table 4). The analysis of diarrhoeal incidence among children aged 23-35 months also showed a higher incidence in Hides (32%) than in Hiri and Asaro (11%) (20). Findings from these two studies have confirmed that diarrhoea provides the second highest infectious disease burden at the primary health care level. Further strengthening of the primary health care system for more effective prevention and management of diarrhoeal diseases, particularly among CU5, is still among the top priorities of the health sector; this requires specific public health interventions to increase public awareness of the issue.

There has been significant change in malaria epidemiology in rural PNG over the last five years. Although malaria was still a significant factor, contributing 4% of all the infections in the surveillance sites, particularly 11% in Hiri and 5% in Karkar, it was as low as 2% in Hides and Asaro (Table 4). These data suggest that malaria may no longer be the significant public health issue in the highlands that it was. More accurate diagnosis with wider availability of rapid testing is likely to be the answer in the highlands. Also, according to the CU5 data, malaria-suspected cases were infrequent in the highlands, less than 2% among CU5 in the Asaro site (20). The nation-wide distribution of long-lasting insecticidal nets (LLINs) between 2005 and 2009 may have had an impact on the overall burden of malaria in PNG. A survey conducted by PNGIMR in 2010-2011 found a reduction in the prevalence of malaria infection nation-wide from 18.2% to 6.7% alongside an increase in ownership and use of LLINs from 65% to 82% and from 33% to 48%, respectively (21). It was suggested that further surveillance data are needed to monitor the trends in malaria epidemiology in PNG.

The data showed that tuberculosis accounted for a very small proportion of visits to the primary health facilities. There were only 145 suspected cases of TB, accounting for 0.2% of total infections recorded in the four surveillance sites over the period 2011-2015 (Table 4). Hiri data showed the highest record of 71 patients, representing 1% of the total infectious diseases there. A tuberculosis prevalence rate of 1.29% of the population was published in a previous study (22) and data reported by WHO indicated that 25,000 new TB cases were detected in PNG in 2012 (23). Low numbers of TB patients detected at the primary health facilities in the surveillance sites could be explained by the lack of expertise and equipment for proper diagnosis and management of TB in the primary health care level. The high level of social stigma and discrimination against TB patients in the community has driven TB patients to bypass the primary health care level to seek better services at a higher-level health facility. Lessons learnt and experiences from a previous study on TB prevalence conducted by PNGIMR in Kikori District, Gulf Province in 2012-2013 showed that many TB patients delayed visiting primary health care facilities for this reason (22). Another possibility is that some of the TB patients could have been misdiagnosed as respiratory infections. Therefore, the low records of TB in the primary health facilities in the surveillance sites might not reflect the real burden of TB in the communities. The inconsistencies in the TB data reported by different studies suggest large variations in the epidemiology of TB between the national and subnational levels and from one province to another. For that reason, surveillance on TB needs to be continued to provide longitudinal data that will provide more reliable estimates of TB for better understanding the situation throughout the country.

Impact of the free health care policy on development of the primary health care level

The provision of basic health services has been improved as reflected in the increased utilization of child and maternal health services recorded across all surveillance sites over the period 2014-2015 (Tables 5 and 6). The high numbers of immunization records in the Asaro and Hides sites were due to two factors: (i) a large number of measles vaccinations had taken place after a major measles outbreak

happened in the country, particularly in the highlands, in 2014; and (ii) supplementary immunization activities had been conducted in 2014 and the following years, supported by the government health care system or church health agencies. Antenatal care and family planning services were major works, sharing one-fourth of the workload at the primary health care level, and accounted for 40% and 16% of the total primary health care services provided by Karkar health facilities (Table 5). This could be attributed to the recent efforts of the PNG Government and non-government organizations working in the site.

The introduction of the PNG Government's Free Primary Health Care (FPHC) Policy in 2013 has been seen as a factor contributing to the enhanced access and utilization of services at the primary health care level and in health facilities of the surveillance sites in particular. As shown in Tables 2, 3 and 6, the morbidity data indicated huge differences in the total number of caseloads, infectious diseases and provision of primary health care services recorded before and after the implementation of the policy. For example, the total caseloads reported in 2011 and 2012, before the introduction of the policy, were 9631 and 13,989, respectively. By contrast, the caseloads increased to 18,019 in 2014 and 36,562 in 2015 (Table 2). Similarly, the provision of primary health care services before and after implementation of the policy showed huge differences: the proportions of antenatal care provided in 2011, 2012 and 2013 were 1.2%, 0.8% and 0.8% respectively compared to the 47% and 50% in 2014 and 2015 (Table 6). These observations may indicate that the policy has had some impact on the performance of the primary health facilities in the surveillance sites. However, fees were imposed on some patients for the provision of health care services. For example, 'bed or admission fees', ranging from K5 to K10, were charged on postnatal mothers after delivery in some health centres. Furthermore, fees were imposed on patients with injuries related to tribal fighting and domestic violence even after 2014 when the FPHC policy was implemented. With additional support from the health sector, including the National Department of Health and the Provincial Health Authorities, the procurement and supply of essential drugs, including vaccines, have improved in the primary health facilities in the surveillance sites. It is believed that more people are happy with the services as reflected in the increased number of patients who sought services at the primary health care level.

However, the increased numbers of patients visiting primary health facilities have also put more constraints on the limited health facility infrastructure and increased the workload of the front-line health workers. Further strengthening of health care infrastructure, including procurement and supply of health commodities and the storage and distribution of essential drugs, is needed to make sure that the primary health system can cope with the increased demand of the communities and maintain the quality of the health services. Sustainability of funds and human resources at the primary health care level are among the top priorities for the PNG Government to ensure that the health sector will continue to effectively deliver health services to the population, particularly for those in the rural areas.

Conclusion

The PNGIMR has provided a new data source for monitoring and reporting the burden of diseases and illnesses at the primary health care level of PNG. The large numbers of morbidity data certainly give us an idea of the sort of cases presenting and the types of health services available at these particular sites. In the meantime, infectious diseases are still the heaviest burden at the primary health facilities in the rural areas of PNG. Respiratory infections are the leading cause, followed by diarrhoea, but malaria and TB need to be closely monitored to confirm the changes initially reported by the surveillance data. The increased utilization of immunization services and antenatal care require more resources to further improve the quality of services. The availability and access to family planning services require more attention and further investigations are needed to ascertain the demand and improve the supply of those services in the rural areas of PNG. Accidents and injuries continue to make new demands on health services for prevention and treatment, adding a further burden on the primary health services that the government needs to consider.

The morbidity surveillance data available from the iHDSS can be used in monitoring and reporting changes in provisions and utilization of basic health care services

at the primary health care level in PNG. Further strengthening and scaling up of the surveillance system will assist in the timely reporting of any change in the burden of diseases, new patterns of health services and emerging trends in epidemiology. This will help the government to provide more equity in allocating resources for the primary health care level, which will be crucial for the sustainable development of the health systems in PNG. It is probable that the FPHC policy has had an initial effect on the increase of access to and utilization of the primary health services. However, more research on the health policy and health systems are needed to confirm this observation. The PNG Government needs to continue funding to maintain the infrastructure and strengthen the labour force at the primary health care level.

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CONFLICT OF INTEREST

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Acute febrile encephalopathy in children at Port Moresby General Hospital: aetiology and quality of care

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SUMMARY

Introduction **Acute febrile encephalopathy is a common clinical syndrome in children in tropical countries, including Papua New Guinea (PNG), with varied aetiology, including Japanese encephalitis virus (JEV). There are few reports on quality of care for this condition. We investigated the aetiology of acute febrile encephalopathy and designed an assessment checklist to monitor the quality of care.** ***Methods*** **Children 1 month to 12 years old with acute febrile encephalopathy had blood and cerebrospinal fluid (CSF) tested using an IgM-capture ELISA test for JEV, CSF Gram stain, bacterial culture and dengue virus serology on blood. A cause was assigned based on clinical features and laboratory tests. Assessment of the quality of care on day 1 and day 7 of admission included whether certain actions were performed appropriately: Glasgow coma score, pupillary assessment, basic observations (heart rate, respiratory rate, temperature), blood pressure, blood glucose, oxygen saturation and oxygen therapy, weight recording, head elevation to 15-30˚, enteral nutrition provided early, anticonvulsants, changing posture to prevent pressure sores and physiotherapy for limb contractures.** ***Results*** **Of 97 children with febrile encephalopathy, 5 had laboratory-confirmed JEV encephalitis, 6 dengue, 5** ***Streptococcus pneumoniae*** **infection, 1** ***Haemophilus influenzae*** **infection, 6 malaria and 19 probable tuberculous meningitis. There were 14 cases of aseptic meningitis with no identifiable cause, and 41 cases of acute encephalopathy with no CSF inflammation and no cause identified. 57% of cases had no identifiable microbial cause. 70 children had quality of care assessed. The parameters that were often performed included measurements of weight, oxygen saturation monitoring, providing adequate oxygen and early use of enteral nutrition. Simple measures such as elevating the head of the bed, measuring blood pressure, Glasgow coma score and pupillary assessment were rarely done.** ***Conclusions*** **There are many causes of febrile encephalopathy, but in more than half the cases the cause is unknown. Quality of care for children with febrile encephalopathy is variable and many simple aspects of supportive care are not consistently done. To improve outcomes for such patients, a multisystem approach to monitoring and supportive care is required.**

Introduction

Acute febrile encephalopathy is a common presentation in children in tropical countries, but it is less studied than the other common syndromic presentations such as pneumonia, diarrhoea and malnutrition. Acute febrile encephalopathy is defined as acute onset of fever and either a change in mental state (such as confusion, disorientation, coma or inability to talk) or new onset of seizures (not including simple febrile convulsions).

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There are many causes: bacterial meningitis or meningoencephalitis, viral encephalitis, fungal infection and non-infectious causes. Japanese encephalitis virus (JEV) is the commonest cause of viral encephalitis in Asia (1). 24 countries in Asia and the Pacific reported cases of JE in 2016, and 12 have national or subnational JE vaccination programs. In Papua New Guinea (PNG), JEV is known to be present but the disease burden remains uncertain; JEV was first reported in Western Province between 1989 and 1998 (2), and suspected outbreaks were reported in Milne Bay Province in 2003. In 2004 a case of encephalitis was reported in an adult travelling from Port Moresby who had cerebrospinal fluid (CSF) seroconversion for both JEV and dengue viruses (3,4).

A previous study on the aetiology of febrile encephalopathy in children in Port Moresby showed that JE caused only 2 of 149 cases (5). This current study was set up as part of sentinel surveillance in PNG for JE in 2011, designed to identify the disease burden of JEV in PNG and guide the implementation of disease control programs.

Despite how common febrile encephalopathy is as a syndrome in low- and middle-income countries, there has been minimal research on the quality of care provided for affected children, even though in many cases the outcomes are more crucially dependent on emergency and ongoing supportive care than on specific medicines to treat a known aetiology. We aimed to conduct a quality of care audit, based on actions that are important for the management of patients in coma, with seizures, or raised intracranial pressure. Important objectives in monitoring and supportive care are the prevention, early identification and treatment of complications of febrile encephalopathy which increase the risk of secondary brain injury: including hypoxaemia, hypercarbia, hypotension, hypoglycaemia, cerebral oedema and persistent seizures (6-8). Also important are the prevention of pulmonary aspiration, care of pressure areas and prevention of limb contractures. We designed a quality of care assessment checklist which audited these actions at the bedside.

Methodology

The study was conducted at the Port Moresby General Hospital (PMGH), a tertiary referral hospital which serves all areas of the country but largely sees patients from the National Capital District (NCD) and nearby Central and Gulf Provinces. Acute febrile encephalopathy was defined as acute onset of fever and either a change in mental state (including confusion, disorientation, coma or inability to talk) or new onset of seizures, not including simple febrile convulsions. All children 1 month to 12 years old who met the case definition were recruited. Children were excluded if they were less than 1 month or over 12 years of age, presented with simple febrile convulsions, had a background of epilepsy or had a chronic neurodevelopmental condition.

Demographic and clinical data were collected including the child's age, residential location, duration of illness, history of antibiotic use and recent history of travel.

Diagnostic tests included: rapid diagnostic test and blood slide for malaria, full blood examination, electrolytes and liver function tests, and blood culture. Cerebrospinal fluid was taken if there was no contraindication. This was processed for Gram stain and culture and investigations for tuberculosis (TB) if indicated. If tuberculosis was suspected on history or examination a gastric aspirate was obtained for Ziehl-Neelsen (ZN) staining for acid-fast bacilli and GeneXpert testing, a chest X-ray was taken, and CSF was stained with ZN stain. Indian ink testing for *Cryptococcus neoformans* was also done on CSF.

Tests for flaviviruses were done on serum and CSF where possible. Serum was obtained on day 1 and day 7 of admission; 5 ml of blood was taken in older children and 0.5-2 ml in infants. Testing for JEV and dengue was done using the IgM-capture ELISA (enzyme-linked immunosorbent assay) at the Central Public Health Laboratory at Port Moresby General Hospital, using a standard technique recommended by the World Health Organization (WHO) (9).

Based on the aggregate of clinical and laboratory information, a final diagnosis was assigned to children in the study.

Quality of care assessment

In 2015 a component was introduced into this study to assess the quality of care of these patients. The clinical information included whether 12 quality indicators were carried out:

1. Glasgow coma score (GCS) recorded
2. Blood glucose recorded and hypoglycaemia prevented
3. Oxygen saturation recorded and oxygen applied as appropriate
4. Blood pressure recorded and kept within the normal range for age
5. Weight monitored throughout admission
6. Nursed with head elevation at 15-30˚ above horizontal
7. Pupillary assessment recorded
8. Enteral nutrition provided early in treatment course (within 48 hours)
9. Basic observations (heart rate, respiratory rate, temperature) recorded
10. Anticonvulsants given as appropriate
11. Turning and positional changes and surveillance for pressure areas
12. Physiotherapy as appropriate, for chest or prevention of limb contractures.

Data were collected on days 1 and 7 of admission to assess whether these aspects of care were being provided.

Parents whose children met the study criteria were invited to allow their child's participation in the study and written consent was obtained. The study was approved by the Research Committee at University of PNG, School of Medicine and Health Sciences, and by the Port Moresby General Hospital.

Results

97 children fulfilled the criteria for febrile encephalopathy. The median age was 18 months (IQR 6-69 months). The majority of the children (74%) came from suburbs within the NCD, 24% from villages in Central Province and 2% from other provinces. The median duration of illness prior to hospital presentation was 5 days (IQR 2-12 days). 7% presented within 24 hours of becoming unwell, 32% within 1-3 days of onset of symptoms, 27% within 4-7 days and 33% more than 7 days after the onset of symptoms. The commonest reason for presenting late was that the child had presented to a primary health clinic, received antibiotics from which there was no improvement, and then sought medical care at the hospital (n = 14). Another reason was difficulties in transportation to hospital when families lived in remote areas beyond NCD (n = 5).

Clinical features

The common clinical features were fever, neck stiffness, seizures and altered mental state. 83 (86%) had fever on presentation, 78 (80%) had neck stiffness on examination, 57 (59%) either had a history of or a clinical presentation with seizures, and 43 (44%) were poorly conscious (GCS <8). Of the 57 patients with seizures, 33 had seizures on admission and 24 patients had a history of one or more seizures during that current illness.

Laboratory investigations

70 patients (72%) had both serum and CSF collected for the JEV IgM test at days 1 and 7. 82 children (85%) had blood collected for the JEV IgM test. Parents declined a second blood collection for JEV IgM testing in 15 children. 83 patients (86%) had CSF collected for JEV IgM testing. 14 patients did not have a lumbar puncture because the child was too systemically unwell or had signs of elevated intracranial pressure, including deeply unconscious, a full fontanelle or focal neurological signs (12 patients), had papilloedema (1 patient) or parent refused (1 patient). 82 of the 83 CSF specimens were tested for *Cryptococcus* using Indian ink; all were negative.

Diagnoses

42 children (43%) had an identifiable cause of acute encephalitis syndrome, either a definite (n = 23) or probable diagnosis (n = 19). 5 patients had laboratory-confirmed IgM for JEV, 6 dengue, 5 *Streptococcus pneumoniae*, 1 *Haemophilus influenzae*, 6 malaria and 19 probable tuberculous meningitis. There were 14 cases of meningoencephalitis with no identifiable cause (aseptic meningitis), and 41 cases of acute encephalopathy without CSF inflammation and no known cause.

Of the 5 JE cases, 2 were JE IgM positive on both the serum and cerebrospinal fluid.

One of these patients also had a mixed or falciparum malaria infection based on the result of a rapid diagnostic test. 2 patients were JEV IgM positive on cerebrospinal fluid and negative on serum, and 1 was JEV IgM positive on serum and negative on cerebrospinal fluid. 6 patients were IgM positive for dengue virus. 1 CSF was culture positive for *Haemophilus influenzae* and 2 for *Streptococcus pneumoniae*. The other 3 cases of *S. pneumoniae* meningitis were diagnosed with the Binax Now *S. pneumoniae* Antigen Test (rapid immune-chromatographic test), which was only performed on a minority of CSF specimens with a white cell count >5. However, during this study there was a limited supply of test kits and only 6 specimens were tested (3 were positive for *S. pneumoniae* and 3 negative).

6 cases of malaria were diagnosed using malaria lateral flow immune-chromatographic antigen detection tests; 3 were *Plasmodium falciparum* infection and 3 mixed species or *P. falciparum*.

For TB diagnosis, a combination of history, physical examination, PNG TB score (10), chest X-ray and CSF testing was used. 15 children had CSF with high protein concentration and lymphocytic predominant pleocytosis and were treated for TB; 3 patients did not have a lumbar puncture done as they were very sick on admission; 1 patient had normal cerebrospinal fluid but was eventually treated for TB based on the clinical features.

Quality of care

70 patients had quality of care assessed (Table 1). In 43/70 (61%) conscious state was monitored and documented using the GCS. 13 (19%) had blood glucose measurement recorded. Oxygen saturation was recorded and oxygen applied if needed in 60 patients (86%). Basic observations –

TABLE 1

QUALITY OF CARE INDICATORS IN 70 PATIENTS

Quality of care assessment items	Number (%)
Glasgow coma score assessed and recorded	43 (61)
Blood glucose measured and recorded and hypoglycaemia prevented	13 (19)
Oxygen saturation recorded and oxygen applied as appropriate	60 (86)
Blood pressure measured and recorded and kept within the normal range for age	1 (1)
Weight monitored throughout admission	56 (80)
Head elevation at 15-30˚above the horizontal	25 (36)
Pupillary assessment recorded	24 (34)
Enteral nutrition provided early in treatment course (within 48 hours)	56 (80)
Basic observations (heart rate, respiratory rate, temperature) recorded every 6 hours at least	41 (59)
Anticonvulsants given as appropriate	22 (67)*
Turning and positional changes and surveillance for pressure areas	40 (57)
Physiotherapy provided as appropriate, for chest or prevention of limb contractures	10 (14)

* 33 children developed convulsions while inpatients and 22 children received appropriate ongoing anticonvulsants

pulse rate, respiratory rate and temperature – were recorded in 41 patients (59%). Blood pressure measurement was carried out on only 1 patient (1%).

Head elevation of 15-30˚ was carried out in 25 patients (36%). Pupillary assessment was recorded in 24 patients (34%). Enteral nutrition was provided in 56 patients (80%). All patients had weight recorded at presentation, but only 56 patients (80%) had subsequent weight monitoring.

Of the 33 patients with seizures on admission, only 22 patients were adequately treated with anticonvulsants; 11 patients had inappropriate anticonvulsants given or their seizures were not controlled and were still having seizures by day 2 of hospital admission. These 11 patients were given paraldehyde with each seizure episode to stop the seizures and were not commenced on longer-acting anticonvulsants to prevent further seizures. In 40 patients (57%) it was observed or recorded that regular turning and repositioning and surveillance for pressure areas was done. 10 children (14%) received physiotherapy to avoid limb contractures.

Outcomes

There were 13 deaths. 4 deaths occurred in the first 24 hours after admission, 6 children died 1-5 days after admission, and 3 died later on days 7, 8 and 14 of admission. 13 children (15% of survivors) developed neurological sequelae; 5 had hydrocephalus on a head CT (computed tomography) scan, 7 had spastic quadriplegia, 2 spastic hemiparesis and 4 hypotonia.

Discussion

This study confirms that JE is an uncommon cause of acute febrile encephalopathy among children in PNG and that most cases of acute febrile encephalopathy are undiagnosed. These findings are similar to a previous study in children conducted in 2007-2008 in PNG, where the most common identifiable causes of febrile encephalopathy were *S. pneumoniae* and *H. influenzae*, tuberculosis and malaria (5). In that study, of the 149 children there were 2 cases of IgM-confirmed Japanese encephalitis. In these two studies combined there have been 7 confirmed JE encephalitis cases out of 246 children with febrile encephalopathy, representing 2.8% of this patient group. In another study from PNG where testing for other viruses was possible, of 554 children undergoing lumbar puncture for suspected CNS infection in Madang, 67 had bacteria identified on CSF (47 by culture and 20 on polymerase chain reaction [PCR]); 93 had malaria; and 42 had viruses positive on PCR. The common viruses isolated were cytomegalovirus (CMV) (n = 17) and herpes viruses (human herpes virus 6 and 7, and herpes simplex virus 1, n = 22) (11). Several children had more than one virus identified, and it was uncertain if some of the herpes virus and CMV infections were pathogenic or represented prior infection of a virus that can maintain a reservoir in the nervous system. Other studies which have evaluated the aetiology of a cohort of children with febrile encephalopathy in low- and middle-income countries are summarized in Table 2 (5,11-20). These studies are heterogeneous, and most studies tested selectively for different pathogens based often on what diagnostic tests were available. However, a picture emerges of the common and varied pathogens and the substantial gaps in our understanding of the aetiology of febrile encephalopathy in children.

Despite how common the clinical syndrome of febrile encephalopathy is, there has been minimal research on the quality of care provided for children with this presentation (21). This is particularly surprising as in many cases the outcomes are more crucially dependent on monitoring and supportive care in the emergency and ongoing care phases than on specific medicines to treat a known aetiology. Important objectives in monitoring and supportive care are the prevention of secondary brain injury from hypoxaemia, hypercarbia, hypotension, hypoglycaemia, cerebral oedema and persistent seizures (6,22). Ongoing aims in supportive care include providing adequate nutrition, avoiding hospital-acquired complications of secondary infection and intravenous therapy, avoiding aspiration lung disease and pressure sores, and rehabilitation (23). This current study identified substantial deficiencies in monitoring and supportive care using a simple 12-point checklist. Only two-thirds of these children had their conscious state assessed and documented. One-third had head elevated to 30 degrees, a simple measure which can reduce intracranial pressure (8), and about the same proportion had their pupils assessed. Not all patients had a weight documented,

TABLE 2

Summary of studies investigating the aetiology of febrile encephalopathy in children in low- and middle-income countries

Causes	Karmarkar (12) India	Laman (11) PNG	Modi (13) India	Le (14) Vietnam	Rayamajhi (15) Nepal	Schubart (16) Kenya	Bokade (17) India	Rathore (18) India	Srey (19) Cambodia	Xu (20) China	Anga (5) PNG	Kiromat PNG (this study)	Total N (%)
Total	157	369	120	194	94	96	126	526	52	97	149	97	2077
Bacterial meningitis	51	67	44	12	6		39		4		33	6	262 (12.6)
Tubercular meningitis	12		26				27		1		23	19	108 (5.2)
Cerebral malaria	8	93	5		4	49	28				10	6	203 (9.8)
Cryptococcus neoformans											1		1
Disordered electrolytes	6												6
Hepatic encephalopathy	3												3
DKA	3												3
ADEM	2												2
Septicaemia	2		11										13
Reyes syndrome	3												3
Shigellosis	1												1
Enteric fever	1												1
Prolonged coma after seizure	1												1

Intracranial bleed	1											1
Viruses	57	42	34				82	47	35			297 (14.3)
Enterovirus	20	1		21		1			15			58 (2.8)
Mumps	6								7			13
JE	5		15	50	58			16	5	2	5	156 (7.5)
Measles	4											4
Varicella zoster	1				1	1						3
Rubella	1								6			7
HHV-6		9							2			11
HHV-7		12										12
HSV		1	4	1	1	6			2			15
CMV		17		1		1						19
Dengue		3		17				4		1	6	31 (1.5)
Adenovirus												0
Influenza				9								9
Epstein-Barr Virus									1			1

PNG = Papua New Guinea
DKA = diabetic ketoacidosis
ADEM = acute disseminated encephalomyelitis
JE = Japanese encephalitis
HHV = human herpes virus
HSV = herpes simplex virus
CMV = cytomegalovirus

despite having medications prescribed and written on their medication order charts. The most basic observations which included pulse rate, respiratory rate and temperature were carried out on less than two-thirds of children. These basic observations can identify children who are deteriorating: bradycardia and respiratory irregularity are common in raised intracranial pressure; high fever can lead to increased cerebral metabolic demand, reduce the threshold for seizures and signal an undiagnosed condition or comorbidity. Blood pressures were rarely taken, even though systemic hypertension can be both a cause of encephalopathy and a consequence of intracranial hypertension, and hypotension can adversely affect outcome in brain injury because of reduced cerebral perfusion pressure. Blood glucose levels were often not monitored in children with impaired consciousness. Oxygen saturations were monitored, levels documented and hypoxia corrected in 86% of patients. A third of the children presented with seizures at admission. The standard initial anticonvulsant to stop the fit was paraldehyde, given intramuscularly. Of these 33 patients, 11 were not commenced on longer-acting anticonvulsants and continued to have seizures into day 2 and day 3 of admission. Children with febrile encephalopathy who continue to have convulsions should be commenced on longer-acting anticonvulsants to prevent further seizures.

Conclusions

The causes of acute encephalitis syndrome or febrile encephalopathy in children in PNG are diverse, and include JEV, dengue and other viral pathogens, as well as cerebral malaria and bacterial meningitis. However, for more than half the cases an aetiology is not identified. A proportion of children are treated for TB on moderate evidence using integration of clinical and laboratory findings. In the era of conjugate vaccines, bacterial meningitis will cause a smaller proportion of febrile encephalopathy, and investigations for other treatable and preventable pathogens are required, including TB and herpes viruses.

There is much scope for improving the quality of care for these children. This requires a multisystem approach to acute and convalescent care, including management guidelines which cover aspects of supportive care relevant to children with impaired conscious state or acute seizures. Simple measures, close monitoring and supportive care can improve survival and reduce complications.

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Haemophilus influenzae type b (Hib) meningitis in Port Moresby and Mt Hagen General Hospitals before and after the introduction of Hib vaccine

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SUMMARY

Introduction **Before the introduction of *Haemophilus influenzae* type b (Hib) vaccine, 40% of cerebrospinal fluid (CSF) culture-positive meningitis cases in children were reported by the World Health Organization to be due to Hib. This study assessed the impact of Hib vaccine, introduced to Papua New Guinea in 2008, on the incidence of Hib meningitis.** ***Methods*** **Details of CSF results from children up to 5 years of age, from three years before and four years after introduction of Hib vaccine, were extracted from laboratory records. Population estimates were used to calculate the incidence of Hib disease.** ***Results*** **There was a significant reduction in the proportion of CSF specimens from which Hib was isolated – 87/698 (12%) using culture and Gram stain in the pre-vaccine period compared with 37/440 (8%) using culture, Gram stain and latex antigen testing in the post-vaccine period (p = 0.040). The estimated population incidence of Hib in children aged less than 5 years fell by 86% in the post-vaccine period.** ***Conclusion*** **The findings strongly suggest that the Hib vaccine reduced the burden of Hib meningitis in children less than 5 years of age.**

Introduction

Before the advent of conjugate vaccines against *Haemophilus influenzae* type b (Hib) in the early 1990s, Hib and *Streptococcus pneumoniae* (pneumococcus) accounted for the majority of cases of bacterial pneumonia and meningitis in children, particularly young children, throughout the world. 40% of meningitis cases in children for which a bacterial pathogen was isolated from cerebrospinal fluid (CSF) were due to Hib and approximately half of these were children less than 6 months of age (1). Hib meningitis in many countries carried a fatality rate of 10-20%, and 15%-35% of survivors were left with serious neurological damage (1). In some low- and middle-income countries mortality was considerably higher. A death rate of 43% was reported from Malawi with 19% of survivors left with severe neurological damage (2). The introduction of the Hib vaccine in the industrialized world was followed by a dramatic reduction in the incidence of Hib meningitis to the extent that in these countries it was almost eliminated within a few years (3,4). It is only in recent years that Hib vaccine has been introduced into many low- and middle-income countries through the Global Alliance for Vaccines and Immunization (GAVI). The results have been dramatic. A recent study from Kenya reported a reduction from 62.6 to 4.5/100,000, with a vaccine effectiveness of 93% (5). Studies in Papua New Guinea (PNG) in the 1980s and 1990s and more recently have confirmed the importance of Hib as a major cause of bacterial meningitis and pneumonia (6-10). In the early 2000s, meningitis caused about

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13% of all child deaths in Goroka Hospital in PNG. 30% of the cases were caused by Hib, with a case fatality rate of 12% (8,9), whilst a follow-up study confirmed the high incidence of major neurological sequelae in survivors (11). In PNG the emergence of resistance to chloramphenicol, for long the standard treatment of meningitis in children, and the expense of 3rd generation cephalosporins gave added urgency to the introduction of Hib vaccine (12). The vaccine was introduced in 2008 (without a catch-up program) as a component of the pentavalent vaccine, given at 1, 2 and 3 months of age, and was accompanied by an improved surveillance system, and improved diagnostic capacity with the addition of latex antigen testing. This study aimed to assess the impact of the vaccine on the incidence of Hib meningitis in two major hospitals in PNG.

Methodology

The methodology was based on the World Health Organization (WHO) Rapid Assessment Tool for estimating the local burden of *Haemophilus influenzae* type b disease preventable by vaccination (13). The number of CSF samples from children 0-5 years of age received, tests performed and results obtained were extracted from the laboratory CSF logbooks at Port Moresby General Hospital (PMGH) and Mt Hagen General Hospital for the periods 2005-2007 (before introduction of the vaccine) and 2009-2012 (after vaccine introduction). Only Gram stain and culture were available in the pre-vaccine period, whilst latex agglutination tests for Hib, pneumococcus and *Neisseria meningitidis* were also available in the post-vaccine period. A positive diagnosis of meningitis was defined as culture positive, or Gram stain positive or having a positive latex agglutination test for a meningitis pathogen. Data were entered onto an Excel spread sheet and analysed using SPSS and Open Epi programs. Proportions of Hib, pneumococcus and other organisms in the periods before and after the introduction of vaccine were compared using Fisher's Exact Test. Data from the 2000 census were extrapolated to estimate the incidence of Hib meningitis /100,000 children less than 5 years of age in the National Capital District (NCD), where PMGH is situated, and in the Mt Hagen District. Ethical approval was obtained from the School of Medicine and Health Sciences. Approval to conduct the study was granted by the chief executive officers and the laboratory managers of both hospitals.

