

# BMJ Open Health service needs and perspectives of a rainforest conserving community in Papua New Guinea's Ramu lowlands: a combined clinical and rapid anthropological assessment with parallel treatment of urgent cases

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## ABSTRACT

**Objectives** Determine community needs and perspectives as part of planning health service incorporation into Wanang Conservation Area, in support of locally driven sustainable development.

**Design** Clinical and rapid anthropological assessment (individual primary care assessments, key informant (KI) interviews, focus groups (FGs), ethnography) with treatment of urgent cases.

**Setting** Wanang (pop. c189), a rainforest community in Madang province, Papua New Guinea.

**Participants** 129 villagers provided medical histories (54 females (f), 75 males (m); median 19 years, range 1 month to 73 years), 113 had clinical assessments (51f, 62m; median 18 years, range 1 month to 73 years). 26 ≥18 years participated in sex-stratified and age-stratified FGs (f<40 years; m<40 years; f≥40 years; m≥40 years). Five KIs were interviewed (1f, 4m). Daily ethnographic fieldnotes were recorded.

**Results** Of 113 examined, 11 were 'well' (a clinical impression based on declarations of no current illness, medical histories, conversation, no observed disease signs), 62 (30f, 32m) were treated urgently, 31 referred (15f, 16m), indicating considerable unmet need. FGs top-4 ranked health issues concurred with KI views, medical histories and clinical examinations. For example, ethnoclassifications of three ((A) 'malaria', (B) 'sotwin', (C) 'grile') translated to the five biomedical conditions diagnosed most ((A) malaria, 9 villagers; (B) upper respiratory infection, 25; lower respiratory infection, 10; tuberculosis, 9; (C) tinea imbricata, 15) and were highly represented in declared medical histories ((A) 75 participants, (B) 23, (C) 35). However, 29.2% of diagnoses (49/168) were limited to one or two people. Treatment approaches included plant medicines, stored pharmaceuticals, occasionally rituals. Travel to hospital/pharmacy was sometimes undertaken for severe/refractory disease. Service barriers included: no health patrols/accessible aid post, remote hospital, unfamiliarity with institutions and

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This research was a response to a community request rather than external disease priorities, thus better supporting community determined service planning.
- ⇒ The methodology enabled rapid assessment of Wanang's health issues within cost-effective time frames.
- ⇒ The mixed-method approach provided increased confidence in findings by triangulation of qualitative and quantitative data.
- ⇒ Treating urgent cases was an immediate benefit to partner communities in advance of full provision of health services.
- ⇒ Rapid assessments can overlook nuances which may be picked up by more prolonged ethnographic methodologies, and the breadth of health issues assessed reduced capacity to report specific health burdens as accurately as single-disease focused research.

medicine costs. Service introduction priorities were: aid post, vaccinations, transport, perinatal/birth care and family planning.

**Conclusions** This study enabled service planning and demonstrated a need sufficient to acquire funding to establish primary care. In doing so, it aided Wanang's community to develop sustainably, without sacrificing their forest home.

## INTRODUCTION

Papua New Guinea's (PNG) health-related UN Sustainable Development Goal indicators are worse than all but two nations outside Africa,<sup>1</sup> and its rainforests are threatened by commercial logging driven primarily by



**Figure 1** Study setting. (A) Overgrown logging road on the way to Wanang. (B) Wanang area. (C) Mural honouring the role of aid posts in PNG medicine on the wall of Madang Provincial Hospital. (D, E) Examples of individual health books in-use in-region at the time of this assessment. (F) Traditional house in Wanang village. (G) New Guinea common spiny bandicoot (*Echymipera kalubu*). Credit: A, C–F, first author JM; B, coauthor JPaliau; G, Daniel Heuclin (SuperStock).

global commodity demands.<sup>2,3</sup> We report a health needs assessment carried out as our first step to simultaneously act on both these crises, by supporting a medically neglected community who are conserving their forest. Here, we outline site-specific context, biodiversity and health issues in PNG and our methodological rationale are discussed in detail in our published protocol.<sup>4</sup>

### Medicine and remoteness in PNG

If you were to find yourself in the provincial town of Madang on New Guinea's north coast and had access to a 4x4 vehicle that could traverse seasonal logging roads, you could start to make your way to the village of Wanang. After 3–4 hours of driving into the forested interior, the increasingly deteriorating roads (figure 1) abruptly end. A waist-deep river crossing and

a few hours of trekking later and you would arrive in a distributed settlement of c.189 people, surrounded by food gardens and 15 000ha of conserved rainforest (map, figure 1). For two decades, scientists from PNG and as far away as the Czech Republic and the USA have made this journey to conduct ecological research with the people of Wanang. For the first author, and probably others, this journey is experienced as an exciting adventure into a remote interior. Yet, this is an outsider perspective, likely shaped in part by colonial era established cultural tropes around 'expeditions'.<sup>5,6</sup> In contrast, for Wanang villagers (such as coauthors JPhilip and RU), the 80 km journey in-reverse to Madang, is that needed to access the nearest hospital or pharmacy. Given the absence of primary

care services in the community, from this perspective it is not their community that has been 'remote', but rather modern medicine.

Difficulties in accessing health services are common for c87% of PNG's c9 million population who live in rural communities.<sup>7</sup> PNG has one national referral hospital and 36 provincial and district hospitals, largely sited in towns. Reaching these facilities is expensive and difficult for most rural residents, even when healthy. Official rural primary care is provided at c3000 health centres and aid posts,<sup>7</sup> staffed by health-extension officers and nurses, and operated by government, churches, non-governmental organisations (NGOs) or commercial interests such as mines.<sup>8</sup> These offer basic diagnoses, medical supply and trauma treatment, and refer on to specialist services. However, even these can take days to walk to over rough terrain. This was the case at Wanang in 2016 when ecologists from New Guinea Binatang Research Centre (<https://www.ngbinatang.com/>) and community members (including leaders of all Wanang's nine clans) met to discuss the future of a long-standing conservation collaboration. This had been formed in 2001 when the logging frontier reached Wanang, and clans refused corporate inducements and pressure, declaring most of their forest home as the Wanang Conservation Area.<sup>3</sup> To make their initiative viable in the long-term they reached out to ecological researchers to access development benefits. These have included research training and employment, a school, transportation and income.<sup>3</sup> The meeting in 2016 identified health-care as 'the main missing service'<sup>9</sup> to be developed in the collaboration's next phase.

In more industrialised countries, clinical interactions are commonly recorded electronically in routinely collected patient data.<sup>10</sup> In contrast, in rural PNG aid post workers have traditionally recorded total consultations and broadly what they were for on a single-sheet yearly form, but generally do not keep patient data. Instead, individuals have been encouraged to obtain pamphlet-style health books which they keep at home (figure 1), in which information is entered for reference the next time treatment is sought. In principle this has been sensible given available resources. However, health books are often scarce, and can deteriorate quickly in wet, humid rainforest environments. Additionally, some hospitals require individuals to have health books to receive treatment (effectively making them care passports), so they are often surreptitiously shared and thus include records of multiple individuals as though they are one person, making them inaccurate sources of medical history.<sup>11</sup> During the design of this health needs assessment<sup>12</sup> community members reported that few people had health books. With no aid post, summary information on burdens was unavailable. This then was the clinical situation at Wanang: remote secondary care; no primary care services in the community; sparse, unreliable and dispersed patient data.

## Aims

We aimed to plan health service incorporation into the conservation collaboration, to support a locally driven sustainable development pathway. Seeking to describe disease burden and determine service priorities, our research question was: What are Wanang's health needs?

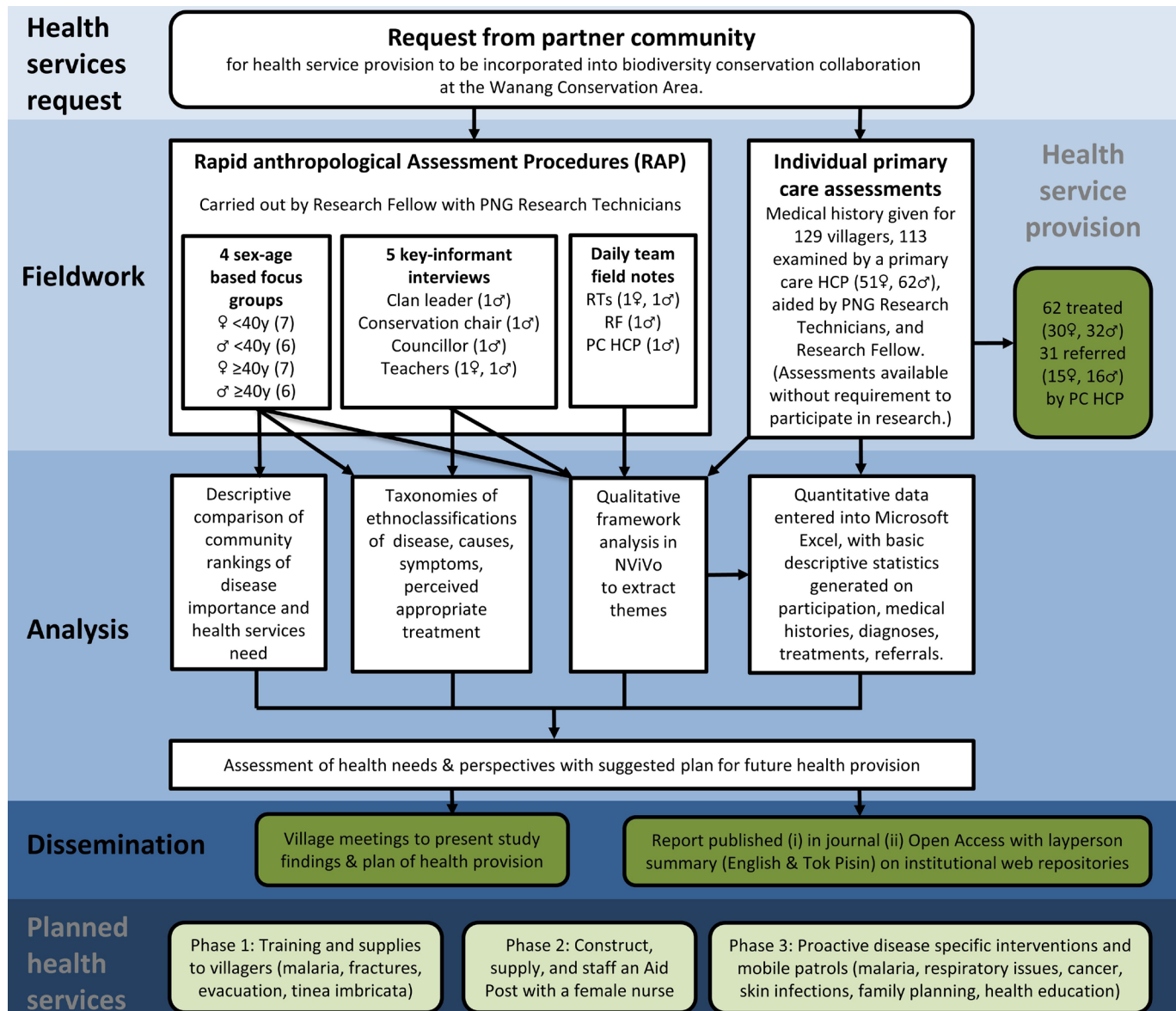
To understand community perspectives and the context for interventions, we also had two subsidiary questions: (1) How do people in Wanang classify diseases, their symptoms and causes? (2) How are these treated and by whom?

