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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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Keywords: Primary care; Tropical medicine – anthropology, epidemiology; Qualitative research; Health services administration and management; Neglected diseases.

ABSTRACT

Objectives. Determine community needs and perspectives as part of planning health service incorporation into Wanang Conservation Area.

Design. Clinical and rapid anthropological assessment (individual primary care assessments, Key Informant [KI] interviews, Focus Groups [FGs], ethnography) with parallel treatment of urgent cases.

Setting. Wanang (pop. c189), a village in the rainforests of Madang province, Papua New Guinea.

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

Results. Of 113 examined, 11 were 'well', 62 (30f, 32m) treated urgently, 31 referred (15f, 16m), indicating considerable unmet need. FGs top-4 ranked health issues concorded 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 of 168) were limited to one or two people. Treatment approaches included plant-medicines, stored pharmaceuticals and occasionally rituals. Protracted travel to hospital/pharmacy was sometimes undertaken for severe/refractory disease. Service barriers included: no health patrols or easily reachable aid post; remote town hospital; unfamiliarity with institutions; medicine costs. FG service introduction priorities were: aid post; child vaccinations; transport; perinatal/birth care; family planning.

Conclusions. In a place with no prior health data, this study enabled service planning and demonstrated medical need sufficient to acquire funding to establish local primary care. In doing so, it has aided Wanang's community to develop sustainably, without sacrificing their forest home.

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.

INTRODUCTION

Papua New Guinea's (PNG) health-related UN Sustainable Development Goal indicators are worse than all but two nations outside Africa,[1] and its rainforests are threatened by commercial logging driven primarily by global commodity demands.[2, 3] 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. In a community with no prior patient data, this study enabled service planning and demonstrated medical need sufficient to successfully acquire funding for establishment of primary care services sited in the community. Here we outline site-specific context, biodiversity and health issues in PNG and our methodological rationale are discussed in detail in our published protocol.[4]

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 (figure 1 a). After 3–4 hours of driving into the forested interior, the increasingly deteriorating roads (figure 1 b) 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 c). 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'.[5, 6] In contrast, for Wanang villagers (such as co-authors JP and RU), the 80km 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.[7] 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,[7] staffed by health-extension officers and nurses, and operated by government, churches, NGOs, or commercial interests such as mines.[8] 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.[3] 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.[3] The meeting in 2016 identified healthcare as 'the main missing service' [9] to be developed in the collaboration's next phase.

In more industrialised countries, clinical interactions are commonly recorded electronically in routinely collected patient data.[10] 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 e and f), 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 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.[11] During the design of this health needs assessment [12] 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. 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

We carried out a clinical and rapid anthropological assessment with parallel treatment of urgent cases, in Wanang between 17–25 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;[4] here we give an outline and describe changes. A reporting checklist following 'Appraising studies in health using rapid assessment procedures'[13] is in supplementary file (p.2). JM designed the protocol in discussion with its co-authors,[4] after consideration of participatory planning case studies archived at the Participation Resource Centre.[14]

Data was collected by a team from Brighton and Sussex Medical School in the UK (co-authors JM and GC) and Binatang Research Centre in PNG (co-authors MJ, JP, and SS) (backgrounds and capacity building, supplementary file, p.3). All residents of Wanang were eligible and invited for clinical assessments, those ≥18y for FGs. Recruitment for both was self-selecting, by attending the temporary research shelter after a village meeting. KIs ≥18y 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]<40y, males [m]<40y, f≥40y, m≥40y) in Tok Pisin (PNGs national creole). Similarly, interviews and clinical assessments, unless participants preferred English. Recordings were transcribed verbatim in Tok Pisin, then translated into English. 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 supplementary file[15] includes: topic guides; consent and clinical data collection forms; treatment formulary and equipment; safety measures.

JM conducted analysis informed by multidisciplinary reflection from fellow co-investigators 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 co-authors who are PNG nationals (FD, MJ, ML, JP, JP, WP, SS, 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 1.6.1 (QSR International, Melbourne) and analysed to produce three outputs. Firstly, sex-age FG rankings of health issues affecting the community and service priorities (collected using nominal group technique[16]) were tabulated, compared, and contextualized with explanations from the wider data. Secondly, disease ethnoclassification taxonomies were created by coding data to pre-chosen higher order themes (e.g., perceived causes, symptoms, appropriate treatments) as per Scrimshaw & Hurtado.[17] Thirdly, 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[18] 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; co-author 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 (tables S3–S6, supplementary file, p.6–9). 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 (box 1) in consultation with other Co-Is with health service backgrounds (GC, JAC, ML, 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'[4] 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).[19] In addition to sex-age FG rankings of health issues and service priorities, we generated all-group rankings by adding inversely weighting ranks (supplementary file, p.3).

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 design, including co-author JP from Wanang. Community members advised on research conduct and burden, aided recruitment, and co-authored 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 19y, range 1mo–73y) and 113 examined (51f, 62m; median 18y, range 1mo–73y) (table S1, supplementary file, p.3). Data from all were used in analysis. In our

protocol[4] we reported a survey recording 189 individuals (89f, 100m). KIs did not consider there had been major population changes in the intervening two years. Based on this, medical history and examination data would represent 68.3% and 59.8% coverage respectively. Twenty-six ≥18y took part in FGs (sex and age, figure 2), five KIs were interviewed (sex and backgrounds, figure 2). 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 there were no participants with missing data.

Disease burdens

Key informants and focus groups

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 (e.g., "*TB*"), (2) trackable to specific biomedical conditions (e.g., "*pukpuk*" meaning 'crocodile', a reference to body-wide skin scaling pathognomonic of tinea imbricata), and (3) naming signs/symptoms with unspecified aetiology (e.g., "*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"* (i.e., 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≥40y 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<40y and m≥40y 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≥40y or <40y as a community health problem, but m≥40y and <40y 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 (co-author 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 smoking tobacco wrapped in newspaper seemed very common amongst adults.

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

Ranked lists were produced using the nominal group technique [16], combined group ranks by reverse weighting (scores in brackets, method, supplementary file, p.3). Italic text is untranslated direct speech, Tok Pisin names/descriptions are given at first use left to right (transcripts retained). Ethnoclassifications of the top four ranked health issues (*"Malaria"*, *"Sotwin"*, Cancer, *"Grille"*) are summarised in the main text, and detailed with quotes in tables S3–6 (supplementary file, p.6–9).