Results

Table 1 shows the details of all the CSF samples examined over the two time periods. Details of the diagnoses by year are shown in Table 2. At Port Moresby General and Mt Hagen Hospitals 698 CSF specimens were included in the 3-year pre-vaccination era, and 440 in the post-vaccination era. A meningitis pathogen was identified in 29% and 25% of cases of CSF specimens examined in the pre-vaccine and post-vaccine eras, respectively (Table 1). In the post-vaccine period 24 cases of Hib were detected by latex antigen testing when samples were negative on culture or not done (Table 2).

In the 3-year pre-vaccination era, out of 698 CSF specimens received from children aged less than 5 years there were 87 (12%) documented cases of Hib meningitis (Table 1). In the 4-year post-vaccination era, out of 440 CSF specimens there were 37 (8%) proven Hib cases – either culture (13 cases) or latex antigen positive (24 cases) (Table 2). In both hospitals combined, there was a significant reduction in the proportion of CSF specimens where Hib was isolated (Fisher's Exact Test p = 0.040). 87 (13%) of 662 cultured specimens grew Hib in the pre-vaccine era compared with 13 (3%) of 431 in the post-vaccine era ($p < 0.001$).

In PMGH in the post-vaccination era there was a significant reduction in the proportion of cases of meningitis in which Hib was isolated (Fisher's Exact Test p = 0.045), but not in Mt Hagen (p = 0.53).

There was a non-significant increase in the proportion of CSF samples from which *S. pneumoniae* was isolated between the pre- and post-vaccination eras (9.3% vs 12.3%, Fisher's Exact Test p = 0.11) (Table 1).

There was a decrease in the number of CSF samples tested in each hospital following the introduction of the Hib vaccine. At PMGH the proportion of positive samples was similar for the two time periods, whilst in Mt Hagen the proportion of positive samples was lower in the post-vaccination period (Table 1).

Based on population projections of the number of children less than 5 years of age, the incidence of Hib meningitis fell by 89%

TABLE 1

Results of CSF testing: culture and latex antigen testing

Hospital	Era	Number CSF	Mean CSF/year	Number cultured	Number culture positive or latex antigen positive (%)	Hib No (%)	Pneumococcus No (%)	Others No (%)
PMGH	Pre-vaccine	471	157	467	111 (23.6)	52 (11.0)	36 (7.6)	23 (4.9)
	Post-vaccine	312	78	312	74 (23.7)	21 (6.7)*	38 (12.2)	15 (4.8)
Mt Hagen	Pre-vaccine	227	76	195	89 (39.2)	35 (15.4)	29 (12.8)	25 (11.0)
	Post-vaccine	128	32	119	36 (28.1)	16 (12.5)#	16 (12.5)	4 (3.1)
Both hospitals	Pre-vaccine	698	233	662	200 (28.7)	87 (12.5)	65 (9.3)	48 (6.9)
	Post-vaccine	440	110	431	110 (25.0)	37 (8.4)*	54 (12.3)	19 (4.3)

CSF = cerebrospinal fluid
Hib = *Haemophilus influenzae* type b
PMGH = Port Moresby General Hospital
*Significant reduction in proportion of meningitis cases in which Hib was isolated from CSF (p = 0.045 in PMGH and p = 0.040 in both hospitals combined) in the post-vaccination era compared with the pre-vaccination era
No significant difference in Hib isolation at Mt Hagen between the pre- and post-vaccination eras (p = 0.53)
Note: all CSF samples that were not cultured were tested with Gram stain and, for post-vaccine samples, latex agglutination

TABLE 2

Summary of confirmed meningitis cases (culture and/or latex antigen positive) by year

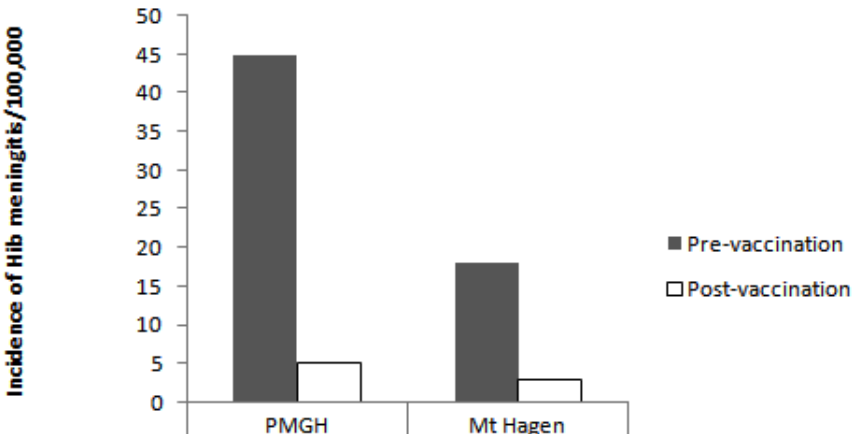
	Year	Hib			Pneumococcus			Others			Total		
		Culture	LA*	All	Culture	LA*	All	Culture	LA*	All	Culture	LA*	All
Pre-vaccine	2005	30			24			11			65		
	2006	29			15			18			62		
	2007	28			26			19			73		
	Total	87			65			48			200		
Post-vaccine	2009	5	5	10	8	2	10	3	3	6	16	10	26
	2010	0	6	6	7	2	9	6	2	8	13	10	23
	2011	3	7	10	5	9	14	1	0	1	9	16	25
	2012	5	6	11	13	8	21	0	4	4	18	18	36
	Total	13	24	37	33	21	54	10	9	19	56	54	110

Hib = *Haemophilus influenzae* type b
LA = latex antigen
* Additional when culture was negative or not done

from 45 to 5 per 100,000 in NCD and by 83% from 18 to 3 per 100,000 in Mt Hagen (Figure 1).

Discussion

There are limitations to the study. Data were obtained from the laboratory records and not cross-checked with the Paediatric Ward records. Information on the administration of antibiotics prior to lumbar puncture, which would have affected culture positivity, was not available. Latex agglutination testing, more sensitive than culture, was not available in the pre-vaccine era. However, the study provides strong support for the effectiveness of the Hib vaccine in the PNG population. Whilst the data from Mt Hagen did not show a reduction in the proportion of meningitis cases due to Hib, the reduction in Port Moresby was striking. Importantly this result occurred in the context of increased case-finding in the post-vaccination era compared to the pre-vaccination era, using both culture and latex antigens. We found many cases which were latex antigen positive but culture negative. So one might expect the number of cases identified in the pre-vaccination era to be less than what would have been identified if latex antigen testing had been available in that era. Thus the true reduction in Hib cases is likely to have been greater than estimated by this study. The overall reduction in culture-positive Hib was highly significant ($p < 0.001$). The reduction in numbers of all organisms was recorded not only for Mt Hagen, where laboratory and clinical services may have been stretched, but also in Port Moresby, the country's tertiary and relatively well staffed and provisioned teaching hospital. Whilst the reasons for the reductions are unclear, it is difficult to escape the conclusion that the reduction in number of cases of Hib meningitis was real and associated with the introduction of the Hib vaccine. The overall 86% reduction in estimated incidence (83% in Mt Hagen and 89% in National Capital District) was similar to those reported in other studies in low- and middle-income countries (5,14,15). Such countries struggle to achieve high vaccination coverage. In PNG national coverage for the third dose of pentavalent vaccine has remained below 70% for many years, with many districts reaching coverage of less than 50%. This might suggest that the impact of introducing the Hib vaccine would be limited, but a highly significant decline in Hib meningitis from 47% of all culture-positive CSFs to less than 9% after the introduction of Hib vaccine was recently reported from Madang in spite of a low coverage (16). Other reports indicate the Hib vaccine to be highly cost-effective in



	PMGH	Mt Hagen
Pre-vaccination	45	18
Post-vaccination	5	3

Figure 1 . Estimated incidence of Hib meningitis in children aged <5 years before and after vaccine introduction.
Hib = *Haemophilus influenzae* type b; PMGH = Port Moresby General Hospital

low- and middle-income countries (17).

This study provides strong evidence for the high effectiveness of the Hib vaccine, and is in accordance with data from many other low- and middle-income countries. However, lack of facilities to isolate the infecting organisms significantly hampers attempts to monitor the effect of the vaccine in many parts of the country. Meningitis remains a devastating condition. Data collected from the paediatric sections of 16 hospitals in Papua New Guinea between 2009 and 2014 reported 1011 deaths from 5752 admissions of children with meningitis – a case fatality rate of 17.6% (18). Benefits similar to those obtained from the Hib vaccine have been reported for the more recent introduction of pneumococcal vaccine into low- and middle-income countries (17). The 13-valent pneumococcal conjugate vaccine was introduced into the PNG EPI program in 2014. Every effort needs to be made to ensure that all children in PNG receive the vaccines provided under the National Department of Health program. The reduction (and possible elimination) of the mortality and morbidity from diseases which are almost entirely preventable by vaccination should be a national priority.

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Comprehensive health and epidemiological surveillance system (CHESS): a new generation of population health surveillance for the sustainable development of Papua New Guinea

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SUMMARY

Longitudinal health surveillance systems have a long history in Papua New Guinea (PNG). The first surveillance system was set up by the Papua New Guinea Institute of Medical Research in the 1970s and continued into the 1990s. It focused on collecting demographic data for surveying disease prevalence and programming health interventions such as pneumococcal vaccination, management of typhoid fever and malaria control. The second generation of health and demographic surveillance developed in the decade 2000-2010, and integrated morbidity and mortality data in primary health facilities with routine demographic data surveillance in the community. The aim was to provide longitudinal, up-to-date and timely data for monitoring the long-term impact of socioeconomic programs on health status, and reporting key population health indicators by locality. This paper discusses the next generation. This new approach in Papua New Guinea, a comprehensive health and epidemiological surveillance system (CHESS), is based on the existing systems to provide comprehensive data for assessing key population health indicators and epidemiological trends at the national and subnational levels in the context of PNG's Vision 2050 and the United Nations' Sustainable Development Goals 2016-2030 (SDGs). The paper provides an overall description of CHESS, from objectives to study design, scope of data collection and reporting, geographical and population coverage, target surveillance populations, data collection tools and methods. It discusses the capacity to use the data generated to report upon key national development indicators and SDG health-related indicators. The paper highlights potential benefits of CHESS to PNG Government agencies, especially the health and social planning sectors, as well as development partners, research and training institutions and the community.

Introduction

Papua New Guinea (PNG) has great potential through its natural resources – land, cash crops, forests and fisheries – to improve its socioeconomic development status. The mining and energy sectors contribute approximately 80% of the total export revenue of the country (1). The majority of the population live in traditional societies and practise subsistence-based agriculture (2). Rapid changes in lifestyles and living conditions are leading to shifts in the pattern of epidemiology and the types of disease. PNG will soon be facing a double burden of increasing non-communicable diseases while it is still dealing with the unfinished agenda of reducing infectious diseases and poor maternal and child health. PNG Government policies stress the need for establishing targets and monitoring progress. In December 2008, the PNG Government tasked the National Planning Committee with the responsibility of developing a framework for setting a long-term vision and directions for the country's socioeconomic development.

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These strategies were subsequently set out in the Papua New Guinea Vision 2050, which boldly states that:

- all future medium- to long-term strategies and plans must align to this vision;
- any successive PNG governments will continue to monitor and review the performance against the targets set out; and
- a major review will be carried out by 2019 in order to measure its continued efficacy and to set new targets for the period 2020-2030, with ensuing reviews in 2029 and 2039.

To respond to the Papua New Guinea Vision 2050, the National Department of Health (NDoH) approved the PNG National Health Plan 2010-2020 to ensure that health services are delivered to communities more effectively and equitably (3). Strengthening health data collection and reporting systems is clearly a priority of the plan.

Globally, there has been increased demand of data for development (4), particularly after the United Nations (UN) launched the Sustainable Development Goals (SDGs) in September 2015, with 17 goals to be achieved by 2030 (5,6). The UN recently redefined the implementation of the SDGs, with 169 targets and 232 indicators; many of the SDG health indicators are based on the previous indicators of the Millennium Development Goals (MDGs) (7). The World Health Organization (WHO) also published the 2015 Global Reference List of 100 Core Health Indicators, a new standard set of indicators reporting global health priorities relating to the SDGs, grouped in four domains: health status, risk factors, service coverage and health systems (8).

The UN also called for a data revolution at the global, regional and country levels, particularly in low- and middle-income countries, which are the primary focus of the SDGs but often lack the necessary financial and human resources (7). Civil society, the private sector and development partners will need to align their priorities with those of the governments, not only to support implementation, but also to conduct monitoring and reporting on SDG progress.

As a country member of the UN, the PNG Government is expected to review and submit the country's SDG progress report every 5 years.

Challenges in collecting and reporting data for development

Like many other countries, PNG lacks reliable data to inform decision-making processes for planning and implementation of development programs and reporting the country's progress toward achievement of its goals and targets (B.N. Pham and P. Siba. Unpublished conference presentation at Resource Development and Human Well-being in Papua New Guinea, Port Moresby, 17-19 Mar 2015). According to the 2010 Country MDG Report, PNG had achieved some of the national targets, but failed to achieve any of the MDG targets (9). The report has highlighted three systemic data issues:

- the existing data collection systems are unable to provide reliable data for reporting MDG indicators;
- the country has no nation-wide comprehensive monitoring and evaluation system for tracking the country's progress toward achieving the MDGs; and
- the country lacks adequate human resources and technical expertise to make use of the available data to report upon the country's progress (10).

Specifically, PNG has inadequate data for monitoring and evaluation of health care programs, policies and interventions, as well as for measuring and reporting health indicators (9-11). The civil registration and vital statistics (CRVS) system is not fully functioning and needs further development. The National Health Information System (NHIS) only reports aggregated data from health facilities, mostly available in tally numbers, which are possibly appropriate for managing health care delivery but not for research (12).

In the absence of reliable data, cross-sectional data have been used as the main source for planning, monitoring and evaluation of population health indicators (13). In PNG, national censuses are conducted by the National Statistics Office (NSO) every

ten years, with the last one conducted in 2010. Similarly, the last Demographic and Health Survey (DHS) was conducted in 2006 (14). There have been concerns about the quality of data available from these data sources. The 2006 DHS data were under-representative due to the limited access to populations that live in rural and remote areas of PNG (15). The 2010 National Census collected a limited number of variables, mostly on population count, residence and age and sex of individuals, leaving a large data gap. Neither the 2010 National Census nor the 2006 DHS can offer longitudinal data series for projection of future trends of fertility and mortality in PNG. A new 2016 DHS report is planned to be released soon.

For all of these reasons, monitoring of the country's progress toward achieving the international and national development goals is of much interest to the PNG Government and its development partners (16). The Department of National Planning and Monitoring (DNPM) called for more comprehensive, integrated and sustainable approaches to facilitate data collection, data sharing and linkage, in order to improve the availability, accessibility and utilization of existing national data sources for monitoring of the SDG implementation (17).

To respond to the increased demand of data for development, the Papua New Guinea Institute of Medical Research (PNGIMR) proposed to develop a new Comprehensive Health and Epidemiological Surveillance System (CHESS) for the period 2017-2030 to provide data for assessing key population health indicators at the national and subnational levels.

Comprehensive health and epidemiological surveillance system (CHESS)

CHESS is a new generation of population health surveillance, recently discussed in *Lancet Global Health* (18). CHESS provides more comprehensive data at both national and subnational levels, with more focus on health and epidemiological transition at the global and regional levels. It combines the strengths of health and demographic surveillance systems, based on the routine collection of population and health information from households and individuals, and of data on morbidity, mortality and health care services collected from primary health facilities. CHESS will be built on the well-established foundation of the current integrated Health and Demographic Surveillance System (iHDSS). The transformation from the iHDSS into CHESS is proposed for the period 2017-2022.

Description

Like iHDSS, CHESS is designed as a longitudinal follow-up intervention cohort study. CHESS adopts a life-cycle approach, allowing the system to record key life-cycle events, including birth, education, marriage, migration and death, as well as capture changes in health status at each phase of the life cycle such as childhood, adulthood, parenthood and old age (19).

However, CHESS is more comprehensive than the iHDSS in terms of scope of data collection and reporting (Table 1). CHESS aims to provide data for monitoring and evaluation of development programs and health care interventions to guide the country's responses to emerging health and epidemiological issues, thereby contributing to the sustainable development of PNG.

CHESS will cover a surveillance population of approximately 80,000 people and 15,000 households, equivalent to 1% of the PNG population, estimated at around 8 million for the period 2017-2020. CHESS will cover all the four geographical regions of PNG: Highlands, Southern, Momase and Islands. Unlike the iHDSS, which focused only on rural areas, CHESS will consist of 10 surveillance sites, covering both rural and urban populations, in 5 provinces of these regions. CHESS will continue operating in the existing surveillance sites of Asaro/Goroka, Hiri/Port Moresby and Karkar/Madang and will also integrate into the PNGIMR's ongoing activities in Rabaul in East New Britain Province and Maprik in East Sepik Province.

CHESS will continue collecting health and demographic surveillance data from the defined populations, including children aged under 5 years, women of reproductive age, 15-49 years, and men of working age, 15-64 years. Data on adolescents and the elderly will be integrated into household socioeconomic data. Morbidity data will include patients seeking health services at primary health facilities. Verbal autopsy interviews will be

conducted to identify the causes of the deaths in the community, using the new 2016 WHO Guidelines (20,21).

The most significant improvement of CHESS is the enhanced reporting capacity at both national and subnational levels. Table 2 shows the reporting potential capacity of CHESS compared to other national data sources. CHESS will be able to report upon 31 of the 38 national key development indicators, as defined by the PNG Government (22). The system is able to report on 52 indicators in the 2015 WHO Global Reference List of Core Health Indicators, including 21 of 27 population health indicators, 12 of 21 risk factor indicators, 13 of 27 health services coverage indicators and 6 of 24 health systems indicators (Table 3). CHESS will be able to report on 14 of the 21 indicators of the SDG 3 of "Ensuring healthy lives and promoting well-being for people of all ages" (Table 4).

Electronic data collection methods will be applied, using mobile phones and tablets, instead of paper-based data collection forms. This new data collection method facilitates transferring data, allowing data to be downloaded directly from the mobile devices onto the database, thus reducing the manual work of data entry and improving data quality. This approach would help: (i) reduce the overlapping and repetitions, and hence save time and cost; (ii) focus on key population health indicators, aligned with the SDGs and WHO; and (iii) standardize data collection tools and methods in line with international practices.

Benefits

CHESS is a powerful public health tool in PNG. CHESS establishes a broader framework for conducting population-based intervention follow-up cohort studies. It provides a comprehensive, longitudinal and up-to-date data series on epidemiology, morbidity and mortality at the individual level, interlinked with household socioeconomic demographic data. CHESS offers both clinical and laboratory services to the community. The system is therefore ideal for the monitoring and evaluation of long-term impacts of socioeconomic development programs and measuring outcomes of health care policies and interventions.

CHESS would benefit PNG Government agencies and development partners, including international and national non-government organizations, bilateral and multilateral donors and funding agencies. The new system is designed to be complementary to the existing national data sources such as national censuses, CRVS and NHIS. The linkages between CHESS and national databases would enhance access and utilization of the existing national data sources. This is an essential step towards establishing a national database for the entire PNG population.

National and international research institutions would benefit from CHESS. They could utilize the established research infrastructure, data collection framework, data collection tools, standard operating procedures, laboratory equipment and technical expertise. CHESS could serve as an entry point for overseas institutions, particularly for those which are interested in international collaboration and research programs in PNG.

CHESS will continue its function as a surveillance centre of the INDEPTH Global Surveillance Network in PNG. A review of 49 surveillance centres operating in 20 countries suggests that INDEPTH has a great potential to become a key data source for monitoring of epidemiological trends at the global, regional and country levels (23). Having similar methodologies and sampling frames at a number of sites across the world can both increase the statistical power of surveillance studies as well as provide genotypic and environmental variability for epidemiological studies. For example, longitudinal data were analysed to provide trends in the morbidity and mortality of infectious diseases in China (24), helped United States scientists understand the progression of heart disease and its risk factors (25), provided insights into Australian women's physical and mental health and their use of health services (26), and captured socioeconomic circumstances, attitudes and health-seeking behaviour of communities in the United Kingdom (27).

Next steps

The country's need of data for development has been raised higher than ever in the context of SDGs 2030. Reforming national statistics and data systems is among the top priorities of the PNG Vision 2050 and underpins the

TABLE 1

ADVANTAGES OF THE COMPREHENSIVE HEALTH AND EPIDEMIOLOGICAL SURVEILLANCE SYSTEM (CHESS) COMPARED TO THE INTEGRATED HEALTH AND DEMOGRAPHIC SURVEILLANCE SYSTEM (IHDSS)

	iHDSS	CHESS
Phase	Piloting phase: 2011-2016	Scaling-up phase: 2017-2022
Objective	To monitor the long-term impacts of the PNG LNG project upon a broad set of core health, demographic and socioeconomic development indicators at each locality studied	To provide an up-to-date and longitudinal data series to inform decision-making processes and policy development and guide PNG's responses to changes in health, epidemiology and its socioeconomic development
Population coverage	54,000 people and 11,000 households	80,000 people and 15,000 households (equivalent to 1% of the total population for the period 2017-2020)
Surveillance populations	General population	General population and defined populations, including children aged 0-4 years, women aged 15-49 years, men aged 15-64 years, patients (at primary health care facilities) and deaths at households
Geographical coverage	Three regions: Highlands region Southern region Momase region	Four regions: Highlands region Southern region Momase region Islands region
Surveillance sites	4 sites in 4 provinces	10 sites in 5 provinces
Urban-rural sector	Rural area only	Both urban and rural sectors

Scope of data collection	Households' socioeconomic data, including births, deaths and migrations (in and out)	Households' socioeconomic data, plus population health data on: Children under 5 years Women of reproductive age, 15-49 years Men of working age, 15-64 years Morbidity at primary health care facilities Mortality at households
Data collection tools	Household questionnaire Household update book	Women aged 15-49 years questionnaire Children aged under 5 years questionnaire Men aged 15-64 years questionnaire Morbidity questionnaire Mortality questionnaire
Data collection method	Paper-based data collection	Tablet-based data collection
Data entry	Manually entered into the database	Electronically transferred from tablets onto the database
Data management	Closed database with limited link between data components	Open database, possible link within data components and with other data sources: census, DHS, NHIS
Data reporting capacity	33/60 MDG-related indicators at subnational level	52/100 core health indicators metadata at the national and subnational levels

PNG = Papua New Guinea
LNG = Liquefied Natural Gas
DHS = Demographic and Health Survey
NHIS = National Health Information System
MDG = Millennium Development Goal

TABLE 2

Capacity of CHESS compared to other data sources to report upon key development indicators of PNG, 2015

No	National development indicators	PNGIMR				Other national stakeholders			
		Stakeholder	Data source	Frequency	Type of data	Stakeholder	Data source	Frequency	Type of data
1	GNI per capita	NA	NA	NA	NA	NSO	Census	10 years	Sample survey
2	Standard of living index	NA	NA	NA	NA	NSO	Census	10 years	Sample survey
3	Female-male life expectancy at birth	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
4	Female-male adult literacy ratio	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
5	Female-male earned income share	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
6	Total population	NA	NA	NA	NA	NSO	Census	10 years	Sample survey
7	Life expectancy at birth	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
8	Population growth rate	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
9	Children under 5 mortality	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
10	Fertility rate	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey

11	Adult, youth literacy ratio	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
12	Gross enrolment ratio	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
13	Household income and wage rates	PNGIMR	CHESS	Routinely	Surveillance data	NSO	Census	10 years	Sample survey
14	Infant mortality rate	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
15	Maternal mortality rate	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
16	Morbidity rate	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
17	Crude death rate	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
18	Supervised birth deliveries	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
19	Immunization coverage	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
20	Access to health services	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
21	Prevalence of HIV	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
22	% of PLHIV on ART	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report
23	Underweight children <5	PNGIMR	CHESS	Routinely	Surveillance data	NDoH	NHIS	Annually	Aggregated report

24	Net enrolment rate	PNGIMR	CHESS	Routinely	Surveillance data	NDoE	Education report	Annually	Aggregated report
25	Completion rate (Grade 8-12)	PNGIMR	CHESS	Routinely	Surveillance data	NDoE	Education report	Annually	Aggregated report
26	Male to female enrolment ratios	PNGIMR	CHESS	Routinely	Surveillance data	NDoE	Education report	Annually	Aggregated report
27	Retention rate	PNGIMR	CHESS	Routinely	Surveillance data	NDoE	Education report	Annually	Aggregated report
28	Enrolment at tertiary institutions	PNGIMR	CHESS	Routinely	Surveillance data	NDoE	OHE report	Annually	Aggregated report
29	Females in tertiary institutions	PNGIMR	CHESS	Routinely	Surveillance data	NDoE	OHE report	Annually	Aggregated report
30	Skilled workforce	NA	NA	NA	NA	NDoL	Labour report	Annually	Aggregated report
31	Employment statistics	NA	NA	NA	NA	NDoL	Labour report	Annually	Aggregated report
32	Human poverty index	NA	NA	NA	NA	DNPM	Various sources	Annually	Aggregated report
33	Crude birth rate	PNGIMR	CHESS	Routinely	Surveillance data	Civil Registry	Vital statistics	Annually	Aggregated report
34	Migration rates	PNGIMR	CHESS	Routinely	Surveillance data	Office of Urbanization	Migration statistics	Annually	Aggregated report
35	Ease of doing business	NA	NA	NA	NA	INA	Financial survey	5 years	Aggregated report
36	Access to safe water	PNGIMR	CHESS	Routinely	Surveillance data	Water PNG	Annual report	Annually	Aggregated report

37	Access to postal services	PNGIMR	CHESS	Routinely	Surveillance data	Post PNG	Annual report	Annually	Aggregated report
38	Access to electricity	PNGIMR	CHESS	Routinely	Surveillance data	PNG Power	Annual report	Annually	Aggregated report

CHESS = Comprehensive Health and Epidemiological Surveillance System
PNG = Papua New Guinea
PNGIMR = Papua New Guinea Institute of Medical Research
GNI = Gross National Income
NA = not available
NSO = National Statistics Office
NDoH = National Department of Health
NHIS = National Health Information System
HIV = human immunodeficiency virus
PLHIV = people living with HIV
ART = antiretroviral therapy
NDoE = National Department of Education
OHE = Office of Higher Education
NDoL = National Department of Labour
DNPM = Department of National Planning and Monitoring
INA = Institute of National Affairs

TABLE 3

CAPACITY OF CHESS TO REPORT UPON THE 2015 WHO GLOBAL REFERENCE LIST OF CORE HEALTH INDICATORS

Population health indicators (27 indicators)	**CHESS reporting capacity (21 indicators)**	**Risk factor indicators (21 indicators)**	**CHESS reporting capacity (12 indicators)**	**Health services coverage indicators (27 indicators)**	**CHESS reporting capacity (13 indicators)**	**Health systems indicators (24 indicators)**	**CHESS reporting capacity (6 indicators)**
Mortality by age and sex (6 indicators)	**6/6**	**Nutrition (7 indicators)**	**5/7**	**Reproductive, maternal, newborn, child and adolescent health (8 indicators)**	**8/8**	**Quality and safety of care (7 indicators)**	**1/7**
Life expectancy at birth	Yes	Exclusive breastfeeding rate 0-5 months of age	Yes	Demand for family planning satisfied with modern methods	Yes	Peri-operative mortality rate	No
Adult mortality rate between 15 and 60 years of age	Yes	Early initiation of breastfeeding	Yes	Contraceptive prevalence rate	Yes	Obstetric and gynaecological admissions due to abortion	No
Under-five mortality rate	Yes	Incidence of low birth weight among newborns	Yes	Antenatal care coverage	Yes	Institutional maternal mortality ratio	No
Infant mortality rate	Yes	Children under 5 years who are stunted	Yes	Births attended by skilled health personnel	Yes	Maternal death reviews	No
Neonatal mortality rate	Yes	Children under 5 years who are wasted	Yes	Postpartum care coverage	Yes	ART retention rate	No

Stillbirth rate	Yes	Anaemia prevalence in children	No	Care-seeking for symptoms of pneumonia	Yes	TB treatment success rate	Yes
Mortality by cause (7 indicators)	**7/7**	Anaemia prevalence in women of reproductive age	No	Children with diarrhoea receiving oral rehydration solution	Yes	Service-specific availability and readiness	No
Maternal mortality ratio	Yes	**Infections (1 indicator)**	**1/1**	Vitamin A supplementation coverage	Yes	**Access (4 indicators)**	**2/4**
TB mortality rate	Yes	Condom use at last sex with high-risk partner	Yes	**Immunization (1 indicator)**	**1/1**	Service utilization	Yes
AIDS-related mortality rate	Yes	**Environmental risk factors (4 indicators)**	**3/4**	Immunization coverage rate by vaccine in the national schedule	Yes	Health service access	Yes
Malaria mortality rate	Yes	Population using safely managed drinking water	Yes	**HIV (5 indicators)**	**0/5**	Hospital bed density	No
Mortality between 30 and 70 years from NCDs (cardiovascular, cancer, diabetes, chronic respiratory diseases)	Yes	Population using safely managed sanitation services	Yes	People living with HIV who have been diagnosed	No	Availability of essential medicines and commodities	No
Suicide rate	Yes	Population using modern fuels for cooking/lighting	Yes	Prevention of mother-to-child transmission	No	**Health workforce (2 indicators)**	**0/2**

Mortality rate from road traffic injuries	Yes	Air pollution level in cities	No	HIV care coverage	No	Health worker density and distribution	No
Fertility (2 indicators)	**2/2**	**Non-communicable diseases (8 indicators)**	**2/8**	ART coverage	No	Output training institutions	No
Adolescent fertility rate	Yes	Total alcohol consumption per capita (aged 15+ years)	No	HIV viral load suppression	No	**Health information (3 indicators)**	**3/3**
Total fertility rate	Yes	Tobacco use among persons aged 18+ years	Yes	**HIV/TB (3 indicators)**	**0/3**	Birth registration coverage	Yes
Morbidity (12 indicators)	**6/12**	Children aged under 5 years who are overweight	Yes	TB preventive therapy for HIV-positive people newly enrolled in HIV care	No	Death registration coverage	Yes
New cases of vaccine-preventable diseases	No	Overweight and obesity in adults *(Also: adolescents)*	No	HIV test results for registered new and relapse TB patients	No	Completeness of reporting by facilities	Yes
New cases of IHR-notifiable diseases and other notifiable diseases	No	Raised blood pressure among adults	No	HIV-positive new and relapse TB patients on ART during TB treatment	No	**Health financing (7 indicators)**	**0/7**
HIV incidence rate	No	Raised blood glucose/diabetes among adults	No	**Tuberculosis (3 indicators)**	**1/3**	Total current expenditure on health (% of gross domestic product)	No

HIV prevalence rate	No	Salt intake	No	TB patients with results for drug susceptibility testing	No	Current expenditure on health by general government and compulsory schemes (% of current expenditure on health)	No
Hepatitis B surface antigen prevalence	No	Insufficient physical activity in adults	No	TB case detection rate	Yes	Out-of-pocket payment for health (% of current expenditure on health)	No
Sexually transmitted infections (STIs) incidence rate	Yes	**Injuries (1 indicator)**	**1/1**	Second-line treatment coverage among multidrug-resistant tuberculosis (MDR-TB) cases	No	Externally sourced funding (% of current expenditure on health)	No
TB incidence rate	Yes	Intimate partner violence prevalence	Yes	**Malaria (4 indicators)**	**3/4**	Total capital expenditure on health (% current + capital expenditure on health)	No
TB notification rate	Yes			Intermittent preventive therapy for malaria during pregnancy (IPTP)	No	Headcount ratio of catastrophic health expenditure	No
TB prevalence rate	Yes			Use of insecticide-treated nets (ITNs)	Yes	Headcount ratio of impoverishing health expenditure	No

Malaria parasite prevalence among children aged 6−59 months	Yes	Treatment of confirmed malaria cases	Yes	**Health security (1 indicator)**	**0/1**
Malaria incidence rate	Yes	Indoor residual spraying (IRS) coverage	Yes	International Health Regulations core capacity index	No
Cancer incidence, by type of cancer	No	**Neglected tropical diseases (1 indicator)**	**0/1**		
		Coverage of preventive chemotherapy for selected neglected tropical diseases	No		
		Screening and preventive care (1 indicator)	**0/1**		
		Cervical cancer screening	No		
		Mental Health (1 indicator)	**0/1**		
		Coverage of services for severe mental health disorders	No		

Note: The proposed CHESS will be able to report on many indicators in the list of 'additional indicators' for the 2015 WHO 100 Core Health Indicators
CHESS = Comprehensive Health and Epidemiological Surveillance System
WHO = World Health Organization
ART = antiretroviral therapy
TB = tuberculosis
HIV = human immunodeficiency virus
NCDs = non-communicable diseases
IHR = International Health Regulations

TABLE 4

CHESS reporting capacity upon Sustainable Development Goal (SDG) 3-related targets and indicators

SDG target	SDG indicator	CHESS reporting capacity
Target 1: By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births	• Maternal mortality ratio	Yes
	• Proportion of births attended by skilled health personnel	Yes
Target 2: By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under-5 mortality to at least as low as 25 per 1000 live births	• Under-5 mortality rate	Yes
	• Neonatal mortality rate	Yes
Target 3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases	• Number of new HIV infections per 1000 uninfected population, by age, sex and key populations	No
	• Tuberculosis incidence per 1000 population	Yes
	• Malaria incidence per 1000 population	Yes
	• Hepatitis B incidence per 100,000 population	No
	• Number of people requiring interventions against neglected tropical diseases	No
Target 4: By 2030, reduce by one-third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being	• Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease	Yes
	• Suicide mortality rate	Yes

Target 5: Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol	• Coverage of treatment interventions for substance use disorders	No
	• Harmful use of alcohol rates	Yes
Target 6: By 2020, halve the number of global deaths and injuries from road traffic accidents	• Death rate due to road traffic injuries	Yes
Target 7: By 2030, ensure universal access to sexual and reproductive health care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programs	• Proportion of women of reproductive age who have their need for family planning satisfied by modern methods	Yes
	• Adolescent birth rate (in age groups of 10-14 and 15-19 years) per 1000 women in that age group	Yes
Target 8: Achieve universal health coverage, including financial risk protection, access to quality essential health care services and access to safe, effective, quality and affordable essential medicines and vaccines for all	• Coverage of essential health services	Yes
	• Number of people covered by health insurance or a public health system per 1000 people	No
Target 9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	• Mortality rate attributed to household and ambient air pollution	No
	• Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene	Yes
	• Mortality rate attributed to unintentional poisoning	No

CHESS = Comprehensive Health and Epidemiological Surveillance System
AIDS = acquired immune deficiency syndrome
HIV = human immunodeficiency virus

implementation of the National Health Plan 2020. CHESS is a valuable option for the PNG Government to consider for monitoring and reporting the implementation of these agendas. Sustainable development of CHESS needs a high level of political commitment and long-term funding.