## METHODS

### Study design and procedures

We carried out a clinical and rapid anthropological assessment with parallel treatment of urgent cases, in Wanang between 17 July 2018 and 25 July 2018. It consisted of key informant (KI) interviews, focus groups (FGs), individual clinical assessments by a general practitioner (with treatment and referral where necessary), and ethnography (methodological flowchart, figure 2). This enabled rapid collection of qualitative and quantitative data (at individual and community levels), and subsequent triangulation. It also provided immediate clinical benefits. Our methods are detailed in our published protocol<sup>4</sup>; here we give an outline and describe changes. A reporting checklist following 'Appraising studies in health using rapid assessment procedures'<sup>13</sup> is in online supplemental file 1 (p.2). JM designed the protocol in discussion with its coauthors,<sup>4</sup> after consideration of participatory planning case studies archived at the Participation Resource Centre.<sup>14</sup>

Data were collected by a team from Brighton and Sussex Medical School in the UK (coauthors JM and GC) and Binatang Research Centre in PNG (coauthors MJ, JPhilip, and SS) (backgrounds and capacity building, online supplemental file 1 (p.3)). All residents of Wanang were eligible and invited for clinical assessments, those  $\geq 18$  years for FGs. Recruitment for both was self-selecting, by attending the temporary research shelter after a village meeting. KIs  $\geq 18$  years were purposively selected based on research technician (RT) knowledge. Informed consent is described in the ethics statement. Digitally recorded FGs were held separately by sex-age (females (f) <40 years, males (m) <40 years, f  $\geq 40$  years, m  $\geq 40$  years) in Tok Pisin (PNG's national creole). Similarly, interviews and clinical assessments, unless participants preferred English. Recordings were transcribed verbatim in Tok Pisin, then translated into English. The tok ples (meaning local language in Tok Pisin) of Wanang is Magi, which is unique to the Wanang area.<sup>15</sup> Part of the Aisian language group of the Trans-New Guinea family, Magi is largely mutually intelligible with neighbouring Aisi,<sup>15</sup> which is also the mother tongue of some Wanang villagers. In addition, a handful of Kalam people from Simbai settled in the community over a decade previously and speak Etp (also Trans-New Guinean<sup>16</sup>). Our assumption when designing



**Figure 2** Methodological approach, participants and resulting plan of health service provision. Green boxes are outputs: dark, delivered as part of this assessment; light, requiring additional funding for provision. PC HCP, primary care healthcare professional (in this assessment a general practitioner); PNG, Papua New Guinea; RTs, research technicians; RF, research fellow.

the study was that most potential participants would understand either spoken Tok Pisin or English, and we planned that RTs would arrange translation by KIs for those who only spoke a tok ples (presumed to be a small minority).<sup>4</sup> Primary care assessments were conducted simultaneously with FGs, and involved taking medical history, clinical interview and examinations, using basic diagnostic equipment and malaria rapid diagnostic tests (RDTs) when deemed necessary. Team members wrote daily ethnographic fieldnotes. Our protocol's online supplemental file 1<sup>4</sup> includes: FG and KI interview topic guides; participant information sheets and consent forms; our primary care assessment questionnaire and data collection form; treatment formulary and equipment; safety measures.

JM conducted analysis informed by multidisciplinary reflection from fellow coinvestigators and collaborators:

specifically, from anthropology (JF and HM), ecology (FD, VN, MP, AJS), global health (MGH), mycology (JI), PNG health research (ML, WP), primary care (GC), epidemiology (JAC), statistics (CIJ), philosophy of medicine (JAS) and dermatology (SLW). The eight coauthors who are PNG nationals (FD, MJ, ML, JPhilip, JPaliau, WP, SS and RU) contributed, in addition to disciplinary knowledge, essential contextual understanding. Quantitative data were entered into Microsoft Excel, and descriptive statistics generated on participation, medical histories, diagnoses, treatments and referrals. Qualitative data from FG and KI transcripts (primarily in national language Tok Pisin with side-by-side English translations), alongside medical history from patient assessments, and research staff fieldnotes were imported into NVivo V.1.6.1 (QSR International, Melbourne) and analysed

to produce three outputs. First, sex–age FG rankings of health issues affecting the community and service priorities (collected using nominal group technique<sup>17</sup>) were tabulated, compared and contextualised with explanations from the wider data. Second, disease ethnoclassification taxonomies were created by coding data to prechosen higher order themes (eg, perceived causes, symptoms, appropriate treatments) as per Scrimshaw and Hurtado.<sup>18</sup> Third, a narrative description of community perspectives on service provision was produced by coding to main themes in our topic guides, with additional themes added as they emerged during repeated readings. In all cases, framework analysis<sup>19</sup> was conducted with matrixes generated in NVivo to enable ordering of themes and comparative analysis. To increase credibility: qualitative and quantitative data were triangulated; available KIs were given transcripts to check; coauthor RTs with prior experience of the community, including two from Wanang, commented on interpretations; disease names/descriptions identified by FGs are given in Tok Pisin as well as English to demonstrate valid translation (table 1); supporting quotes are provided in the main text and in ethnoclassification taxonomies. To reduce bias, the diagnosing clinician (GC) was not involved in FGs or KI interviews and was not told their results until after all diagnoses were given.

Findings were disseminated to the Madang Provincial Health Authority, and to the UK Darwin Initiative (<https://www.darwininitiative.org.uk/>) as part of a successful application to fund health service introduction into the Wanang Conservation Area. JM authored the resultant health service plan in consultation with other Co-Is with health service backgrounds (GC, JAC, ML and SLW). A verbal summary was provided at a village meeting, and this manuscript (with Tok Pisin plain language summary) given to the community's health committee (formed as a result of this assessment).

### Changes from our published protocol

On RT advice, we additionally interviewed two teachers from the school in Wanang, whose students attend from communities in the surrounding area. We adhered to our protocol's triage for clinical assessments, but additionally issued numbered queue tickets so those 'perceived (by themselves or their parent) to not have an illness'<sup>4</sup> could estimate when their examination would likely take place, so they had the option of leaving and returning. To support comparison with data collected elsewhere JM recoded diagnoses (verified by GC) to International Classification of Diseases 11 (ICD-11).<sup>20</sup> In addition to sex–age FG rankings of health issues and service priorities, we generated all-group rankings by adding inversely weighting ranks (online supplemental file 1 (p.3)).

### COVID-19

COVID-19 did not affect data collection or most analysis as they were conducted prior to the pandemic, as was our subsequent obtaining of funding for health service

introduction (outlined in the discussion section of this paper). However, secondment of multiple coauthors to national level public health responses delayed writing up for journal publication. In addition, international and intranational travel restrictions delayed further community health assessments with conservation communities elsewhere in PNG (specifically on Mount Wilhelm<sup>4</sup>).

### Patient and public involvement

The study determined clinical and community priorities as part of co-planning services following community request for healthcare. PNG staff from the province were involved in the design, including coauthor JPaliau from Wanang. Community members advised on research conduct and burden, aided recruitment and coauthored this paper.

## RESULTS

### Participants

Individual consents for clinical assessments were provided for 135 people. Of these, medical history was obtained for 129 (54f, 75m; median 19 years, range 1 month to 73 years) and 113 examined (51f, 62m; median 18 years, range 1 month to 73 years) (online supplemental table S1). Data from all were used in analysis. In our protocol,<sup>4</sup> we reported a survey recording 189 individuals (89f, 100m). KIs did not consider there had been major population changes in the intervening 2 years. Based on this, medical history and examination data would represent 68.3% and 59.8% coverage, respectively. Twenty-six ≥18 years took part in FGs (sex and age, figure 2), five KIs were interviewed (sex and backgrounds, figure 2). Our linguistic expectations were borne out during data collection. Most participants understood and spoke Tok Pisin, a small number preferred to talk with us in English, and translation support for local languages was only required for a few villagers (mostly from older age groups). Quotes in roman typeface are translated from Tok Pisin (dual transcripts retained), those in italics are written as spoken. Attributed texts without quotation marks are from patient histories summarised by RTs at the time. Some subjects in the topic guides were not addressed by some FGs and KIs, but for all reported quantitative variables of interest (such as diagnoses, online supplemental table S2) there were no participants with missing data.