(a) Health issues affecting the Wanang community, identified and ranked by sex-age based focus groups

	Females <40y	Males <40y	Females ≥40y	Males ≥40y	Combined rankings
	Top five health issues, as ranked by sex-age focus group				
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"*	
	Health issues identified by all sex-age focus group, but not included in their individual top fives				
	(in top five)	(in top five)	*"Sotwin"*	(in top five)	
	Cough/cold	(in top five)	Cough/cold		
	(in top five)	Headache			
	Health issues identified by only three sex-age focus groups				
	Skin pain/damaged skin *"Skin pen"*				
	Back pain *"Baksait pen"*			Back pain	
	Diarrhoea *"Pekpek wara"*			Diarrhoea	
	(in top five)		Cancer ‡	(in top five)	
	Knee pain *"Kneepen"*		(in top five)	Knee pain	
	Stomach-ache *"Bel pen"*		Stomach-ache		
	Toothache *"Tit pen"*		Toothache #		
	Earache *"Ia pen"*		Earache		
	Loss of vision *"ai bilong mipela olsem i no save lukluk gut"* (*f*≥40y)				
	Sores *"Sua"*				
	Health issue identified by only two sex-age focus groups				
		Scabies *"Kaskas"*		Scabies	
	Health issues identified by only one sex-age focus group				
	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) Priorities for service introduction, identified and ranked by sex-age based focus groups

	Females <40y	Males <40y	Females ≥40y	Males ≥40y	Combined rankings
1	*"Transport"*	"Aid Post"			"Aid Post" (15)
2	Vaccinations *"Bebi sut"* *	Road *"Rot"*	Vaccinations	*"Family planning"*	Vaccinations (11)
3	*"Family Planning"*	*"Transport"*	Perinatal & birth care	Vaccinations	*"Transport"* (10)
4	Perinatal & birth care †	*"Awareness"*	Transport ‡	*"Awareness"* §	Perinatal/birth (7)
5	Fracture treatment ‖			Perinatal & birth care	*"Family planning"*(7)

(a) * "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<40y, cervical cancer, "*sik bilong Mama*"; f≥40y, breast cancer, *"Susu cancer"*; m≥40y, "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. Δ *"Animol sa kaikai"*. ◊ *"Kol sik"*. ** "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"*.(b) * For infants and children. † f<40y, **"**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≥40y, "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 tuberculosis, 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*".

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%) had 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<18y reported having children or problems during pregnancy/birth. Of 30 f≥18y, 27 had given birth to live children: 128 in total (mean 4.7 per female with a 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 supplementary file (table S2, p.4). 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%). 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 *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%) (supplementary 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";* [c]*"grile"*. Ethnoclassification taxonomies, supplementary tables S3–6, supplementary file, p.6–9), translated to the five biomedical conditions we diagnosed most ([a] malaria; [b] URI, LRTI, TB; [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 ethnoclassifications

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, and fishing. Males ≥40y described preventing diseases through bathing, not eating rotten food, avoiding rain, and not "working too hard". Males <40y also mentioned care when walking in the forest and working with axes and knives. Females <40y 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 re-treating nets. Villagers said they learned 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 whilst 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<40y 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<40y).

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≥40y 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 traveling 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≥40y).

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

Ethnoclassification taxonomies for each of the top four health issues identified by FGs are in supplementary tables S3–6 (supplementary file, p.6–9), including example quotes from KIs, FGs, and patient histories on how the diseases are understood, who treats them, and how. Though the belief "*sanguma* poison" (sorcery) causes some illness was voiced in the m≥40y 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" (table S3, supplementary file, p.6): 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 (i.e., 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≥40y FG described treatments using steam from boiled plants and fruits. According to the m<40y 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.[20] A FG and KI described how hospital treatment was sometimes sought for severe cases, using Binatang Research Centre transport when available.

"Sotwin" (table S4, supplementary file, p.7)*:* This Tok Pisin word has a dual meaning as both sign/symptom (shortness of breath), and specific biomedical condition (asthma).[21] Given this, people were likely sometimes describing experiences of conditions beyond asthma (only one case diagnosed on examination). A KI emphasized 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≥40y (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 >5y 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 (table S5, supplementary file, p.8): 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≥40y 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 <40y were "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; table S6, supplementary file, p.9): 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 f≥40y 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 observations that predisposition seems to be linked to recessive inheritance [22]). 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<40y 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 1 b shows FG identified priorities for service introduction. The highest scoring was aid post sited in Wanang, top for all but f<40y who thought it an unrealistic expectation from 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<40y. Transport was ranked first by f<40y, a priority by two other FGs. Pregnancy and birth care within the community was vocalised by female FGs and m≥40y, but not m<40y. Jointly scoring with pregnancy and birth care was family planning, identified by f<40y and m≥40y (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).

Whilst 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≥40y and f<40y 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 concorded 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 we diagnosed most ([a] malaria, [b] URI, LRTI, TB, [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. We successfully used the study's findings to secure funding to establish such services, 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 multi-day queue is likely to have biased the sample towards those with greater morbidity. In our protocol paper[4] 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'[23] (e.g., HIV, guinea worm[13]). 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 to 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 someway to making the relationship between the community and researchers a fair transaction, rather than one of dispossession and accumulation as West[24] has characterised some foreign-driven research and NGO activity in PNG.

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 reflect those seen nationwide (e.g., GBD 2019 ranks respiratory infection as the leading cause of all-age PNG DALYs[25]) and community perspectives and ethnoclassifications resonate with some voiced elsewhere (particularly Whittaker et al.[26]), however we caution against extrapolating beyond Wanang. PNG is hugely diverse culturally (it has more languages than any other nation on earth[27]) and biogeographically (lowland forests, peri-urban slums, swamplands, high mountains, island archipelagos), and its communities have markedly different levels of engagement with state, industry, and the money economy. The myriad eco-cultural 'entanglements' (in the sense used by Nading[28] and Tsing[29]) 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. For insights into relations within and around a hospital in Madang town, see Street[11]. In conclusion, whilst 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 policymakers

Wanang health service plan

Health needs assessments commonly make recommendations for clinicians or policymakers to act on identified needs. However, here 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.[30] 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 end of 2020, registered with the provincial health authority, and continues to be staffed by a full-time nurse (figure 4). Given PNG's health care 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 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[7]. 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.