To establish CHESS, the PNGIMR needs to further strengthen its strategic partnership with the Government Departments of Health, Planning and Statistics and local governments, as well as collaboration with international and local development partners, the private sector and research training institutions. Setting up a reliable mechanism for collaboration in data collection, reporting, sharing and linkage between PNGIMR, NDoH, DNPM and NSO, and with the INDEPTH, is the key to success in this initiative. Together with its partners, the PNG Government can seek and secure long-term funding to support the establishment and ongoing activities of CHESS.

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Computed tomography in patients diagnosed with stroke at Port Moresby General Hospital: a prospective descriptive study

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SUMMARY

In common with many other low/middle-income countries Papua New Guinea (PNG) is experiencing a rapid increase in non-communicable diseases (NCDs). Provision of appropriate diagnostic and treatment facilities presents a major challenge to the health system. In this, the first prospective descriptive study to determine the causes and pattern of stroke in Papua New Guinean patients, 200 patients diagnosed clinically with stroke were investigated with CT (computed tomography) at Port Moresby General Hospital. Of the 151 patients with confirmed stroke, 123 had infarcts, 25 haemorrhagic stroke and 3 haemorrhagic infarcts. 132 strokes (87%) occurred in the anterior cerebral circulation. 74 (49%) of the strokes were in the subcortical region, of which 36 were in the internal capsule. Of the 147 patients with information on risk factors 66 patients (45%) had hypertension as the only known risk factor whilst 60 (41%) had other risk factors in addition to hypertension. Only 16 (11%) had no known risk factors. Only 9 patients presenting with stroke accessed CT within 6 hours of onset – the window of opportunity for possible thrombolytic treatment. The study highlights the need for the development of policies that will allow timely access to appropriate diagnosis and treatment and indicates the pressing need for the population to be educated on preventive measures.

Introduction

Non-communicable diseases (NCDs), comprising cardiovascular diseases, cancers, diabetes and chronic lung diseases, are the leading causes of adult deaths globally (1). Cardiovascular diseases account for 31% of these adult deaths. Nearly 80% of NCD deaths occur in low- and middle-income countries (1). Stroke or cerebrovascular accident (CVA) is a focal neurological deficit of vascular origin lasting more than 24 hours and is preceded by a transient ischaemic attack in 10-15% of cases (2). It may be due to infarction (ischaemic stroke) or haemorrhage. Haemorrhagic stroke results either from aneurysmal subarachnoid bleeding or hypertensive intracranial bleeding. Changes in lifestyle and the increase in lifestyle diseases such as hypertension and diabetes contribute to atherosclerosis, which predisposes to thrombosis and embolism – the causes of ischaemic stroke. Ischaemic stroke is the second commonest cause of adult deaths and the sixth leading cause of disease burden globally and is expected to move to the fourth place by 2020. Over 80% of all stroke deaths occur in developing countries (3). In the Pacific region, the incidence of NCDs, including stroke, is increasing rapidly due to the pronounced changes in lifestyle (4).

According to the National Institute for Health and Care Excellence (NICE) guidelines for stroke, thrombolysis with alteplase is recommended for the treatment of acute ischaemic stroke in a well-organized stroke service with staff trained in delivering thrombolysis and in monitoring for its complications. Aspirin and anticoagulant treatment are given to ischaemic stroke patients as soon as they are diagnosed, if possible within 24 hours. These and other guidelines depend on an accurate and

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rapid diagnosis and a distinction between haemorrhagic and ischaemic stroke, and this can only be done with modern imaging such as computed tomography (CT) or magnetic resonance imaging (MRI) (5-7).

Whilst CT has been available in the private sector for a number of years, Port Moresby General Hospital was the only public hospital in Papua New Guinea (PNG) with a functioning CT facility at the time of the study. There are often delays in patients with stroke reaching the hospital and being assessed and managed and for these patients and for those in other parts of the country management is clearly substandard, with no early interventional management and less than optimal outcome. Aspirin administration is at least theoretically dangerous for those who have suffered haemorrhagic stroke. There is, therefore, a need to formulate a policy on the management of stroke but this requires information on the type of stroke, and the risk factors associated with each type.

The aim of this study was to determine the patterns of stroke seen on CT in a cohort of Papua New Guinean patients and if possible to link these with risk factors. The objectives were to determine:

- the type of stroke and its vascular origin;
- associated risk factors; and
- factors contributing to delayed presentation, diagnosis and management.

It is hoped that the findings from the study might help in formulating effective stroke management guidelines for Papua New Guinea.

Patients and Methods

This prospective descriptive study conducted between 22 September 2014 and 27 April 2015 at Port Moresby General Hospital included all indigenous patients clinically diagnosed with stroke by the emergency medical practitioners and internal medicine doctors and sent to the Department of Medical Imaging for CT. Our machine is a Siemens serial No 4104, Model No 08098555, and 3 mm and 5 mm CT slices were made. Since time to CT scanning is a crucial factor in determining the type and appropriate management of stroke patients, all patients presenting with stroke symptoms during the duration of the study had CT scans whether or not they were able to pay. A semi-structured questionnaire was used to interview the patient or the guardian in the CT room. Questions related to patient identification, risk factors, social habits and other demographics including age, sex, province of origin and duration of residence in Port Moresby. Additional information regarding risk factors for stroke and investigation results was obtained from the patient's clinic record books and charts. Patients who had a recent history of trauma to the head and patients clinically suspected of any brain infections were excluded from the study.

CT scans were initially reported by the registrar on call or the first author and were reviewed and signed out by the Chief Radiologist. Data were entered onto an Excel spreadsheet.

Results

204 patients diagnosed clinically with stroke between 22 September 2014 and 27 April 2015 were included. Figure 1 illustrates the CT scan diagnoses.

Patient sex and age are shown in Table 1. 98 (65%) of the 151 Papua New Guinean stroke patients were males. The median age was 65 years for females and 59.5 years for males. 81% of the strokes (n = 123) were due to infarcts, 17% (n = 25) were haemorrhagic and 2% (n = 3) were haemorrhagic infarcts. The distribution was similar in males and females. Of the 49 non-stroke patients 30 had a normal scan (probably a transient ischaemic attack [TIA]), 16 had a space-occupying lesion (SOL), 1 had evidence of trauma and 2 were of unknown cause.

The types of stroke in the different cerebral circulations are shown in Table 2. 87% (n = 132) of the stroke cases occurred in the anterior cerebral circulation (middle and anterior cerebral artery territories) while 9% (n = 13) occurred in the posterior circulation (vertebrobasilar arteries territory). 4% (n = 6) of the stroke cases involved both the anterior and posterior cerebral circulations.

The distribution of stroke according to cortical and subcortical regions and

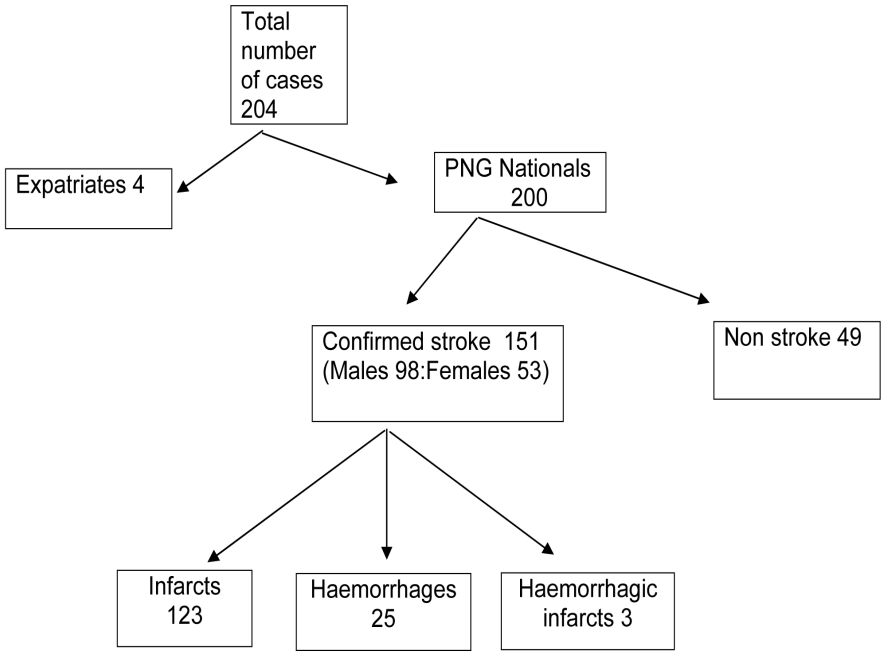

Figure 1. Patients diagnosed clinically with stroke and investigated with computed tomography at Port Moresby General Hospital, Sep 2014-Apr 2015.

structures is shown in Table 3. 74 (49%) of the strokes were subcortical, 27 (18%) were cortical, 37 (25%) involved both cortical and subcortical structures and 13 (9%) involved the brainstem and cerebellum. The most common subcortical structure involved was the internal capsule. Of the 36 lesions in the internal capsule, 5 were in the anterior limb, 9 in the genu, 8 in the posterior limb and 7 in each of the genu/anterior limb and genu/posterior limb regions.

The presenting symptoms are shown in Table 4 and risk factors in the stroke patients are shown in Table 5. 45% of stroke patients had hypertension as the only risk factor, whilst 41% had other risk factors in addition to hypertension. Among them 19 patients had diabetes with hypertension, 18 had hyperlipidaemia with hypertension and 8 patients had all three risk factors. Diabetes, hyperlipidaemia and cardiovascular disease were present in the majority of patients with hypertension. 45 of the patients smoked tobacco whilst 10 had previously smoked.

Only 9 patients (6%) presented for CT within 6 hours. The median number of days taken to do CT scans among all stroke patients was 4 days. 29 patients presented for CT scan in the first 24 hours. Only 5 of the 123 patients with infarcts had a CT scan within 6 hours. The most common reasons for late CT scan were delayed presentation to the hospital (65/142) and delay in diagnosis at the Emergency Department (45/142).

Discussion

This paper has described the pattern of stroke seen in Papua New Guinean patients at Port Moresby General Hospital. The pattern is similar to that seen in other countries, including low/middle-income countries (2,8-11), with the majority of strokes being infarcts and with a median age higher in females than males. Whilst the study was not designed to assess the magnitude of association of attributable risk factors with stroke in this population, risk factors were present in the majority of patients. 126 (86%) of 147 patients were hypertensive, consistent with global data (12), and half of these patients had other risk factors (Table 5). 55 patients (36%) were either current or past smokers and smoking doubles the risk of stroke (13). 18 were known to have elevated lipids, and 19 to be diabetic. The median age of stroke in females (65 years) and males

TABLE 1

Sex and age of Papua New Guinean stroke patients

Type of CVA	Age in years									
	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Not known	Total
Male										
Haemorrhagic	0	2	3	3	5	1	0	0	0	14
Infarct	1	5	10	24	23	7	4	1	6	81
Haemorrhagic infarct	-	-	1	1	1	-	-	-	-	3
Total	1	7	14	28	29	8	4	1	6	98
Female										
Haemorrhagic	1	0	3	2	2	3	0	0	0	11
Infarct	6	0	3	9	14	6	2	2	0	42
Haemorrhagic infarct	-	-	-	-	-	-	-	-	-	-
Total	7	0	6	11	16	9	2	2	0	53
Total	8	7	20	39	45	17	6	3	6	151

CVA = cerebrovascular accident

TABLE 2

Types of stroke according to anterior and posterior cerebral circulation

	Anterior		Posterior		Both	
Stroke type	**n**	**%**	**n**	**%**	**n**	**%**
Infarct	105	80	13	100	5	83
Haemorrhage	24	18	0	0	1	17
Haemorrhagic infarct	3	2	0	0	0	0
Total	132	100	13	100	6	100

TABLE 3

Distribution of stroke according to cortical and subcortical regions and structures

Stroke distribution in brain		**n**	**%**
Cortical		27	17.9
Subcortical		74	49.0
Lentiform nucleus	4		
Internal capsule	36		
External capsule	1		
Caudate nucleus	2		
Corpus callosum	4		
Internal capsule and Lentiform nucleus	17		
Posterior limb internal capsule/Thalamus	2		
Corpus callosum/Lentiform/Internal capsule	2		
Corpus callosum/Internal capsule	4		
Internal capsule/Thalamus	1		
External capsule/Lentiform nucleus	1		
Total	74		
Both cortical and subcortical		37	24.5
Brainstem/Cerebellum		13	8.6
Total		151	100

TABLE 4

Presenting symptoms among confirmed stroke patients

Presenting symptoms		**n**	**% N = 149**
Hemiparesis		27	18
Hemiparesis and other symptoms		101	68
Other symptoms without hemiparesis:			
Headache and other symptoms	7		
Fitting and collapse	2		
Speech difficulty	7		
Bilateral weakness and hemianopsia	5		
Total		21	14
Unknown		2	
Total		151	100

TABLE 5

Risk factors among stroke patients

Risk factors	**n**	**% N = 147**
Hypertension alone	66	45
Hypertension and other risk factors	60	41
Normotensive with other risk factors	5	3
No risk factors	16	11
No information	4	
Total	151	100

(59.5 years) suggests a lower age group than in the United States of America (USA), where almost 75% of stroke victims are older than 65 years (12).

The disease pattern in PNG is changing from that of predominant infectious diseases with little non-communicable disease to that of infectious disease plus a considerable and rapidly increasing burden of NCDs – the double burden of a rapidly developing low/middle-income country. This changing pattern is driven primarily by a change from a village-based to a western lifestyle and presents major challenges for a fragile health system.

Only 9 (6%) of the patients presenting with stroke accessed CT scan within 6 hours of onset, which is the window of opportunity for thrombolytic treatment (14). There is

little advantage to the patient in knowing the underlying pathology of the stroke, if nothing can be done to ameliorate the sequelae other than to prescribe aspirin if the stroke is ischaemic. If the full benefit of the CT scan is to be obtained in our context, every effort needs to be made to reduce the time from onset to scan. This involves formulating and following appropriate guidelines not only for doctors working in the hospital, but for general practitioners and health workers in community clinics. It also involves education of the community about non-communicable diseases, the presentations of stroke and the need to access the health services quickly.

This is the first study of stroke victims in PNG based on CT findings. It confirms that ischaemic stoke accounts for the majority of cases, and highlights the need for the development of policies that will allow timely access to appropriate investigations and treatment for those who have suffered a stroke.

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List of Medical Research Projects in Papua New Guinea

Approved or Noted

By the Medical Research Advisory Committee in 2016

Sexual, reproductive and maternal health (SRMH) related vulnerabilities for young women in the Autonomous Region of Bougainville
Mr Morgan Garcia (Manager, Sexual, Reproductive and Maternal Health, Care International in PNG, PO Box 1157, Goroka, Eastern Highlands Province, Papua New Guinea)

Experiences of women accessing unsafe abortion services in Papua New Guinea
Mr Elias Namosha (Marie Stopes PNG, PO Box 972, Waigani, National Capital District, Papua New Guinea)

What are the reasons for and pattern of early discontinuation of contraceptive implant among women in PNG
Mr Elias Namosha (Marie Stopes PNG, PO Box 972, Waigani, National Capital District, Papua New Guinea)

Assessing client satisfaction and perception of quality with services through exit interviews
Ms Francisca Base (Marie Stopes PNG, PO Box 972, Waigani, National Capital District, Papua New Guinea)

Global Youth Tobacco Survey
Ms Vicky Wari (National Department of Health, PO Box 807, Waigani, National Capital District, Papua New Guinea)

Transition into professional practice: The experience of new graduate nurses at a large teaching hospital in Papua New Guinea
Ms Julieanne Omaro (Pacific Adventist University, Private Mail Bag, Boroko, National Capital District, Papua New Guinea)

Community based study of 2-drug versus 3-drug therapy for lymphatic filariasis in Papua New Guinea
Dr Christopher King, Dr Leanne Robinson and Prof. Peter Siba (Papua New Guinea Institute of Medical Research, PO Box 400, Maprik, East Sepik Province)

Understanding human, parasite, vector and environmental interactions driving residual malarial transmission in Papua New Guinea
Dr Moses Laman (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

PNG pneumonia and meningitis aetiology study of the impact of the pneumococcal conjugate vaccine in hospitalized children with pneumonia and meningitis
Dr Christopher Blyth and Dr William Pomat (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Impact of vector control on human immunity to malaria and genetic complexity of *P. falciparum* and *P. vivax* in two holoendemic areas of Papua New Guinea (ICEMR DMID#10-0035)
Dr James Kazura and Prof. Peter Siba (Center for Global Health & Diseases, Case Western Reserve University School of Medicine, 10900 Euclid Avenue (BRB Bldg, Room 423), Cleveland, OH 44106-7286, USA)

Optimisation of antimicrobial therapy for severe bacterial infections in neonates and young children in Papua New Guinea
Dr Laurens Manning (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Evaluate triple drug therapy with diethylcarbamazine (DEC), albendazole (ALB) and ivermectin (IVM) that could accelerate LF elimination
Dr Christopher L. King and Prof. Peter Siba (Center for Global Health & Diseases,

Case Western Reserve University School of Medicine, Wolstein Research Building, Room 4-125 2103, 2103 Cornell Road, Cleveland, Ohio 44106-7286, USA)

Immunogenicity of pneumonia conjugate vaccination in non-pregnant Papua New Guinean women

Dr Anita van den Biggelaar, Dr William Pomat, Dr Deborah Lehmann, Dr Deborah Strickland, Dr Peter Richmond, Dr Christopher Blyth, Ms Wendy Kirarok, Ms Jacinta Francis (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Pilot study for NIH proposal: Characterizing global molecular (OMIC) signatures induced by Expanded Program on Immunization (EPI) vaccines in infancy

Dr Anita van den Biggelaar, Dr William Pomat, Dr Peter Richmond, Dr Ofer Levy and Dr Tobias Kollman (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Prevalence of TB in a remote district of Papua New Guinea

Ms Bindu Kumari Karki (Holtzendorffstrasse 20, 14057 Berlin, Germany)

Safety and efficacy of oral misoprostol for the induction of labour in Papua New Guinean women: low dose regimen versus standard treatment regimen

Dr John Bolgna (Modilon General Hospital, PO Box 2119, Madang, Madang Province, Papua New Guinea)

Exploring enablers and barriers to creating an Electronic Health (E-Health) patient record system in PNG

Mr Rone Aikebuse (Griffith University, 604/4 Como Crescent, Southport, Queensland 4215, Australia)

Improved testing rates among HIV-exposed infants using a newly developed early infant diagnostic test in Myanmar and Papua New Guinea: accelerating HIV testing and ART initiation among infants (AAMI)

A/Prof. Stanley Luchters, Prof. Andrew Vallely and Dr Hla Htay (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Health patrol and data collection program in the Nautilus Minerals Coastal Area of Benefit, New Ireland Province, PNG

Dr Jethro Usurup (Abt JTA, PO Box 1206, Waigani, National Capital District, Papua New Guinea)

Settlement history in Papua New Guinea: multidisciplinary approach from archaeo-sciences and molecular anthropology to reveal complex cultural and biological history

Dr Francois-Xavier Ricaut (UMR5288 CNRS, University of Toulouse, France)

Health services for postnatal and infancy care: Healthy Mothers Healthy Babies, Study 2a

Dr Christopher Morgan, Dr Nicholas Larme and Ms Nelly Saweri (Public Health Interventions Research Group, The Kirby Institute, University of New South Wales, Sydney, New South Wales 2033, Australia)

The prognostic value of intraleukocytic malaria pigment in predicting disease severity and its association with clinical manifestations of malaria in Papua New Guinea children

Mr Elvin Lufele, Dr Moses Laman and Dr Leanne Robinson (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

Cluster randomized cross-over trial to evaluate point-of-care testing and treatment of sexually transmitted infections to improve birth outcomes in high-burden, low-income settings - WANTAIM: Women and Newborn Trial of Antenatal Interventions and Management

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

Metabolic markers of *Plasmodium vivax* liver-stage infection and genetic determinants of relapse

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

P. vivax invasion assays and *P. vivax* and *P. falciparum* membrane feeding assays as tools to significantly improve research capability on a neglected parasite

Dr Stephan Karl, Dr Leanne Robinson, Dr Moses Laman, Dr Wai-Hong Tham and Dr

Christopher King (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

Increased awareness of and access to diabetes and tuberculosis care in New Ireland Province

A/Prof. Usman Malabu (School of Medicine and Dentistry, James Cook University, Townsville, Queensland 4811, Australia)

Sports for Development (S4D): understanding linkages for enhanced outcomes in sport participation, WASH, and women's leadership in Papua New Guinea (PNG)

Dr Regina Souter (International Water Centre, 16/333 Ann St, Brisbane, Queensland 4000, Australia)

Kauntim mi tu: KP IBBS

Dr Angela Kelly-Hanku (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

CYP2B6 polymorphisms and efavirenze plasma monitoring in PNG HIV/AIDS patients with TB co-infection

Dr Paul Pumuye (Division of Basic Medical Sciences, School of Medicine and Health Sciences, University of Papua New Guinea, PO Box 5623, Boroko, National Capital District, Papua New Guinea)

Situation analysis of imported salt and rice into Papua New Guinea: number and quantity of imports and extent of fortification

A/Prof. Victor Temple (Division of Basic Medical Sciences, School of Medicine and Health Sciences, University of Papua New Guinea, PO Box 5623, Boroko, National Capital District, Papua New Guinea)

Robust information technology (IT) health database: case study analysis of health in Papua New Guinea

Ms Pita Luke (Queensland University of Technology (QUT), 5/3 Grove St, Toowong, Queensland 4066, Australia)

Rapid assessment of avoidable blindness in Papua New Guinea

Dr Anthea Burnett (PNG Eye Care, PO Box 913, Boroko, National Capital District, Papua New Guinea and Lions National Resources Centre for Eye Health, School of Medicine and Health Sciences, University of Papua New Guinea, PO Box 5623, Boroko, National Capital District, Papua New Guinea)

Mapping trachoma in Papua New Guinea as part of the Global Trachoma Mapping Project (GTMP) and other vaccine-preventable and tropical diseases

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

Efficacy of multi-micronutrient fortified food on nutrition status of primary school children in Lae

Dr Jayashree Arcot (Faculty of Engineering, University of New South Wales, Sydney, New South Wales 2052, Australia)

Therapeutic efficacy of artemether-lumefantrine for the treatment of uncomplicated *Plasmodium falciparum* malaria in Papua New Guinea, 2016-2017

Dr Leonard Nawara (Malaria and Vector Borne Diseases, National Department of Health, PO Box 807, Waigani, National Capital District, Papua New Guinea)

Pre-treatment HIV drug resistance in Papua New Guinea

Dr Nick Dala and Dr Janet Gare (HIV/AIDS/STI, National Department of Health, PO Box 807, Waigani, National Capital District, Papua New Guinea)

Retrospective surveillance for *P. falciparum* and *P. vivax* parasites carrying artemisinin resistant mutations in the Pacific region

Dr Qin Cheng (Head, Drug Resistance and Diagnostics, Australian Army Malaria Institute, K10-1-G-77, Weary Dunlop Drive, Gallipoli Barracks, Enoggera, Queensland 4051, Australia)

Epidemiology of antimalarial drug resistance in Papua New Guinea: Monitoring currently used anti-malarial drugs for parasite resistance

Prof. Francis Hombhanje (Center for Health Research and Diagnostics, Divine Word University, PO Box 483, Madang, Madang Province, Papua New Guinea)

Use of whole genome sequencing to improve patient care and control of the M/XDR-TB epidemic on Daru Island, Papua New Guinea

Dr Evelyn Lavu and Dr Chris Coulter (Director, Central Public Health Laboratory, Port Moresby General Hospital, Private Mail Bag No 1, Boroko, National Capital District, Papua New Guinea)

Improving understanding and diagnostic capacity of important bacterial gastrointestinal pathogens in Papua New Guinea

Dr Andrew Greenhill, Ms Elisheba Malau, Dr Rebecca Ford, A/Prof. Kathryn Holt, Dr William Pomat and Prof. Peter Siba (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Whole genome analysis of isolates from Papua New Guinea (inclusion in Global Pneumococcal Sequencing Project)

Dr Lesley McGee and Dr William Pomat (Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, Eastern Highlands Province, Papua New Guinea)

Field-based evaluation of a novel rapid and sensitive technique to diagnose malaria

Dr Stephan Karl, Dr Moses Laman, Prof. Istvan Kezsmarki and Dr Leanne Robinson (Papua New Guinea Institute of Medical Research, PO Box 378, Madang, Madang Province, Papua New Guinea)

Note:

These projects have been examined and cleared by the MRAC but they have not all started, nor is there any guarantee that they all will, since in many cases this still depends on funding. It should be noted that the project funds for the MRAC were deleted from the Health Budget from 1997 to 2016.

Information about these projects may be obtained from the investigators or from the Chairperson of the Medical Research Advisory Committee (Director of Research and Monitoring, Department of Health, PO Box 807, Waigani, National Capital District, Papua New Guinea).

MEDLARS BIBLIOGRAPHY

Publications of relevance to Papua New Guinea and Melanesia

Bibliographic Citation List generated from MEDLARS

1 **Allen T, Taleo F, Graves PM, Wood P, Taleo G, Baker MC, Bradley M, Ichimori K.**
Impact of the Lymphatic Filariasis Control Program towards elimination of filariasis in Vanuatu, 1997-2006.
Trop Med Health 2017 Jun 1;45:8. doi: 10.1186/s41182-017-0047-8. eCollection 2017.

BACKGROUND: Lymphatic filariasis (LF) occurs when filarial parasites are transmitted to humans through mosquitoes. The filarial worms affect the lymphatic system which leads to abnormal enlargement of body parts, chronic pain, disability, and social discrimination. In 1999, a commitment was made to eliminate LF from the Pacific Region by 2010. The Pacific Program to Eliminate LF began, with Vanuatu being one of the 16 endemic countries included in this program. METHODS: In 1997/1998 a LF prevalence baseline survey was conducted to determine the need for mass drug administration (MDA) in Vanuatu. In 1999, the Vanuatu Lymphatic Filariasis Control Program was established, and nationwide MDA was implemented from 2000 to 2004. LF prevalence was collected during the MDA through sentinel site and spot check surveys, and after 5 years of MDA. MDA implementation methods included health worker training, social mobilization, and culturally appropriate health promotion strategies. RESULTS: LF prevalence at baseline was 4.79%; after MDA this declined to 0.16% in 2005/2006. Average MDA coverage ranged from 75.5-81.5% across 5 years. All three evaluation units surveyed in 2005/2006 were below the 1% threshold required to stop MDA. CONCLUSIONS: The LF Control Program between 1997 and 2006 was successful in reducing LF prevalence to <1%. High MDA coverage was a critical component of this success. This period of the Vanuatu LF Control Program played an important role in helping to eliminate LF in Vanuatu.

2 **Almaliti J, Malloy KL, Glukhov E, Spadafora C, Gutiérrez M, Gerwick WH.**
Dudawalamides A-D, antiparasitic cyclic depsipeptides from the marine cyanobacterium *Moorea producens*.
J Nat Prod 2017 Jun 23;80(6):1827-1836. doi: 10.1021/acs.jnatprod.7b00034. Epub 2017 May 23.