### Disease burdens

#### KIs and FGs

All KIs said '*malaria*' significantly affects their community. Other leading burdens identified were shortness of breath ('*sotwin*'), tinea imbricata (a superficial fungal infection), cough, and tropical ulcers ('most people in Wanang, they've ulcer on their legs, arms' (KI)). FGs identified 31 health issues affecting their community, ranking top-5's (table 1). These included ethnoclassifications (1) largely imported from biomedical English (eg, '*TB*'), (2) trackable to specific biomedical conditions (eg, '*pukpuk*'

**Table 1** Health issues affecting the Wanang community and priorities for service introduction, as identified and ranked by sex-age based focus groups

<b>(A) Health issues affecting the wanang community, identified and ranked by sex-based and age-based focus groups</b>					
	<b>Females &lt;40 years</b>	<b>Males &lt;40 years</b>	<b>Females ≥40 years</b>	<b>Males ≥40 years</b>	<b>Combined rankings</b>
<b>Top five health issues, as ranked by sex-age focus group</b>					
1	'Malaria'	'Sotwin'	Lower body painful/ stiff*	'Malaria'	'Malaria' (15)
2	'Sotwin'	'Malaria'	Pregnancy anaemia†	Cancer‡	'Sotwin' (12)
3	Lower abdominal pain§	'Grile'	Fish-eye sore¶	'Sotwin'	Cancer (6)
4	Cancer‡	Fever 'Skin hot'	Retained placenta**	'TB'	'Grile' (4)
5	Headache 'Het pen'	Cough/cold 'Kus'	'Malaria'	'Grile'	
<b>Health issues identified by all sex-age focus group, but not included in their individual top fives</b>					
	(in top five)	(in top five)	'Sotwin'	(in top five)	
	Cough/cold	(in top five)	Cough/cold	Cough/cold	
	(in top five)	Headache	Headache	Headache	
<b>Health issues identified by only three sex-age focus groups</b>					
	Skin pain/damage 'Skin pen'	Skin pain/damage	Skin pain/damage		
	Back pain 'Baksait pen'	Back pain		Back pain	
	Diarrhoea 'Pekpek wara'	Diarrhoea		Diarrhoea	
	(in top five)		Cancer‡	(in top five)	
	Knee pain 'Kneepen'		(in top five)	Knee pain	
	Stomach-ache 'Bel pen'		Stomach-ache	Stomach-ache	
	Toothache 'Tit pen'		Toothache††	Toothache	
	Earache 'la pen'		Earache	Earache	
		Loss of vision 'ai bilong mipela olsem i no save lukluk gut' (f≥40 years)			
		Sores 'Sua'	Sores	Sores	
<b>Health issue identified by only two sex-age focus groups</b>					
		Scabies 'Kaskas'		Scabies	
<b>Health issues identified by only one sex-age focus group</b>					
	Blood in urine 'Pispisblut'				
	Liver/heart pain 'Lewapen'				
		Animal bites Δ			
		Cold sickness ◇			
			Bone sickness 'Bun sik'		
			Faint during period‡‡		
				Blocked urine§§	
				Swollen stomach¶¶	
<b>(B) Priorities for service introduction, identified and ranked by sex-based and age-based focus groups</b>					
	<b>Females &lt;40 years</b>	<b>Males &lt;40 years</b>	<b>Females ≥40 years</b>	<b>Males ≥40 years</b>	<b>Combined rankings</b>
1	'Transport'	'Aid Post'			'Aid Post' (15)
2	Vaccinations 'Bebisut'****	Road 'Rot'	Vaccinations	'Family planning'	Vaccinations (11)
3	'Family Planning'	'Transport'	Perinatal and birth care	Vaccinations	'Transport' (10)

Continued

Table 1 Continued

<b>(B) Priorities for service introduction, identified and ranked by sex-based and age-based focus groups</b>					
	<b>Females &lt;40 years</b>	<b>Males &lt;40 years</b>	<b>Females ≥40 years</b>	<b>Males ≥40 years</b>	<b>Combined rankings</b>
4	Perinatal and birth care†††	'Awareness'	Transport‡‡‡	'Awareness'§§§	Perinatal/birth (7)
5	Fracture treatment¶¶¶			Perinatal and birth care	'Family planning'(7)

Ranked lists were produced using the nominal group technique,<sup>17</sup> combined group ranks by reverse weighting (scores in brackets, method, online supplemental file 1 (p.3)). Italic text is untranslated direct speech, Tok Pisin names/descriptions are given at first use left to right (transcripts retained). Ethnoscifications of the top four ranked health issues ('Malaria', 'Sotwin', cancer, 'Grile') are summarised in the main text, and detailed with quotes in online supplemental tables S3–6.

Δ 'Animol sa kaikai'. ◇ 'Kol sik'.  
 \*\*'When we work a lot, our legs tend to get stiff', 'Taim mipela wok lot, em lek bilong mipela save tait nambaut'.  
 †'In pregnant women, stiff arms and anaemia', 'Mama gat bel, na han tait na skin yellow'.  
 ‡f<40 years, cervical cancer, 'sik bilong Mama'; f≥40 years, breast cancer, 'Susu cancer'; m≥40 years, 'breast cancer or cancers inside the body', 'susu cancer o cancer bodi insait'.  
 §'As bilong bel pain'.  
 ¶'Ai bilong pis'.  
 \*\*\*'Withold bilum bilong pikinini'.  
 ††'binatang eat the teeth', 'binatang kaikai tit'. In tok pisin binatang refers to insects and all small living things (apart from mammals) including those invisible, such as bacteria.  
 ‡‡'During periods your eye can spin... and you will faint, in this case', 'Taim i westim blut ai bilong yu i ken raun... nau olsem ap indai, long dispela'.  
 §§'Pispis blok'.  
 ¶¶'Bel solap sik'.  
 \*\*\*For infants and children.  
 †††f<40 years, 'When women are pregnant, make it easier for them so they don't to travel', 'Taim ol mama i gat bel, ol bai no inap go longwe bai isi long karim'; m≥40 years, 'Helping mothers to give birth', 'Helpim ol mama long karim bebi'.  
 ‡‡‡'If older women and older men are ill, it's difficult to carry wood to the hospital.', 'Ol mama papa sik, had bilong karim ol diwai kam long haus sik'.  
 §§§'Awareness about like HIV and AIDS, one example is HIV and AIDS, and TB, all those—health education', 'awareness bilong kain olsem HIV and AIDS, example olsem HIV and AIDS, na TB, all those—health education'.  
 ¶¶¶'Broken necks, arms and bones—to have some way to treat', 'nek bruk o han bruk, bun bruk—em bai i gat olsem bai stretim'.  
 TB, tuberculosis.

meaning 'crocodile', a reference to body-wide skin scaling pathognomonic of tinea imbricata) and (3) naming signs/symptoms with unspecified aetiology (eg, 'pispis blut', blood in urine). 'Malaria' scored highest (top-5 for all FGs, highest for two, second highest for one), followed by 'sotwin' (three FGs), cancer (two FGs) and 'grile' (ie, tinea imbricata) (two FGs). Each FG ranked at least one top-5 issue which was not selected by the others. The greatest discordance was between f≥40 years and everyone else. They identified 'malaria' as a top-5 issue, but ranked it fifth. None of their other top-5s were similarly ranked by others or, except one, listed. They ranked two pregnancy related conditions as top-5s, no others listed any (f<40 years and m≥40 years identified related service need later in FG discussions). Cancer ranking third was surprising given the community age structure. One male FG participant went as far to say: 'now a lot of us here are living with cancer'. Interviews indicated concerns partly arose from a recent unexpected death of an influential woman:

*think she is OK but the sickness is inside... we all surprised when we took her to hospital, and go to the x-ray and they said 'oh, cancer' (KI).*

Tinea imbricata was not identified by f≥40 years or <40 years as a community health problem, but m≥40 years and <40 years ranked it a top-5. The latter said it: 'tends to occur in children, and also in people like us... older men and older women it just occurs occasionally'. The female RT (coauthor MJ) recorded the same impression in her fieldnotes based on living in the community. All field staff observed skin ulcers were common in children. Similarly, when watching children in daily life it seemed to MJ many had prolonged coughs, as did older men and women. Three of the team noted that smoking tobacco wrapped in newspaper seemed very common among adults.

#### Medical histories, clinical assessment, and urgent treatments

Seventy-five participants (40m, 35f; 58.1%, n=129) were reported to have ever had 'malaria'; 23 (6f, 17m; 17.8%) 'sotwin'; two (1f, 1m; 1.6%) cancer. Thirty-five (12f, 23m; 27.1%) were reported to have ever had 'grile', with other infectious skin conditions also highly represented: skin ulcers, 16 (6f, 10m; 12.4%); scabies, 11 (4f, 7m; 8.5%). No f<18 years reported having children or problems during pregnancy/birth. Of 30 f≥18 years, 27 had given birth to live children: 128 in total (mean 4.7 per female with a



**Figure 3** Clinical results of primary care assessments at Wanang. 113 Wanang villagers examined (51 females, 62 males), 168 diagnoses given (not including 11 classifications of ‘well’). The proportion of each concentric circle relates to the proportion a diagnosis was given as part of the total number of diagnoses, with categories arranged clockwise high to low. The inner circle shows ICD-11 primary categories, the outer circle ICD-11 specific conditions (or ICD-11 symptoms/signs/clinical findings) with number of diagnoses given for each. Infections/parasitic conditions primarily affecting skin are outlined in red. \*Developmental. †Ear/mastoid process. ‡Factors influencing health status/contact with services. §Mental, behavioural or neurodevelopmental disorders. ¶Sleep-wake disorders. ¶¶External causes of morbidity/mortality. ICD-11, International Classification of Diseases 11.