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^2 to 150 km^2. 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[31]. The impacts of this work indicate simultaneously addressing health (SDG 3) and biodiversity (SDG 15) can be a successful 'synergy driver'[31] 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 pulmonary TB/tuberculosis.[32] Similarly, *"malaria"* may seem simple to translate; the Tok Pisin dictionary definition of *"malaria"* equals malaria in English.[21] However, in practice it is often used generally to mean fever.[26] This is clinically important as non-malarial febrile illnesses are widespread in PNG,[33] underlining the potential value of RDTs in determining when *"malaria"* is malarial, to avoid inappropriate treatment (which is common [34]). Translational issues between ethnoclassifications and biomedicine are particularly prevalent in PNG,[26, 35, 36] 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'. Studies to determine effectiveness of traditional treatments would be helpful (we discuss ethical issues elsewhere[30]). 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 [37]) 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.[38] The region has been key to developing integrated skin interventions to control scabies and reduce soft tissue infections.[39] Tinea imbricata, which is only found in a small number of populations worldwide but is highly distributed across Melanesia,[40, 41] has been neglected as regards research and treatment [22]. An integrated skin intervention[42] 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.

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: (i) malaria treatment (including RDTs, appropriate medications, evacuation triggers), (ii) fracture management, (iii) off-road medical evacuation, (iv) 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). 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.

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, (i) Malaria: mosquito net audit, supply, and re-treatment; elsewhere ivermectin MDAs have reduced vector populations and thus human cases,[45] local trials may be beneficial, particularly combined with MDAs on neglected tropical skin diseases already including ivermectin (see iv). (ii) Respiratory issues: preventive child vaccinations; TB screening and referrals; RDTs should guide appropriate treatment given PNG wide shifts from bacterial to viral lung infections and pneumonia. (iii) Cancer: in addition to aid post referrals, preventive (both-sex) HPV 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.[46–48] (iv) 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.[49] (v) Family planning: facilitate Marie Stopes mobile clinic visit. (vi) 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.[50, 51] (vii) Health education: nurse-provided STD training sessions; exercises for youth to reduce sports related lower back pain. (viii) Mobile patrols: nurse-led patrols to reach villages across the aid post catchment area.

STATEMENTS

Supplementary file: This web only file has been produced by the BMJ Publishing Group from an electronic file supplied by the authors and has not been edited for content.

Contributors: Author order is alphabetical by surname, except first and last. Co-Investigator backgrounds are detailed in the methods section, and in line with recommendations from Utarini et al.,[13] we also detail relevant prior experience of the fieldwork team (supplementary file, p.3). Contributions to this publication are outlined using the CRediT Contributor Taxonomy (https://credit.niso.org), and research assistants (RAs), technicians (RTs), and collaborators (C) flagged at first appearance. Conceptualization: JM, GC, JF, MGH, JI, HM, VN, MP, AJS, SLW, JAC. Data curation: JM, GC, AE(RA), RH(RA). Formal analysis: JM. Funding acquisition: JM, GC, JF, MGH, JI, ML, HM, VN, MP, WP, AJS, SLW, JAC. Investigation: JM, GC, MJ, JP(RT), SS(RT). Methodology: JM, GC, FD, JF, MGH, JI, MJ, CIJ, ML, HM, VN, MP, JP, WP, SS, AJS, SLW, JAC. Project administration: JM. Supervision: JAC, AJS. Visualisation: JM, JP(RT). Writing—original draft: JM. Writing—review and editing: JM, GC, FD, AE, JF, RH, MGH, JI, MJ, CIJ, ML, HM, VN, MP, JP, JP, WP, JAS(C), SS, AJS, RU(RT), SLW, JAC. All authors reviewed the study findings and read and approved the final version before submission. JM is responsible for the overall content as guarantor, and attests all listed authors meet authorship criteria and no others meeting the criteria have been omitted.

Ethics: 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[43] was obtained though speaking to clan leaders, and a mass village meeting. Individual consent was provided for participation in FGs, KI interviews, and individual primary care assessments. Acute medical needs and absence of local health services risked participation would not be truly voluntary. Thus, to avoid conditionality through passive coercion[44] villagers were offered examinations and treatments without requirement to participate in the study. We discuss related ethical issues in our published study protocol.[4]

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Data availability: All data relevant to the study are included in the article or uploaded as supplementary 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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FIGURES

Figure 1 Study setting.

A: Wanang community. B: Overgrown logging road on the way to Wanang. C: Wanang area. D: Mural honouring the role of aid posts in PNG medicine on the wall of Madang Provincial Hospital. E & F: Examples of individual health books in-use in-region at the time of this assessment. [Images: A, New Guinea Binatang Research Centre; C, co-author JP; others, first author JM].

Figure 2 Methodological approach, participants, and resulting plan of health service provision.

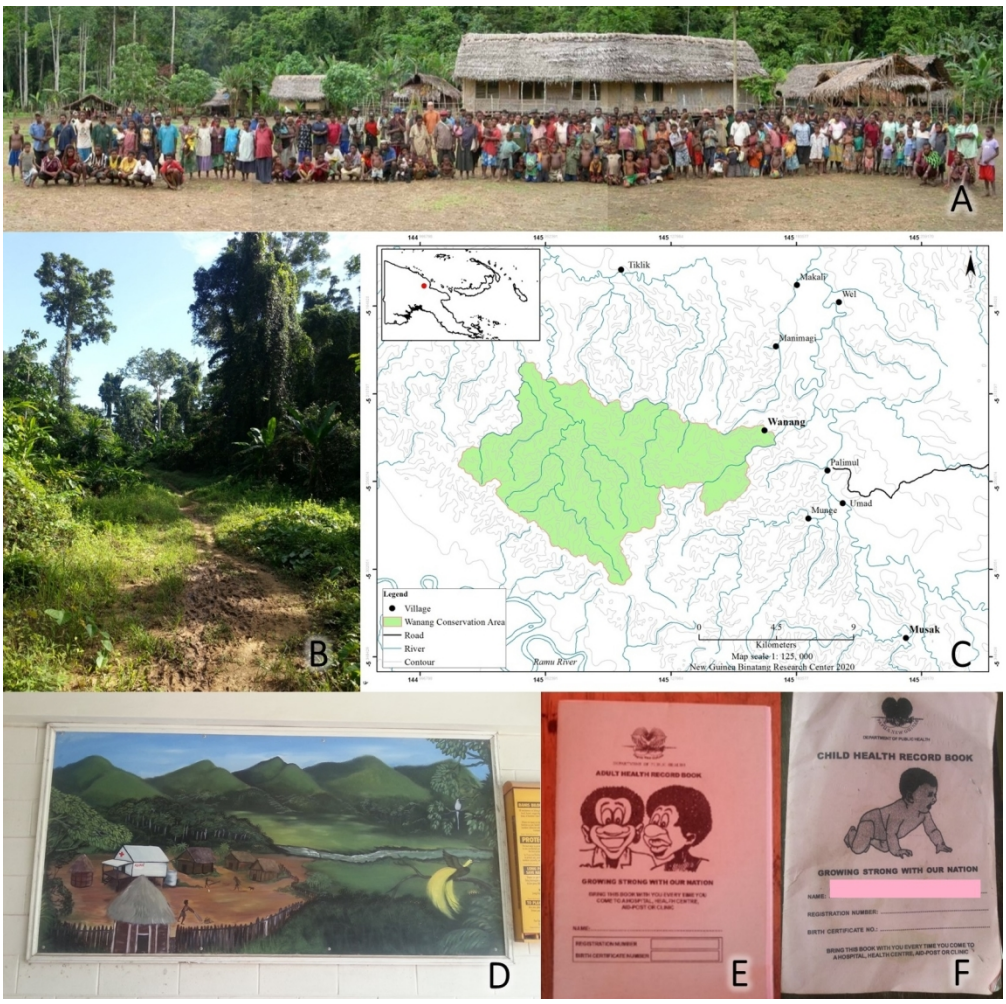
Green boxes are outputs: dark, delivered as part of this assessment; light, requiring additional funding for provision. Role abbreviations: PC HCP, primary care health care professional (in this assessment a General Practitioner); RTs, research technicians; RF, research fellow.