A family of 2,2-dimethyl-3-hydroxy-7-octynoic acid (Dhoya)-containing cyclic depsipeptides, named dudawalamides A-D (1-4), was isolated from a Papua New Guinean field collection of the cyanobacterium *Moorea producens* using bioassay-guided and spectroscopic approaches. The planar structures of dudawalamides A-D were determined by a combination of 1D and 2D NMR experiments and MS analysis, whereas the absolute configurations were determined by X-ray crystallography, modified Marfey's analysis, chiral-phase GCMS, and chiral-phase HPLC. Dudawalamides A-D possess a broad spectrum of antiparasitic activity with minimal mammalian cell cytotoxicity. Comparative analysis of the Dhoya-containing class of lipopeptides reveals intriguing structure-activity relationship features of these NRPS-PKS-derived metabolites and their derivatives.

3 **Ash A, Elliot A, Godfrey S, Burmej H, Abdad MY, Northover A, Wayne A, Morris K, Clode P, Lymbery A, Thompson RC.**
Morphological and molecular description of *Ixodes woyliei* n. sp. (Ixodidae) with consideration for co-extinction with its critically endangered marsupial host.
Parasit Vectors 2017 Feb 7;10(1):70. doi: 10.1186/s13071-017-1997-8.

BACKGROUND: Taxonomic identification of ticks obtained during a longitudinal survey of the critically endangered marsupial, *Bettongia penicillata* Gray, 1837 (woylie, brush-tailed bettong) revealed a new species of *Ixodes* Latrielle, 1795. Here we provide morphological data for the female and nymphal life stages of this novel species (*Ixodes woyliei* n. sp.), in combination with molecular characterisation using the mitochondrial cytochrome c oxidase subunit 1 gene (*cox1*). In addition, molecular characterisation was conducted on several described *Ixodes* species and used to provide phylogenetic context. RESULTS: *Ixodes* spp. ticks were collected from the two remaining indigenous *B. penicillata* populations in south-western Australia. Of 624 individual *B. penicillata* sampled, 290 (47%) were host to ticks of the genus *Ixodes*; specifically *I. woyliei* n. sp., *I. australiensis* Neumann, 1904, *I. myrmecobii* Roberts, 1962, *I. tasmani* Neumann, 1899 and *I. fecialis* Warburton & Nuttall, 1909. Of these, 123 (42%) were host to the newly described *I. woyliei* n. sp. In addition, 268 individuals from sympatric marsupial species (166 *Trichosurus vulpecula hypoleucus* Wagner, 1855 (brushtail possum), 89 *Dasyurus geoffroii* Gould, 1841 (Western quoll) and 13 *Isoodon obesulus fusciventer* Gray, 1841 (southern brown bandicoot)) were sampled for ectoparasites and of these, *I. woyliei* n. sp. was only found on two *I. o. fusciventer*. CONCLUSIONS: Morphological and molecular data have confirmed the first new Australian *Ixodes* tick species described in over 50 years, *Ixodes woyliei* n. sp. Based on the long-term data collected, it appears this tick has a strong predilection for *B. penicillata*, with 42% of *Ixodes* infections on this host identified as *I. woyliei* n. sp. The implications for this host-parasite relationship are unclear but there may be potential for a future co-extinction event. In addition, new molecular data have been generated for collected specimens of *I. australiensis*, *I. tasmani* and museum specimens of *I. victoriensis* Nuttall, 1916, which for the first time provides molecular support for the subgenus *Endopalpiger* Schulze, 1935 as initially defined. These genetic data provide essential information for future studies relying on

genotyping for species identification or for those tackling the phylogenetic relationships of Australian *Ixodes* species.

4 **Aubry M, Teissier Y, Mapotoeke M, Teissier A, Giard M, Musso D, Cao-Lormeau VM.**
High risk of dengue type 2 outbreak in French Polynesia, 2017.
Euro Surveill 2017 Apr 6;22(14). pii: 30505. doi: 10.2807/1560-7917.ES.2017.22.14.30505.

In French Polynesia, the four serotypes of dengue virus (DENV-1 to -4) have caused 14 epidemics since the mid-1940s. From the end of 2016, an increasing number of Pacific Island countries and territories have reported DENV-2 outbreaks and in February 2017, DENV-2 infection was detected in French Polynesia in three travellers from Vanuatu. As DENV-2 has not been circulating in French Polynesia since December 2000, there is high risk for an outbreak to occur.

5 **Bardají A, Martínez-Espinosa FE, Arévalo-Herrera M, Padilla N, Kochar S, Ome-Kaius M, Bôtto-Menezes C, Castellanos ME, Kochar DK, Kochar SK, Betuela I, Mueller I, Rogerson S, Chitnis C, Hans D, Menegon M, Severini C, Del Portillo H, Dobaño C, Mayor A, Ordi J, Piqueras M, Sanz S, Wahlgren M, Slutsker L, Desai M, Menéndez C; PregVax Study Group.**
Burden and impact of *Plasmodium vivax* in pregnancy: a multi-centre prospective observational study.
PLoS Negl Trop Dis 2017 Jun 12;11(6):e0005606. doi: 10.1371/journal.pntd.0005606. eCollection 2017 Jun.

BACKGROUND: Despite that over 90 million pregnancies are at risk of *Plasmodium vivax* infection annually, little is known about the epidemiology and impact of the infection in pregnancy. METHODOLOGY AND PRINCIPAL FINDINGS: We undertook a health facility-based prospective observational study in pregnant women from Guatemala (GT), Colombia (CO), Brazil (BR), India (IN) and Papua New Guinea (PNG). Malaria and anemia were determined during pregnancy and fetal outcomes assessed at delivery. A total of 9388 women were enrolled at antenatal care (ANC), of whom 53% (4957) were followed until delivery. Prevalence of *P. vivax* monoinfection in maternal blood at delivery was 0.4% (20/4461) by microscopy [GT 0.1%, CO 0.5%, BR 0.1%, IN 0.2%, PNG 1.2%] and 7% (104/1488) by PCR. *P. falciparum* monoinfection was found in 0.5% (22/4463) of women by microscopy [GT 0%, CO 0.5%, BR 0%, IN 0%, PNG 2%]. *P. vivax* infection was observed in 0.4% (14/3725) of placentas examined by microscopy and in 3.7% (19/508) by PCR. *P. vivax* in newborn blood was detected in 0.02% (1/4302) of samples examined by microscopy [in cord blood; 0.05% (2/4040) by microscopy, and 2.6% (13/497) by PCR]. Clinical *P. vivax* infection was associated with increased risk of maternal anemia (Odds Ratio-OR, 5.48, [95% CI 1.83-16.41]; p = 0.009), while submicroscopic vivax infection was not associated with increased risk of moderate-severe anemia (Hb<8g/dL) (OR, 1.16, [95% CI 0.52-2.59]; p = 0.717), or low birth weight (<2500g) (OR, 0.52, [95% CI, 0.23-1.16]; p = 0.110). CONCLUSIONS: In this multicenter study, the prevalence of *P. vivax* infection in pregnancy by microscopy was overall low across all endemic study sites; however, molecular methods revealed a significant number of submicroscopic infections. Clinical vivax infection in pregnancy was associated with maternal anemia, which may be deleterious for infant's health. These results may help to guide maternal health programs in settings where vivax malaria is endemic; they also highlight the need of addressing a vulnerable population such as pregnant women while embracing malaria elimination in endemic countries.

6 **Binns CW, Lee MK, Kagawa M, Low WY, Liqian Q, Guldan GS, Hokama T, Nanishi K, Oy S, Tang L, Zerfas A.**
Dietary Guidelines for the Asia Pacific Region.
Asia Pac J Public Health 2017 Mar;29(2):98-101. doi: 10.1177/1010539517694295.

Nutrition is a major determinant of health throughout all stages of life and together with smoking is the most important risk factor for morbidity and mortality in the Asia Pacific Region. The workshop participants examined Dietary Guidelines and Food Guides that are in use in our region, together with additional materials from the World Health Organization, UNICEF and the World Cancer Research Foundation. The resulting set of guidelines is meant as a reminder of the main issues to be covered in a general public health education program. It may also be of value in reminding public health practitioners, educators, administrators, and policy makers of current nutrition issues. It may additionally be useful as a checklist of the issues to be considered in public health programs and regulations. The main areas of nutrition that are included in the Guidelines are eating a variety of foods, including vegetables, fruits, whole grain cereals, and nuts. Choose fish, poultry, and meats grown in a sustainable way. Appropriate growth, including avoiding obesity, and physical activity are important. Breastfeeding is the basis of infant nutrition and nutrition of mothers is an important public health measure. Negative factors in the Asian diet include salt, refined sugar, alcohol and fats. The APACPH Dietary Guidelines will need to be kept under review and modified to meet regional differences in food supply. The Guidelines will be useful as a checklist of the issues to be considered in public health programs, addressing both acute and chronic diseases.

7 **Blyth CC, Ford R, Sapura J, Kumani T, Masiria G, Kave J, Yuasi L, Greenhill A, Hwaihwanje I, Lang A, Lehmann D, Pomat W; Papua New Guinea Pneumonia and Meningitis Etiology Study Team.**
Childhood pneumonia and meningitis in the Eastern Highlands Province, Papua New Guinea in the era of conjugate vaccines: study methods and challenges.
Pneumonia (Nathan) 2017 Mar 5;9:5. doi: 10.1186/s41479-017-0029-y. eCollection 2017.

BACKGROUND: Pneumonia and meningitis are common causes of severe childhood illness in Papua New Guinea (PNG). The etiology of both clinical conditions in PNG has not been recently assessed. Changes in lifestyle, provision and access to healthcare, antimicrobial utilization and resistance, and the national childhood vaccination schedule necessitate reassessment. METHODS: A prospective case-control study was undertaken, enrolling children <5 years of age to determine the contemporary etiology of clinically defined moderate or severe pneumonia or suspected meningitis. Cases were identified following presentation for

inpatient or outpatient care in Goroka town, the major population centre in the Eastern Highlands Province. Following enrolment, routine diagnostic specimens including blood, nasopharyngeal swabs, urine and (if required) cerebrospinal fluid, were obtained. Cases residing within one hour's drive of Goroka were followed up, and recruitment of healthy contemporaneous controls was undertaken in the cases' communities. RESULTS: 998 cases and 978 controls were enrolled over 3 years. This included 784 cases (78.6%) with moderate pneumonia, 187 (18.7%) with severe pneumonia and 75 (7.5%) with suspected meningitis, of whom 48 (4.8%) had concurrent pneumonia. The median age of cases was 7.8 months (Interquartile range [IQR] 3.9-14.3), significantly lower than community controls, which was 20.8 months (IQR 8.2-36.4). Half the cases were admitted to hospital (500/998; 50.1%). Recruitment of cases and controls and successful collection of diagnostic specimens improved throughout the study, with blood volume increasing and rates of blood culture contamination decreasing. The overall case fatality rate was 18/998 (1.8%). Of cases eligible for follow-up, outcome data was available from 76.7%. Low but increasing coverage of *Haemophilus influenzae* type b conjugate vaccines on the national schedule was observed during the study period: three dose DTPw-HepB-Hib coverage in children >3 months increased from 14.9 to 43.0% and 29.0 to 47.7% in cases and controls (both $p < 0.001$). Despite inclusion in the national immunization program in 2014, 2015 PCV13 three-dose coverage in cases and controls >3 months was only 4.0 and 6.5%. CONCLUSIONS: Recruitment of large numbers of pediatric pneumonia and meningitis cases and community controls in a third-world setting presents unique challenges. Successful enrolment of 998 cases and 978 controls with comprehensive clinical data, biological specimens and follow up was achieved. Increased vaccine coverage remains an ongoing health priority.

8 **Bradbury RS, Hii SF, Harrington H, Speare R, Traub R.**
Ancylostoma ceylanicum hookworm in the Solomon Islands.
Emerg Infect Dis 2017 Feb;23(2):252-257. doi: 10.3201/eid2302.160822.

Although hookworm is highly prevalent in the Solomon Islands, the species involved are unknown. We initiated this study in response to finding *Ancylostoma ceylanicum* hookworm in a peacekeeper in Australia who had returned from the Solomon Islands. Kato-Katz fecal surveys performed in 2013 and 2014 in 2 village groups in East Malaita, Solomon Islands, identified hookworm-positive samples. These specimens were tested by cytochrome oxidase 1 (cox-1) gene multiplex PCR and sequenced. Of 66 positive specimens, 54 (81.8%) contained only *Necator americanus*, 11 (16.7%) contained only *A. ceylanicum*, and 1 (1.5%) contained both species. *A. duodenale* was not found. Haplotype analysis of *cox-1* sequences placed all human isolates (99% bootstrap support) of *A. ceylanicum* within the zoonotic clade rather than the human-specific clade. This study confirms that *A. ceylanicum* is endemic in the East Malaita region of this Pacific Island nation. The strain of the *A. ceylanicum* in this region can be shared among humans, dogs, and cats.

9 **Breakwell L, Anga J, Dadari I, Sadr-Azodi N, Ogaoga D, Patel M.**
Evaluation of storing hepatitis B vaccine outside the cold chain in the Solomon Islands: identifying opportunities and barriers to implementation.
Vaccine 2017 May 15;35(21):2770-2774. doi: 10.1016/j.vaccine.2017.04.011. Epub 2017 Apr 18.

Monovalent hepatitis B vaccine (HepB) is heat stable, making it suitable for storage outside cold chain (OCC) at 37°C for 1 month. We conducted an OCC project in the Solomon Islands to determine the feasibility of and barriers to national implementation and to evaluate impact on coverage. Healthcare workers at 13 facilities maintained monovalent HepB birth dose (HepB-BD) OCC for up to 28 days over 7 months. Vaccination data were recorded for children born during the project and those born during 7 months before the project. Timely HepB-BD coverage among facility and home births increased from 30% to 68% and from 4% to 24%, respectively. Temperature excursions above 37°C were rare, but vaccine wastage was high and shortages common. Storing HepB OCC can increase HepB-BD coverage in countries with insufficient cold chain capacity or numerous home births. High vaccine wastage and unreliable vaccine supply must be addressed for successful implementation.

10 **Brookes VJ, Ward MP.**
Expert opinion to identify high-risk entry routes of canine rabies into Papua New Guinea.
Zoonoses Public Health 2017 Mar;64(2):156-160. doi: 10.1111/zph.12284. Epub 2016 Jun 30.

The proximity of Papua New Guinea (PNG) to canine rabies-endemic countries in South-East Asia presents a risk of incursion of this disease into PNG and the rest of the Oceanic region. The objective of this study was to identify the highest risk routes for entry of dogs – associated with movement of people – into PNG from canine rabies-endemic countries. A structured, in-country expert-elicitation workshop was used, and 20 entry routes were identified. The highest risk routes were three land routes from Papua, Indonesia (hunters, traditional border crossers and unregulated, unchecked 'shopper-crossers') and two sea routes (fishing and logging). These results will be used to direct more detailed risk assessments to develop surveillance strategies and incursion response plans.

11 **Brookes VJ, Kennedy E, Dhagapan P, Ward MP.**
Qualitative research to design sustainable community-based surveillance for rabies in Northern Australia and Papua New Guinea.
Front Vet Sci 2017 Feb 22;4:19. doi: 10.3389/fvets.2017.00019. eCollection 2017.

Given the proximity and recent spread of rabies in Indonesia, effective rabies surveillance in dogs is a priority in Northern Australia and Papua New Guinea (PNG). Reporting of potential cases requires community engagement; therefore, the value and acceptability of such a system is critical to ensure sustainable surveillance. We used qualitative research methods to identify factors that influence the acceptability and value of community-based rabies surveillance. Thirty-two semi-structured interviews were conducted with informants in 16 communities in East Arnhem, the Northern Peninsula Area, the Torres Strait in Australia, and in Western Province, PNG. Thematic analysis identified common themes including the importance of verbal communication,

particularly via radio, community meetings, and direct conversation. We also found that dogs have high value to community members through connection to culture, economic (especially hunting), and companionship. The greatest barrier to the reporting of sick dogs was insufficient veterinary services and the subsequent lack of treatment response. In some regions, acceptance that sick dogs are a normal daily occurrence and lack of trust of authorities were also barriers to reporting. The findings from this study will be used to design sustainable rabies surveillance in Northern Australia and PNG by utilizing traditional communication channels and building on existing and valued animal-management services. The methods and findings of this study complement previous quantitative research, so as to target surveillance to high-risk areas within these regions.

12 **Brunton PA, Ghazali A, Tarif ZH, Loch C, Lynch C, Wilson N, Blum IR.**
Repair vs replacement of direct composite restorations: a survey of teaching and operative techniques in Oceania.
J Dent 2017 Apr;59:62-67. doi: 10.1016/j.jdent.2017.02.010. Epub 2017 Feb 20.

OBJECTIVES: To evaluate the teaching and operative techniques for the repair and/or replacement of direct resin-based composite restorations (DCRs) in dental schools in Oceania. METHODS: A 14-item questionnaire was mailed to the heads of operative dentistry in 16 dental schools in Oceania (Australia, New Zealand, Fiji and Papua New Guinea). The survey asked whether the repair of DCRs was taught within the curriculum; the rationale behind the teaching; how techniques were taught, indications for repair, operative techniques, materials used, patient acceptability, expected longevity and recall systems. RESULTS: All 16 schools participated in the study. Thirteen (81%) reported the teaching of composite repairs as an alternative to replacement. Most schools taught the theoretical and practical aspects of repair at a clinical level only. All 13 schools (100%) agreed on tooth substance preservation being the main reason for teaching repair. The main indications for repair were marginal defects (100%), followed by secondary caries (69%). All 13 schools that performed repairs reported high patient acceptability, and considered it a definitive measure. Only three schools (23%) claimed to have a recall system in place following repair of DCRs. Most respondents either did not know or did not answer when asked about the longevity of DCRs. CONCLUSIONS: Repair of DCRs seems to be a viable alternative to replacement, which is actively taught within Oceania. Advantages include it being minimally invasive, preserving tooth structure, and time and money saving. However, standardised guidelines need to be developed and further clinical long-term studies need to be carried out. CLINICAL SIGNIFICANCE: The decision between replacing or repairing a defective composite restoration tends to be based on what clinicians have been taught, tempered by experience and judgement. This study investigated the current status of teaching and operative techniques of repair of direct composite restorations in dental schools in Oceania.

13 **Busch JT, Watson-Jones RE, Legare CH.**
The coexistence of natural and supernatural explanations within and across domains and development.
Br J Dev Psychol 2017 Mar;35(1):4-20. doi: 10.1111/bjdp.12164. Epub 2016 Oct 27.

People across highly diverse cultural contexts use both natural and supernatural explanations to explain questions of fundamental concern such as death, illness, and human origins. The present study examines the development of explanatory coexistence within and across domains of existential concern in individuals in Tanna, Vanuatu. We examined three age groups: 7- to 12-year-old children, 13- to 18-year-old adolescents, and 19- to 70-year-old adults (N = 72). Within the domain of death, biological and spontaneous explanations were most common across all ages. For illness, children showed the highest rates of explanatory coexistence, while adolescents and adults favoured biological explanations. Within the human origins domain, theistic explanations were most common across the age groups. Overall, these data show that coexistence reasoning in these domains is pervasive across cultures, yet at the same time it is deeply contextually specific, reflecting the nuanced differences in local ecologies and cultural beliefs. *Statement of contribution* What is already known on this subject? Individuals across highly diverse cultural contexts use both natural and supernatural explanations to understand the events that occur in their lives. Context and cultural input play a large role in determining when and how individuals incorporate natural and supernatural explanations. The development of explanatory coexistence has primarily studied explanations for isolated domains. What does this study add? We examined explanatory coexistence in a culture with recent conversion to Christianity and formal education. The current research examines how individuals reason within and across the domains of human origins, illness, and death. Developmental differences associated with explanatory coexistence are examined.

14 **Cassar O, Charavay F, Touzain F, Jeannin P, Grangeon JP, Laumond S, Chungue E, Martin PM, Gessain A.**
A novel human T-lymphotropic virus type 1c molecular variant in an indigenous individual from New Caledonia, Melanesia.
PLoS Negl Trop Dis 2017 Jan 6;11(1):e0005278. doi: 10.1371/journal.pntd.0005278. eCollection 2017 Jan.

BACKGROUND: Human T-lymphotropic virus type 1 (HTLV-1) is endemic among people of Melanesian descent in Papua New Guinea, Solomon Islands and Vanuatu, and in Indigenous populations from Central Australia. Molecular studies revealed that these Australo-Melanesian strains constitute the highly divergent HTLV-1c subtype. New Caledonia is a French overseas territory located in the Southwest Pacific Ocean. HTLV-1 situation is poorly documented in New Caledonia and the molecular epidemiology of HTLV-1 infection remains unknown. OBJECTIVES: Studying 500 older adult Melanesian natives from New Caledonia, we aim to evaluate the HTLV-1 seroprevalence and to molecularly characterize HTLV-1 proviral strains. STUDY DESIGN: Plasma from 262 men and 238 females (age range: 60-96 years old, mean age: 70.5) were screened for anti-HTLV-1 antibodies by particle agglutination (PA) and indirect immunofluorescence assay (IFA). Serological confirmation was obtained using Western blot assay. DNAs were extracted from

peripheral blood buffy coat of HTLV-1 seropositive individuals, and subjected to four series of PCR (LTR-gag; pro-pol; pol-env and tax-LTR). Primers were designed from highly common conserved regions of the major HTLV-1 subtypes to characterize the entire HTLV-1 proviral genome. RESULTS: Among 500 samples, 3 were PA and IFA positive. The overall seroprevalence was 0.6%. The DNA sample from 1 New Caledonian woman (NCP201) was found positive by PCR and the complete HTLV-1 proviral genome (9,033-bp) was obtained. The full-length HTLV-1 genomic sequence from a native woman from Vanuatu (EM5), obtained in the frame of our previous studies, was also characterized. Both sequences belonged to the HTLV-1c Australo-Melanesian subtype. The NCP201 strain exhibited 0.3% nucleotide divergence from the EM5 strain from Vanuatu. Furthermore, divergence reached 1.1% to 2.9% with the Solomon Islands and Australian sequences respectively. Phylogenetic analyses on a 522-bp-long fragment of the gp21-env gene showed the existence of two major clades. The first is composed of strains from Papua New Guinea; the second includes strains from all neighboring archipelagos (Solomons, Vanuatu, New Caledonia), and Australia. Interestingly, this second clade itself is divided into two sub-clades: strains from Australia on one hand, and strains from Solomon Islands, Vanuatu and New Caledonia on the other hand. CONCLUSIONS: The HTLV-1 seroprevalence (0.6%) in the studied adult population from New Caledonia appears to be low. This seroprevalence is quite similar to the situation observed in Vanuatu and Solomon Islands. However, it is very different to the one encountered in Central Australia. Taken together, these results demonstrated that Australo-Melanesia is endemic for HTLV-1 infection with a high diversity of HTLV-1c strains and a clear geographic clustering according to the island of origin of HTLV-1 infected persons.

15 **Cayley W Jr.**
Biomedicine in an unstable place – infrastructure and personhood in a Papua New Guinean hospital.
Fam Med 2017 Feb;49(2):150-151.

16 **Chan CW, Iata H, Yaviong J, Kalkoa M, Yamar S, Taleo G, Isozumi R, Fukui M, Aoyama F, Pomer A, Dancause KN, Kaneko A.**
Surveillance for malaria outbreak on malaria-eliminating islands in Tafea Province, Vanuatu after Tropical Cyclone Pam in 2015.
Epidemiol Infect 2017 Jan;145(1):41-45. Epub 2016 Sep 9.

The risk of malaria outbreak surfaced in Vanuatu after Tropical Cyclone (TC) Pam in March 2015. In June and July 2015 we conducted malariometric surveys on the islands of Tanna, Aneityum, and Erromango in Tafea Province, where malaria elimination had been targeted, to determine if malaria incidence had increased after TC Pam. No *Plasmodium* infection was detected by microscopy and PCR in 3009 survey participants. Only 6·3% (190/3007) of participants had fever. Spleen rates in children aged ≤12 years from Aneityum and Tanna were low, at 3·6% (14/387) and 5·3% (27/510), respectively. Overall bednet use was high at 72·8% (2175/2986); however, a significantly higher ($p < 0·001$) proportion of participants from Aneityum (85·9%, 796/927) reported net use than those from Tanna (67·1%, 751/1119) and Erromango (66·8%, 628/940). A recent decrease in malaria incidence in Tafea Province through comprehensive intervention measures had reduced the indigenous parasite reservoir and limited the latter's potential to spur an outbreak after TC Pam. The path towards malaria elimination in Tafea Province was not adversely affected by TC Pam.

17 **Chan KL, Emery CR, Fulu E, Tolman RM, Ip P.**
Association among father involvement, partner violence, and paternal health: UN multi-country cross-sectional study on men and violence.
Am J Prev Med 2017 May;52(5):671-679. doi: 10.1016/j.amepre.2016.12.017. Epub 2017 Feb 10.

INTRODUCTION: The influence of father involvement on intimate partner violence (IPV) and men's health is poorly understood. This study aimed to investigate the prevalence of six aspects of father involvement in delivery and child care, and to explore their individual associations with IPV against women and paternal health in an Asia-Pacific context. METHODS: This study analyzed data from the 2011-2012 UN Multi-Country Cross-Sectional Study on Men and Violence, which surveyed >10,000 men from Bangladesh, Cambodia, China, Indonesia, Papua New Guinea, and Sri Lanka. Multivariate regression analyses were conducted in 2016 to examine the associations among father involvement, IPV, and paternal health. RESULTS: The sample comprised 6,184 men (aged 18-49 years) who had at least one child. The prevalence ranged from 40.0% to 62.9% across different aspects of father involvement. Presence at prenatal visits, taking paternity leave, and helping children with homework were associated with a reduced likelihood of IPV against women (all $p < 0.05$). When possible confounding factors were adjusted for, father involvement accounted for 2% of the variance of men's perceived health, 4% of depression, and 2% of life satisfaction (all $p < 0.05$). CONCLUSIONS: Father involvement may be beneficial in reducing IPV and improving paternal health. More family-friendly policies should be adopted by policymakers to promote father involvement throughout pregnancy to improve family well-being and child development.

18 **Charlier P, Coppens Y, Malaurie J, Brun L, Kepanga M, Hoang-Opermann V, Correa Calfin JA, Nuku G, Ushiga M, Schor XE, Deo S, Hassin J, Hervé C.**
A new definition of health? An open letter of autochthonous peoples and medical anthropologists to the WHO.
Eur J Intern Med 2017 Jan;37:33-37. doi: 10.1016/j.ejim.2016.06.027. Epub 2016 Jul 7.

Currently, for many practitioners (hospital and liberals) and researchers (including public health), the WHO definition of health is outdated: first it seems more utopian than pragmatic; then, it proves unsuitable for a large part of the world population. There is clearly a need to refine this definition or propose additional criteria to be more relevant or discriminating. In this perspective, what can indigenous people offer in the elaboration of a new definition of health? In this article, leaders or representatives of autochthonous peoples, anthropologists and physicians from many cultural origins (Amazonia, Patagonia, Papua New Guinea, Inuit, North American Indian, sub-Saharan Africa, India, China, Melanesia and Polynesia) have tried to identify and explain several key concepts that WHO

should reintegrate into its new definition of health: human equilibrium in nature, accepted spirituality and adaptation. On the sidelines of the application of COP21 decisions that should give back to man his place in the environment, autochthonous people leaders, anthropologists and MDs explain why these three concepts are fundamental and universal health determinants, and need to be included in a new WHO definition of health.

19 **Clarke GM, Rockett K, Kivinen K, Hubbart C, Jeffreys AE, Rowlands K, Jallow M, Conway DJ, Bojang KA, Pinder M, Usen S, Sisay-Joof F, Sirugo G, Toure O, Thera MA, Konate S, Sissoko S, Niangaly A, Poudiougou B, Mangano VD, Bougouma EC, Sirima SB, Modiano D, Amenga-Etego LN, Ghansah A, Koram KA, Wilson MD, Enimil A, Evans J, Amodu OK, Olaniyan S, Apinjoh T, Mugri R, Ndi A, Ndila CM, Uyoga S, Macharia A, Peshu N, Williams TN, Manjurano A, Sepúlveda N, Clark TG, Riley E, Drakeley C, Reyburn H, Nyirongo V, Kachala D, Molyneux M, Dunstan SJ, Phu NH, Quyen NN, Thai CQ, Hien TT, Manning L, Laman M, Siba P, Karunajeewa H, Allen S, Allen A, Davis TM, Michon P, Mueller I, Molloy SF, Campino S, Kerasidou A, Cornelius VJ, Hart L, Shah SS, Band G, Spencer CC, Agbenyega T, Achidi E, Doumbo OK, Farrar J, Marsh K, Taylor T, Kwiatkowski DP; MalariaGEN Consortium.**
Characterisation of the opposing effects of G6PD deficiency on cerebral malaria and severe malarial anaemia.
Elife 2017 Jan 9;6. pii: e15085. doi: 10.7554/eLife.15085.

Glucose-6-phosphate dehydrogenase (G6PD) deficiency is believed to confer protection against *Plasmodium falciparum* malaria, but the precise nature of the protective effect has proved difficult to define as G6PD deficiency has multiple allelic variants with different effects in males and females, and it has heterogeneous effects on the clinical outcome of *P. falciparum* infection. Here we report an analysis of multiple allelic forms of G6PD deficiency in a large multi-centre case-control study of severe malaria, using the WHO classification of G6PD mutations to estimate each individual's level of enzyme activity from their genotype. Aggregated across all genotypes, we find that increasing levels of G6PD deficiency are associated with decreasing risk of cerebral malaria, but with increased risk of severe malarial anaemia. Models of balancing selection based on these findings indicate that an evolutionary trade-off between different clinical outcomes of *P. falciparum* infection could have been a major cause of the high levels of G6PD polymorphism seen in human populations.

20 **Clegg JM, Wen NJ, Legare CH.**
Is non-conformity WEIRD? Cultural variation in adults' beliefs about children's competency and conformity.
J Exp Psychol Gen 2017 Mar;146(3):428-441. doi: 10.1037/xge0000275.

Cross-cultural comparisons provide critical insight into variation in reasoning about intelligence. In two studies, the authors used a novel methodology based on multivocal ethnography to assess the role of conformity in US and Ni-Vanuatu adults' judgments of children's intelligence and, as a comparison trait, good behavior. In Study 1, there were cultural differences in the impact of conformity on US and Ni-Vanuatu adults' judgments of children's intelligence and good behavior. When evaluating US children only, US adults were less likely to endorse high conformity children as intelligent, often citing creativity as a justification for their judgments. In contrast, Ni-Vanuatu adults were more likely to endorse Ni-Vanuatu high conformity children as intelligent. Ni-Vanuatu adults were also more likely to endorse high conformity children as well-behaved than US adults. In Study 2, there were no effects of socioeconomic status on US adults' evaluations of conformity. US adults were less likely to endorse high conformity children as intelligent than Ni-Vanuatu adults. Taken together, the data demonstrate that beliefs about the relations between intelligence, conformity, and creativity vary within and across cultures.

21 **Cooperrider K, Marghetis T, Núñez R.**
Where does the ordered line come from? Evidence from a culture of Papua New Guinea.
Psychol Sci 2017 May;28(5):599-608. doi: 10.1177/0956797617691548. Epub 2017 Mar 10.