child, range 1–14), of which 15 (11.7%) had since died. Nine (33.3%) had experienced problems during pregnancy/birth. Summary clinical results are illustrated in figure 3 and listed (disaggregated by sex) against ICD-11 primary and specific codes in online supplemental table S2. Primary categories with the highest diagnoses were ‘certain infectious or parasitic diseases’ and ‘diseases of

the respiratory system’ (each respectively with 41 diagnoses, 24.4% of the total 168), followed by ‘symptoms, signs or clinical findings, not elsewhere classified’ (25, 14.9%). The next largest grouping was ‘well’, an evaluation given to just 11 of 113 examined (9.7%). This was a clinical impression based primarily on self/parent declarations of no current illness, but also appraisal of



medical histories, conversation with the persons and not observing signs of disease. The five most common diagnosed specific conditions were acute upper respiratory infection (URI) (25, 22.1% of those examined), tinea imbricata (15, 13.3%), lower respiratory tract infection (LRTI) (10, 8.8%), malaria (9, 8.0%) and confirmed or suspected tuberculosis (9, 8.0%). GC noted a wide spectrum of malaria severity, and *Plasmodium falciparum* and *Plasmodium vivax* were both present (mixed in some cases). A greater proportion of females had URI (16, 31.4%) than males (9, 14.5%), in contrast to tinea imbricata (11m, 17.7%; 4f, 7.8%) (online supplemental table S2). Many diagnoses were only made in one or two individuals (29.2% of total illness diagnoses, 49 of 168). Sixty-two villagers received urgent treatments (30f, 32m), 31 (15f, 16m) were referred to Madang hospital for further investigation. ICD-11 has a 'diseases of the skin' primary category, but many infectious skin diseases are categorised elsewhere, mainly as 'certain infectious or parasitic diseases'. Figure 3 compensates by outlining in red infections or parasitic conditions primarily affecting the skin (30 diagnoses, 17.9% of morbidities). In addition to tinea imbricata (the second most diagnosed illness overall), tropical ulcers, scabies, yaws and post-traumatic wound infections were diagnosed. Multiple participants reported these substantially affected their life because of itch, pain, disruption of sleep and inability to walk.

### Concordance

There was generally strong concordance between diagnoses most frequently made following assessment, medical histories, and the health issues the community identified as being most important. For example, three of FGs top four ranked health issues ((A) 'malaria', (B) 'sotwin' and (C) 'grile'. Ethn classification taxonomies, online supplemental tables S3–6), translated to the five biomedical conditions we diagnosed most ((A) malaria; (B) URI, LRTI, tuberculosis; (C) tinea imbricata figure 3). These three FG ranked health issues were also highly represented in declared medical histories ((A) 75 participants, (B) 23, (C) 35). The remaining of the FGs top four ranked health issues, cancer, was not similarly mirrored in patient histories or clinical diagnoses given.

### Existing disease prevention, treatment and ethn classifications

One KI perceived the community had got healthier over the preceding decade due to changes in the village environment and behaviours, specifically: reduced mosquito populations; introduction of covered pit latrines; improved personal hygiene; enhanced nutrition through diversified cropping. An agronomy trained RT noted 'almost everyone makes garden and continues to live a subsistence life', and counted 20 crops under cultivation, supplemented by hunting wild pigs and bandicoot (figure 1), and fishing. Males  $\geq 40$  years described preventing diseases through bathing, not eating rotten food, avoiding rain and not 'working too hard'. Males  $< 40$  years also mentioned

care when walking in the forest and working with axes and knives. Females  $< 40$  years focused discussion of prevention on bathing (both oneself and children) and keeping cookware clean. Mosquito nets and bed sheets were often referred to, but participants believed only half of Wanang were thought to have them; no-one reported retreating nets. Villagers said they learnt about health from mothers, teachers and through sharing advice given at aid posts or hospital. Participants reported traditional treatments were made at Wanang, biomedical treatments acquired at a neighbouring area's aid post (now usually closed) or from hospital/pharmacy in Madang town. If diseases were treated, which they were often not, a plurality of treatment approaches were used. Whatever was to hand was used first (usually traditional plant-based medicines or stored pharmaceuticals, sometimes rituals), with individuals only leaving Wanang to obtain medicines for severe or refractory disease. FGs and KIs reported that while some people were more skilled in plant medicines than others, there were no specific medical roles in the community, rather everyone knew something, at least for minor ailments:

we live in the forest so we have information about all little types of forest medicine... we know to take sap from vines [for] coughs... Diarrhoea too can be treated by medicine from the forest... [but] lower abdominal pain doesn't have a forest medicine... you go out to the hospital (f $< 40$  y FG).

Rituals were reported in a patient history and FGs:

they use a spell... take cold water from the mountain, do a little ritual and 'WHSSHHH!'... they can touch the belly button and stomach will no longer be in pain... Cough/cold... tends to stop it completely (m $< 40$  y).

Ability to conduct such practices was reported to be less common, but not specialised to any age/sex group. Some were more cynical, saying sometimes its 'proper, sometimes they pretend', and specifying that in 'reality these things like malaria or snake bites... shaman/traditional healer from the village will not be able to sort it out' (m $\geq 40$  y FG). Notably, someone known for skill with traditional treatments articulated this latter view.

The ward councillor reported no aid posts, patrols, or health NGOs operated in the upper Ramu lowlands; an area he estimated to have c8000 persons. To reach the nearest post:

you have to walk for a day... sleep there, get treatment and then walk back... [but it often doesn't have supplies as] whenever there is a lot of medicine everyone from Musak, Kibirai and Ramu, they all come... the medicine tends to run out in one day (KI).

Combined with concerns about violence in the neighbouring area, this meant travelling to Madang town in a Public Motor Vehicle or with Binatang Research Centre was often preferred. Maternal mortality is high in PNG,

but one KI reported that with road evacuation by Binatang Research Centre:

in the last five years, not a single mother giving birth... died in childbirth. Because we are safe in the time since conservation work has been occurring, we have [Binatang Research Centre] emergency vehicle tends to come and take us (KI).

However, improvised stretchers were still required transport for ill/immobile individuals to the roadhead. KIs and FGs discussed further barriers on reaching the provincial hospital, including that it often didn't have sufficient supplies:

*hospitals... are running out of medicines, normally they check the patient... and send them to go to the chemist to buy. So you'll see, when people don't have money how will they... be cured (KI).*

Illiteracy and unfamiliarity with institutions left some unable to navigate the hospital (spatially or bureaucratically), deterring attendance:

sometimes they afraid come to the hospital because most things are written in English (KI);

some older women/mothers, they don't tend to go, big hospitals have a lot of wards. When you go inside, you will go back and forth looking over a lot of areas... you will be confused... making you not want to go to the hospital ( $f \geq 40$  y).

Without an aid post, villagers lacked formal referrals. Given such barriers, participant medical histories and KI reports indicated secondary care attendance was frequently delayed, and clinical diagnosis and treatment bypassed by purchasing medicines from pharmacies for immediate/future use, or simply by not seeking biomedical care despite wishing to do so.

#### Top four health issues identified by FGs as affecting the community

Ethnoscience taxonomies for each of the top four health issues identified by FGs are in online supplemental tables S3–6, including example quotes from KIs, FGs and patient histories on how the diseases are understood, who treats them and how. Though the belief '*sanguma*' (sorcery) causes some illness was voiced in the  $m \geq 40$  years FG, they seemed in agreement that 'malaria... sores, '*sotwin*' or that kind of thing... are not to do with this'. All causes given by FGs and KIs for the top four diseases were biological, none mentioned sorcery as causal. However, two examined participants declared they thought sorcery explained their ailments ('*sotwin*'; lower body pain), and two others attributed death of some of their children to sorcery.

'Malaria' (online supplemental table S3): FGs all used the Tok Pisin and English word '*malaria*', saying everyone can be affected, though some KIs highlighted children and old people as at particular risk. Mosquitoes were uniformly identified as the '*malaria*' vector, and linked

to sleeping outdoors/without a bed net. However, explanations differed and included biomedically erroneous beliefs (ie, malaria results from mosquitoes laying their eggs, or transferring pig/dog blood to humans). Listed signs/symptoms aligned with biomedically labelled malaria. Treatments included doing nothing and resting, '*medicine from the forest*', pharmacy drugs and hospital attendance. Members of  $f \geq 40$  years FG described treatments using steam from boiled plants and fruits. According to the  $m < 40$  years FG few know how to do this (though it included one of them). One stated pharmaceutical treatment used was amoxicillin which is not an antimalarial drug.<sup>21</sup> A FG and KI described how hospital treatment was sometimes sought for severe cases, using Binatang Research Centre transport when available.

'*Sotwin*' (online supplemental table S4): This Tok Pisin word has a dual meaning as both sign/symptom (shortness of breath), and specific biomedical condition (asthma).<sup>22</sup> Given this, people were likely sometimes describing experiences of conditions beyond asthma (only one case diagnosed on examination). A KI emphasised that without medical support the community cannot differentiate between '*TB*' or '*asthma*', for example. On clinical assessment, some who said they had '*sotwin*' were diagnosed as having respiratory infections, chronic obstructive pulmonary disease and in one case tuberculosis. Though '*TB*' was listed by  $m \geq 40$  years (and no other FGs) as a specific health issue, given evident conceptual overlap in Wanang due to lack of diagnostic testing to generate a distinct class of tuberculosis cases, the community's classification of '*sotwin*' can practically speaking be taken to include '*TB*' (considered further in discussion). Most FGs, and some KIs, said '*sotwin*' affected all parts of the community. Others highlighted risk to  $> 5$  years and youth, or older ages. Causes stated were diverse: smoking; chewing betel nut; cooked meat/fish, or contaminated containers; sex with women (mentioned by both male FGs); proximity to others; rubbish and dust; the sun. Associated signs and symptoms included heavy breathing, difficulties during exercise, and coughing. Some patients presenting with '*sotwin*' had had no prior treatment, others had used pharmacy drugs. Plant-based oral treatments were described; one person stated child cases could be healed in the village, another that forest medicines usually only work temporarily for '*sotwin*'.