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.

Figure 4. Phased health service introduction at Wanang.

Top: Examples of training provided, (left to right) fracture management, off-road vacuum-stretcher evacuation, use of malaria RDTs. Middle: Wanang Aid Post (left) and nurse consultation (right). Bottom: Examples of disease targets for proactive integrated interventions, specifically (left to right) tropical ulcer, yaws, tinea imbricata, scabies mite and eggs. Images from Wanang, apart from *Sarcoptes S*cabiei microscopy (Credit: top and bottom, JM; middle, Binatang Research Centre).



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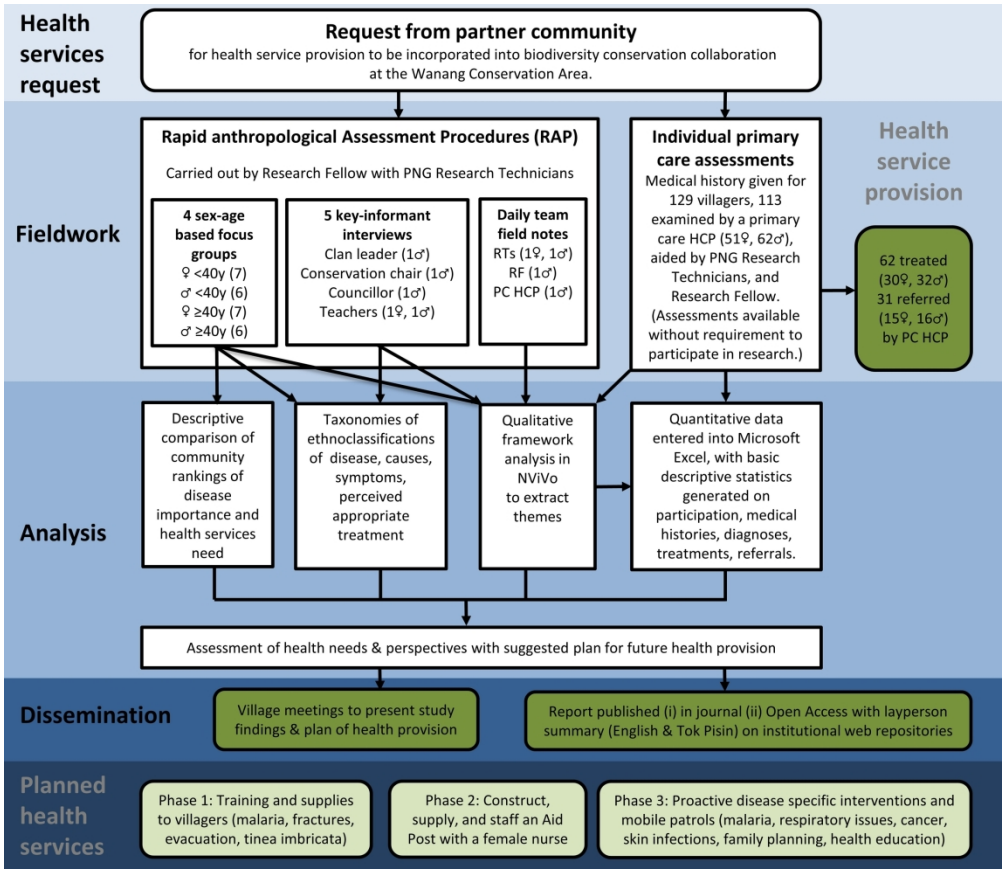

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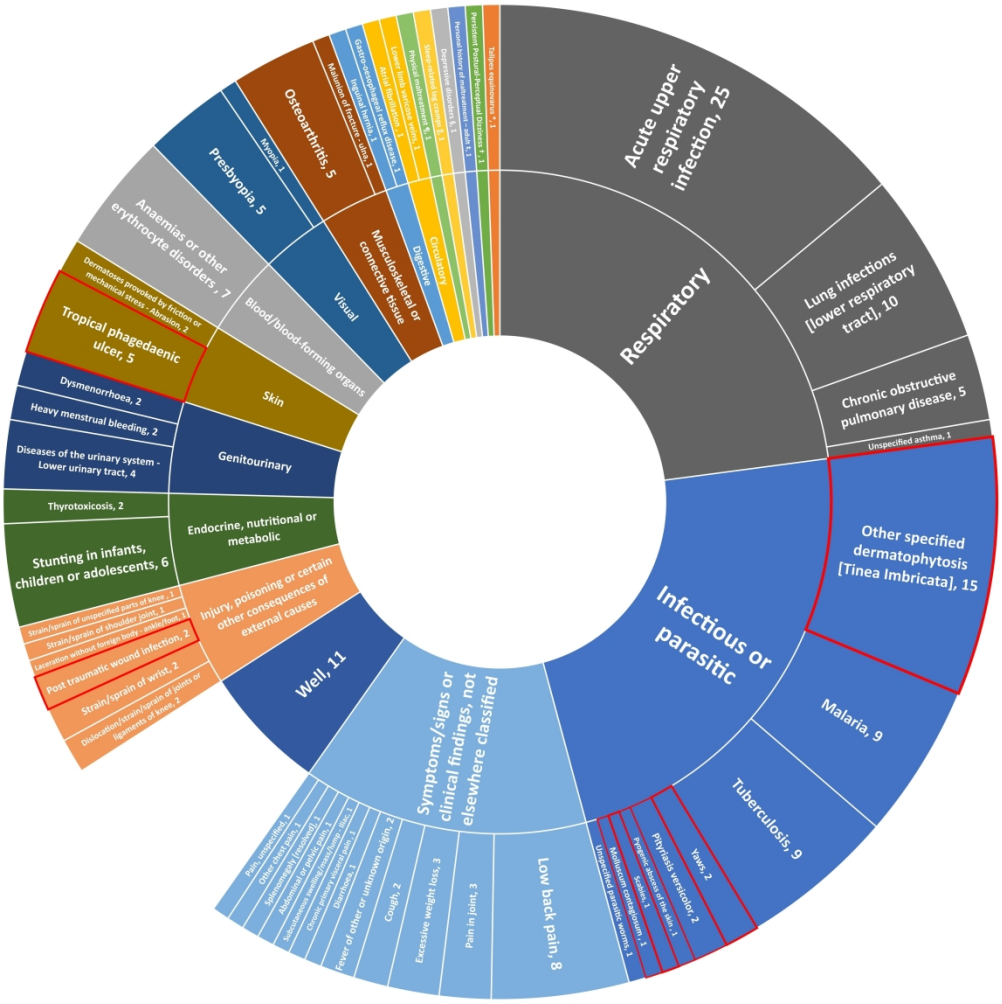