Number lines, calendars, and measuring sticks all represent order along some dimension (eg, magnitude) as position on a line. In high-literacy, industrialized societies, this principle of spatial organization – linear order –is a fixture of visual culture and everyday cognition. But what are the principle's origins, and how did it become such a fixture? Three studies investigated intuitions about linear order in the Yupno, members of a culture of Papua New Guinea that lacks conventional representations involving ordered lines, and in US undergraduates. Presented with cards representing differing sizes and numerosities, both groups arranged them using linear order or sometimes spatial grouping, a competing principle. But whereas the US participants produced ordered lines in all tasks, strongly favoring a left-to-right format, the Yupno produced them less consistently, and with variable orientations. Conventional linear representations are thus not necessary to spark the intuition of linear order – which may have other experiential sources – but they nonetheless regiment when and how the principle is used.

22 **Cooperrider K, Slotta J, Núñez R.**
Uphill and downhill in a flat world: the conceptual topography of the Yupno house.
Cogn Sci 2017 Apr;41(3):768-799. doi: 10.1111/cogs.12357. Epub 2016 Mar 10.

Speakers of many languages around the world rely on body-based contrasts (eg, left/right) for spatial communication and cognition. Speakers of Yupno, a language of Papua New Guinea's mountainous interior, rely instead on an environment-based uphill/downhill contrast. Body-based contrasts are as easy to use indoors as outdoors, but environment-based contrasts may not be. Do Yupno speakers still use uphill/downhill contrasts indoors and, if so, how? We report three studies on spatial communication within the Yupno house. Even in this flat world, uphill/downhill contrasts are pervasive. However, the terms are not used according to the slopes beyond the house's walls, as reported in other groups. Instead, the house is treated as a microworld, with a 'conceptual topography' that is strikingly reminiscent of the physical topography of the Yupno valley. The phenomenon illustrates some of the distinctive properties of environment-based reference systems,

as well as the universal power and plasticity of spatial contrasts.

23 **Crivelli C, Russell JA, Jarillo S, Fernández-Dols JM.**
Recognizing spontaneous facial expressions of emotion in a small-scale society of Papua New Guinea.
Emotion 2017 Mar;17(2):337-347. doi: 10.1037/emo0000236. Epub 2016 Oct 13.

We report 2 studies on how residents of Papua New Guinea interpret facial expressions produced spontaneously by other residents of Papua New Guinea. Members of a small-scale indigenous society, Trobrianders (Milne Bay Province; N = 32, 14 to 17 years) were shown 5 facial expressions spontaneously produced by members of another small-scale indigenous society, Fore (Eastern Highlands Province) that Ekman had photographed, labeled, and published in The Face of Man (1980), each as an expression of a basic emotion: happiness, sadness, anger, surprise, and disgust. Trobrianders were asked to use any word they wanted to describe how each person shown felt and to provide valence and arousal ratings. Other Trobrianders (N = 24, 12 to 14 years) were shown the same photographs but asked to choose their response from a short list. In both studies, agreement with Ekman's predicted labels was low: 0% to 16% and 13% to 38% of observers, respectively.

24 **Céspedes N, Li Wai Suen CSN, Koepfli C, França CT, Felger I, Nebie I, Arévalo-Herrera M, Mueller I, Corradin G, Herrera S.**
Natural immune response to *Plasmodium vivax* alpha-helical coiled coil protein motifs and its association with the risk of *P. vivax* malaria.
PLoS One 2017 Jun 26;12(6):e0179863. doi: 10.1371/journal.pone.0179863. eCollection 2017.

Protein α-helical coiled coil structures are known to induce antibodies able to block critical functions in different pathogens. In a previous study, a total of 50 proteins of *Plasmodium vivax* erythrocytic asexual stages containing α-helical coiled coil structural motifs were identified in silico, and the corresponding peptides were chemically synthesized. A total of 43 peptides were recognized by naturally acquired antibodies in plasma samples from both Papua New Guinea (PNG) and Colombian adult donors. In this study, the association between IgG antibodies to these peptides and clinical immunity was further explored by measuring total IgG antibody levels to 24 peptides in baseline samples from a longitudinal study of children aged 1-3 years (n = 164) followed for 16 months. Samples were reactive to all peptides tested. Eight peptides were recognized by >50% of individuals, whereas only one peptide had <20% reactivity. Children infected at baseline were seropositive to 23/24 peptides. No significant association was observed between antibody titers and age or molecular force of infection, suggesting that antibody levels had already reached an equilibrium. There was a strong association between antibody levels to all peptides and protection against *P. vivax* clinical episodes during the 16 months follow-up. These results suggest that the selected coiled coil antigens might be good markers of both exposure and acquired immunity to *P. vivax* malaria, and further preclinical investigation should be performed to determine their potential as *P. vivax* vaccine antigens.

25 **De Sanctis V, Kattamis C, Canatan D, Soliman AT, Elsedfy H, Karimi M, Daar S, Wali Y, Yassin M, Soliman N, Sobti P, Al Jaouni S, El Kholy M, Fiscina B, Angastiniotis M.**
β-Thalassemia distribution in the Old World: an ancient disease seen from a historical standpoint.
Mediterr J Hematol Infect Dis 2017 Feb 20;9(1):e2017018. doi: 10.4084/MJHID.2017.018. eCollection 2017.

BACKGROUND: Haemoglobinopathies constitute the commonest recessive monogenic disorders worldwide, and the treatment of affected individuals presents a substantial global disease burden. β-thalassaemia is characterised by the reduced synthesis (β+) or absence (βo) of the β-globin chains in the HbA molecule, resulting in accumulation of excess unbound α-globin chains that precipitate in erythroid precursors in the bone marrow and in the mature erythrocytes, leading to ineffective erythropoiesis and peripheral haemolysis. Approximately 1.5% of the global population are heterozygotes (carriers) of the β-thalassemias; there is a high incidence in populations from the Mediterranean basin, throughout the Middle East, the Indian subcontinent, Southeast Asia, and Melanesia to the Pacific Islands. AIM: The principal aim of this paper is to review, from a historical standpoint, our knowledge about an ancient disease, the β-thalassemias, and in particular, when, how and in what way β-thalassemia spread worldwide to reach such high incidences in certain populations. RESULTS: Mutations involving the β-globin gene are the most common cause of genetic disorders in humans. To date, more than 350 β-thalassaemia mutations have been reported. Considering the current distribution of β-thalassemia, the wide diversity of mutations and the small number of specific mutations in individual populations, it seems unlikely that β-thalassemia originated in a single place and time. CONCLUSIONS: Various processes are known to determine the frequency of genetic disease in human populations. However, it is almost impossible to decide to what extent each process is responsible for the presence of a particular genetic disease. The wide spectrum of β-thalassemia mutations could well be explained by looking at their geographical distribution, the history of malaria, wars, invasions, mass migrations, consanguinity, and settlements. An analysis of the distribution of the molecular spectrum of haemoglobinopathies allows for the development and improvement of diagnostic tests and management of these disorders.

26 **Diefenbach-Elstob T, Plummer D, Dowi R, Wamagi S, Gula B, Siwaeya K, Pelowa D, Siba P, Warner J.**
The social determinants of tuberculosis treatment adherence in a remote region of Papua New Guinea.
BMC Public Health 2017 Jan 13;17(1):70. doi: 10.1186/s12889-016-3935-7.

BACKGROUND: Papua New Guinea (PNG) is a diverse and culturally rich country with severe infrastructural and health problems. Tuberculosis (TB) is widespread, and the number of cases with drug resistance is rising. Treatment adherence is known to be important for both effective treatment and limiting the emergence of drug resistance. The aim of this study was to construct a matrix of the factors that act as facilitators or barriers to TB treatment adherence in a remote region of PNG. METHODS: The study was based in the Balimo

region of the Western Province. People known to have undergone TB treatment, as well as staff involved in managing people with TB, were asked to participate in an in-depth interview about their experiences. Purposive sampling was used to identify a diverse range of participants, from different geographic locations, social backgrounds, and with successful and unsuccessful treatment outcomes. The interview data was analysed based on grounded theory methodology. RESULTS: The study identified a range of factors that influence TB treatment adherence, with these being classified as personal, systems, and sociocultural. These factors are presented along with suggested recommendations for adaptations to DOTS-based treatment in this region. Barriers included the challenges associated with travel to treatment sites, and the difficulties of undertaking treatment alongside the daily need to maintain subsistence food production. However, facilitators were also identified, including the positive influence of religious beliefs, and high confidence in the ability of DOTS-based treatment to cure TB. CONCLUSIONS: Documenting the wide range of factors that influence treatment adherence in a severely affected remote population will assist in improving TB control. These results provide impetus for further community-based efforts aimed at improving access to TB diagnosis and treatment, and maintaining successful treatment outcomes in the face of emerging drug resistance.

27 **Donnan EJ, Coulter C, Simpson G, Clark J, Nourse C.**
Paediatric tuberculosis in Queensland, Australia: overrepresentation of cross-border and Indigenous children.
Int J Tuberc Lung Dis 2017 Mar 1;21(3):263-269. doi: 10.5588/ijtld.16.0313.

SETTING: Queensland, Australia. BACKGROUND: Understanding paediatric tuberculosis (TB) is important, as children with TB typically reflect recent community transmission. Children pose unique diagnostic challenges and are at risk of developing severe disseminated infection. OBJECTIVE: To describe the epidemiology, presentation and outcomes of children with TB disease in Queensland. DESIGN: This is a retrospective case series of children diagnosed with TB aged 0-16 years notified in 2005-2014. Data collected in the Queensland Notifiable Conditions System were extracted and analysed. RESULTS: Of 127 children diagnosed with TB, 16 were Australian-born (including 12 Indigenous Queenslanders), 41 were overseas-born permanent and temporary residents and 70 were cross-border Papua New Guinea (PNG) children; 88 children had pulmonary disease (with/without other sites) and 39 had extra-pulmonary disease only, with lymph node TB the predominant extra-pulmonary site; 70.1% of children had laboratory confirmation; and 14 cross-border children had multidrug-resistant TB. Treatment outcomes among children residing in Australia were good (100% among Australian-born and 97.2% among permanent and temporary residents), but they were less favourable among PNG children diagnosed in the Torres Strait Protected Zone (76.6%). CONCLUSION: Queensland has unique challenges in TB control, with a high proportion of cross-border diagnoses and over-representation of Indigenous children. Vigilance is needed given the wide spectrum of clinical presentation, particularly in high-risk communities.

28 **Duke T, Hwaihwanje I, Kaupa M, Karubi J, Panauwe D, Sa'avu M, Pulsan F, Prasad P, Maru F, Tenambo H, Kwaramb A, Neal E, Graham H, Izadnegahdar R.**
Solar powered oxygen systems in remote health centers in Papua New Guinea: a large scale implementation effectiveness trial.
J Glob Health 2017 Jun;7(1):010411. doi: 10.7189/jogh.07.010411.

BACKGROUND: Pneumonia is the largest cause of child deaths in Papua New Guinea (PNG), and hypoxaemia is the major complication causing death in childhood pneumonia, and hypoxaemia is a major factor in deaths from many other common conditions, including bronchiolitis, asthma, sepsis, malaria, trauma, perinatal problems, and obstetric emergencies. A reliable source of oxygen therapy can reduce mortality from pneumonia by up to 35%. However, in low and middle income countries throughout the world, improved oxygen systems have not been implemented at large scale in remote, difficult to access health care settings, and oxygen is often unavailable at smaller rural hospitals or district health centers which serve as the first point of referral for childhood illnesses. These hospitals are hampered by lack of reliable power, staff training and other basic services. METHODS: We report the methodology of a large implementation effectiveness trial involving sustainable and renewable oxygen and power systems in 36 health facilities in remote rural areas of PNG. The methodology is a before-and-after evaluation involving continuous quality improvement, and a health systems approach. We describe this model of implementation as the considerations and steps involved have wider implications in health systems in other countries. RESULTS: The implementation steps include: defining the criteria for where such an intervention is appropriate, assessment of power supplies and power requirements, the optimal design of a solar power system, specifications for oxygen concentrators and other oxygen equipment that will function in remote environments, installation logistics in remote settings, the role of oxygen analyzers in monitoring oxygen concentrator performance, the engineering capacity required to sustain a program at scale, clinical guidelines and training on oxygen equipment and the treatment of children with severe respiratory infection and other critical illnesses, program costs, and measurement of processes and outcomes to support continuous quality improvement. CONCLUSIONS: This study will evaluate the feasibility and sustainability issues in improving oxygen systems and providing reliable power on a large scale in remote rural settings in PNG, and the impact of this on child mortality from pneumonia over 3 years post-intervention. Taking a continuous quality improvement approach can be transformational for remote health services.

29 **Echeverry DF, Deason NA, Makuru V, Davidson J, Xiao H, Niedbalski J, Yu X, Stevenson JC, Bugoro H, Aparaimo A, Reuben H, Cooper R, Burkot TR, Russell TL, Collins FH, Lobo NF.**
Fast and robust single PCR for *Plasmodium* sporozoite detection in mosquitoes using the cytochrome oxidase 1 gene.
Malar J 2017 May 31;16(1):230. doi: 10.1186/s12936-017-1881-1.

BACKGROUND: Molecular tools for detecting malaria-infected mosquitoes with improved practicality, sensitivity and specificity, and high-throughput are required. A common PCR technique used to detect mosquitoes infected with *Plasmodium* spp. is a nested PCR assay based on the 18s-rRNA gene. However, this technique has several technical limitations, is laborious and time consuming. METHODS: In this study, a PCR based on the *Plasmodium* cytochrome oxidase 1 (COX-1) gene was compared with the 18s-rRNA nested PCR using serial dilutions (330-0.0012 pg) of DNA from *Plasmodium vivax*, *Plasmodium falciparum* and *Plasmodium knowlesi* and with DNA from 48 positive and negative Kenyan mosquitoes (previously detected by using both ELISA and PCR). This assay for *Plasmodium* spp. DNA detection using the fast *COX-1* PCR assay was then performed individually on 2122 field collected mosquitoes (from the Solomon Islands) in which DNA was extracted from head and thorax. RESULTS: The fast *COX-1* PCR assay took 1 h to run and consistently detected as low as to 0.043 pg of parasite DNA (equivalent to two parasites) in a single PCR, while analyses with the 18s-rRNA nested PCR required 4 h to complete with a consistent detection threshold of 1.5 pg of DNA. Both assays produced concordant results when applied to the 48 Kenyan control samples with known *Plasmodium* spp. infection status. The fast *COX-1* PCR identified 23/2122 *Plasmodium*-infected mosquitoes from the Solomon Islands. CONCLUSIONS: This new *COX-1* PCR adapted for a single PCR reaction is a faster, simpler, cheaper, more sensitive technique amenable to high-throughput analyses for *Plasmodium* DNA detection in mosquitoes and is comparable to the 18s-rRNA nested PCR. The improved sensitivity seen with the fast *COX-1* PCR will improve the accuracy of mosquito infection rate determination.

30 **Einbond LS, Negrin A, Kulakowski DM, Wu HA, Antonetti V, Jalees F, Law W, Roller M, Redenti S, Kennelly EJ, Balick MJ.**
Traditional preparations of kava (*Piper methysticum*) inhibit the growth of human colon cancer cells in vitro.
Phytomedicine 2017 Jan 15;24:1-13. doi: 10.1016/j.phymed.2016.11.002. Epub 2016 Nov 5.

BACKGROUND: Epidemiological studies indicate there is low incidence of colon cancer in the South Pacific islands, including Fiji, West Samoa, and Vanuatu. Cancer incidence has been shown to be inversely associated with kava (*Piper methysticum* G. Forst.) ingestion. HYPOTHESIS/PURPOSE: Kava prepared traditionally will inhibit the growth of human cancer cells. This investigation entails preparation and analysis of kava extracts and study of the growth inhibitory activity of the extracts, alone and combined with hibiscus. STUDY DESIGN: We will prepare kava as in Micronesia – as a water extract, high in particulate content, alone or combined with sea hibiscus (*Hibiscus tiliaceus* L.) – and examine the components and growth inhibitory activity. METHODS: We obtained ground kava prepared in the traditional way from lateral roots and sea hibiscus mucilage and sap from different sources in Micronesia, and prepared water extracts (unfiltered, as well as filtered, since in traditional use the kava beverage contains a high particulate content) and partitions. We used the MTT assay to determine the growth inhibitory activity of the preparations on colon and breast cancer cells and nonmalignant intestinal epithelial cells. LC-MS analysis was used to examine the components of the kava and sea hibiscus extracts and partitions. RESULTS: Traditional preparations of kava inhibit the growth of breast and colon cancer cells. Among the kava preparations, the order of decreasing activity was Fiji(2), Fiji(1), Hawaii; the unfiltered preparations from Fiji were more active than the filtered. Phytochemical analysis indicated that filtering reduced most kavalactone and chalcone content. For example, for Fiji(2), the ratio of dihydromethysticin in filtered/unfiltered kava was 0.01. Thus, for the extracts from Fiji, growth inhibitory activity correlates with the content of these compounds. Unfiltered and filtered kava from Fiji(1) were more active on malignant than nonmalignant intestinal epithelial cells. Since kava is prepared in Micronesia by squeezing the extract through sea hibiscus bark, we assayed the growth inhibitory activity of combinations of kava and sea hibiscus sap and found that sea hibiscus enhanced the growth inhibitory effect of kava. CONCLUSION: Our results show that traditional kava, alone or combined with sea hibiscus, displays activity against human cancer cells and indicate it will be worthwhile to develop and further analyze these preparations to prevent and treat colon and other cancers. Our findings suggest it is important to examine the activity of plants in the form that people consume them.

31 **Flaxman AD, Stewart A, Joseph JC, Alam N, Alam S, Chowdhury H, Gamage S, Gouda H, Joshi R, Lucero M, Mooney MD, Praveen D, Rampatige R, Remolador H, Sanvictores D, Serina PT, Streatfield PK, Tallo V, Wijesekera N, Murray CJL, Hernandez B, Lopez AD, Riley ID.**
Implementing the PHMRC shortened questionnaire: survey duration of open and closed questions in three sites.
PLoS One 2017 Jun 1;12(6):e0178085. doi: 10.1371/journal.pone.0178085. eCollection 2017.

BACKGROUND: More countries are using verbal autopsy as a part of routine mortality surveillance. The length of time required to complete a verbal autopsy interview is a key logistical consideration for planning large-scale surveillance. METHODS: We use the PHMRC shortened questionnaire to conduct verbal autopsy interviews at three sites and collect data on the length of time required to complete the interview. This instrument uses a novel checklist of keywords to capture relevant information from the open response. The open response section is timed separately from the section consisting of closed questions. RESULTS: We found the median time to complete the entire interview was approximately 25 minutes and did not vary substantially by age-specific module. The median time for the open response section was approximately 4 minutes and 60% of interviewees mentioned at least one keyword within the open response section. CONCLUSIONS: The length of time required to complete the interview was short enough for large-scale routine use. The open-response section did not add a substantial amount of time and provided useful information which can be used to increase the accuracy of the predictions of the cause of death. The novel checklist approach further reduces the burden of transcribing and translating a large amount of free text. This makes the PHMRC instrument ideal for national mortality surveillance.

32 **Fola AA, Harrison GLA, Hazairin MH, Barnadas C, Hetzel MW, Iga J, Siba PM, Mueller I, Barry AE.**
Higher complexity of infection and genetic diversity of *Plasmodium vivax* than *Plasmodium falciparum* across all malaria transmission zones of Papua New Guinea.
Am J Trop Med Hyg 2017 Mar;96(3):630-641. doi: 10.4269/ajtmh.16-0716. Epub 2017 Apr 6.

Plasmodium falciparum and *Plasmodium vivax* have varying transmission dynamics that are informed by molecular epidemiology. This study aimed to determine the complexity of infection and genetic diversity *of P. vivax* and *P. falciparum* throughout Papua New Guinea (PNG) to evaluate transmission dynamics across the country. In 2008-2009, a nationwide malaria indicator survey collected 8,936 samples from all 16 endemic provinces of PNG. Of these, 892 positive *P. vivax* samples were genotyped at *PvMS16* and *PvmspF3*, and 758 positive *P. falciparum* samples were genotyped at *Pfmsp2*. The data were analyzed for multiplicity of infection (MOI) and genetic diversity. Overall, *P. vivax* had higher polyclonality (71%) and mean MOI (2.32) than *P. falciparum* (20%, 1.39). These measures were significantly associated with prevalence for *P. falciparum* but not for *P. vivax*. The genetic diversity of *P. vivax* (*PvMS16*: expected heterozygosity = 0.95, 0.85-0.98; *PvMsp1F3*: 0.78, 0.66-0.89) was higher and less variable than that of *P. falciparum* (*Pfmsp2*: 0.89, 0.65-0.97). Significant associations of MOI with allelic richness (rho = 0.69, p = 0.009) and expected heterozygosity (rho = 0.87, p <0.001) were observed for *P. falciparum*. Conversely, genetic diversity was not correlated with polyclonality nor mean MOI for *P. vivax*. The results demonstrate higher complexity of infection and genetic diversity of *P. vivax* across the country. Although *P. falciparum* shows a strong association of these parameters with prevalence, a lack of association was observed for *P. vivax* and is consistent with higher potential for outcrossing of this species.

33 **Francis JP, Richmond PC, Strickland D, Prescott SL, Pomat WS, Michael A, Nadal-Sims MA, Edwards-Devitt CJ, Holt PG, Lehmann D, van den Biggelaar AH.**
Cord blood *Streptococcus pneumoniae*-specific cellular immune responses predict early pneumococcal carriage in high-risk infants in Papua New Guinea.
Clin Exp Immunol 2017 Mar;187(3):408-417. doi: 10.1111/cei.12902. Epub 2016 Dec 18.

In areas where *Streptococcus pneumoniae* is highly endemic, infants experience very early pneumococcal colonization of the upper respiratory tract, with carriage often persisting into adulthood. We aimed to explore whether newborns in high-risk areas have pre-existing pneumococcal-specific cellular immune responses that may affect early pneumococcal acquisition. Cord blood mononuclear cells (CBMC) of 84 Papua New Guinean (PNG; high endemic) and 33 Australian (AUS; low endemic) newborns were stimulated in vitro with detoxified pneumolysin (dPly) or pneumococcal surface protein A (PspA; families 1 and 2) and compared for cytokine responses. Within the PNG cohort, associations between CBMC dPly and PspA-induced responses and pneumococcal colonization within the first month of life were studied. Significantly higher PspA-specific interferon (IFN)-γ, tumour necrosis factor (TNF)-α, interleukin (IL)-5, IL-6, IL-10 and IL-13 responses, and lower dPly-IL-6 responses were produced in CBMC cultures of PNG compared to AUS newborns. Higher CBMC PspA-IL-5 and PspA-IL-13 responses correlated with a higher proportion of cord CD4 T cells, and higher dPly-IL-6 responses with a higher frequency of cord antigen-presenting cells. In the PNG cohort, higher PspA-specific IL-5 and IL-6 CBMC responses were associated independently and significantly with increased risk of earlier pneumococcal colonization, while a significant protective effect was found for higher PspA-IL-10 CBMC responses. Pneumococcus-specific cellular immune responses differ between children born in pneumococcal high versus low endemic settings, which may contribute to the higher risk of infants in high endemic settings for early pneumococcal colonization, and hence disease.

34 **Frostegård J, Tao W, Råstam L, Lindblad U, Lindeberg S.**
Antibodies against phosphorylcholine among New Guineans compared to Swedes: an aspect of the hygiene/missing old friends hypothesis.
Immunol Invest 2017 Jan;46(1):59-69. doi: 10.1080/08820139.2016.1213279. Epub 2016 Sep 9.

BACKGROUND: We here study antibodies against phosphorylcholine (anti-PC) which we reported to be inversely associated with atherosclerosis, cardiovascular disease (CVD), and autoimmune conditions. In previous studies, we determined that this inverse association is more pronounced at low levels with high risk and at high levels, with decreased risk. We compare individuals from Kitava, New Guinea (with low risk of these conditions), with Swedish controls. METHODS: We studied a group of 178 individuals from Kitava (age 20-86), and compared those above age 40 (n = 108) with a group of age- and sex-matched individuals from a population based cohort in Sweden (n = 108). Traditional risk factors for CVD and fatty acids were determined. IgM, IgG, and IgA anti-PC were tested by enzyme-linked immunosorbent assay (ELISA). RESULTS: All anti-PC measures were significantly lower among Swedish controls as compared to Kitavans (p <0.001), independent of traditional risk factors. Having low levels of anti-PC, defined as below 25th percentile of values among Swedish controls, was associated with this cohort after adjustment for other risk factors (OR 5.7, 95% CI 2.2-14.7 for IgM; OR 31.7, 95% CI 3.9-252 for IgA; and OR 11.1, 95% CI 2.4-51 for IgG). CONCLUSIONS: PC is highly exposed on microorganisms and helminths (common on Kitava) exposing much PC which humans and hominids may have been exposed to for millions of years. We propose that low anti-PC levels in the developed world could be a new aspect of the hygiene hypothesis, generating a pro-inflammatory and pro-atherosclerotic state.

35 **Fulu E, Miedema S, Roselli T, McCook S, Chan KL, Haardörfer R, Jewkes R; UN Multi-country Study on Men and Violence study team.**
Pathways between childhood trauma, intimate partner violence, and harsh parenting: findings from the UN Multi-country Study on Men and Violence in Asia and the Pacific.
Lancet Glob Health 2017 May;5(5):e512-e522. doi: 10.1016/S2214-109X(17)30103-1.

BACKGROUND: Although childhood trauma and violence against women are global public

health issues, few population-based data from low-income and middle-income countries exist about the links between them. We present data from the UN Multi-country Study on Men and Violence in Asia and the Pacific, exploring the pathways between different forms of childhood trauma and violence against women. METHODS: In this multicountry study, we interviewed multistage representative samples of men and women, aged 18-49 years, in Asia and the Pacific, using standardised population-based household surveys. Men were interviewed in six countries, and women in four. Respondents were asked questions about their perpetration or experience of intimate partner violence or non-partner sexual violence, childhood trauma, and harsh parenting (smacking their children as a form of discipline). We used maximum likelihood multivariate logit models to explore associations between childhood trauma and violence against women, and fitted path models to explore associations between experience and perpetration of child maltreatment. FINDINGS: Between Jan 1, 2011, and Dec 1, 2012, 10 178 men and 3106 women completed interviews in this study, with between 815 and 1812 men per site and 477 and 1103 women per site. The proportion of men who experienced any childhood trauma varied between 59% (n = 478, 95% CI 54·0-63·3; Indonesia rural site) and 92% (n = 791, 89·4-93·8; Bougainville, Papua New Guinea). For women, the results ranged from 44% (n = 272, 37·7-50·8; Sri Lanka) to 84% (n = 725, 80·7-86·8; Bougainville, Papua New Guinea). For men, all forms of childhood trauma were associated with all forms of intimate partner violence perpetration. For women, all forms of childhood trauma were associated with physical intimate partner violence, and both physical and sexual intimate partner violence. There were significant, often gendered, pathways between men's and women's perpetration and experiences of childhood trauma, physical intimate partner violence, harsh parenting, and other factors. INTERPRETATION: The data point to both a co-occurrence and a cycle of abuse, with childhood trauma leading to violence against women and further child maltreatment, which in turn increases the risk of experience or perpetration of violence during adulthood. Efforts to prevent both forms of violence would benefit from a meaningful integrated approach. Interventions should promote positive parenting, address inequality and the normalisation of violence across the life course, and transform men's power over women and children.

36 **Furusawa T, Naka I, Yamauchi T, Natsuhara K, Eddie R, Kimura R, Nakazawa M, Ishida T, Ohtsuka R, Ohashi J.**
Polymorphisms associated with a tropical climate and root crop diet induce susceptibility to metabolic and cardiovascular diseases in Solomon Islands.
PLoS One 2017 Mar 2;12(3):e0172676. doi: 10.1371/journal.pone.0172676. eCollection 2017.

The people of the Solomon Islands represent an Austronesian (AN)-speaking population's adaptation to a humid tropical environment and subsistence of tuberous crops. Genome-wide association studies (GWASs) of other populations (eg, the Human Genome Diversity Project [HGDP]) have suggested the existence of genotypes adaptive to ecoregion, diet, and subsistence, and that those genotypes are also associated with metabolic and cardiovascular diseases. Recently, the incidence of non-communicable diseases has been increasing in the Solomon Islands. In the present study, we explored the association of genotypes adaptive to a tropical environment and tuberous crop diet with metabolic and cardiovascular conditions in rural and urban AN-speaking Melanesian and Micronesian populations of the Solomon Islands. A total of 561 participants were genotyped for single nucleotide polymorphisms (SNPs) potentially associated with a tropical environment (rs174570 and rs2237892) and a tuberous crop diet (rs162036, rs185819, and rs2722425). The results showed that the allele frequencies of the Solomon Islands populations adopted patterns similar to those in populations from other hot, tropical areas with a tuberous crop diet in previous studies. Furthermore, rs162036, rs185819, rs2237892, and rs2722425 were all strongly associated with one or more metabolic and cardiovascular conditions. The derived allele of rs2722425 (i.e. rs2722425-G) was significantly associated with an elevated LDL level ($p = 0.000264$) even after the significance level was adjusted for multiple testing (ie, $\alpha = 0.0005$). Our results suggest that the inhabitants of the Solomon Islands exhibit the effects of the tropical environment and tuberous crop diet on their allele frequencies, and that their susceptibility to metabolic and cardiovascular diseases is therefore considered to be associated with their environment and diet.

37 **González-Beiras C, Vall-Mayans M, González-Escalante Á, McClymont K, Ma L, Mitjà O.**
Yaws osteoperiostitis treated with single-dose azithromycin.
Am J Trop Med Hyg 2017 May;96(5):1039-1041. doi: 10.4269/ajtmh.16-0943. Epub 2017 Feb 13.

The etiologic agent of yaws, *Treponema pallidum* subsp. *pertenue*, causes a multistage infection transmitted by nonsexual contact with the exudates from active lesions. Bone lesions in the form of osteoperiostitis are common and occur in numerous bones simultaneously in early stages. Although a multinational eradication campaign with mass administration of intramuscular benzathine benzylpenicillin in the 1950s greatly reduced its global incidence, a resurgence of yaws has occurred since around 2000 in western and central Africa and the Pacific Islands. The finding that a single oral dose of azithromycin (30 mg/kg) was as effective as benzathine benzylpenicillin prompted renewed interest by World Health Organization in 2012 toward eradication of this infection by 2020. We previously reported the excellent response to benzathine benzylpenicillin therapy for yaws osteoperiostitis. Herein, we document a confirmed case of yaws with osteoperiostitis successfully treated with single-dose azithromycin and discuss the pathology of yaws periostitis and comment on the implications of this in light of the new campaign toward yaws eradication.

38 **Goris JM, Zomerdijk N, Temple VJ.**
Nutritional status and dietary diversity of Kamea in Gulf Province, Papua New Guinea.
Asia Pac J Clin Nutr 2017;26(4):665-670. doi: 10.6133/apjcn.052016.09.