Cancer (online supplemental table S5): Three Tok Pisin named cancer types were identified by participants: '*susu cancer*' (breast cancer), '*cancer bodi insait*' (cancers inside the body) and '*sik bilong ol mama*' (cervical cancer). The  $m \geq 40$  years FG was particularly concerned. When asked who is affected, they answered both 'a lot of us' and 'we don't know ourselves'. Such a combination of high concern and declared powerlessness permeated statements about cancer by all those who discussed it. Unlike all other conditions, cancer was uniformly described as something only distant doctors could see or treat. Badly prepared meat and fish, smoking tobacco, and chewing betel nut were given as causes. Females  $< 40$  years were



**Figure 4** Phased health service introduction at Wanang. Examples of training provided: fracture management (A), off-road vacuum-stretcher evacuation (B). Wanang Aid Post, outside with a northern cassowary (*Casuarus unappendiculatus*) chick (C) and backrooms for nurse consultations (D). Examples of disease targets for proactive integrated interventions, tropical ulcer (E), yaws (F), tinea imbricata (G), scabies mite and eggs (H). Images from Madang Province in PNG (specifically: A, Baitabag; B, Nagada; C, D–F, H, Wanang) apart from *Sarcoptes scabiei* microscopy (H). Credit: A, D–F, H, first author JM; B, G, coauthor JAS; C, coauthor VN. Photographic consents were provided by individuals pictured.

‘not sure’ of what brings about cervical cancer. Though coughing and flushed skin were mentioned as signs of cancer, the main message was ‘we find out from the doctor’. A linked stated issue was that without primary care to assess community members and provide hospital referrals, subsequent therapy was thought likely to come too late. This was powerfully voiced by one KI whose mother had recently died of cervical cancer after protracted delayed diagnosis. Fear of medical interventions was also seen as a barrier to ‘cure’.

‘Grile’ (tinea imbricata) (figure 4; online supplemental table S6): Also known as ‘Kavnam’ and ‘Pukpuk’. All ages and sexes were said to be affected, younger groups especially (a teacher stated most of her schoolchildren). A  $\geq 40$  years said she and many others like her hide it. People associated ‘grile’ with continuing to wear clothes sodden from bathing/rain/sweat. Rivers contaminated with ‘crocodile skin particles’ from affected people bathing or washing clothes upstream were believed by a KI and both male FGs to be responsible. Male FGs and affected

individuals associated sharing clothes and co-sleeping with transmission. Differing within-community susceptibility was also suggested (which is in line with some, but not all, observations from PNG that predisposition may be inherited<sup>23–25</sup>). Signs and symptoms reported were ‘skin like crocodile’ (body-wide), scratching, itch, pain. Treatments included local plants (lime, peppers, tree bud paste; heated tree seeds; papaya) and biomedicine from chemists/hospitals (tolnaftate cream; oral terbinafine). Remission post-treatment was expected, and many go entirely untreated. One  $m < 40$  years described a traditional practice he’d used: ‘take a knife and make a hole in a banana plant... put the skin infected with pukpuk inside... now it ends their pukpuk... there is no spoken words or anything’. Others listening said this is not a method they use now.

#### Community identified priorities for health service provision

Table 1B shows FG identified priorities for service introduction. The highest scoring was an aid post sited in

Wanang, top for all but f<40 years who thought it an unrealistic expectation from the government so did not list it. The ward councillor confirmed one had been requested previously but never delivered. KIs were not asked to rank priorities but all strongly called for aid post establishment. For example:

*this is remote area, so the best thing is we must have a aid post. We must because we have too many sicknesses here... [and] there is no hospital or clinic around... an aid post will... benefit many people... That's what we want, we are a community and we are thinking about this for us (KI).*

Child vaccinations ranked next highest, identified by three FGs, but not m<40 years. Transport was ranked first by f<40 years, a priority by two other FGs. Pregnancy and birth care within the community was vocalised by female FGs and m≥40 years, but not m<40 years. Jointly scoring with pregnancy and birth care was family planning, identified by f<40 years and m≥40 years (the latter ranking it their second highest priority). One KI stated people would welcome family planning services to enable increased birth spacing and reduced family sizes:

*they got no times for body to rest... If they go over six, seven, eight, nine, and ten, that's too much... it's very expensive... to buy clothes and school fee and... for their safety, three children to a father and mother, or four or five, it's enough (KI).*

While not a combined top five, both male FGs ranked health education as a top five (specifically 'HIV' and 'TB' awareness), but neither female FG did. Given opportunity only m≥40 years and f<40 years identified five priorities (the latter adding fracture management).

## DISCUSSION

### Principal findings

We established service needs of the community by determining disease burdens and voiced service priorities. Of 113 examined, only 11 were 'well', 62 treated urgently, 31 referred, indicating considerable unmet need. FGs top four ranked health issues strongly concurred with KI views, medical histories, and clinical examinations. For example, ethnoclassifications of three ((A) 'malaria', (B) 'sotwin' and (C) 'grile') translated to the five biomedical conditions we diagnosed most ((A) malaria, (B) URI, LRTI, tuberculosis, (C) tinea imbricata), and were highly represented in declared medical histories. We built a picture of existing disease prevention and treatment, including who community members think are affected by each of the top four, how they recognise them, what they think causes them, and how they are treated and by whom (answering our subsidiary research questions). FGs generally ascribed their top health issues biological explanations but not always correct ones. Treatment was pluralistic, with whatever was to hand used first (usually plant medicines/stored pharmaceuticals, sometimes rituals) and travel to hospital/pharmacy reserved for severe/refractory disease. Plant medicines were

considered common knowledge, healing rituals less so. Stated barriers to biomedical services included: no local health patrols or easily reachable aid post; remote town hospital; unfamiliarity with institutions; medicine costs. Given these barriers, attendance was frequently delayed, clinical diagnosis and treatment bypassed by purchasing familiar (not always appropriate) drugs from pharmacies for immediate/future use, or biomedical care was simply not sought (despite stated desire). FG health service priorities were: aid post, child vaccinations; transport; pregnancy and birth care; family planning; health education; fracture management. In a community with no prior patient data, this study enabled service planning and demonstrated medical need sufficient for us to successfully acquire funding for establishment of primary care services sited in the community, and target some of the lead health issues identified.

### Strengths and weaknesses

Study strengths include its cost-effective time frame, and a mixed-method approach that increases confidence in findings by triangulating qualitative and quantitative data. However, speed was also a limitation as we inevitably overlooked social nuance that slower ethnography may have identified. KI selection was biased towards highly influential, mostly male individuals in Wanang to obtain perspectives of those with influence who could facilitate or block interventions. However, this limitation is balanced by individual clinical discussions and age-sex segregated FGs, across which most adult villagers participated. Importantly, these provided opportunity to talk freely, unobserved by fellow-villagers from other sexes or age groups. We examined most of the population of Wanang but loss of some of those triaged towards the end of a multiday queue is likely to have biased the sample towards those with greater morbidity. In our protocol paper,<sup>4</sup> we describe strengths and weaknesses of rapid anthropological assessment procedures in health research including those of our study. Many previous studies using this methodology have been based on disease prioritisations set by global 'vertical health programmes'<sup>26</sup> (eg, HIV, guinea worm<sup>13</sup>). In contrast, our research was initiated following a community request, better supporting community-led service planning. Our broad focus reduces capacity to detect some health burdens as accurately as single-disease targeted research. A strength compared with assessments without clinical components, was parallel treatment of urgent cases. Collecting data on Wanang's health burdens can be expected to benefit those of us employed as professional researchers and our institutions. Health service implementation had not been secured at the time of data collection and treatment provision went some way to making the relationship between the community and researchers a fair transaction, rather than one of dispossession and accumulation as West<sup>27</sup> has characterised some foreign-driven research and NGO activity in PNG.

Some who participated in primary care assessments were classified as 'well', a clinical impression based

primarily on self/parent declarations of no current illness (ie, answering ‘*nogat*’ (‘no’) to the question ‘*Yu gat sampela sik nau yet?*’ (‘Do you currently suffer from any illness?’)), but also appraisal of medical histories, conversation with the persons, and not observing signs of disease. In Tok Pisin one might say ‘*malaria I kism em, tassel nau i orait gen*’ (‘he had malaria, but now he’s well again’<sup>22</sup>). It is broadly in this vein we are using ‘well’. We do not mean it in the more holistic sense, such as that signalled by the WHO definition of health (‘complete physical, mental and social well-being and not merely the absence of disease’<sup>28</sup>), nor have we attempted to create an ethnoclassification of what it means in Wanang to be ‘well’. Instead, we just mean a clinical impression of absence of disease (expressed or observed). This narrow usage, similar in form to ‘Sick/Not Sick’ in emergency patient assessment,<sup>29</sup> was appropriate given our main objective in conducting primary care assessments was to determine disease burdens at the community level, as part of planning health service introduction. Others have investigated and discussed ways communities in PNG socioculturally understand concepts translatable to well-being or health, and how they relate to biomedical ideas (eg, see references<sup>30–32</sup>). Especially pertinent, given our aim to support a locally driven sustainable development pathway, is the expansive view of another forest people of PNG, the Huli. According to a letter coauthored by one of their community: ‘if their environment is not considered healthy, so the community and each individual in itself are not healthy... According to the Huli conceptions, health is not limited to their bodies, it encompasses their land and all that surrounds them.’<sup>32</sup> Determining how people at Wanang understand what it means to them to be well/healthy would be useful (particularly to support long-term health promotion activities), but it was beyond the narrow remit or capacity of this rapid needs assessment.