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386x386mm (300 x 300 DPI)

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97x95mm (300 x 300 DPI)

SUPPLEMENTARY FILE

Middleton, Colthart, Dem, *et al*. 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. Submitted to *BMJ Open* 2023.

CONTENTS

REPORTING

Reporting checklist based on 'Appraising studies in health using rapid assessment procedures' [13]
This checklist is provided in line with the following statement in our protocol: 'The article will reference this protocol noting changes in method, and include a filled-in reporting checklist based on criteria for appraising studies in health using RAP' [4]. All changes are noted in the manuscript under the subheader 'Changes from our published protocol' in the methods section. Criteria in '_' are quoted from [13].

Criteria	Page, line number
'1. Aim (Is the aim of the study clearly described?)'	5, 124–127.
'2. Subjectivity (Are the researchers' background, prior knowledge and relationship to the community, and cultural competence clearly presented and addressed?)'	Paper: 6, 157–162, 176–177; 21, 598–609. Sup. File: 3.
'3. Field research guidelines (Is there an adequate description of the field guide and the rationale and process of its development?)'	Fully detailed in published protocol, which also includes all recruitment materials, KI and FG topic guides, clinical data collection forms, pharmacy, etc.[4]. Paper: 5–6, 133–142, 154–156.
'4. Staff (Is the recruitment process and training of research assistants presented, and is it sound?) RAP studies usually use research assistants in the collection of primary data from the field. Many researchers establish specific criteria for selecting assistants and these should be communicated. Further, the training process and content should be presented.'	Detailed in published protocol. Fieldwork RAs were existing RTs and PNG nationals at in-country New Bintang Research Centre. Sup. File: 3.
'5. Data collection methods (Is the rationale for the data collection methods and types of information collected with each method clearly presented?)'	Detailed in published protocol. Paper: 6, 143–156.
'6. Selection of research sites (Is an appropriate sampling strategy for selecting the study area(s) or research site(s) described?)'	n/a – site (Wanang village) was studied as it was the community that had requested health service incorporation in their existing conservation area. See 4–5, 79–123; detailed in protocol paper.
'7. Informant selection (Is a systematic process of selecting informants used and is it adequately described?)'	Fully detailed in published protocol. Paper: 6, 145–148; 7, 190–194.
'8. Credibility (Is a strategy for assessing credibility established and presented?)'	Fully detailed in published protocol. Paper: 5, 136–137; 6, 164–165; 6–7, 175-181.
'9. Analysis (Is the analysis process adequately described and was it sound?)'	Fully detailed in published protocol. Paper: Fig 2; 6–7, 157–181; 7, 194–197. Sup. File: 3.
'10. Presentation (Are the findings and discussion clearly presented?)'	Paper: 7–19, 203–593. Table 1, Figs. 3 and 4. Sup. File: 3–9, Tables S1–S6.
'11. Ethics (Are ethical principles respected and is the process for informed consent described?)'	Detailed in published protocol (including recruitment scripts, consent forms etc.). Paper: 21, 613–621.

METHODS

Fieldwork team backgrounds

BSMS: JM is a research fellow in public health with a background in pre-hospital emergency care, including in remote areas, and training in disease ecology and qualitative methods. GC is a general practitioner and experienced expedition medic with training in tropical dermatology. Both had prior field experience in Melanesia (PNG; Solomon Islands). BRC: MJ and SS were research technicians (RTs) with degrees in forestry science who were brought up in rural PNG villages, had previously worked with the community, and had pre-existing skills in social studies. JP is a RT from Wanang, where he continues to live with his family.

Capacity building for PNG staff

RTs were trained in study procedures by JM, provided the protocol [4] and [15] for reference in the field, and gained practical experience working alongside JM and GC who were present during all fieldwork. BRC staff were also given a lecture on conservation and health integration projects worldwide, and a certificated 3-day course on remote care and medical evacuation (taught by JM). FD, ML, JP, SS, and RU were additionally brought to the UK from PNG in 2019 and 2022. There they received training from Brighton and Sussex Medical School and University of Sussex (e.g., project monitoring and evaluation, eDNA, ecological and health analysis) and were taken on institutional visits nationwide (e.g., Millennium Seed Bank, University of Southampton, University of Oxford, London School of Hygiene & Tropical Medicine, Kew) to build their network of collaborators and co-plan future PNG-led work.

Generating combined all-group rankings

We generated combined all-group rankings of health issues and priorities for health service introduction by adding together inversely weighting ranks from sex-age focus groups. For example, two groups ranked malaria highest, another second highest, and the remaining as fifth highest: (1st=5) + (1st=5) + (2nd=4) + (5th=1) = 15. This was the largest combined score, so malaria was reported as the overall highest ranked health issue.

RESULTS

Supplementary Table S1. Primary care assessment participants.