BACKGROUND AND OBJECTIVES: To assess the nutritional status of infants, children and non-pregnant women and underlying factors, dietary diversity and community food security, in the Kamea community in Gulf Province, Papua New Guinea. METHODS AND STUDY DESIGN: Prospective

cross sectional study. Study population 69 infants (0-59 months), 151 children (6-12 years) and 79 non-pregnant women from 10 villages in Kotidanga Local Level Government, Kerema District, Gulf Province, Papua New Guinea. RESULTS: Among infants prevalence of moderate stunting, wasting and underweight were 38.9%, 8.3% and 44.4%, respectively; after adjusting Hb concentration for altitude, the anaemia prevalence was 53.8%. Among children prevalence of severe stunting was 21.2%; moderate stunting, wasting and underweight were 57.6%, 12.2% and 48.5%, respectively; anaemia was 30.3%; median urinary iodine concentration was 32.0 µg/L and iodine deficiency was prevalent among 88.1%. Among women, mean height, weight and BMI were 1.46±0.04 m, 43.9±5.91 kg and 20.4±2.32 kg/m^2, respectively; low BMI (<18.5 kg/m^2) and anaemia were prevalent among 22.8% and 35.4%, respectively; median urinary iodine concentration was 36.0 µg/L and iodine deficiency was prevalent among 80.3%. Exclusive breastfeeding was universal for young infants; complementary foods were limited in variety and frequency. Dietary diversity was limited, implementation of the universal salt iodisation strategy restricted and community food security was inadequate. CONCLUSIONS: The high prevalence of malnutrition and anaemia among the three age groups, including moderate status of iodine deficiency among women and children, are significant public health concerns. Improvements in dietary diversity, adequate use of iodised salt and community food security are needed.

39 **Gupta S, Mola G, Ramsay P, Jenkins G, Stein W, Bolnga J, Black K.**
Twelve month follow-up of a contraceptive implant outreach service in rural Papua New Guinea.
Aust NZ J Obstet Gynaecol 2017 Apr;57(2):213-218. doi: 10.1111/ajo.12596.

BACKGROUND: Poor access to contraception contributes to persistently high maternal mortality rates in Papua New Guinea (PNG). Since 2012 contraceptive implants have been provided to women in rural areas of PNG through outreach services but follow-up data in these communities on continuation and acceptability is lacking. OBJECTIVE: To gain insight into women's experience with contraceptive implants by assessing the acceptability, satisfaction, 12 month continuation rates and efficacy of contraceptive implants among women in rural PNG. MATERIAL AND METHODS: We undertook a cross-sectional survey of women in two rural provinces who had received a contraceptive implant at least 12 months prior using a structured questionnaire. We sought information on device continuation rates, satisfaction scores, side effects and failure rates. RESULTS: Of the 860 women surveyed, 97% (n = 836) still had the device in situ after 12 months and 92% (n = 793) were very happy with it. Seventy-six percent of women (n = 654) reported no side effects. Irregular bleeding was the most commonly reported side effect (n = 178, 20.6%) but only 7% (n = 13) said the bleeding was bothersome. Documented failure rates were 0.8% although pregnancy at the time of insertion could not be excluded in any of these cases. CONCLUSION: Twelve month implant follow-up data in this study showed high continuation rates and high levels of satisfaction among a rural population in PNG. Implants have the potential to lower maternal morbidity and mortality and simultaneously address the unmet need for contraception in these communities.

40 **Gushchin AG, Crum AV, Limbu BB, Quigley EP 3rd, Seward MS, Tabin GC.**
Simbu ptosis: an outreach approach to myogenic ptosis in Eastern Highlands of Papua New Guinea – experience and results from a high-volume oculoplastic surgical camp.
Ophthal Plast Reconstr Surg 2017 Mar/Apr;33(2):139-143. doi: 10.1097/IOP.0000000000000818.

PURPOSE: To present the results of a high-volume oculoplastic surgical outreach in a remote region of Simbu Province in the Eastern Highlands of Papua New Guinea. The authors describe the clinical features and evaluation and treatment of a novel ptosis syndrome found in this area. DESIGN: A team of 4 international ophthalmologists and 3 local doctors and 3 local nurses involved in a high-volume field intervention for all patients presenting with a bilateral ptosis to Mingende Rural Hospital. METHODS: Patients were systematically evaluated and treated during a 6-day surgical outreach and followed daily for 1 week and as needed via telemedicine. Visiting surgeons provided skills-transfer instruction for 3 local doctors and 3 nurses. Data collected included demographic information, history of present illness, past medical history, family history, social history, and a complete ophthalmologic and targeted neurologic evaluation. Patients were offered surgical intervention if they met criteria for safe eyelid elevation and could present for follow ups. Detailed notes of patient geographic location, history, and risk factors were collected in addition to pre- and postoperative photos. MAIN OUTCOME MEASURES: Efficient triage and treatment of all patients referred to the remote oculoplastic clinic. RESULTS: A total of 97 patients presented to the camp; of these, 87 underwent complete evaluation. There were 72 patients with ptosis, of which 60 were found to be of Simbu-type. These patients were grouped clinically by degree of ptosis: mild, moderate, and severe. Thirty-eight patients had moderate ptosis of which 34 underwent surgical intervention. Eleven patients with mild ptosis were counseled and observed. The 10 patients with severe ptosis and 2 with moderate ptosis were treated medically with ptosis crutches manufactured on site. A new technique for creating ptosis crutch glasses was developed. CONCLUSIONS: A new variant of progressive myogenic ptosis was identified. A high-volume oculoplastic surgical camp is an efficient way to systematically evaluate and treat this new entity. Skills-transfer training for local doctors and staff ensured continuity of care for the surgical patients.

41 **Herawati L, Budiman JA, Haryono W, Mulyani W.**
Jayapura teenagers' smoking behavior.
J Community Health 2017 Feb;42(1):78-82. doi: 10.1007/s10900-016-0232-4.

Smoking behavior is a threat for Indonesian teenagers, including in the city of Jayapura, Papua Province. The purpose of this study was to access Jayapura teenagers' smoking behavior and knowledge and include parents and other family members. The study was conducted on 78 respondents (grade 7, aged 11-14 years old), using cluster random sampling for selecting from the public and private junior high schools in Jayapura. The data collected was smoking behavior of respondents, parents and other family

members (using a self-reported questionnaire), and respondents' knowledge about the dangers of smoking (using tests with Cronbach's alpha 0.701). Data were analyzed descriptively and analytically using Chi-square, with a 95% level of significance. The results showed 29.3% of teenagers, 69.23% of parents and 25.6% of other family members were smokers, their knowledge was low (an average score of 60.81 out of 100), there was no significant statistical relationship between knowledge and smoking behavior among respondents (p = 0.079), and there was no significant relationship between teenagers' behavior and the behavior of the parents (p = 0.609) or other family members (p = 0.578). Nevertheless, 87% of teenagers became smokers because there were individuals who smoke at home.

42 **Homer CSE, Turkmani S, Rumsey M.**
The state of midwifery in small island Pacific nations.
Women Birth 2017 Jun;30(3):193-199. doi: 10.1016/j.wombi.2017.02.012. Epub 2017 Mar 21.

BACKGROUND: Strengthening midwifery is a global priority. Recently, global evidence has provided momentum toward developing the midwifery workforce. In 2014, the State of the World's Midwifery 2014 Report explored midwifery services in 73 low to middle income countries. In the South Pacific region, only Papua New Guinea and the Solomon Islands were included. This means that there is little known on the state of midwifery in the small island countries in the South Pacific. AIM: To explore the current situation of the education, regulation and association of midwives in 12 small island nations of the South Pacific and determine the gaps in these areas. METHODS: A descriptive study was undertaken. Data were collected through a survey completed by key representatives (usually the Chief Nursing and Midwifery Officer) from each of the 12 countries. Ethical approval was received from the relevant Human Research Ethics Committee. FINDINGS: Many of the countries had few midwives, in some instances, only two midwives for the whole country. Midwifery education programs included post-graduate diploma, certificates and bachelor degrees. Midwives were required to be registered nurses in all countries. Regulation and licensing also varied – most countries did not have a separate licensing system for midwives. Only three countries have a specific professional association for midwives. CONCLUSION: The variation and the small number of midwives poses challenges for workforce planning. Consideration could be given to developing regional standards and potentially a shared curriculum framework. Ongoing collaboration and networking between countries is a critical part of future developments.

43 **Houinei W, Godornes C, Kapa A, Knauf S, Mooring EQ, González-Beiras C, Watup R, Paru R, Advent P, Bieb S, Sanz S, Bassat Q, Spinola SM, Lukehart SA, Mitjà O.**
Haemophilus ducreyi DNA is detectable on the skin of asymptomatic children, flies and fomites in villages of Papua New Guinea.
PLoS Negl Trop Dis 2017 May 10;11(5):e0004958. doi: 10.1371/journal.pntd.0004958. eCollection 2017 May.

BACKGROUND: *Haemophilus ducreyi* and *Treponema pallidum* subsp. *pertenue* are major causes of leg ulcers in children in Africa and the Pacific Region. We investigated the presence of DNA (PCR positivity) from these bacteria on asymptomatic people, flies, and household linens in an endemic setting. METHODOLOGY/ PRINCIPAL FINDINGS: We performed a cross-sectional study in rural villages of Lihir Island, Papua New Guinea during a yaws elimination campaign. Participants were asymptomatic subjects recruited from households with cases of leg ulcers, and from households without cases of leg ulcers. We rubbed swabs on the intact skin of the leg of asymptomatic individuals, and collected flies and swabs of environmental surfaces. All specimens were tested by PCR for *H. ducreyi* and *T. p. pertenue* DNA. Of 78 asymptomatic participants that had an adequate specimen for DNA detection, *H. ducreyi*-PCR positivity was identified in 16 (21%) and *T. p. pertenue*-PCR positivity in 1 (1%). In subgroup analyses, *H. ducreyi*-PCR positivity did not differ in participants exposed or not exposed to a case of *H. ducreyi* ulcer in the household (24% vs 18%; p = 0.76). Of 17 cultures obtained from asymptomatic participants, 2 (12%) yielded a definitive diagnosis of *H. ducreyi*, proving skin colonization. Of 10 flies tested, 9 (90%) had *H. ducreyi* DNA and 5 (50%) had *T. p. pertenue* DNA. Of 6 bed sheets sampled, 2 (33%) had *H. ducreyi* DNA and 1 (17%) had *T. p. pertenue* DNA. CONCLUSIONS/SIGNIFICANCE: This is the first time that *H. ducreyi* DNA and colonization have been demonstrated on the skin of asymptomatic children and that *H. ducreyi* DNA and *T. p. pertenue* DNA have been identified in flies and on fomites. The ubiquity of *H. ducreyi* in the environment is a contributing factor to the spread of the organism.

44 **Idris ZM, Chan CW, Mohammed M, Kalkoa M, Taleo G, Junker K, Arcà B, Drakeley C, Kaneko A.**
Serological measures to assess the efficacy of malaria control programme on Ambae Island, Vanuatu.
Parasit Vectors 2017 Apr 26;10(1):204. doi: 10.1186/s13071-017-2139-z.

BACKGROUND: Seroepidemiology can provide evidence for temporal changes in malaria transmission and is an important tool to evaluate the effectiveness of control interventions. During the early 2000s, Vanuatu experienced an acute increase in malaria incidence due to a lapse in funding for vector control. After the distribution of subsidised insecticide-treated nets (ITNs) resumed in 2003, malaria incidence decreased in the subsequent years. This study was conducted to find the serological evidence supporting the impact of ITNs on exposure to *Anopheles* vector bites and parasite prevalence. METHODS: On Ambae Island, blood samples were collected from 231 and 282 individuals in 2003 and 2007, respectively. Parasite prevalence was determined by microscopy. Antibodies to three *Plasmodium falciparum* (PfSE, PfMSP-119, and PfAMA-1) and three *Plasmodium vivax* (PvSE, PvMSP-119, and PvAMA-1) antigens, as well as the *Anopheles*-specific salivary antigen gSG6, were detected by ELISA. Age-specific seroprevalence was analysed using a reverse catalytic modeling approach to estimate seroconversion rates (SCRs). RESULTS: Parasite rate decreased significantly ($p < 0.001$) from 19.0% in 2003 to 3.2% in 2007, with a shift from *P. falciparum* predominance to *P. falciparum-P. vivax* co-dominance. Significant ($p < 0.001$) decreases were observed in seroprevalence to all three *P.*

falciparum antigens but only two of three *P. vivax* antigens (except PvAMA-1; p = 0.153), consistent with the more pronounced decrease in *P. falciparum* prevalence. Seroprevalence to gSG6 also decreased significantly (p <0.001), suggesting that reduced exposure to vector bites was important to the decrease in parasite prevalence between 2003 and 2007. Analyses of age-specific seroprevalence showed a three-fold decrease in *P. falciparum* transmission, but the evidence for the decrease in *P. vivax* transmission was less clear. CONCLUSIONS: Serological markers pointed to the effectiveness of ITNs in reducing malaria prevalence on Ambae Island between 2003 and 2007. The recombinant gSG6 antigen originally developed to indicate exposure to the Afrotropical vector *An. gambiae* may be used in the Pacific to complement the traditional measure of entomological inoculation rate (EIR).

45 **Johnston CI, Ryan NM, O'Leary MA, Brown SG, Isbister GK.**
Australian taipan (*Oxyuranus* spp.) envenoming: clinical effects and potential benefits of early antivenom therapy – Australian Snakebite Project (ASP-25).
Clin Toxicol (Phila) 2017 Feb;55(2):115-122. doi: 10.1080/15563650.2016.1250903. Epub 2016 Nov 30.

CONTEXT: Taipans (*Oxyuranus* spp.) are medically important venomous snakes from Australia and Papua New Guinea. The objective of this study was to describe taipan envenoming in Australia and its response to antivenom. METHODS: Confirmed taipan bites were recruited from the Australian Snakebite Project. Data were collected prospectively on all snakebites, including patient demographics, bite circumstances, clinical effects, laboratory results, complications and treatment. Blood samples were taken and analysed by venom specific immunoassay to confirm snake species and measure venom concentration pre- and post-antivenom. RESULTS: There were 40 confirmed taipan bites: median age 41 years (2-85 years), 34 were males and 21 were snake handlers. Systemic envenoming occurred in 33 patients with neurotoxicity (26), complete venom induced consumption coagulopathy (VICC) (16), partial VICC (15), acute kidney injury (13), myotoxicity (11) and thrombocytopenia (7). Venom allergy occurred in seven patients, three of which had no evidence of envenoming and one died. Antivenom was given to 34 patients with a median initial dose of one vial (range 1-4), and a median total dose of two vials (range 1-9). A greater total antivenom dose was associated with VICC, neurotoxicity and acute kidney injury. Early antivenom administration was associated with a decreased frequency of neurotoxicity, acute kidney injury, myotoxicity and intubation. There was a shorter median time to discharge of 51 hours (19-432 hours) in patients given antivenom <4 hours post-bite, compared to 175 hours (27-1104 hours) in those given antivenom >4 hours. Median peak venom concentration in 25 patients with systemic envenoming and a sample available was 8.4 ng/L (1-3212 ng/L). No venom was detected in post-antivenom samples, including 20 patients given one vial initially and five patients bitten by inland taipans. DISCUSSION: Australian taipan envenoming is characterised by neurotoxicity, myotoxicity, coagulopathy, acute kidney injury and thrombocytopenia. One vial of antivenom binds all measurable venom and early antivenom was associated with a favourable outcome.

46 **Kamac K, Paterson B, Flint J.**
Lessons learnt from a measles outbreak in Madang Province, Papua New Guinea, June 2014-March 2015.
Western Pac Surveill Response J 2017 Mar 14;8(1):1-5. doi: 10.5365/WPSAR.2016.7.2.013. eCollection 2017 Jan-Mar.

OBJECTIVE: This study examined measles vaccine wastage during an outbreak response in Madang Province of Papua New Guinea from June 2014 to March 2015. METHODS: Vaccine wastage was defined as the number of doses received by a health centre minus the total number of doses administered during and returned following the outbreak vaccination campaign. Vaccine data were collected from the Provincial Health Information Office, the Provincial Vaccine Store register and clinic and health centre immunization registers for calculating the vaccine wastage. Interviews were conducted with all 48 health centres involved in the outbreak response using a structured questionnaire to explore the reasons for vaccine wastage. RESULTS: Of the 154 110 doses issued by Madang Province during the outbreak, a total of 85 236 (55%) doses were wasted. The wastage varied by district from 31% to 90%. The total cost of the vaccine wastage was estimated to be 589 810 Kina (US$ 196 604). None of the health centres maintained vaccine stock registers. Most health centres indicated multiple failures in cold chain logistics. Almost 40% of health centres reported incorrectly diluting vaccines. The same percentage of health centres reported using incorrect injection techniques. DISCUSSION: Regular audits of cold chain logistics, staff training and improved processes for recording vaccine administration and wastage will decrease vaccine wastage during vaccine-preventable disease outbreaks and also benefit routine immunization activities.

47 **Karki B, Kittel G, Bolokon I Jr, Duke T.**
Active community-based case finding for tuberculosis with limited resources.
Asia Pac J Public Health 2017 Jan;29(1):17-27. doi: 10.1177/1010539516683497. Epub 2016 Dec 29.

Papua New Guinea is one of the 14 highest-burden countries for tuberculosis (TB) infection, but few community-based studies exist. We evaluated a low-cost method of active community case finding in Kabwum and Wasu in Morobe Province, Papua New Guinea. Over 3 months we visited 26 villages and screened adults and children for symptoms and signs of TB. Sputum samples were examined using smear microscopy. A total of 1700 people had chronic symptoms, of which 267 were suspicious for TB on further examination. Sputum from 230 symptomatic adults yielded 97 samples that were positive for acid-fast bacilli. In addition, 15 cases of extrapulmonary TB in adults and 17 cases of TB in children were identified. One hundred and thirty people were identified with active TB disease among the source population of approximately 17 000, giving an estimated prevalence of 765 per 100 000. One hundred and six (82%) cases were not previously diagnosed. The cost per case identified was US$146. It is feasible to conduct active community-based case finding and treatment initiation for TB with limited resources and in remote areas, and in Papua New Guinea the yield was

high. Active case finding and follow-up of treatment in villages is needed to address the hidden burden of TB in Papua New Guinea and other high-burden Asia Pacific countries.

48 **Keven JB, Reimer L, Katusele M, Koimbu G, Vinit R, Vincent N, Thomsen E, Foran DR, Zimmerman PA, Walker ED.**
Plasticity of host selection by malaria vectors of Papua New Guinea.
Parasit Vectors 2017 Feb 21;10(1):95. doi: 10.1186/s13071-017-2038-3.

BACKGROUND: Host selection is an important determinant of vectorial capacity because malaria transmission increases when mosquitoes feed more on humans than non-humans. Host selection also affects the outcome of long-lasting insecticidal nets (LLIN). Despite the recent nationwide implementation of an LLIN-based malaria control program in Papua New Guinea (PNG), little is known about the host selection of the local *Anopheles* vectors. This study investigated the host selection of *Anopheles* vectors in PNG. METHODS: Blood-engorged mosquitoes were sampled using the barrier screen method and blood meals analyzed for vertebrate host source with PCR-amplification of the mitochondrial cytochrome b gene. Abundance of common hosts was estimated in surveys. The test of homogeneity of proportions and the Manly resource selection ratio were used to determine if hosts were selected in proportion to their abundance. RESULTS: Two thousand four hundred and forty blood fed *Anopheles* females of seven species were sampled from five villages in Madang, PNG. Of 2,142 samples tested, 2,061 (96.2%) yielded a definitive host source; all were human, pig, or dog. Hosts were not selected in proportion to their abundance, but rather were under-selected or over-selected by the mosquitoes. Four species, *Anopheles farauti* (sensu stricto) (s.s.), *Anopheles punctulatus* (s.s.), *Anopheles farauti* no. 4 and *Anopheles longirostris*, over-selected humans in villages with low LLIN usage, but over-selected pigs in villages with high LLIN usage. *Anopheles koliensis* consistently over-selected humans despite high LLIN usage, and *Anopheles bancroftii* over-selected pigs. CONCLUSIONS: The plasticity of host selection of an *Anopheles* species depends on its opportunistic, anthropophilic or zoophilic behavior, and on the extent of host availability and LLIN usage where the mosquitoes forage for hosts. The high anthropophily of *An. koliensis* increases the likelihood of contacting the LLIN inside houses. This allows its population size to be reduced to levels insufficient to support transmission. In contrast, by feeding on alternative hosts the likelihood of the opportunistic species to contact LLIN is lower, making them difficult to control. By maintaining high population size, the proportion that feed on humans outdoors can sustain residual transmission despite high LLIN usage in the village.

49 **Koolhof IS, Carver S.**
Epidemic host community contribution to mosquito-borne disease transmission: Ross River virus.
Epidemiol Infect 2017 Mar;145(4):656-666. doi: 10.1017/S0950268816002739. Epub 2016 Nov 28.

Most vector-borne diseases infect multiple host species, but disentangling the relative importance of different host species to transmission can be complex. Here we study how host species' abundance and competence (duration and titre of parasitaemia) influence host importance during epidemic scenarios. We evaluate this theory using Ross River virus (RRV, family *Togaviridae*, genus *Alphavirus*), a multi-host mosquito-borne disease with significant human health impacts across Australia and Papua New Guinea. We used host contribution models to find the importance of key hosts (possums, wallabies, kangaroos, horses, humans) in typical mammal communities around five Australian epidemic centres. We found humans and possums contributed most to epidemic RRV transmission, owing to their high abundances, generally followed by macropods. This supports humans as spillover hosts, and that human-mosquito and possum-mosquito transmission is predominant during epidemics. Sensitivity analyses indicate these findings to be robust across epidemic centres. We emphasize the importance of considering abundance and competence in identifying key hosts (during epidemics in this case), and that competence alone is inadequate. Knowledge of host importance in disease transmission may help to equip health agencies to bring about greater effectiveness of disease mitigation strategies.

50 **Kuadima JJ, Timinao L, Naidi L, Tandrapah A, Hetzel MW, Czeher C, Pulford J.**
Long-term acceptability, durability and bio-efficacy of ZeroVector® durable lining for vector control in Papua New Guinea.
Malar J 2017 Feb 28;16(1):93. doi: 10.1186/s12936-017-1742-y.

BACKGROUND: This study examined the acceptability, durability and bio-efficacy of pyrethroid-impregnated durable lining (DL) over a three-year period post-installation in residential homes across Papua New Guinea (PNG). METHODS: ZeroVector® ITPS had previously been installed in 40 homes across four study sites representing a cross section of malaria transmission risk and housing style. Structured questionnaires, DL visual inspections and group interviews (GIs) were completed with household heads at 12- and 36-months post-installation. Three DL samples were collected from all households in which it remained 36-months post-installation to evaluate the bio-efficacy of DL on *Anopheles* mosquitoes. Bio-efficacy testing followed WHO guidelines for the evaluation of indoor residual spraying. RESULTS: The DL was still intact in 86 and 39% of study homes at the two time periods, respectively. In homes in which the DL was still intact, 92% of household heads considered the appearance at 12-months post installation to be the same as, or better than, that at installation compared to 59% at 36-months post-installation. GIs at both time points confirmed continuing high acceptance of DL, based in large part of the perceived attractiveness and functionality of the material. However, participants frequently asserted that they, or their family members, had ceased or reduced their use of mosquito nets as a result of the DL installation. A total of 16 houses were sampled for bio-efficacy testing across the 4 study sites at 36-months post-installation. Overall, combining all sites and samples, both knock-down at 30 min and mortality at 24 h were 100%. CONCLUSIONS: The ZeroVector® DL installation remained highly acceptable at 36-months post-installation, the material and fixtures proved durable and the efficacy against malaria vectors did not decrease. However, the DL material had been

removed from over 50% of the original study homes 3 years post-installation, largely due to deteriorating housing infrastructure. Furthermore, the presence of the DL installation appeared to reduce ITN use among many participating householders. The study findings suggest DL may not be an appropriate vector control method for large-scale use in the contemporary PNG malaria control programme.

51 **Lamprell G, Braithwaite J.**
Mainstreaming gender and promoting intersectionality in Papua New Guinea's health policy: a triangulated analysis applying data-mining and content analytic techniques.
Int J Equity Health 2017 Apr 20;16(1):65. doi: 10.1186/s12939-017-0555-5.

BACKGROUND: Gender mainstreaming is an approach to policy and planning that emphasizes equality between the sexes. It is the stated policy for gender equity in Papua New Guinea's (PNG) health sector, as well as all other sectors, and is enshrined in the policies of its biggest aid givers. However, there is criticism that gender mainstreaming's application has too often been technocratic and lacking in conceptual clarity not only in PNG but elsewhere. In the health sector this is further exacerbated by a traditional bio-medical approach, which is often paternalistic and insufficiently patient- and family-centered. METHODS: This study analyses the policy attitudes toward gender in PNG's health sector using both data-mining and a traditional, summative content analysis. RESULTS: Our results show that gender is rarely mentioned. When it is, it is most often mentioned in relation to programs such as maternity and childcare for women, and elsewhere is applied technocratically. CONCLUSION: For PNG to promote greater levels of equity, the focus should first be on conceptualizing gender in a way that is meaningful for Papuans, taking into account the diversity of experiences and setting. Second, there should be greater focus on activists and civil society groups as the stakeholders most likely to make a difference in gender equity.

52 **Landi M, Swakin E, Minijihau C, Welch H, Tefuarani N, Duke T.**
Severe malnutrition in children in Papua New Guinea: effect of a multi-faceted intervention to improve quality of care and nutritional outcomes.
Paediatr Int Child Health 2017 Feb;37(1):21-28. doi: 10.1080/20469047.2015.1106079. Epub 2016 Jan 9.

BACKGROUND AND AIMS: Severe malnutrition remains a major problem in Papua New Guinea; it is associated with 11% of paediatric hospital admissions and 33% of all child deaths, with a case fatality rate around 20%. This article aims to evaluate the effectiveness of a multi-faceted intervention for improving care for children with severe malnutrition. METHODS: Severe malnutrition was defined as weight-for-age (WFA) <-3 Z-scores with severe wasting or mid upper arm circumference <115 mm or generalised oedema owing to malnutrition. The intervention included training for health-care workers on WHO guidelines for severe malnutrition, ward-round checklists, posters and support for nurses to provide better patient nutrition. Three point prevalence surveys were conducted, one before the intervention and two afterwards at 3-month intervals. The main outcomes were weight change since admission, energy intake and the proportion of the calculated required energy intake in the previous 24 hours. Each stage of the WHO guidelines for severe malnutrition management was assessed for adherence. RESULTS: There were significant improvements in the WHO steps for the management of severe malnutrition. At pre-intervention baseline, children received a median of 356 ml/day (IQR 178-450): 31% (95% CI 21-48) of their estimated daily energy requirements for weight. In the first follow-up survey, children received a median of 820 (IQR 600-1110) ml/day: 98% (95% CI 67-100) of daily energy requirements; and in the second follow-up survey they received 780 (IQR 480-900) ml/day: 86% (95% CI 46-100%) of daily requirement (p <0.001 both for volume received and percentage of energy requirements). Median weight gain prior to the intervention was 1.55 g/kg/day (IQR -4.3-6.0) which increased to 5.56 g/kg/day (IQR -3.7-12.0) and 10.19 g/kg/day (IQR 0-16.0) in the first and second follow-up surveys, respectively (p=0.013). CONCLUSION: Implementation of a multi-faceted intervention to improve the management of children with severe malnutrition was associated with improved quality of care and improved weight gain.

53 **Lavu E, Kave E, Mosoro E, Markby J, Aleksic E, Gare J, Elsum IA, Nano G, Kaima P, Dala N, Gurung A, Bertagnolio S, Crowe SM, Myatt M, Hearps AC, Jordan MR.**
High levels of transmitted HIV drug resistance in a study in Papua New Guinea.
PLoS One 2017 Feb 1;12(2):e0170265. doi: 10.1371/journal.pone.0170265. eCollection 2017.

INTRODUCTION: Papua New Guinea is a Pacific Island nation of 7.3 million people with an estimated HIV prevalence of 0.8%. ART initiation and monitoring are guided by clinical staging and CD4 cell counts, when available. Little is known about levels of transmitted HIV drug resistance in recently infected individuals in Papua New Guinea. METHODS: Surveillance of transmitted HIV drug resistance in a total of 123 individuals recently infected with HIV and aged less than 30 years was implemented in Port Moresby (n = 62) and Mount Hagen (n = 61) during the period May 2013-April 2014. HIV drug resistance testing was performed using dried blood spots. Transmitted HIV drug resistance was defined by the presence of one or more drug resistance mutations as defined by the World Health Organization surveillance drug resistance mutations list. RESULTS: The prevalence of non-nucleoside reverse transcriptase inhibitor transmitted HIV drug resistance was 16.1% (95% CI 8.8%-27.4%) and 8.2% (95% CI 3.2%-18.2%) in Port Moresby and Mount Hagen, respectively. The prevalence of nucleoside reverse transcriptase inhibitor transmitted HIV drug resistance was 3.2% (95% CI 0.2%-11.7%) and 3.3% (95% CI 0.2%-11.8%) in Port Moresby and Mount Hagen, respectively. No protease inhibitor transmitted HIV drug resistance was observed. CONCLUSIONS: The level of non-nucleoside reverse transcriptase inhibitor drug resistance in antiretroviral drug naïve individuals recently infected with HIV in Port Moresby is amongst the highest reported globally. This alarming level of transmitted HIV drug resistance in a young sexually active population threatens to limit the on-going effective use of NNRTIs as a component of first-line ART in Papua New Guinea. To support the choice of nationally recommended first-line antiretroviral therapy, representative surveillance of

HIV drug resistance among antiretroviral therapy initiators in Papua New Guinea should be urgently implemented.

54 **Luang-Suarkia D, Ernst T, Alpers MP, Garruto R, Smith D, Imrie A.**
Serological evidence for transmission of multiple dengue virus serotypes in Papua New Guinea and West Papua prior to 1963.
PLoS Negl Trop Dis 2017 Apr 24;11(4):e0005488. doi: 10.1371/journal.pntd.0005488. eCollection 2017 Apr.

Little is known about the natural history of dengue in Papua New Guinea (PNG). We assessed dengue virus (DENV)-specific neutralizing antibody profiles in serum samples collected from northern and southern coastal areas and the highland region of New Guinea between 1959 and 1963. Neutralizing antibodies were demonstrated in sera from the northern coast of New Guinea: from Sabron in Dutch New Guinea (now known as West Papua) and from four villages in East Sepik in what is now PNG. Previous monotypic infection with DENV-1, DENV-2, and DENV-4 was identified, with a predominance of anti-DENV-2 neutralizing antibody. The majority of positive sera demonstrated evidence of multiple previous DENV infections and neutralizing activity against all four serotypes was detected, with anti-DENV-2 responses being most frequent and of greatest magnitude. No evidence of previous DENV infection was identified in the Asmat villages of the southern coast and a single anti-DENV-positive sample was identified in the Eastern Highlands of PNG. These findings indicate that multiple DENV serotypes circulated along the northern coast of New Guinea at different times in the decades prior to 1963 and support the notion that dengue has been a significant yet neglected tropical infection in PNG for many decades.

55 **Maddock ST, Childerstone A, Fry BG, Williams DJ, Barlow A, Wüster W.**
Multi-locus phylogeny and species delimitation of Australo-Papuan black snakes (*Pseudechis* Wagler, 1830: Elapidae: Serpentes).
Mol Phylogenet Evol 2017 Feb;107:48-55. doi: 10.1016/j.ympev.2016.09.005. Epub 2016 Sep 13.