Ours is the only health assessment of Wanang village, and the most comprehensive study of a community’s general health in the rainforests of Madang province. Many high burden illnesses identified in our study reflect those seen regionally and nationwide. For example, malaria was one of the five most common diagnoses we gave, in the declared medical histories of over half of our participants, and trackable to the highest community-ranked health issue. Beyond Wanang, it is widespread in lowland and coastal provinces, including Madang.<sup>33</sup> In 2021, PNG accounted for nearly 87% of malaria cases and 94% of associated deaths across the entire WHO Western Pacific Region.<sup>34</sup> This is an area of 37 countries and territories in which live 1.9 billion people.<sup>35</sup> Similarly, GBD 2019 ranks respiratory infection as the leading cause of all-age PNG disability-adjusted life years.<sup>36</sup> This chimes with our findings in Wanang that URI and LRTI were two of the five most common diagnoses we gave, and trackable to the second highest community-ranked health issue (‘*sotwin*’). Unfortunately, beyond select diseases such

as malaria that are the target of international action (and therefore have resources allocated to collect well-grounded indicators), there is limited reliable national or province-level statistics available to compare our community-level findings with. This is particularly so regarding disease prevalence beyond towns and areas well-connected to them by road. To put this in context, in Madang province only an estimated 3% of child-births are registered (the lowest in the country),<sup>37</sup> while at the other end of life only an estimated 26% of deaths nationally are recorded by health services. Most of these are from urban areas and without medical certification, so not reliable for developing national mortality statistics.<sup>38</sup> Treatment data from a large subset of health centres is in the process of being pooled nationally,<sup>39</sup> but is not yet available for comparison. Likewise, at a provincial level, aggregation and digitisation of datum from health facilities across Madang is planned but presently (August 2023) faces logistical issues which mean regional treatment data are also unavailable for comparison.

Community perspectives and ethnoclassifications outlined in our study resonate with some voiced elsewhere in PNG (particularly Whittaker *et al*<sup>40</sup>), however we caution against extrapolating beyond Wanang. PNG is hugely diverse culturally (it has more languages than any other nation on earth<sup>41</sup>) and biogeographically (lowland forests, periurban slums, swamplands, high mountains, island archipelagos), and its communities have markedly different levels of engagement with state, industry and the money economy. The myriad ecocultural ‘entanglements’ (in the sense used by Nading<sup>42</sup> and Tsing<sup>43</sup>) resulting from these diversities militate against generalisations about PNG’s disease ecologies. Nevertheless, given this kind of health assessment is otherwise absent in the region, our results may be usefully indicative of similar settings elsewhere in inland Madang province in communities to which biomedical care remains remote. Notably, a recent PNG statistical office survey<sup>37</sup> asked women about difficulties accessing healthcare. Across Madang province 77% of rural women respondents 15–49 years reported ‘serious problems in accessing healthcare for themselves’. The leading barriers were needing to get money for treatment (70%), and distance to health facilities (61%). This resonates with our related findings from Wanang. (For insights into settings in the region where medicine is less remote, see Street<sup>11</sup> on relations within and around a hospital in Madang town.) In conclusion, while generalisability is limited, given participation levels and composition the sample is representative of Wanang sufficient to fulfil the study aim (to co-plan health service incorporation into the conservation collaboration), and given this kind of health assessment is otherwise absent in the region our results imply substantial unmet medical needs might be found in other forest communities across Madang Province.

## Implications for clinicians and policy-makers

### Wanang health service plan

Health needs assessments commonly make recommendations for clinicians or policy-makers to act on identified needs. However, there were no clinicians providing in-community care to advise, and no expectation from participants that local government would act to establish such services. Given this, any intervention would be by the conservation collaboration itself, and thus this exercise had always been understood as a process by which the community and its academic allies in the collaboration co-plan action together. We outline here the plan for health service introduction developed, and its rationale. Based on clinical observations and voiced community perspectives, targeting malaria, respiratory issues, tinea imbricata, and maternal and child health were clear priorities. Disease-specific actions such as bed-nets, high vaccination coverage, and mass drug administration (MDAs) carried out without permanent infrastructure or staffing could potentially reduce these burdens. However, there was clear community demand for a full-time staffed aid post, and our assessment was that the most effective and sustainable treatment of these burdens would necessitate permanent biomedical health provision sited within the community. This could improve diagnostic certainty and medicine supply, and provide clinician-led treatment, follow-up and referrals. In addition, while examinations confirmed community-identified health issues were key burdens, over a quarter of diagnoses were for conditions seen in only one or two people. This argued strongly for a holistic primary care approach, rather than just targeting high-prevalence diseases. We concluded to set up an aid post at Wanang, yet given this could be expected to take time and our assessment demonstrated substantial health burdens, 'holding action' was needed to empower community members to act on identified needs in the meantime. Once established, the aid post could be used as a base for proactive measures in the surrounding communities, targeting the high priority burdens identified here, rather than providing responsive-only treatment. Our plan thus has three phases (figure 4; detailed in box 1), with on-road evacuation from trailheads continuing to be provided by Binatang Research Centre when possible.

Phases 1 and 2 are complete. We used this study's evidence to obtain Darwin Initiative (<https://www.darwininitiative.org.uk/>) funding for aid post construction, supply and nurse staffing as part of a 3-year integrated health and conservation project.<sup>44</sup> As holding action, in 2019 first author JM returned to Wanang and trained community members in off-road medical evacuation, and self-treatment of malaria, tinea imbricata and fractures (figure 4). The aid post was then built and opened at the end of 2020, registered with the provincial health authority, and continues to be staffed by a full-time nurse (figure 4). Given PNG's healthcare shortages, Wanang's population wouldn't be large enough to secure government financial support after project funding ends. However, the total population of the communities

### Box 1 Community health plan for Wanang conservation area

Phase 1: Training and supplies to support community members acting on needs before aid post establishment: (1) malaria treatment (including rapid diagnostic tests (RDTs), appropriate medications, evacuation triggers), (2) fracture management, (3) off-road medical evacuation and (4) tinea imbricata treatment.

Phase 2: Construct, supply and staff an aid post to introduce responsive primary care, managed by a community health committee with equal sex representation and involvement of those who have provided traditional treatments. Obtain provincial health authority aid post registration and commitment to provide supplies and nurse salary beyond grant period. In addition, the nurse should facilitate childhood vaccinations, and pregnancy and emergency birth care (with telemedicine-based support when available). To enable the latter, the aid post should have a mobile phone (with solar charging) with which to seek advice from obstetrics at Madang hospital when sufficiently timely evacuation is not available. The recently introduced mobile coverage of the area remains weak and patchy, so the aid post should be sited in the highest part of the settlement to maximise reception. To support continuity of care (and treatment auditing) patient-level data should be recorded and securely stored at the aid post, in addition to individually retained health books. On-road evacuation from trailheads can be provided by Binatang Research Centre when possible, with the pre-existing good quality high frequency radio link between the centre and Wanang maintained to support this.

Phase 3: Once established, the aid post should conduct disease-specific interventions and mobile patrols (reaching c2000 people), acting on identified community health burdens and service priorities (in addition to routine treatment). Specifically, (1) Malaria: mosquito net audit, supply and retreatment; elsewhere ivermectin mass drug administrations (MDAs) have reduced vector populations and thus human cases,<sup>57</sup> local trials may be beneficial, particularly combined with MDAs on neglected tropical skin diseases already including ivermectin (see tinea imbricata and other skin infections below). (2) Respiratory issues: preventive child vaccinations; tuberculosis screening and referrals; RDTs should guide appropriate treatment given Papua New Guinea's (PNG) wide shifts from bacterial to viral lung infections and pneumonia. (3) Cancer: in addition to aid post referrals, preventive (both-sex) Human papillomavirus vaccinations could be introduced (if supplies imported) as PNG has a higher-than-average burden of cervical cancer for comparable nations and it is thought to be the second leading cause of cancer in the country.<sup>58-60</sup> (4) Tinea imbricata and other skin infections: joint-MDAs and targeted follow-ups for yaws, tinea imbricata, impetigo and scabies; introduction of ethnomedicine treatments for tropical ulcers already trialled elsewhere in PNG.<sup>61</sup> (5) Family planning: facilitate Marie Stopes mobile clinic visit. (6) Pregnancy related anaemia: birth spacing; other solutions are not evident given local genetic predisposition to anaemia is partially protective against malaria, and iron supplementation can be expected to have negative impacts while infection rates remain high.<sup>62 63</sup> (7) Health education: nurse-provided sexually transmitted diseases training sessions; exercises for youth to reduce sports related lower back pain. (8) Mobile patrols: nurse-led patrols to reach villages across the aid post catchment area.

including Wanang in the government ward area is c2000 people. Thus, the establishment of an aid post at Wanang was in line with aspirations of PNG's Medium-Term Development Plan, which aimed to have an aid post operational in every ward, serving populations of up to c2000 people

each.<sup>7</sup> The provincial health authority has undertaken to fund the nurse's salary and aid post supplies at the end of the Darwin Initiative funding, ensuring the long-term sustainability of this health service initiative.

### COVID-19

Two authors of this paper (ML and WP) have coauthored with colleagues a report assessing COVID-19 impacts on PNG's primary health services and public health infectious disease programmes.<sup>45</sup> One key identified theme at a national level is especially relevant to the local findings and recommendations of our study. Newland *et al*<sup>45</sup> found the scaling back of some services and reduced ability to travel to facilities for both staff and those seeking medical services (particularly during lockdowns) impacted access to and continuity of care. However, locally in our study area, during the pandemic access to and continuity of care increased due to the operationalising of a key study recommendation, that permanent primary care be established for the Wanang area. When the aid post opened (November 2020) few cases had been seen nationwide compared with many other countries at the time, and it was prior to PNG's two main waves of COVID-19 infections and death (both in 2021).<sup>45</sup> Continuity of care amidst the pandemic was mainly possible because the nurses lived among the people they treated. Other approaches we considered, such as only providing medical patrols from outside the area, may have served the communities less well in the context of a pandemic when many mobile health programmes closed due to workforce retasking and restrictions on travel.<sup>45</sup> As of August 2023, no cases of COVID-19 have been identified in Wanang, but this is not verifiable due to limitations on testing capacity in PNG.