		Medical History (n=129) (%)	Examined (n=113) (%)
Sex	Female	54 (41.9)	51 (45.1)
	Male	75 (58.1)	62 (54.9)
Age in years	0–9	50 (38.8)	45 (39.2)
	10–19	21 (16.3)	15 (13.3)
	20–29	9 (7.0)	7 (6.2)
	30–39	18 (14.0)	16 (14.2)
	40–49	10 (7.8)	9 (8.0)
	50–59	17 (13.2)	17 (15.0)
	60–69	2 (1.6)	2 (1.8)
	70–79	2 (1.6)	2 (1.8)
	Median (range)	19y (1mo–73y)	18y (1mo–73y)

Supplementary Table S2. Diagnoses from clinical examinations in Wanang village

Specific clinical diagnoses are listed in descending order and categorised as per the International Classification of Diseases 11th Revision Version 02/2022 (ICD-11, https://icd.who.int/browse11/l-m/en), followed by the relevant ICD-11 primary code when appropriate. For example, 'Yaws' is listed as a specific condition, and as a sub-category of 'Certain infectious or parasitic diseases'. Diagnoses were recoded to ICD-11 by author JM and confirmed by author GC. Percentages are of examined males/females/all, totals are greater than n as many of those examined had multi-morbidity. In this table, preserving order of individual conditions based on their frequency only allows partial grouping by ICD-11 primary categories. However, figure 3 in the main article shows full grouping by primary categories (but not break down by sex). Five young children (all male) of the 113 individuals examined were only partially examined, due to non-compliance.

Conditions, as per International Classification of Diseases 11th Revision Version 02/2022 (ICD-11) (ICD-11 code) [authors additional information]	**ICD-11 Primary category (ICD-11 code)** [authors additional information]	**Males N=62 (%)**	**Females N=51 (%)**	**All N=113 (%)**
Acute upper respiratory infection, site unspecified (CA07.0)	Diseases of the respiratory system (ICD 12)	9 (14.5)	16 (31.4)	25 (22.1)
Other specified dermatophytosis (1F28.Y) [Tinea Imbricata]	Certain infectious or parasitic diseases (ICD 01)	11 (17.8)	4 (7.8)	15 (13.3)
Well *		**5* (8.1)**	**6* (11.8)**	**11* (9.7)**
Lung infections (CA4Z) [lower respiratory tract] †	Diseases of the respiratory system (ICD 12)	4 (6.5)	6 (11.8)	10 (8.8)
Malaria	Certain infectious or parasitic diseases (ICD 01)	4 (6.5)	5 (9.8)	9 (8.0)
Tuberculosis, unspecified (1B1Z) ‡		4 (6.5)	5 (9.8)	9 (8.0)
Low back pain (ME84.2)	Symptoms, signs or clinical findings, not elsewhere classified (ICD 21)	6 (9.7)	2 (3.9)	8 (7.1)
Anaemias or other erythrocyte disorders, unspecified (3A9Z) §	Diseases of the blood or blood-forming organs (ICD 03)	2 (3.2)	5 (9.8)	7 (6.2)
Stunting in infants, children or adolescents (5B53) ‖	Endocrine, nutritional or metabolic diseases (ICD 05)	3 (4.8)	3 (5.9)	6 (5.3)
Tropical phagedaenic ulcer (EA40)	Diseases of the skin (ICD 14)	4 (6.5)	1 (2.0)	5 (4.4)
Osteoarthritis, unspecified (FA0Z)	Diseases of the musculoskeletal system or connective tissue (ICD 15)	2 (3.2)	3 (5.9)	5 (4.4)
Chronic obstructive pulmonary disease, unspecified (CA22.Z) ¶	Diseases of the respiratory system (ICD 12)	4 (6.5)	1 (2.0)	5 (4.4)
Presbyopia (9D00.3)	Diseases of the visual system (ICD 9)	5 (8.1)		5 (4.4)
Diseases of the urinary system, unspecified (GC2Z) - Lower urinary tract (XA34X0)	Diseases of the genitourinary system (ICD 16)	3 (4.8)	1 (2.0)	4 (3.5)
Pain in joint (ME82)	Symptoms, signs or clinical findings, not elsewhere classified (ICD 21)	2 (3.2)	1 (2.0)	3 (2.7)
Excessive weight loss (MG43.5)		1 (1.6)	2 (3.9)	3 (2.7)
Cough (MD12)			2 (3.9)	2 (1.8)
Fever of other or unknown origin (MG26)		1 (1.6)	1 (2.0)	2 (1.8)
Pityriasis versicolor (1F2D.0)	Certain infectious or parasitic diseases (ICD 01)	1 (1.6)	1 (2.0)	2 (1.8)
Yaws (1C1D) Δ			2 (3.9)	2 (1.8)
Dysmenorrhoea (GA34.3)	Diseases of the genitourinary system (ICD 16)		2 (3.9)	2 (1.8)
Heavy menstrual bleeding (GA20.50)			2 (3.9)	2 (1.8)
Thyrotoxicosis (5A02)	Endocrine, nutritional or metabolic diseases (ICD 05)	1 (1.6)	1 (2.0)	2 (1.8)
Dermatoses provoked by friction or mechanical stress (EH92) - Abrasion (XJ652)	Diseases of the skin (ICD 14)	1 (1.6)	1 (2.0)	2 (1.8)
Strain or sprain of wrist (NC54.6)	Injury, poisoning or certain other consequences of external causes	2 (3.2)		2 (1.8)
Post traumatic wound infection, not elsewhere classified (NF0A.3)	(ICD 22)	2 (3.2)		2 (1.8)
Dislocation or strain or sprain of joints or ligaments of the knee (NC93) **		2 (3.2)		2 (1.8)
Strain or sprain of other or unspecified parts of knee (NC93.7)		1 (1.6)		1 (0.9)
Strain or sprain of shoulder joint (NC13.5)		1 (1.6)		1 (0.9)
Laceration without foreign body of ankle or foot (ND12.0)		1 (1.6)		1 (0.9)