Genetic analyses of Australasian organisms have resulted in the identification of extensive cryptic diversity across the continent. The venomous elapid snakes are among the best-studied organismal groups in this region, but many knowledge gaps persist: for instance, despite their iconic status, the species-level diversity among Australo-Papuan black snakes (*Pseudechis*) has remained poorly understood due to the existence of a group of cryptic species within the *P. australis* species complex, collectively termed “pygmy mulga snakes”. Using two mitochondrial and three nuclear loci we assess species boundaries within the genus using Bayesian species delimitation methods and reconstruct their phylogenetic history using multispecies coalescent approaches. Our analyses support the recognition of 10 species, including all of the currently described pygmy mulga snakes and one undescribed species from the Northern Territory of Australia. Phylogenetic relationships within the genus are broadly consistent with previous work, with the recognition of three major groups, the viviparous red-bellied black snake *P. porphyriacus* forming the sister species to two clades consisting of ovoviviparous species.

56 **Marella M, Yu M, Paudel P, Michael A, Ryan K, Yasmin S, Minto H.**
The situation of low vision services in Papua New Guinea: an exploratory study.
Clin Exp Optom 2017 Jan;100(1):54-60. doi: 10.1111/cxo.12446. Epub 2016 Sep 1.

BACKGROUND: The aim of this study was to investigate the current situation of low vision services and barriers to low vision service delivery in Papua New Guinea (PNG). METHODS: An exploratory study was undertaken to assess the situation of available services, human resources, training, equipment and assistive devices, supportive policies, needs of people with low vision and community attitudes toward people with low vision. In-depth interviews with 50 key informants were conducted in-country. Key informants included eye-care practitioners (n = 13), special education teachers (n = 10), community-based rehabilitation workers (n = 3), other stakeholders providing disability-related services (n = 8), and people with low vision (n = 14) and their family members (n = 2). Interview transcripts were analysed inductively and deductively using thematic analysis. RESULTS: Barriers were identified at systems and community levels. The barriers at the systems level were: low vision not a priority area for eye care and rehabilitation programs, limited availability of low vision services, trained personnel and low vision devices; low vision not included in training programs of eye-care practitioners and lack of awareness of available referral services among service providers. The barriers identified at the community level were lack of awareness of services, distance, costs and limited transport to access services and negative community attitudes. CONCLUSION: This study has identified barriers from the perspectives of different stakeholders, including service providers and people with low vision and their families. Knowledge of these barriers can now guide the development of future low vision services in PNG.

57 **Maynard AJ, Ambrose L, Cooper RD, Chow WK, Davis JB, Muzari MO, van den Hurk AF, Hall-Mendelin S, Hasty JM, Burkot TR, Bangs MJ, Reimer LJ, Butafa C, Lobo NF, Syafruddin D, Maung Maung YN, Ahmad R, Beebe NW.**
Tiger on the prowl: invasion history and spatio-temporal genetic structure of the Asian tiger mosquito *Aedes albopictus (*Skuse 1894) in the Indo-Pacific.
PLoS Negl Trop Dis 2017 Apr 14;11(4):e0005546. doi: 10.1371/journal.pntd.0005546. eCollection 2017 Apr.

BACKGROUND: Within the last century, increases in human movement and globalization of trade have facilitated the establishment of several highly invasive mosquito species in new geographic locations with concurrent major environmental, economic and health consequences. The Asian tiger mosquito, *Aedes albopictus*, is an extremely invasive and aggressive daytime-biting mosquito that is a major public health threat throughout its expanding range. METHODOLOGY/PRINCIPAL FINDINGS: We used 13 nuclear microsatellite loci (on 911 individuals) and mitochondrial COI sequences to gain a better understanding of the historical and contemporary movements of *Ae. albopictus* in the Indo-Pacific region and to characterize its population structure. Approximate Bayesian computation (ABC) was employed to test competing historical routes of invasion of *Ae. albopictus* within the

Southeast (SE) Asian/Australasian region. Our ABC results show that *Ae. albopictus* was most likely introduced to New Guinea via mainland Southeast Asia, before colonizing the Solomon Islands via either Papua New Guinea or SE Asia. The analysis also supported that the recent incursion into northern Australia's Torres Strait Islands was seeded chiefly from Indonesia. For the first time documented in this invasive species, we provide evidence of a recently colonized population (the Torres Strait Islands) that has undergone rapid temporal changes in its genetic makeup, which could be the result of genetic drift or represent a secondary invasion from an unknown source. CONCLUSIONS/SIGNIFICANCE: There appears to be high spatial genetic structure and high gene flow between some geographically distant populations. The species' genetic structure in the region tends to favour a dispersal pattern driven mostly by human movements. Importantly, this study provides a more widespread sampling distribution of the species' native range, revealing more spatial population structure than previously shown. Additionally, we present the most probable invasion history of this species in the Australasian region using ABC analysis.

58 **McKee J, Clark N, Shapter F, Simmons G.**
A new look at the origins of gibbon ape leukemia virus.
Virus Genes 2017 Apr;53(2):165-172. doi: 10.1007/s11262-017-1436-0. Epub 2017 Feb 20.

Is the origin of gibbon ape leukemia virus (GALV) human after all? When GALV was discovered and found to cause neoplastic disease in gibbons, it stimulated a great deal of research including investigations into the origins of this virus. A number of publications have suggested that the GALV progenitor was a retrovirus present in one of several species of South East Asian rodents that had close contact with captive gibbons. However, there are no published retroviral sequences from any South East Asian species to support this view. Here we present an alternative hypothesis that the origin of GALV is a virus closely related to *Melomys burtoni* retrovirus, and that this virus infected human patients in Papua New Guinea from whom biological material was obtained or in some way contaminated these samples. This material we propose contained infectious MbRV-related virus that was then unwittingly introduced into gibbons which subsequently developed GALV infections.

59 **Mitjà O, Marks M, Bertran L, Kollie K, Argaw D, Fahal AH, Fitzpatrick C, Fuller LC, Garcia Izquierdo B, Hay R, Ishii N, Johnson C, Lazarus JV, Meka A, Murdoch M, Ohene SA, Small P, Steer A, Tabah EN, Tiendrebeogo A, Waller L, Yotsu R, Walker SL, Asiedu K.**
Integrated control and management of neglected tropical skin diseases.
PLoS Negl Trop Dis 2017 Jan 19;11(1):e0005136. doi: 10.1371/journal.pntd.0005136. eCollection 2017 Jan.

60 **Muzari MO, Devine G, Davis J, Crunkhorn B, van den Hurk A, Whelan P, Russell R, Walker J, Horne P, Ehlers G, Ritchie S.**
Holding back the tiger: successful control program protects Australia from *Aedes albopictus* expansion.
PLoS Negl Trop Dis 2017 Feb 13;11(2):e0005286. doi: 10.1371/journal.pntd.0005286. eCollection 2017 Feb.

BACKGROUND: The Asian tiger mosquito, *Aedes albopictus*, is an important vector of dengue, chikungunya and Zika viruses and is a highly invasive and aggressive biter. Established populations of this species were first recognised in Australia in 2005 when they were discovered on islands in the Torres Strait, between mainland Australia and Papua New Guinea. A control program was implemented with the original goal of eliminating *Ae. albopictus* from the Torres Strait. We describe the evolution of management strategies that provide a template for *Ae. albopictus* control that can be adopted elsewhere. METHODOLOGY / PRINCIPAL FINDINGS: The control strategy implemented between 2005 and 2008 targeted larval habitats using source reduction, insect-growth regulator and pyrethroid insecticide to control larvae and adults in the containers. However, the infrequency of insecticide reapplication, the continual accumulation and replacement of containers, and imminent re-introduction of mosquitoes through people's movement from elsewhere compromised the program. Consequently, in 2009 the objective of the program changed from elimination to quarantine, with the goal of preventing *Ae. albopictus* from infesting Thursday and Horn islands, which are the transport hubs connecting the Torres Strait to mainland Australia. However, larval control strategies did not prevent the species establishing on these islands in 2010. Thereafter, an additional strategy adopted by the quarantine program in early 2011 was harborage spraying, whereby the vegetated, well shaded resting sites of adult *Ae. albopictus* were treated with a residual pyrethroid insecticide. Inclusion of this additional measure led to a 97% decline in *Ae. albopictus* numbers within two years. In addition, the frequency of container treatment was increased to five weeks between treatments, compared to an average of 8 weeks that occurred in the earlier iterations of the program. By 2015 and 2016, *Ae. albopictus* populations on the two islands were undetectable in 70-90% of surveys conducted. Importantly, a comprehensive surveillance network in selected strategic areas has not identified established populations of this species on the Australian mainland. CONCLUSIONS / SIGNIFICANCE: The program has successfully reduced *Ae. albopictus* populations on Thursday Island and Horn Island to levels where it is undetectable in up to 90% of surveys, and has largely removed the risk of mainland establishment via that route. The vector management strategies adopted in the later years of the program have been demonstrably successful and provide a practical management framework for dengue, chikungunya or Zika virus outbreaks vectored by *Ae. albopictus*. As of June 2016, *Ae. albopictus* had not established on the Australian mainland and this program has likely contributed significantly to this outcome.

61 **Nguyen TK, Tran TH, Roberts CL, Graham SM, Marais BJ.**
Child pneumonia – focus on the Western Pacific Region.
Paediatr Respir Rev 2017 Jan;21:102-110. doi: 10.1016/j.prrv.2016.07.004. Epub 2016 Jul 18.

Worldwide, pneumonia is the leading cause of death in infants and young children (aged <5 years). We provide an overview of the global pneumonia disease burden, as well as the aetiology

and management practices in different parts of the world, with a specific focus on the WHO Western Pacific Region. In 2011, the Western Pacific Region had an estimated 0.11 pneumonia episodes per child-year with 61,900 pneumonia-related deaths in children less than 5 years of age. The majority (>75%) of pneumonia deaths occurred in six countries: Cambodia, China, Laos, Papua New Guinea, the Philippines and Viet Nam. Historically *Streptococcus pneumoniae* and *Haemophilus influenzae* were the commonest causes of severe pneumonia and pneumonia-related deaths in young children, but this is changing with the introduction of highly effective conjugate vaccines and socio-economic development. The relative contribution of viruses and atypical bacteria appear to be increasing and traditional case management approaches may require revision to accommodate increased uptake of conjugated vaccines in the Western Pacific Region. Careful consideration should be given to risk reduction strategies, enhanced vaccination coverage, improved management of hypoxaemia and antibiotic stewardship.

62 **Ome-Kaius M, Karl S, Wangnapi RA, Bolnga JW, Mola G, Walker J, Mueller I, Unger HW, Rogerson SJ.**
Effects of *Plasmodium falciparum* infection on umbilical artery resistance and intrafetal blood flow distribution: a Doppler ultrasound study from Papua New Guinea.
Malar J 2017 Jan 19;16(1):35. doi: 10.1186/s12936-017-1689-z.

BACKGROUND: Doppler velocimetry studies of umbilical artery (UA) and middle cerebral artery (MCA) flow help to determine the presence and severity of fetal growth restriction. Increased UA resistance and reduced MCA pulsatility may indicate increased placental resistance and intrafetal blood flow redistribution. Malaria causes low birth weight and fetal growth restriction, but few studies have assessed its effects on uteroplacental and fetoplacental blood flow. METHODS: Colour-pulsed Doppler ultrasound was used to assess UA and MCA flow in 396 Papua New Guinean singleton fetuses. Abnormal flow was defined as an UA resistance index above the 90th centile, and/or a MCA pulsatility index and cerebroplacental ratio (ratio of MCA and UA pulsatility index) below the 10th centile of population-specific models fitted to the data. Associations between malaria (peripheral infection prior to and at ultrasound examination, and any gestational infection, ie, 'exposure') and abnormal flow, and between abnormal flow and birth outcomes, were estimated. RESULTS: Of 78 malaria infection episodes detected before or at the ultrasound visit, 62 (79.5%) were *Plasmodium falciparum* (34 sub-microscopic infections), and 16 were *Plasmodium vivax*. *Plasmodium falciparum* infection before or at Doppler measurement was associated with increased UA resistance (adjusted odds ratio (aOR) 2.3 95% CI 1.0-5.2, p = 0.047). When assessed by 'exposure', *P. falciparum* infection was significantly associated with increased UA resistance (all infections: 2.4, 1.1-4.9, p = 0.024; sub-microscopic infections 2.6, 1.0-6.6, p = 0.051) and a reduced MCA pulsatility index (all infections: 2.6, 1.2-5.3, p = 0.012; sub-microscopic infections: 2.8, 1.1-7.5, p = 0.035). Sub-microscopic *P. falciparum* infections were additionally associated with a reduced cerebroplacental ratio (3.64, 1.22-10.88, p = 0.021). There were too few *P. vivax* infections to draw robust conclusions. An increased UA resistance index was associated with histological evidence of placental malaria (5.1, 2.3-10.9, p <0.001; sensitivity 0.26, specificity 0.93). A low cerebroplacental Doppler ratio was associated with concurrently measuring small-for-gestational-age, and with low birth weight. DISCUSSION/CONCLUSION: Both microscopic and sub-microscopic *P. falciparum* infections impair fetoplacental and intrafetal flow, at least temporarily. Increased UA resistance has high specificity but low sensitivity for the detection of placental infection. These findings suggest that interventions to protect the fetus should clear and prevent both microscopic and sub-microscopic malarial infections.

63 **Pava Z, Noviyanti R, Handayuni I, Trimarsanto H, Trianty L, Burdam FH, Kenangalem E, Utami RAS, Tirta YK, Coutrier F, Poespoprodjo JR, Price RN, Marfurt J, Auburn S.**
Genetic micro-epidemiology of malaria in Papua Indonesia: extensive *P. vivax* diversity and a distinct subpopulation of asymptomatic *P. falciparum* infections.
PLoS One 2017 May 12;12(5):e0177445. doi: 10.1371/journal.pone.0177445. eCollection 2017.

BACKGROUND: Genetic analyses of *Plasmodium* have potential to inform on transmission dynamics, but few studies have evaluated this on a local spatial scale. We used microsatellite genotyping to characterise the micro-epidemiology of *P. vivax* and *P. falciparum* diversity to inform malaria control strategies in Timika, Papua Indonesia. METHODS: Genotyping was undertaken on 713 sympatric *P. falciparum* and *P. vivax* isolates from a cross-sectional household survey and clinical studies conducted in Timika. Standard population genetic measures were applied, and the data was compared to published data from Kalimantan, Bangka, Sumba and West Timor. RESULTS: Higher diversity (HE = 0.847 vs 0.625; p = 0.017) and polyclonality (46.2% vs 16.5%, p <0.001) were observed in *P. vivax* versus *P. falciparum*. Distinct *P. falciparum* substructure was observed, with two subpopulations, K1 and K2. K1 was comprised solely of asymptomatic infections and displayed greater relatedness to isolates from Sumba than to K2, possibly reflecting imported infections. CONCLUSIONS: The results demonstrate the greater refractoriness of *P. vivax* versus *P. falciparum* to control measures, and risk of distinct parasite subpopulations persisting in the community undetected by passive surveillance. These findings highlight the need for complementary new surveillance strategies to identify transmission patterns that cannot be detected with traditional malariometric methods.

64 **Pla D, Bande BW, Welton RE, Paiva OK, Sanz L, Segura Á, Wright CE, Calvete JJ, Gutiérrez JM, Williams DJ.**
Proteomics and antivenomics of Papuan black snake (*Pseudechis papuanus*) venom with analysis of its toxicological profile and the preclinical efficacy of Australian antivenoms.
J Proteomics 2017 Jan 6;150:201-215. doi: 10.1016/j.jprot.2016.09.007. Epub 2016 Sep 17.

The Papuan black snake (*Pseudechis papuanus*: Serpentes: Elapidae) is endemic to Papua New Guinea, Indonesian Papua and Australia's Torres Strait Islands. We have investigated the biological activity and proteomic composition of its venom. The

P. papuanus venom proteome is dominated by a variety (n ≥18) of PLA2s, which together account for ~90% of the venom proteins, and a set of low relative abundance proteins, including a short-neurotoxic 3FTx (3.1%), 3-4 PIII-SVMPs (2.8%), 3 cysteine-rich secretory proteins (CRISP; 2.3%) and 1-3 l-amino acid oxidase (LAAO) molecules (1.6%). Probing of a *P. papuanus* cDNA library with specific primers resulted in the elucidation of the full-length nucleotide sequences of six new toxins, including vespryn and NGF not found in the venom proteome, and a calglandulin protein involved in toxin expression with the venom glands. Intravenous injection of *P. papuanus* venom in mice induced lethality, intravascular haemolysis, pulmonary congestion and oedema, and anticoagulation, and these effects are mainly due to the action of PLA2s. This study also evaluated the in vivo preclinical efficacy of Australian black snake and polyvalent Seqirus antivenoms. These antivenoms were effective in neutralising the lethal, PLA2 and anticoagulant activities of *P. papuanus* venom in mice. On the other hand, all of the Seqirus antivenoms tested using an antivenomic approach exhibited strong immunorecognition of all the venom components. These preclinical results suggest that Australian Seqirus1 antivenoms may provide paraspecific protection against *P. papuanus* venom in humans. SIGNIFICANCE: The toxicological profile and proteomic composition of the venom of the Papuan black snake, *Pseudechis papuanus*, a large diurnal snake endemic to the southern coast of New Guinea and a handful of close offshore islands, were investigated. Intravenous injection of *P. papuanus* venom in mice induced intravascular haemolysis, pulmonary congestion and oedema, anticoagulation, and death. These activities could be assigned to the set of PLA2 molecules, which dominate the *P. papuanus* venom proteome. This study also showed that Australian Seqirus black snake or polyvalent antivenoms were effective in neutralising the lethal, PLA2 and anticoagulant activities of the venom. These preclinical results support the continued recommendation of these Seqirus antivenoms in the clinical management of *P. papuanus* envenoming in Australia, Papua New Guinea or Indonesian Papua Province.

65 **Prescott TAK, Homot P, Lundy FT, Fang R, Patrick S, Cámara-Leret R, Kiapranis R.**
Tropical ulcer plant treatments used by Papua New Guinea's Apsokok nomads.
J Ethnopharmacol 2017 Jun 9;205:240-245. doi: 10.1016/j.jep.2017.05.001. Epub 2017 May 4.

ETHNOPHARMACOLOGICAL RELEVANCE: The tropical ulcer is a debilitating bacterial infection that is common in Papua New Guinea. Deploying healthcare infrastructure to remote and inaccessible rainforest locations is not practical, therefore local plants may be the best treatment option. Here we present an ethnobotanical survey of the tropical ulcer plant medicines used by the semi-nomadic Apsokok who roam the remote central mountains of Papua New Guinea's West New Britain Province. In vitro biological activity in assays relevant to tropical ulcer wound healing is also presented. MATERIALS AND METHODS: Focus groups and semi-structured interviews were used to acquire information on the uses of plants, vouchers of which were identified by comparison with authentic herbarium specimens. Antibacterial disc diffusion assays with *Staphylococcus aureus* and *Fusobacterium ulcerans*, MMP-9 enzyme inhibition and dermal fibroblast stimulation assays were carried out on plant saps and aqueous extracts of plant material. LC-MS was used to identify known plant metabolites. RESULTS: The ethnobotanical survey identified sixteen species that were used to treat tropical ulcers, all of which were applied topically. A subset of twelve species were investigated further in vitro. Four species produced zones of inhibition with *S. aureus*, all 12 species provided low level inhibition of MMP-9 and 8 species stimulated dermal fibroblast proliferation, although cytotoxicity occurred at higher concentrations. The extract of *Homalium foetidum* Benth. inhibited *S. aureus* and MMP-9 while at lower sub-cytotoxic concentrations stimulated fibroblast proliferation. Trans-3-O-p-coumaroylquinic acid and cis-3-O-p-coumaroylquinic acid were detected in the aqueous extract of *H. foetidum*. CONCLUSIONS: Topical application of plant saps to wounds results in very high localised concentrations of plant metabolites which is likely to result in inhibition of MMP proteases. *H. foetidum* is a candidate plant for tropical ulcer treatment in remote areas.

66 **Rarau P, Vengiau G, Gouda H, Phuanukoonnon S, Kevau IH, Bullen C, Scragg R, Riley I, Marks G, Umezaki M, Morita A, Oldenburg B, McPake B, Pulford J.**
Prevalence of non-communicable disease risk factors in three sites across Papua New Guinea: a cross-sectional study.
BMJ Glob Health 2017 Jun 14;2(2):e000221. doi: 10.1136/bmjgh-2016-000221. eCollection 2017.

Papua New Guinea (PNG) is a culturally, environmentally and ethnically diverse country of 7.3 million people experiencing rapid economic development and social change. Such development is typically associated with an increase in non-communicable disease (NCD) risk factors. *Aim*: To establish the prevalence of NCD risk factors in three different regions across PNG in order to guide appropriate prevention and control measures. *Methods*: A cross-sectional survey was undertaken with randomly selected adults (15-65 years), stratified by age and sex and recruited from the general population of integrated Health and Demographic Surveillance Sites in West Hiri (periurban), Asaro (rural highland) and Karkar Island (rural island), PNG. A modified WHO STEPS risk factor survey was administered along with anthropometric and biochemical measures on study participants. *Results*: The prevalence of NCD risk factors was markedly different across the three sites. For example, the prevalences of current alcohol consumption at 43% (95% CI 35 to 52), stress at 46% (95% CI 40 to 52), obesity at 22% (95% CI 18 to 28), hypertension at 22% (95% CI 17 to 28), elevated levels of cholesterol at 24% (95% CI 19 to 29) and haemoglobin A1c at 34% (95% CI 29 to 41) were highest in West Hiri relative to the rural areas. However, central obesity at 90% (95% CI 86 to 93) and prehypertension at 55% (95% CI 42 to 62) were most common in Asaro whereas prevalences of smoking, physical inactivity and low high-density lipoprotein-cholesterol levels at 52% (95% CI 45 to 59), 34% (95% CI 26 to 42) and 62% (95% CI 56 to 68), respectively, were highest in Karkar Island. *Conclusion*: Adult residents in the three different communities are at high risk of developing NCDs, especially the West Hiri periurban population. There is an urgent need for appropriate multisectoral preventive interventions and improved

health services. Improved monitoring and control of NCD risk factors is also needed in all regions across PNG.

67 **Requena P, Arévalo-Herrera M, Menegon M, Martínez-Espinosa FE, Padilla N, Bôtto-Menezes C, Malheiro A, Hans D, Castellanos ME, Robinson L, Samol P, Kochar S, Kochar SK, Kochar DK, Desai M, Sanz S, Quintó L, Mayor A, Rogerson S, Mueller I, Severini C, Del Portillo HA, Bardají A, Chitnis CC, Menéndez C, Dobaño C.**
Naturally acquired binding-inhibitory antibodies to *Plasmodium vivax* Duffy binding protein in pregnant women are associated with higher birth weight in a multicenter study.
Front Immunol 2017 Feb 17;8:163. doi: 10.3389/fimmu.2017.00163. eCollection 2017.

A vaccine to eliminate malaria would need a multi-stage and multi-species composition to achieve robust protection, but the lack of knowledge about antigen targets and mechanisms of protection precludes the development of fully efficacious malaria vaccines, especially for *Plasmodium vivax* (Pv). Pregnant women constitute a risk population who would greatly benefit from a vaccine preventing the adverse events of *Plasmodium* infection during gestation. We hypothesized that functional immune responses against putative targets of naturally acquired immunity to malaria and vaccine candidates will be associated with protection against malaria infection and/or poor outcomes during pregnancy. We measured (i) IgG responses to a large panel of Pv and *Plasmodium falciparum* (Pf) antigens, (ii) the capacity of anti-Pv ligand Duffy binding protein (PvDBP) antibodies to inhibit binding to Duffy antigen, and (iii) cellular immune responses to two Pv antigens, in a subset of 1,056 pregnant women from Brazil, Colombia, Guatemala, India, and Papua New Guinea (PNG). There were significant intraspecies and interspecies correlations for most antibody responses (eg, PfMSP119 versus PfAMA1, Spearman's rho = 0.81). Women from PNG and Colombia had the highest levels of IgG overall. Submicroscopic infections seemed sufficient to boost antibody responses in Guatemala but not antigen-specific cellular responses in PNG. Brazil had the highest percentage of Duffy binding inhibition (p values versus Colombia: 0.040; Guatemala: 0.047; India: 0.003, and PNG: 0.153) despite having low anti-PvDBP IgG levels. Almost all antibodies had a positive association with present infection, and coinfection with the other species increased this association. Anti-PvDBP, anti-PfMSP1, and anti-PfAMA1 IgG levels at recruitment were positively associated with infection at delivery (p values: 0.010, 0.003, and 0.023, respectively), suggesting that they are markers of malaria exposure. Peripheral blood mononuclear cells from Pv-infected women presented fewer CD8+IFN-γ+ T cells and secreted more G-CSF and IL-4 independently of the stimulus used in vitro. Functional anti-PvDBP levels at recruitment had a positive association with birth weight (difference per doubling antibody levels: 45 g, p value: 0.046). Thus, naturally acquired binding-inhibitory antibodies to PvDBP might confer protection against poor outcomes of Pv malaria in pregnancy.

68 **Roberts P, Gaffney D, Lee-Thorp J, Summerhayes G.**
Persistent tropical foraging in the highlands of terminal Pleistocene/Holocene New Guinea.
Nat Ecol Evol 2017 Feb 6;1(3):44. doi: 10.1038/s41559-016-0044.

The terminal Pleistocene/Holocene boundary (approximately 12-8 thousand years ago) represented a major ecological threshold for humans, both as a significant climate transition and due to the emergence of agriculture around this time. In the highlands of New Guinea, climatic and environmental changes across this period have been highlighted as potential drivers of one of the earliest domestication processes in the world. We present a terminal Pleistocene/Holocene palaeoenvironmental record (12-0 thousand years ago) of carbon and oxygen isotopes in small mammal tooth enamel from the site of Kiowa. The results show that tropical highland forest and open mosaics, and the human subsistence focused on these environments, remained stable throughout the period in which agriculture emerged at nearby Kuk Swamp. This suggests the persistence of tropical forest foraging among highland New Guinea groups and highlights that agriculture in the region was not adopted as a unilinear or dramatic, forced event but was locally and historically contingent.

69 **Salman S, Baiwog F, Page-Sharp M, Griffin S, Karunajeewa HA, Mueller I, Rogerson SJ, Siba PM, Ilett KF, Davis TME.**
Optimal antimalarial dose regimens for sulfadoxine-pyrimethamine with or without azithromycin in pregnancy based on population pharmacokinetic modeling.
Antimicrob Agents Chemother 2017 Apr 24;61(5). pii: e02291-16. doi: 10.1128/AAC.02291-16. Print 2017 May.

Optimal dosing of sulfadoxine-pyrimethamine (SP) as intermittent preventive treatment in pregnancy remains to be established, particularly when coadministered with azithromycin (AZI). To further characterize SP pharmacokinetics in pregnancy, plasma concentration-time data from 45 nonpregnant and 45 pregnant women treated with SP-AZI (n = 15 in each group) and SP-chloroquine (n = 30 in each group) were analyzed. Population nonlinear mixed-effect pharmacokinetic models were developed for pyrimethamine (PYR), sulfadoxine (SDOX), and N-acetylsulfadoxine (the SDOX metabolite NASDOX), and potential covariates were included. Pregnancy increased the relative clearance (CL/F) of PYR, SDOX, and NASDOX by 48, 29, and 70%, respectively, as well as the relative volumes of distribution (V/F) of PYR and SDOX (46 and 99%) and NASDOX (46%). Coadministration of AZI resulted in a greater increase in PYR CL/F (80%) and also increased NASDOX V/F by 76%. Apparent differences between these results and those of published studies of SP disposition may reflect key differences in study design, including the use of an early postpartum follow-up study rather than a nonpregnant comparator group. Simulations based on the final population model demonstrated that, compared to conventional single-dose SP in nonpregnant women, two such doses given 24 h apart should ensure that pregnant women have similar drug exposure, while three daily SP doses may be required if SP is given with AZI. The results of past and ongoing trials using recommended adult SP doses with or without AZI in pregnant women may need to be interpreted in light of these findings and consideration given to using increased doses in

future trials.

70 **Saweri OP, Hetzel MW, Mueller I, Siba PM, Pulford J.**
The treatment of non-malarial febrile illness in Papua New Guinea: findings from cross-sectional and longitudinal studies of health worker practice.
BMC Health Serv Res 2017 Jan 5;17(1):10. doi: 10.1186/s12913-016-1965-6.

BACKGROUND: The Papua New Guinea Department of Health recently shifted from a presumptive to a 'test and treat' malaria case management policy. This shift was supported by the widespread introduction of malaria rapid diagnostic tests in health facilities across the country. Health workers received training and job-aids detailing how to conduct and interpret a malaria rapid diagnostic test and how to treat test positive cases; however, little instruction on treating non-malaria febrile cases was provided. Accordingly, this study examined health worker case management of non-malarial febrile patients in the 12-month period immediately following the introduction of the revised malaria case management policy. METHODS: Data were collected from a country-wide cross-sectional survey of febrile case management at randomly selected health facilities and from longitudinal surveillance at sentinel health facilities. Analysis was restricted to febrile patients who tested negative for malaria infection by rapid diagnostic test (N=303 and 5705 outpatients, respectively). RESULTS AND DISCUSSION: 96.8% of non-malarial febrile patients received a diagnosis in the longitudinal sample, compared to 52.4% of the cross-sectional sample. Respiratory tract infections were the most commonly reported diagnoses. Over 90% of patients in both samples were prescribed one or more medications, most commonly an analgesic (71.3 & 72.9% of the longitudinal and cross-sectional samples, respectively), some form of antibiotic (72.7 & 73.4%, respectively) and/or an anthelminthic (17.9 & 16.5%, respectively). Prescribing behaviour was adherent with the recommendations in the standard treatment guidelines in fewer than 20% of cases (longitudinal sample only). CONCLUSION: Many non-malarial febrile patients are not provided with a diagnosis. When diagnoses are provided they are typically some form of respiratory tract infection. Antibiotics and analgesics are widely prescribed, although medications prescribed rarely adhere to the Papua New Guinea standard treatment guidelines. These findings indicate that Papua New Guinea health workers require support for non-malarial febrile illness case management.

71 **Schofield L, Ioannidis LJ, Karl S, Robinson LJ, Tan QY, Poole DP, Betuela I, Hill DL, Siba PM, Hansen DS, Mueller I, Eriksson EM.**
Synergistic effect of IL-12 and IL-18 induces TIM3 regulation of γδ T cell function and decreases the risk of clinical malaria in children living in Papua New Guinea.
BMC Med 2017 Jun 15;15(1):114. doi: 10.1186/s12916-017-0883-8.