### Integrating action on health and conservation

As well as supporting the conservation community at Wanang, the establishment of an aid post powerfully demonstrated to surrounding communities the benefits of forest preservation, directly leading new clans to join the collaboration and commit to refuse secondary logging of regenerating previously selectively logged forest (expected to commence 2025). This has directly resulted in expansion of the conservation area from 100 km<sup>2</sup> to 150 km<sup>2</sup>. Beyond the direct findings of our health needs assessment, this then has implications for policymakers and others looking to identify innovative ways to make progress on the Sustainable Development Goals (SDGs), which are mostly implemented individually.<sup>46</sup> The impacts of this work indicate simultaneously addressing health (SDG 3) and biodiversity (SDG 15) can be a successful 'synergy driver'<sup>46</sup> to advance SDGs. We welcome conversations with anyone who wishes to take such integrated approaches.

### Challenges of translating between ethnoclassifications and biomedicine

An implication of our study for clinical researchers is to play close attention to meanings within local disease

terms/ethnoclassifications, not leaning too heavily on simple linguistic translation to biomedical diagnostic categories. As 'sotwin' illustrated, ethnoclassification terms may hold dual meanings as both symptom/sign and specific medical conditions. Straight-forward translation as asthma would have hidden that participants were describing a constellation of respiratory illnesses (as examinations confirmed). Risk of false conflation may be especially high when ethnoclassification terms resemble or are identical to biomedical ones, such as with 'tibi', which is sometimes used for severe respiratory conditions other than tuberculosis.<sup>47</sup> Similarly, 'malaria' may seem simple to translate; the Tok Pisin dictionary definition of 'malaria' equals malaria in English.<sup>22</sup> However, in practice, it is often used generally to mean fever.<sup>40</sup> This is clinically important as non-malarial febrile illnesses are widespread in PNG,<sup>48</sup> underlining the potential value of RDTs in determining when 'malaria' is malarial, to avoid inappropriate treatment (which is common<sup>49</sup>). Translational issues between ethnoclassifications and biomedicine are particularly prevalent in PNG,<sup>40 50 51</sup> but are found generally. We suggest publications from similar settings (specifically those seeking to (1) describe community perspectives on diseases or (2) generate non-clinically corroborated prevalence estimates from community surveys) state more often how meanings encoded in local terms have been translated into biomedical categories (and vice versa).

### Unanswered questions and future research

Long-term ethnography could improve understanding of disease ethnoclassifications, especially beyond the 'top four', and explore local ideas related to biomedical conceptions of health. Studies to determine effectiveness of traditional treatments would be helpful (we discuss ethical issues elsewhere<sup>44</sup>). An audit of the now established aid post would support further development, and given its large catchment area beyond Wanang village could aid determination of how representative this study's findings are of surrounding forest communities. Comparison with health data from communities elsewhere (which in the last few years have started to be nationally pooled<sup>39</sup>) may usefully indicate commonalities and differences. Implementation studies of planned disease-specific interventions would be useful service evaluations, potentially with wider value. This may be particularly so for action on neglected tropical skin diseases, which are highly prevalent across the Pacific.<sup>52</sup> The region has been key to developing integrated skin interventions to control scabies and reduce soft tissue infections.<sup>53</sup> Tinea imbricata, which is only found in a small number of populations worldwide but is highly distributed across Melanesia,<sup>25 54 55</sup> has been neglected as regards research and treatment.<sup>23</sup> An integrated skin intervention<sup>56</sup> in Wanang and surrounding areas, targeting tinea imbricata alongside yaws, tropical ulcers and scabies (figure 4), may relieve considerable suffering, and act as a model for the region and beyond.

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**Ethics approval** This study involves human participants and was approved by PNG Institute of Medical Research Institutional Review Board, PNG Medical Research Advisory Committee (MRAC18.06), and Brighton and Sussex Medical School Research, Governance, and Ethics Committee (ER/BSMS61566/1). Community consent was obtained through speaking to clan leaders, and a mass village meeting. Individual consent was provided for participation in FGs, KI interviews and individual primary care assessments. Additional photographic consents were given by all individuals pictured in this paper. Acute medical needs and absence of local health services risked participation would not be truly voluntary. Thus, to avoid conditionality through passive coercion villagers were offered examinations and treatments without requirement to participate in the study. We discuss related ethical issues in our published study protocol.

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All data relevant to the study are included in the article or uploaded as online supplemental information, bar individual-level data from primary care assessments and full interview/group transcripts (neither of which can be sufficiently anonymised for publication given the study's small named community).

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**REFERENCES**

- Lim SS, Allen K, Bhutta ZA, et al. Measuring the health-related sustainable development goals in 188 countries: a baseline analysis from the global burden of disease study 2015. *The Lancet* 2016;388:1813–50. [10.1016/S0140-6736\(16\)31467-2](https://doi.org/10.1016/S0140-6736(16)31467-2) Available: [https://doi.org/10.1016/S0140-6736\(16\)31467-2](https://doi.org/10.1016/S0140-6736(16)31467-2)
- Shearman P, Bryan J. A Bioregional analysis of the distribution of Rainforest cover, deforestation and degradation in Papua New Guinea. *Austral Ecol* 2011;36:9–24. [10.1111/j.1442-9993.2010.02111.x](https://doi.org/10.1111/j.1442-9993.2010.02111.x) Available: <http://doi.wiley.com/10.1111/aec.2011.36.issue-1>
- Novotny V, Toko P. Ecological research in Papua New Guinean Rainforests: insects, plants and people. In: Bryan JE, Shearman PL, eds. *The state of the forests of Papua New Guinea 2014: Measuring change over period 2002–2014*. Port Moresby, Papua New Guinea: University of Papua, New Guinea, 2015: 71–85.
- Middleton J, Abdad MY, Beauchamp E, et al. Health service needs and perspectives of remote forest communities in Papua New Guinea: study protocol for combined clinical and rapid anthropological assessments with parallel treatment of urgent cases. *BMJ Open* 2020;10:e041784.
- Thomas H. The expedition as a cultural form: on the structure of exploratory journeys as revealed by the Australian explorations of Ludwig Leichhardt. In: *Expedition into Empire: Exploratory Journeys and the Making of the Modern World*. New York: Routledge, 2019: 65–97.
- Hviding E, Cato B. *The Ethnographic Experiment: A.M. Hocart and W.H.R. Rivers in Island Melanesia, 1908*. New York and Oxford: Berghahn Books, 2014.