Pain, unspecified (MG3Z)	Symptoms, signs or clinical findings, not elsewhere classified (ICD 21)	1 (1.6)		1 (0.9)
Other chest pain (MD30.1)		1 (1.6)		1 (0.9)
Chronic primary visceral pain (MG30.00)			1 (2.0)	1 (0.9)
Splenomegaly, not elsewhere classified (ME10.01) [resolved]		1 (1.6)		1 (0.9)
Diarrhoea (ME05.1)		1 (1.6)		1 (0.9)
Abdominal or pelvic pain (MD81)			1 (2.0)	1 (0.9)
Subcutaneous swelling, mass or lump of uncertain or unspecified nature (ME61) - Iliac region (XA0NH8)			1 (2.0)	1 (0.9)
Scabies (1G04) §§	Certain infectious or parasitic diseases (ICD 01)	1 (1.6)		1 (0.9)
Other and unspecified infestation by parasitic worms (1F90) ††		1 (1.6)		1 (0.9)
Molluscum contagiosum (1E76)		1 (1.6)		1 (0.9)
Pyogenic abscess of the skin (1B75.3)			1 (2.0)	1 (0.9)
Persistent Postural-Perceptual Dizziness (AB32.0)	Diseases of the ear or mastoid process (ICD 10)	1 (1.6)		1 (0.9)
Personal history of maltreatment (QE82) - adult (XT6S) [domestic]	Factors influencing health status or contact with health services (ICD 24)		1 (2.0)	1 (0.9)
Myopia (9D00.0)	Diseases of the visual system (ICD 09)	1 (1.6)		1 (0.9)
Talipes equinovarus (LB98.00)	Developmental anomalies (ICD 20)	1 (1.6)		1 (0.9)
Unspecified asthma (CA23.3)	Diseases of the respiratory system (ICD 12)	1 (1.6)		1 (0.9)
Sleep-related leg cramps (7A82)	Sleep-wake disorders (ICD 07)	1 (1.6)		1 (0.9)
Inguinal hernia (DD51) - Left (XK8G)	Diseases of the digestive system (ICD 13)	1 (1.6)		1 (0.9)
Gastro-oesophageal reflux disease (DA22)			1 (2.0)	1 (0.9)
Malunion of fracture (FB80.7) - Fracture of upper end of ulna (NC32.0)	Diseases of the musculoskeletal system or connective tissue (ICD 15)		1 (2.0)	1 (0.9)
Depressive disorders, unspecified (6A7Z)	Mental, behavioural or neurodevelopmental disorders (ICD 06)		1 (2.0)	1 (0.9)
Lower limb varicose veins, not further specified (BD74.1Z)	Diseases of the circulatory system (ICD 11)		1 (2.0)	1 (0.9)
Atrial fibrillation (BC81.3)		1 (1.6)		1 (0.9)
Physical maltreatment (PJ20) ⅢⅢ	External causes of morbidity or mortality (ICD 23)	1 (1.6)		1 (0.9)
Totals of diagnosed morbidities *		**92**	**76**	**168**

*'Well' classifications (marked in green) were not included in the final calculations of total diagnoses of morbidities. The following individual diagnoses were classified by the examining primary care clinician (GC) as "possible" or "suspected": † Lung infections [lower respiratory tract], 3 of 10; ‡ Tuberculosis, unspecified, 8 of 9; § Anaemias or other erythrocyte disorders, unspecified, 5 of 7; ‖ Stunting in infants, children or adolescents, 3 of 6; ¶ Chronic obstructive pulmonary disease, unspecified, 2 of 5; Δ Yaws, 1 of 2; ** Dislocation or strain or sprain of joints or ligaments of knee, 1 of 2; †† Other and unspecified parasitic worms, 1 of 1; §§ Scabies, 1 of 1; ⅢⅢ Physical maltreatment, 1 of 1.

Table S3. Ethnoclassification taxonomy of *"Malaria"* (1st in combined group rankings).
Quotes in roman are translated from Tok Pisin (dual transcripts retained), quotes in italics were spoken as written. Attributed texts without quotation marks are from patient histories summarised by PNG research technicians at the time.

<table>
<tr><td>Names</td><td colspan="6">"Malaria" (Tok Pisin and English) (all)</td></tr>
<tr><td>Who</td><td colspan="3">Everyone
All Focus Groups [FG] agreed: "Everyone" (♂≥40y FG)</td><td colspan="3">Old People and young children
"It occurs a lot in young school children" (Key Informant [KI]) ● "Most of the time it's old people, and young children." (KI)</td></tr>
<tr><td>When</td><td colspan="3">All the time
● "malaria can occur at any time" (♂≥40y FG) ● "It's all the time. In the dry season, still there are mosquitoes, in the rainy season – same" (♂<40y FG)</td><td colspan="3">More in the rainy season
"Mostly in wet season. So if it rains more, you see more malaria?" (KI)</td></tr>
<tr><td>Cause</td><td colspan="6">Mosquitos [local name: "nagi"]</td></tr>
<tr><td></td><td>Animal blood
"They might bite our skin… in this way the skin has the same blood… they take it from pigs or dogs or whatever and come back and put it into men's skin." (♂<40y FG)</td><td>Mosquito eggs
"mosquito's eggs will stay inside them and that causes this" (♀<40y FG)</td><td>Sleeping in the open
● "Sleeping in the open" (♀<40y FG) ● "Not having a mosquito net" (♀≥40y FG) ● "maybe they don't sleep in a mosquito net" (KI)</td><td colspan="3">Environment
Bushy "It all grasses near their house." (KI)
Swampy "Swampy areas are a breeding place for mosquitos" (KI)
Rubbish "Tins and plastics… create a breeding place for mosquitoes" (KI)</td></tr>
<tr><td>Signs and symptoms</td><td colspan="6">● High fever ● shivers ● cold skin ● yellow skin ● strong head pain ● feel weak ● cannot walk ● dizziness ● vomiting ● joint pain ● cough ● tired
● "skin becomes yellow, they will be ill in the afternoon and morning. They sleep. They will be shivering" (♀<40y FG) ● **"**fever, shivers, headache, cough, cold skin" (♂≥40y FG) ● "they feel cold, their hairs will be standing on end, very weak" (♂<40y FG) ● "cold sickness" (♀≥40y FG) ● "Chill, when they are feeling chill, high fever, sometimes they feel dizzy, dizziness, and they tend to vomit regularly…we suspect that they have malaria, by looking at those signs." (KI) ● Strong head pain, very high fever, joint pain, vomiting, very weak (Parent [P] of 13y with confirmed malaria) ● Cough (P 7y, confirmed malaria) ● Head pain, high fever, weak (P 1y, confirmed malaria) ● Head pain, feeling cold, fever (P 8y, confirmed malaria) ● Can't walk properly (P 4y, confirmed malaria)</td></tr>
<tr><td>Treatment</td><td>Nothing/rest
● "In this community… they don't go look for treatment… they are sick they just stay in their bed rest until they… feel good, better… maybe two or three weeks after they become ill again, because the bacteria is in their body and it's not dead." (KI) ● **"**A lot of the time we just stay here, and the illness goes and, like it finishes on its own" (♂≥40y FG)</td><td>Pharmacy drugs
Chloroquine Paracetamol Amoxicillin
● **"**When you go to town or hospital they take them, and BRC sometimes sends supplies here" (♂<40y FG) ● "Panadol, bought from pharmacy" (P 4y, confirmed malaria) ● "Panadol, Chloroquine, **Amoxicillin"** (♀<40y FG)</td><td>Steam with medicine from the forest*
Papaya Grass Guava Ginger Citrus fruits
● "We… take grass smell, guava, citrus fruits, boil them, heat water really hot, go to bedside, cover them up, and steam" (♀ ≥40y FG) ● "We use steam - make hot water - cover them up with a bed sheet, find a large pot, stir it with a stick: Papaya leaves, grass leaves, grass smell, guava leaves, ginger, citrus fruits. Only a few people in the community know how to use it - he knows how to do that. Vines no… drinks no, only steam. When finished, we can wash them using cold water" (♂<40y FG) ● "We tend to use medicine from the forest - like tree leaves, papaya… You steam them, cook all of these tree leaves up and steam the body" (♂≥40y FG)</td><td>Hospital
● "the hospital will treat" (♀<40y FG) ● "when they get worse they call the Binatang people so when they have the trip coming up they will just go down to the hospital." (KI)</td><td>Comfort
"Rock cradle them allot" (♀<40y FG)</td><td>Private health care staff
Private doctor (P 7y, confirmed malaria)</td></tr>
</table>

*Similar community plant-usage for *"malaria"* has been reported elsewhere in PNG. For a useful summary (though one that does not evaluate effectiveness) see: WHO. Medicinal plants of Papua New Guinea. Manila: World Health Organization Western Pacific Region 2009.