BACKGROUND: γδ T cells are important for both protective immunity and immunopathogenesis during malaria infection. However, the immunological processes determining beneficial or detrimental effects on disease outcome remain elusive. The aim of this study was to examine expression and regulatory effect of the inhibitory receptor T-cell immunoglobulin domain and mucin domain 3 (TIM3) on γδ T cells. While TIM3 expression and function on conventional αβ T cells have been clearly defined, the equivalent characterization on γδ T cells and associations with disease outcomes is limited. This study investigated the functional capacity of TIM3+ γδ T cells and the underlying mechanisms contributing to TIM3 upregulation and established an association with malaria disease outcomes. METHODS: We analyzed TIM3 expression on γδ T cells in 132 children aged 5-10 years living in malaria endemic areas of Papua New Guinea. TIM3 upregulation and effector functions of TIM3+ γδ T cells were assessed following in vitro stimulation with parasite-infected erythrocytes, phosphoantigen and/or cytokines. Associations between the proportion of TIM3-expressing cells and the molecular force of infection were tested using negative binomial regression and in a Cox proportional hazards model for time to first clinical episode. Multivariable analyses to determine the association of TIM3 and IL-18 levels were conducted using general linear models. Malaria infection mouse models were utilized to experimentally investigate the relationship between repeated exposure and TIM3 upregulation. RESULTS: This study demonstrates that even in the absence of an active malaria infection, children of malaria endemic areas have an atypical population of TIM3-expressing γδ T cells (mean frequency TIM3+ of total γδ T cells 15.2% ± 12). Crucial factors required for γδ T cell TIM3 upregulation include IL-12/IL-18, and plasma IL-18 was associated with TIM3 expression ($p = 0.002$). Additionally, we show a relationship between TIM3 expression and infection with distinct parasite clones during repeated exposure. TIM3+ γδ T cells were functionally impaired and were associated with asymptomatic malaria infection (hazard ratio 0.54, $p = 0.032$). CONCLUSIONS: Collectively our data demonstrate a novel role for IL-12/IL-18 in shaping the innate immune response and provide fundamental insight into aspects of γδ T cell immunoregulation. Furthermore, we show that TIM3 represents an important γδ T cell regulatory component involved in minimizing malaria symptoms.

72 **Silove D, Tay AK, Kareth M, Rees S.**
The relationship of complex post-traumatic stress disorder and post-traumatic stress disorder in a culturally distinct, conflict-affected population: a study among West Papuan refugees displaced to Papua New Guinea.
Front Psychiatry 2017 May 31;8:73. doi: 10.3389/fpsyt.2017.00073. eCollection 2017.

BACKGROUND: Controversy continues about the validity of the construct of complex post-traumatic stress disorder (C-PTSD). In particular, questions remain whether C-PTSD can be differentiated from post-traumatic stress disorder (PTSD) and, secondarily, other common mental disorders. The examination of these issues needs to be expanded to populations of diverse cultural backgrounds exposed to prolonged persecution. We undertake such an inquiry among a community sample of West Papuan refugees exposed to extensive persecution and trauma. METHODS: We interviewed over 300 West Papuan refugees using the Refugee-Mental Health Assessment Package to record symptoms of PTSD, C-PTSD, major depressive disorder (MDD), and complex grief (CG). We used first- and second-order confirmatory factor analysis (CFA) to test aspects of

the convergent and discriminant validity of C-PTSD. RESULTS: The CFA analysis supported both a one-factor and two-factor model of PTSD and C-PTSD. Nested model comparison tests provide support for the parsimonious one-factor model solution. A second-order CFA model of PTSD and C-PTSD produced a poor fit. The modified three-factor multi-disorder solution combining a traumatic stress (TS) factor (amalgamating PTSD and C-PTSD), MDD, and CG yielded a good fit only after removing three CG domains (estrangement, yearning, and behavioral change), a model that produced large standardized residuals (>0.20). CONCLUSION: The most parsimonious model yielded a single TS factor combining symptom domains of C-PTSD and PTSD in this culturally distinct community exposed to extensive persecution and conflict-related trauma. There may be grounds for expanding the scope of psychological treatments for refugees to encompass this wider TS response. Our findings are consistent with theoretical frameworks focusing on the wider TS reaction of refugees exposed to human rights-related traumas of mass conflict, persecution, and displacement.

73 **Smith ME, Singh BK, Irvine MA, Stolk WA, Subramanian S, Hollingsworth TD, Michael E.**
Predicting lymphatic filariasis transmission and elimination dynamics using a multi-model ensemble framework.
Epidemics 2017 Mar;18:16-28. doi: 10.1016/j.epidem.2017.02.006.

Mathematical models of parasite transmission provide powerful tools for assessing the impacts of interventions. Owing to complexity and uncertainty, no single model may capture all features of transmission and elimination dynamics. Multi-model ensemble modelling offers a framework to help overcome biases of single models. We report on the development of a first multi-model ensemble of three lymphatic filariasis (LF) models (EPIFIL, LYMFASIM, and TRANSFIL), and evaluate its predictive performance in comparison with that of the constituents using calibration and validation data from three case study sites, one each from the three major LF endemic regions: Africa, Southeast Asia and Papua New Guinea (PNG). We assessed the performance of the respective models for predicting the outcomes of annual MDA strategies for various baseline scenarios thought to exemplify the current endemic conditions in the three regions. The results show that the constructed multi-model ensemble outperformed the single models when evaluated across all sites. Single models that best fitted calibration data tended to do less well in simulating the out-of-sample, or validation, intervention data. Scenario modelling results demonstrate that the multi-model ensemble is able to compensate for variance between single models in order to produce more plausible predictions of intervention impacts. Our results highlight the value of an ensemble approach to modelling parasite control dynamics. However, its optimal use will require further methodological improvements as well as consideration of the organizational mechanisms required to ensure that modelling results and data are shared effectively between all stakeholders.

74 **Sparke VL, MacLaren D, Mills J, Asugeni R, Moutoa K, West C.**
Improving infection prevention and control practices in a culturally, linguistically and spiritually diverse environment.
Aust Nurs Midwifery J 2017 Mar;24(8):42.

Atoifi Adventist Hospital (AAH) in the Solomon Islands serves a population of 80,000 people, many living in small remote villages. Atoifi is situated on the east side of the island of Malaita in the East Kwaio region. Kwaio is one of 12 language groups on Malaita and most people engage in the subsistence economy.

75 **Stokes MA, Guest GD, Mamadi P, Seta W, Yaubihi N, Karawiga G, Naidi B, Watters DA.**
Measuring the burden of surgical disease averted by emergency and essential surgical care in a district hospital in Papua New Guinea.
World J Surg 2017 Mar;41(3):650-659. doi: 10.1007/s00268-016-3769-6.

BACKGROUND: Timely access to emergency and essential surgical care (EESC) and anaesthesia in low- and middle-income countries (LMICs) prevents premature death, minimises lifelong disability and reduces their economic impact on families and communities. Papua New Guinea is one of the poorest countries in the Pacific region, and provides much of its surgical care at a district hospital level. We aimed to evaluate the surgical capacity of a district hospital in PNG and estimate the effectiveness of surgical interventions provided. METHODS: We performed a prospective study to calculate the number of DALYs averted for 465 patients treated with surgical care over a 3-month period (Sep-Nov 2013) in Alotau Hospital, Milne Bay Province, PNG (pop 210,000). Data were also collected on infrastructure, workforce, interventions provided and equipment available using the World Health Organization's Integrated Management of Emergency and Essential Surgical Care Toolkit, a survey to assess EESC and surgical capacity. We also performed a retrospective one-year audit of surgical, obstetric and anaesthetic care to provide context with regards to annual disease burden treated and surgical activity. RESULTS: EESC was provided by 11 Surgeons/Anaesthetists/Obstetricians (SAO) providers, equating to 5.7 per 100,000 population (including 4 nurse anaesthetists). They performed 783/100,000 procedures annually. Over the 3-month prospective study period, 4954 DALYs were averted by 465 surgical interventions, 52% of which were elective. This equates to 18,330 DALYs averted annually or approximately 18% of the published but estimated disease burden in the Province in the 2013 Global Burden of Disease Study. The overall peri-operative mortality rate was 1.29%, with 0.41% for elective procedures and 2.25% for emergencies. CONCLUSIONS: Much of the burden of surgical disease in Papua New Guinea presenting to Alotau General Hospital serving Milne Bay Province can be effectively treated by a small team providing emergency and essential surgical care. This is despite a relatively low surgical volume and limited numbers of trained surgical anaesthesia obstetric providers, and likely underservicing. The ability of surgical care to avert disease in Papua New Guinea highlights its importance to public health in LMICs.

76 **Sun C, Pomer A, Dancause KN, Chan CW, Olszowy KM, Silverman H, Lee G, Tarivonda L, Taleo G, Regenvanu R, Kaneko A, Weitz CA, Garruto RM, Lum JK.**

Ownership of consumer electronics is associated with measures of adiposity during health transition in Vanuatu.
Am J Hum Biol 2017 Mar;29(2). doi: 10.1002/ajhb.22928. Epub 2016 Oct 15.

OBJECTIVE: The Republic of Vanuatu, like many developing nations, is undergoing a rapid health transition. Our previous study identified several behavioral risk factors for the rising prevalence of obesity. Unexpectedly, daily time spent using television and radio was revealed as a protective factor for obesity in 2007. In this study, we sought to explore associations between ownership of consumer electronics (CE) and measures of adiposity in Vanuatu in 2011. METHODS: We surveyed 873 adults from five islands varying in level of economic development. Height, weight, and waist circumferences; triceps, subscapular, and suprailiac skinfolds; and percent body fat by bioelectrical impedance were measured. Ownership of eight types of CE, diet through 24-h dietary recall and leisure-time activity patterns were assessed using a questionnaire. RESULTS: Participants from more developed islands owned more types of CE, and revealed higher measures of adiposity on average as well as higher prevalence of obesity/central obesity. When controlling for demographic factors, and dietary and activity patterns, increased measures of adiposity and risk for obesity/central obesity were associated with ownership of cellphones, music players, televisions, video players, microwaves, and/or refrigerators. Positive correlations between CE ownership and measures of adiposity were mainly observed among men on the two most developed islands. CONCLUSIONS: The results of this study indicate a possible role of CE use in the rising prevalence of obesity and the shift to a sedentary lifestyle in Vanuatu and many other modernizing regions, where prevention efforts including education on healthy use of CE are imperative.

77 **Taleo F, Macleod CK, Marks M, Sokana O, Last A, Willis R, Garae M, Bong A, Chu BK, Courtright P, Kool J, Taleo G, Rory JJ, Solomon AW; Global Trachoma Mapping Project.**
Integrated mapping of yaws and trachoma in the five northernmost provinces of Vanuatu.
PLoS Negl Trop Dis 2017 Jan 24;11(1):e0005267. doi: 10.1371/journal.pntd.0005267. eCollection 2017 Jan.

Yaws and trachoma are targeted for eradication and elimination as public health problems. In trachoma-endemic populations mass administration of azithromycin can simultaneously treat yaws. We conducted a population-based prevalence survey in the five northernmost provinces of Vanuatu, where trachoma and yaws are suspected to be co-endemic. Clinical signs of trachoma were evaluated using the WHO simplified grading system, and skin examination with a serological rapid diagnostic test used to identify yaws. We enrolled 1004 households in 59 villages over 16 islands, and examined 3650 individuals of all ages for trachoma. The overall adjusted prevalence of trachomatous inflammation-follicular (TF) in 1-9 year-olds was 12.0% (95% Confidence Interval: 8.1-16.7%), and the overall adjusted prevalence of TT in those aged 15 years and greater was 0.04% (95% CI 0-0.14%). In multivariate analysis, the odds of children having TF was 2.6 (95% CI = 1.5-4.4) times higher in households with unimproved latrines, and independently associated with the number of children in the household (OR 1.3, 95% CI = 1.0-1.6 for each additional child). We examined the skin of 821 children aged 5-14 years. Two children had yaws, giving an estimated prevalence of active yaws in those aged 5-14 years of 0.2% (95% CI = 0.03-0.9%). Mass treatment with azithromycin is recommended in these provinces. Given the apparent low burden of yaws, integration of yaws and trachoma control programmes is likely to be useful and cost-effective to national programmes.

78 **Taleo F, Taleo G, Graves PM, Wood P, Kim SH, Ozaki M, Joseph H, Chu B, Pavluck A, Yajima A, Melrose W, Ichimori K, Capuano C.**
Surveillance efforts after mass drug administration to validate elimination of lymphatic filariasis as a public health problem in Vanuatu.
Trop Med Health 2017 Jun 16;45:18. doi: 10.1186/s41182-017-0057-6. eCollection 2017.

BACKGROUND: Vanuatu was formerly highly endemic for lymphatic filariasis (LF), caused by *Wuchereria bancrofti* and transmitted by *Anopheles* mosquitoes. After a baseline survey showing 4.8% antigen prevalence in 1998, the country conducted nationwide (in one implementation unit) annual mass drug administration (MDA) with albendazole and diethylcarbamazine citrate from 2000 to 2004 and achieved prevalence of 0.2% by 2006 in a representative nationwide cluster survey among all age groups. METHODS: Post MDA surveillance was conducted from 2006 to 2012. After MDA, the country was divided for surveillance into three evaluation units (EUs) formed by grouping provinces according to baseline prevalence: EU1: Torba, Sanma and Malampa; EU2: Penama; EU3: Shefa and Tafea. The study compiled all past data and information on surveys in Vanuatu from the country programme. This paper reviews the surveillance activities done after stopping MDA to validate the interruption of transmission and elimination of LF as a public health problem. RESULTS: Post-MDA surveillance consisting of at least three transmission assessment surveys (TAS) in each of the three EUs was conducted between 2006 and 2012. Sentinel and spot check surveys identified a few villages with persistent high prevalence; all antigen positive cases in these sites were treated and additional targeted MDA conducted for 3 years in 13 villages in one area of concern. All three EUs passed all TAS in 2007, 2010 and 2012 respectively, with no positives found except in EU2 (Penama province) in 2012 when 2 children tested positive for circulating filariasis antigen. Assessment of the burden of chronic filariasis morbidity found 95 cases in 2003 and 32 remaining cases in 2007, all aged over 60 years. CONCLUSIONS: Vanuatu has achieved validation of elimination of LF as a public health problem. Post-validation surveillance is still recommended especially in formerly highly endemic areas.

79 **Thomsen EK, Koimbu G, Pulford J, Jamea-Maiasa S, Ura Y, Keven JB, Siba PM, Mueller I, Hetzel MW, Reimer LJ.**
Mosquito behavior change after distribution of bednets results in decreased protection against malaria exposure.
J Infect Dis 2017 Mar 1;215(5):790-797. doi: 10.1093/infdis/jiw615.

Background: Behavioral resilience in mosquitoes poses a significant challenge to mosquito control. Although behavior changes in anopheline vectors

have been reported over the last decade, there are no empirical data to suggest they compromise the efficacy of vector control in reducing malaria transmission. *Methods*: In this study, we quantified human exposure to both bites and infective bites of a major malaria vector in Papua New Guinea over the course of 4 years surrounding nationwide bednet distribution. We also quantified malaria infection prevalence in the human population during the same time period. *Results*: We observed a shift in mosquito biting to earlier hours of the evening, before individuals are indoors and protected by bednets, followed by a return to preintervention biting rates. As a result, net users and non-net users experienced higher levels of transmission than before the intervention. The personal protection provided by a bednet decreased over the study period and was lowest in the adult population, who may be an important reservoir for transmission. Malaria prevalence decreased in only 1 of 3 study villages after the distribution. *Discussion*: This study highlights the necessity of validating and deploying vector control measures targeting outdoor exposure to control and eliminate malaria.

80 **Thriemer K, Ley B, Bobogare A, Dysoley L, Alam MS, Pasaribu AP, Sattabongkot J, Jambert E, Domingo GJ, Commons R, Auburn S, Marfurt J, Devine A, Aktaruzzaman MM, Sohel N, Namgay R, Drukpa T, Sharma SN, Sarawati E, Samad I, Theodora M, Nambanya S, Ounekham S, Mudin RN, Da Thakur G, Makita LS, Deray R, Lee SE, Boaz L, Danansuriya MN, Mudiyanselage SD, Chinanonwait N, Kitchakarn S, Nausien J, Naket E, Duc TN, Do Manh H, Hong YS, Cheng Q, Richards JS, Kusriastuti R, Satyagraha A, Noviyanti R, Ding XC, Khan WA, Swe Phru C, Guoding Z, Qi G, Kaneko A, Miotto O, Nguitragool W, Roobsoong W, Battle K, Howes RE, Roca-Feltrer A, Duparc S, Bhowmick IP, Kenangalem E, Bibit JA, Barry A, Sintasath D, Abeyasinghe R, Sibley CH, McCarthy J, von Seidlein L, Baird JK, Price RN.**
Challenges for achieving safe and effective radical cure of *Plasmodium vivax*: a round table discussion of the APMEN Vivax Working Group.
Malar J 2017 Apr 5;16(1):141. doi: 10.1186/s12936-017-1784-1.

The delivery of safe and effective radical cure for *Plasmodium vivax* is one of the greatest challenges for achieving malaria elimination from the Asia-Pacific by 2030. During the annual meeting of the Asia Pacific Malaria Elimination Network Vivax Working Group in October 2016, a round table discussion was held to discuss the programmatic issues hindering the widespread use of primaquine (PQ) radical cure. Participants included 73 representatives from 16 partner countries and 33 institutional partners and other research institutes. In this meeting report, the key discussion points are presented and grouped into five themes: (i) current barriers for glucose-6-phosphate deficiency (G6PD) testing prior to PQ radical cure, (ii) necessary properties of G6PD tests for wide scale deployment, (iii) the promotion of G6PD testing, (iv) improving adherence to PQ regimens and (v) the challenges for future tafenoquine (TQ) roll out. Robust point of care (PoC) G6PD tests are needed, which are suitable and cost-effective for clinical settings with limited infrastructure. An affordable and competitive test price is needed, accompanied by sustainable funding for the product with appropriate training of healthcare staff, and robust quality control and assurance processes. In the absence of quantitative PoC G6PD tests, G6PD status can be gauged with qualitative diagnostics; however, none of the available tests is currently sensitive enough to guide TQ treatment. TQ introduction will require overcoming additional challenges including the management of severely and intermediately G6PD deficient individuals. Robust strategies are needed to ensure that effective treatment practices can be deployed widely, and these should ensure that the caveats are outweighed by the benefits of radical cure for both the patients and the community. Widespread access to quality controlled G6PD testing will be critical.

81 **Tripathi V, Singh R.**
Regional differences in usage of antenatal care and safe delivery services in Indonesia: findings from a nationally representative survey.
BMJ Open 2017 Feb 3;7(2):e013408. doi: 10.1136/bmjopen-2016-013408.

BACKGROUND: Indonesia has shown a nominal increase in antenatal care (ANC) coverage from 93% to 96% in the Indonesia Demographic Health Survey (IDHS)-2012. This is high but for a comprehensive assessment of maternal health coverage in Indonesia, safe delivery services need to be assessed in conjunction with ANC coverage. MATERIALS AND METHODS: The study uses survey data from the IDHS-2012 that was conducted among women aged 15-49 years who gave birth during the past 3 years preceding the survey. Socioeconomic and demographic factors affecting ANC coverage and safe delivery services are analysed by segregating the data into 7 regions of Indonesia. RESULTS: Multivariate results show that besides wealth and education differentials, regional differences significantly affect the usage of ANC and safe delivery services across the 7 regions. Univariate analyses show that Sulawesi, Maluku and Western New Guinea islands are at a disadvantage in accessing ANC and safe delivery services. CONCLUSIONS: The study recommends that disaggregated regional targets be set in order to further reduce maternal mortality rates in Indonesia.

82 **Vallely AJ, MacLaren D, David M, Toliman P, Kelly-Hanku A, Toto B, Tommbe R, Kombati Z, Kaima P, Browne K, Manineng C, Simeon L, Ryan C, Wand H, Hill P, Law G, Siba PM, McBride WJ, Kaldor JM.**
Dorsal longitudinal foreskin cut is associated with reduced risk of HIV, syphilis and genital herpes in men: a cross-sectional study in Papua New Guinea.
J Int AIDS Soc 2017 Apr 3;20(1):21358. doi: 10.7448/IAS.20.01/21358.

INTRODUCTION: Various forms of penile foreskin cutting are practised in Papua New Guinea. In the context of an ecological association observed between HIV infection and the dorsal longitudinal foreskin cut, we undertook an investigation of this relationship at the individual level. METHODS: We conducted a cross-sectional study among men attending voluntary confidential HIV counselling and testing clinics. Following informed consent, participants had a face-to-face interview and an examination to categorize foreskin status. HIV testing was conducted on site and relevant specimens collected for laboratory-based herpes simplex type-

2 (HSV-2), syphilis, *Chlamydia trachomatis* (CT), *Neisseria gonorrhoeae* (NG), and *Trichomonas vaginalis* (TV) testing. RESULTS: Overall, 1073 men were enrolled: 646 (60.2%) were uncut; 339 (31.6%) had a full dorsal longitudinal cut; 72 (6.7%) a partial dorsal longitudinal cut; and 14 (1.3%) were circumcised. Overall, the prevalence of HIV was 12.3%; HSV-2, 33.6%; active syphilis, 12.1%; CT, 13.4%; NG, 14.1%; and TV 7.6%. Compared with uncut men, men with a full dorsal longitudinal cut were significantly less likely to have HIV (adjusted odds ratio [adjOR] 0.25, 95%CI: 0.12-0.51); HSV-2 (adjOR 0.60, 95%CI: 0.41-0.87); or active syphilis (adjOR 0.55, 95%CI: 0.31-0.96). This apparent protective effect was restricted to men cut prior to sexual debut. There was no difference between cut and uncut men for CT, NG or TV. CONCLUSION: In this large cross-sectional study, men with a dorsal longitudinal foreskin cut were significantly less likely to have HIV, HSV-2 and syphilis compared with uncut men, despite still having a complete (albeit morphologically altered) foreskin. The protective effect of the dorsal cut suggests that the mechanism by which male circumcision works is not simply due to the removal of the inner foreskin and its more easily accessible HIV target cells. Exposure of the penile glans and inner foreskin appear to be key mechanisms by which male circumcision confers protection. Further research in this unique setting will help improve our understanding of the fundamental immunohistologic mechanisms by which male circumcision provides protection, and may lead to new biomedical prevention strategies at the mucosal level.

83 **Vanderpas JB, Moreno-Reyes R.**
Historical aspects of iodine deficiency control.
Minerva Med 2017 Apr;108(2):124-135. doi: 10.23736/S0026-4806.17.04884-4. Epub 2017 Jan 12.

In 1895, iodine was characterized as an essential element of thyroid tissue by Baumann. The efficacy of iodine to prevent goiter was demonstrated by Marine in Northern USA in 1916-1920. Severe endemic goiter and cretinism had been almost entirely eliminated from continental Western Europe and Northern America before the 1930's; however, large populations elsewhere and even some places in Western Europe (Sicily) were still affected up to the 2000's. Public health consequences of iodine deficiency are not limited to endemic goiter and cretinism. Iodine deficiency disorders include also increased neonatal death rate and decreased intellectual development, although these consequences are not included in the current estimation of the Global Burden of Disease related to iodine deficiency. Severe iodine deficiency as a public health problem is now largely under control worldwide, but can still affect isolated places, in hard-to-reach and/or politically neglected populations. We emphasize the importance of maintaining international cooperation efforts, in order to monitor iodine status where iodine deficiency is now adequately controlled, and identify at-risk populations where it is not. The goal should be now global eradication of severe iodine deficiency. Commercial distribution of iodized salt remains the most appropriate strategy. A randomized clinical trial in New Guinea clearly showed in the 1970's that correcting severe iodine deficiency early in pregnancy prevents endemic neurological cretinism. This supports the essential role of thyroid hormones of maternal origin on the normal fetal development, during the first trimester of pregnancy (ie, when fetal thyroid is still not functional). A randomized clinical trial in Congo (RD) in the 1970's also showed that correcting severe iodine deficiency during pregnancy prevents myxœdematous cretinism, particularly prevalent in affected Congolese areas.

84 **Vasilyev SV, Sviridov AA.**
Trepanation and enlarged parietal foramen on skulls from the Loyalty Islands (Melanesia).
Acta Med Hist Adriat 2017 Jun;15(1):67-72.

The goal of this study is a comprehensive examination of openings discovered on two skulls in the collection of skeletal remains from the Loyalty Islands (Melanesia). The skull No. 1524 displayed an evidence of successful trepanation, and the skull No. 7985 revealed openings that were reminiscent of a trepanation; however, we are inclined to believe that in the latter case we are dealing with a rare genetic anomaly – enlarged parietal foramen.

85 **Wall JD.**
Inferring human demographic histories of Non-African populations from patterns of allele sharing.
Am J Hum Genet 2017 May 4;100(5):766-772. doi: 10.1016/j.ajhg.2017.04.002.

Recent human genetics studies have come to different conclusions regarding how and when modern humans spread out of Africa and into the rest of the world. I present here a simple parsimony-based analysis that suggests that East Asians and Melanesians are sister groups, and I discuss what implications this has for recent claims made about the demographic histories of Non-African populations.

86 **Watson-Jones RE, Busch JTA, Harris PL, Legare CH.**
Does the body survive death? Cultural variation in beliefs about life everlasting.
Cogn Sci 2017 Apr;41 Suppl 3:455-476. doi: 10.1111/cogs.12430. Epub 2016 Nov 17.

Mounting evidence suggests that endorsement of psychological continuity and the afterlife increases with age. This developmental change raises questions about the cognitive biases, social representations, and cultural input that may support afterlife beliefs. To what extent is there similarity versus diversity across cultures in how people reason about what happens after death? The objective of this study was to compare beliefs about the continuation of biological and psychological functions after death in Tanna, Vanuatu (a Melanesian archipelago) and the United States (Austin, Texas). Children, adolescents, and adults were primed with a story that contained either natural (non-theistic) or supernatural (theistic) cues. Participants were then asked whether or not different biological and psychological processes continue to function after death. We predicted that across cultures individuals would be more likely to endorse the continuation of psychological processes over biological processes (dualism) and that a theistic prime would increase continuation responses regarding both types of process. Results largely supported predictions; US participants provided more continuation responses for psychological than biological processes following both the theistic and non-theistic primes. Participants in Vanuatu, however, provided

more continuation responses for biological than psychological processes following the theistic prime. The data provide evidence for both cultural similarity and variability in afterlife beliefs and demonstrate that individuals use both natural and supernatural explanations to interpret the same events.

87 **Weitz CA, Olszowy KM, Dancause KN, Sun C, Pomer A, Silverman H, Lee G, Tarivonda L, Chan CW, Kaneko A, Lum JK, Garruto RM.**
Rolling tobacco in banana leaves, newspaper, or copybook paper associated with significant reduction in lung function in Vanuatu.
Asia Pac J Public Health 2017 Apr;29(3):180-188. doi: 10.1177/1010539517696552. Epub 2017 Mar 9.

In addition to the widespread availability of packaged cigarettes, the inhabitants of island nations of the Southwest Pacific frequently smoke commercially available loose tobacco using manufactured rolling papers, as well as locally grown tobacco rolled in manufactured rolling paper or wrapped in leaves, copybook paper or newspaper. In this study, Vanuatu men who smoked local tobacco rolled in leaves, copybook paper, or newspaper showed significantly lower forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), and FEV1/FVC ratios than men who smoked packaged cigarettes, store-bought tobacco rolled in manufactured rolling paper, or who smoked locally grown tobacco rolled in manufactured rolling papers. The addition of toxins from these unusual tobacco-wrapping media produces lung function deficits similar to the pattern noted among tobacco smokers who also inhale smoke from burning biomass. Thus, public health initiatives should consider including strategies addressing the use of wrapping media among smokers in South Pacific island societies.

88 **Whitfield JT, Pako WH, Collinge J, Alpers MP.**
Cultural factors that affected the spatial and temporal epidemiology of kuru.
R Soc Open Sci 2017 Jan 11;4(1):160789. doi: 10.1098/rsos.160789. eCollection 2017 Jan.

Kuru is a prion disease which became epidemic among the Fore and surrounding linguistic groups in Papua New Guinea, peaking in the late 1950s. It was transmitted during the transumption (endocannibalism) of dead family members at mortuary feasts. In this study, we aimed to explain the historical spread and the changing epidemiological patterns of kuru by analysing factors that affected its transmission. We also examined what cultural group principally determined a family's behaviour during mortuary rituals. Our investigations showed that differences in mortuary practices were responsible for the initial pattern of the spread of kuru and the ultimate shape of the epidemic, and for subsequent spatio-temporal differences in the epidemiology of kuru. Before transumption stopped altogether, the South Fore continued to eat the bodies of those who had died of kuru, whereas other linguistic groups, sooner or later, stopped doing so. The linguistic group was the primary cultural group that determined behaviour but at linguistic boundaries the neighbouring group's cultural practices were often adopted. The epidemiological changes were not explained by genetic differences, but genetic studies led to an understanding of genetic susceptibility to kuru and the selection pressure imposed by kuru, and provided new insights into human history and evolution.

89 **Wiessner P.**
Culture matters for life history trade-offs.
Behav Brain Sci 2017 Jan;40:e103. doi: 10.1017/S0140525X16001151.

Van Lange et al. add important life history perspectives to understanding violence. However, direct links between climate and violence are unlikely because cultural institutions modify human responses. Examples are given from the Bushmen of the Kalahari and Enga of Papua New Guinea. The correlations identified may occur because many countries closer to the equator are caught in the gap between the demise of traditional cultural institutions and the rise of modern forms of governance.

90 **Yasukochi Y, Ohashi J.**
Elucidating the origin of HLA-B*73 allelic lineage: did modern humans benefit by archaic introgression?
Immunogenetics 2017 Jan;69(1):63-67. doi: 10.1007/s00251-016-0952-8. Epub 2016 Sep 30.

A previous study reported that some of the human leukocyte antigen (HLA) alleles and haplotypes in present-day humans were acquired by admixture with archaic humans; specifically, an exceptionally diverged HLA-B*73 allele was proposed to be transmitted from Denisovans, although the DNA sequence of HLA-B*73 has not been detected in the Denisovan genome. Here, we argue against the hypothesis that HLA-B*73 introgressed from Denisovans into early modern humans. A phylogenetic analysis revealed that HLA-B*73:01 formed a monophyletic group with a chimpanzee MHC-B allele, strongly suggesting that the HLA-B*73 allelic lineage has been maintained in humans as well as in chimpanzees since the divergence of humans and chimpanzees. The global distribution of HLA-B*73 allele showed that the population frequency of HLA-B*73 in west Asia (0.24%) – a possible site of admixture with Denisovans – is lower than that in Europe (0.72%) and in south Asia (0.69%). Furthermore, HLA-B*73 is not observed in Melanesia even though the Melanesian genome contains the highest proportion of Denisovan ancestry in present-day human populations. Single nucleotide polymorphisms in HLA-A*11-HLA-C*12:02 or HLA-A*11-C*15 haplotypes, one of which was assumed to be transmitted together with HLA-B*73 from Denisovans by the study of Abi-Rached and colleagues, were not differentiated from those in other HLA-A-C haplotypes in modern humans. These results do not support the introgression hypothesis. Thus, we conclude that it is highly likely that HLA-B*73 allelic lineage has been maintained in the direct ancestors of modern humans.

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