- 7 Grundy J, Dakulala P, Wai K, et al. *Papua New Guinea Health System Review (Vol. 9, No. 1)*. New Delhi: World Health Organization, Regional Office for South-East Asia, 2019.
- 8 Brown AN, Gilbert B. The Papua New Guinea medical supply system - documenting opportunities and challenges to meet the millennium development goals. *J Pharm Policy Pract* 2014;7:5.
- 9 Stewart A, Peck M, Novotny V. *Final report to the Waterloo Foundation (July 2016): Creating sustainable livelihoods whilst protecting rainforest in Papua New Guinea (PNG) from logging*. Falmer, UK: University of Sussex, 2016.
- 10 Stockdale J, Cassell JA, Ford E. "Giving something back": A systematic review and ethical enquiry into public views on the use of patient data for research in the United Kingdom and the Republic of Ireland. *Wellcome Open Res* 2018;3:6. 10.12688/wellcomeopenres.13531.2 Available: <https://doi.org/10.12688/wellcomeopenres.13531.2>
- 11 Street A. Biomedicine in an unstable place. In: *Biomedicine in an unstable place: Infrastructure and personhood in a Papua New Guinean hospital*. Durham: Duke University Press, 2014.
- 12 Middleton J, Cassell JA, Novotny V, et al. Surfaces: an Interdisciplinary project to understand and enhance health in the vulnerable Rainforests of Papua New Guinea. Inaugural planetary health / Geohealth annual meeting, 28–30 April 2017. Boston, USA: Harvard Medical School, Available: <http://sro.sussex.ac.uk/67423>
- 13 Utarini A, Winkvist A, Pelto GH. Appraising studies in health using rapid assessment procedures (RAP): eleven critical criteria. *Human Organization* 2001;60:390–400. 10.17730/humo.60.4.3xu3p85amf13avtp Available: <https://doi.org/10.17730/humo.60.4.3xu3p85amf13avtp>
- 14 Institute of Development Studies Participation Research Cluster. Resources. 2022. Available: <https://www.participatorymethods.org/resources>
- 15 Daniels D. Magi: an Undocumented language of Papua New Guinea. *Oceanic Linguistics* 2016;55:199–224.
- 16 Pawley A, Hammerstrom H. The Trans New Guinea Family. In: Palmer B, ed. *The Languages and Linguistics of the New Guinea Area*. Berlin: De Gruyter, 2017: 21–196.
- 17 Gallagher M, Hares T, Spencer J, et al. The nominal group technique: A research tool for general practice *Fam Pract* 1993;10:76–81.
- 18 Scrimshaw S, Hurtado E. *Rapid assessment procedures for nutrition and primary health care: Anthropological approaches to improving programme effectiveness*. Los Angeles: University of California, 1987.
- 19 Goldsmith LJ. Using framework analysis in applied qualitative research. *TQR* 2021;26:2061–76. 10.46743/2160-3715/2021.5011 Available: <https://doi.org/10.46743/2160-3715/2021.5011>
- 20 WHO. *International Classification of Diseases (11th Revision) for Mortality and Morbidity Statistics (Version: 02/2022)*. Geneva: World Health Organization, 2022. Available: <https://icd.who.int/browse11/l-m/en>
- 21 Sié A, Dah C, Ouhiré M, et al. Azithromycin versus Amoxicillin and Malarial Parasitemia among children with uncomplicated severe acute malnutrition: a randomized controlled trial. *Am J Trop Med Hygiene* 2021;106:351–5. 10.4269/ajtmh.21-0595 Available: <https://doi.org/10.4269/ajtmh.21-0595>
- 22 Volker CA. *Papua New Guinea Tok Pisin English Dictionary*. Melbourne: Oxford University Press, 2008.
- 23 Er YX, Lee SC, Than LT-L, et al. Tinea Imbricata among the indigenous communities: Current global epidemiology and research gaps associated with host Genetics and skin Microbiota. *JoF* 2022;8:202. 10.3390/jof8020202 Available: <https://doi.org/10.3390/jof8020202>
- 24 Hay RJ. Genetic susceptibility to Dermatophytosis. *Eur J Epidemiol* 1992;8:346–9. 10.1007/BF00158566 Available: <https://doi.org/10.1007/BF00158566>
- 25 Hay RJ. Tinea Imbricata. In: McGinnis MR, ed. *Current Topics in Medical Mycology, vol 2*. Springer: New York, 1988: 55–72.
- 26 De Maeseneer J, van Weel C, Egilman D, et al. Strengthening primary care: addressing the disparity between vertical and horizontal investment. *Br J Gen Pract* 2008;58:3–4. 10.3399/bjgp08X263721 Available: <https://doi.org/10.3399/bjgp08X263721>
- 27 West P. *Dispossession and the Environment: Rhetoric and Inequality in Papua New Guinea*. New York and Chichester: Columbia University Press, 2016.
- 28 WHO. Constitution of the World Health Organization, Available: <https://www.who.int/about/governance/constitution>
- 29 Helbock M. *Sick Not Sick: A guide to rapid patient assessment*. Sudbury, MA: American Academy of Orthopaedic Surgeons and Jones and Bartlett, 2000.
- 30 Hinton R, Earnest J. Assessing women's understandings of health in rural Papua New Guinea: implications for health policy and practice. *Asia Pacific Viewpoint* 2011;52:178–93. 10.1111/j.1467-8373.2011.01449.x Available: <http://doi.wiley.com/10.1111/apv.2011.52.issue-2>
- 31 Koczburski G, Curry GN. Sik Bilong Ples: an exploration of meanings of illness and well-being amongst the Wosera Abelam of Papua New Guinea. *Aust Geog Studies* 1999;37:230–47. 10.1111/1467-8470.00081 Available: <https://www.doi.org/10.1111/1467-8470.00081>
- 32 Charlier P, Coppens Y, Malaurie J, et al. A new definition of health? an open letter of autochthonous peoples and medical anthropologists to the WHO. *Eur J Intern Med* 2017;37:33–7. 10.1016/j.ejim.2016.06.027 Available: <https://doi.org/10.1016/j.ejim.2016.06.027>
- 33 Keven JB, Katusela M, Vinit R, et al. Vector composition, abundance, biting patterns and malaria transmission intensity in Madang, Papua New Guinea: assessment after 7 years of an LLIN-based malaria control programme. *Malar J* 2022;21:7. 10.1186/s12936-021-04030-4 Available: <https://doi.org/10.1186/s12936-021-04030-4>
- 34 WHO. *World Malaria Report 2022*. Geneva: World Health Organization, 2022.
- 35 WHO. Western Pacific Region, Available: <https://web.archive.org/web/20230804152140/https://www.who.int/westernpacific>
- 36 Institute for Health Metrics and Evaluation. GBD (global burden of disease) compare tool, Papua New Guinea. Both sexes, all ages, 2019, Dalys. n.d. Available: <https://vizhub.healthdata.org/gbd-compare/>
- 37 PNG National Statistical Office. Papua New Guinea Demographic and Health Survey 2016–18. Port Moresby and Rockville: NSO and ICF 2019, Available: <https://web.archive.org/web/20230801120444/https://dhsprogram.com/pubs/pdf/FR364/FR364.pdf>
- 38 Hart JD, Kwa V, Dakulala P, et al. How advanced is the Epidemiological transition in Papua New Guinea? new evidence from verbal autopsy. *Int J Epidemiol* 2022;50:2058–69. 10.1093/ije/dyab088 Available: <https://doi.org/10.1093/ije/dyab088>
- 39 Rosewell A, Shearman P, Ramamurthy S, et al. Transforming the health information system using mobile and geographic information technologies, Papua New Guinea. *Bull World Health Organ* 2021;99:381–387A. 10.2471/BLT.20.267823 Available: <http://doi.org/10.2471/BLT.20.267823>
- 40 Whittaker M, Piliwas L, Agale J, et al. Beyond the numbers: Papua New Guinean perspectives on the major health conditions and programs of the country. *PNG Med J* 2009;52:96–113.
- 41 Novotny V. *Island of a thousand tongues and a wild, wild landscape. In: Notebooks from New Guinea: reflections on life, nature, and science from the depths of the rainforest*. Oxford: Oxford University Press, 2011: 11–51.
- 42 Nading AM. Humans, animals, and health: from ecology to entanglement. *Environment and Society* 2013;4:60–78. 10.3167/ares.2013.040105 Available: <https://doi.org/10.3167/ares.2013.040105>
- 43 Tsing AL. *Enabling entanglements. In: The mushroom at the end of the world: on the possibility of life in capitalist ruins*. Princeton and Woodstock: Princeton University Press, 2015: vii–xiii.
- 44 Middleton J, Cassell JA, Colthart G, et al. Rationale, experience and ethical considerations underpinning integrated actions to further global goals for health and land Biodiversity in Papua New Guinea. *Sustain Sci* 2020;15:1653–64. 10.1007/s11625-020-00805-x Available: <https://doi.org/10.1007/s11625-020-00805-x>
- 45 Newland J, Neuendorf N, Vallely L, et al. *COVID-19 and its impacts on primary health services and public health infectious disease programs in Papua New Guinea*. Goroka and Sydney: PNGIMR and UNSW, 2022. Available: <http://dx.doi.org/10.26190/6mhp-gc18>
- 46 Alcamo J, Thompson J, Alexander A, et al. Analysing interactions among the sustainable development goals: findings and emerging issues from local and global studies. *Sustain Sci* 2020;15:1561–72. 10.1007/s11625-020-00875-x Available: <https://doi.org/10.1007/s11625-020-00875-x>
- 47 Hamnett MP, Connell J. Diagnosis and cure: the resort to traditional and modern medical practitioners in the North Solomons, Papua New Guinea. *Soc Sci Med Part B: Med Anthropol* 1981;15:489–98. 10.1016/0160-7987(81)90023-5 Available: [https://doi.org/10.1016/0160-7987\(81\)90023-5](https://doi.org/10.1016/0160-7987(81)90023-5)
- 48 Saweri OPM, Hetzel MW, Mueller I, et al. 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;17:10. 10.1186/s12913-016-1965-6 Available: <https://doi.org/10.1186/s12913-016-1965-6>
- 49 Joshua IB, Passmore PR, Parsons R, et al. Appropriateness of prescribing in selected Healthcare facilities in Papua New Guinea. *Health Policy Plan* 2014;29:257–65. 10.1093/heapol/czt012 Available: <https://doi.org/10.1093/heapol/czt012>



- 50 Lewis G. The ethnography of an illness. In: *A failure of treatment* Oxford: Oxford University Press, n.d.: 2005. 1–16.
- 51 Frankel S, Lewis G. *A Continuing Trial of Treatment: Medical Pluralism in Papua New Guinea*. Dordrecht: Kluwer Academic Publishers, 1989.
- 52 Kline K, McCarthy JS, Pearson M, *et al*. Neglected tropical diseases of Oceania: review of their prevalence, distribution, and opportunities for control. *PLoS Negl Trop Dis* 2013;7:e1755.
- 53 Middleton J. Can Ivermectin mass drug administrations to control Scabies also reduce skin and soft tissue infections? hospitalizations and primary care presentations lower after a large-scale trial in Fiji. *Lancet Reg Health West Pac* 2022;22:100454:100454..
- 54 Bonifaz A, Archer-Dubon C, Saúl A. Tinea Imbricata or Tokelau. *Int J Dermatol* 2004;43:506–10.
- 55 Angra K, Norton SA. Early Western observations of cutaneous Trichophyton Concentricum infection in the Pacific and a history of its vernacular name, Tokelau. *Australas J Dermatol* 2016;57:e108–11.
- 56 Engelman D, Fuller LC, Solomon AW, *et al*. Opportunities for integrated control of neglected tropical diseases that affect the skin. *Trends Parasitol* 2016;32:843–54.
- 57 Foy BD, Alout H, Seaman JA, *et al*. Efficacy and risk of harms of repeat Ivermectin mass drug administrations for control of malaria (RIMDAMAL): a cluster-randomised trial. *Lancet* 2019;393:1517–26.
- 58 Nguyen DTN, Simms KT, Keane A, *et al*. Towards the elimination of Cervical cancer in low-income and lower-middle-income countries: modelled evaluation of the effectiveness and cost-effectiveness of point-of-care HPV self-collected screening and treatment in Papua New Guinea. *BMJ Glob Health* 2022;7:e007380.
- 59 Kelly-Hanku A, Newland J, Aggleton P, *et al*. HPV vaccination in Papua New Guinea to prevent Cervical cancer in women: gender, sexual morality, outsiders and the de-Feminization of the HPV vaccine. *Papillomavirus Res* 2019;8:100171:100171..
- 60 ICO/IARC Information Centre on HPV and Cancer. Papua New Guinea Human Papillomavirus and Related Cancers, Fact Sheet 2021. Barcelona, Available: [https://hpvcentre.net/statistics/reports/PNG\\_FS.pdf](https://hpvcentre.net/statistics/reports/PNG_FS.pdf)
- 61 Prescott TAK, Homot P, Lundy FT, *et al*. Tropical ulcer plant treatments used by Papua New Guinea's Apsokok nomads. *J Ethnopharmacol* 2017;205:240–5.
- 62 Oppenheimer SJ, Hill AV, Gibson FD, *et al*. The interaction of alpha Thalassemia with malaria. *Trans R Soc Trop Med Hyg* 1987;81:322–6.
- 63 Oppenheimer SJ, Gibson FD, Macfarlane SB, *et al*. Iron supplementation increases prevalence and effects of malaria: report on clinical studies in Papua New Guinea. *Trans R Soc Trop Med Hyg* 1986;80:603–12.