Table S4. Ethnoclassification taxonomy of *"Sotwin"* (2nd in combined group rankings)

Quotes in roman are translated from Tok Pisin (dual transcripts retained), quotes in italics were spoken as written. Attributed texts without quotation marks are from patient histories summarised by PNG research technicians.

<table>
<tr><td>Names</td><td colspan="6">"Sotwin" (all)
Tok Pisin
'1.out of breath, to gasp for breath, to pant; 2. to have asthma' [20]
Symptomatic labelling beyond asthma
Given the dual meaning as biomedical condition and symptom (see left), people were likely sometimes describing experiences of other conditions beyond asthma, particularly when no individual clinical diagnosis had been previously available. ● "I don't know what – is it TB or, we have TB or just asthma or, that's hard to know... If we have… medical report, like most – like at least medical patrol team they go to the Wanang and then they can inform us "you have TB or, just a cough"" (Key Informant [KI]) ● 50y patient (PT), complained of "Sotwin", diagnosed on assessment with TB.</td><td>"Umbang aul"
(Local language)
(♂<40y FG)</td></tr>
<tr><td>Who</td><td colspan="3">"Everybody/Everyone"
● "Everybody/Everyone" Focus Groups [FG]: ♀<40y; ♂ ≥40y; ♂<40y)* ● "asthma is covering all the living people in Wanang, ... from the kids up to the old people." (KI) ● "cold/cough, "sotwin", they are very widespread inside Wanang… not just older men or women." (KI)</td><td colspan="2">>5y, especially children
"especially like kids, but… young one is OK… maybe 5 to 16 years, then people up to like 30 years… and above… most of them are affected with the… coughing." (KI)</td><td>Middle-aged people and old-age people
"middle-aged people and old-age people… Not many young people." (KI)</td></tr>
<tr><td>When</td><td colspan="6">All the time
● "It's not seasonal - any time" (♂≥40y FG) ● "No, all year round. Cough is all year round." (♀KI)</td></tr>
<tr><td>Cause</td><td>Smoking
● (♂≥40y FG) ● "think the cause is… smoking… So most people around this place most of them are smokers" (KI)</td><td>Chewing Betel nut
(♂≥40y FG)</td><td>Meat, fish, cooking
● "Eating bloody meat… Fish, like blood so, you don't dry it" (♂≥40y FG) ● "you cook with fish and it has the smell of fish and you don't wash it properly and use it as a water container or water pot for drinking, this can cause "sotwin". Fish… if you don't dry it properly and you cook it and someone eats it, it can cause "sotwin"" (♀<40y FG) ● "the women… cook, give to you and you eat it" (♂<40y FG)</td><td>Sex with women
● "a woman comes and… has sex with you, this will cause this "sotwin" to occur" (♂≥40y FG) ● "the women [unclear] your leg… Go with them" (♂<40y FG)</td><td>Others
"I'm sitting down and they come round behind and use the same space where you were sitting" (KI)</td><td>Rubbish and dust
" If the house is dirty and you sleep with rubbish, dust, then you will get" (♂<40y FG)</td><td>The sun
(♀<40y FG)</td></tr>
<tr><td>Signs and symptoms</td><td colspan="6">● Heavy breathing ● fast breathing ● difficulty during physical exercise ● coughing ● "sotwin" ● weakness
● "When you walk up and down the mountain, you might call the "stretcher man"" (♀<40y FG) ● "If a man is breathing very heavily then we would know, he has "sotwin". Walking long distances…you will see… coughing a lot as well… when you go up a mountain you will need frequent rests" (♂≥40y FG) ● "The man might be coughing a lot. He will sit down, walk around and just rest… close to [the village]. He will not be able to climb up mountains… it's like, your breath will become locked and you will faint" (♂<40y FG) ● "They tend to cough publicly, like openly. When they walk around you will see them coughing." (KI) ● "everybody cough, but asthma is like times where you can cough cough cough, suddenly… it will come like very strong and you will like breathe very very fast…" (KI) ● said had sotwin, described symptom as cough (55y PT, diagnosed on assessment with LRTI and COPD; Parent [P] of 1y, diagnosed on assessment with URTI) ● has no strength (39y PT, diagnosed on assessment with LRTI) ● Sotwin a lot (P of 11months, diagnosed on assessment with LRTI)</td></tr>
<tr><td>Treatment</td><td colspan="3">Medicine from the forest
Banana drink Papaya leaf Vine sap
● "banana… in a cup, strain it, give it to the child. You can heal it in the village (unlike malaria which is hard - for that you should go straight to the hospital). Papaya leaf" (♀<40y FG) ● "You get some sap from a vine, just sap from a vine, cut it [local name: "bamul"]" (♂<40y FG) ● "it doesn't have this kind of strong medicine from the forest. We have tried many times when "sotwin" has occurred and you take these kinds of medicines and just drink them, it will only help you for a short time… a day and tomorrow or the day after "sotwin" will occur again, OK some "sotwin" doesn't go on for very long, it can go away and stop, and some people if "sotwin" has already taken hold of them, they will try all kinds of medicine but it won't be enough, the "sotwin" will continue all the way until you become old… and they die" (♂≥40y FG) ● Bush rope (cut the rope and drink the white sap) (39y PT diagnosed on assessment with LRTI)</td><td colspan="2">Pharmacy drugs
Septrin (51y PT, diagnosed on assessment with LRTI and COPD)
Amox (55y PT, diagnosed on assessment with LRTI, COPD)</td><td>No treatment
● "[Q: do people treat this illness?] "No. They just live with the kus, cough." (KI) ● Said had "Sotwin" but had had no treatment (P of 2y, diagnosed on assessment with URTI, LRTI; 48y PT (diagnosed on assessment with COPD; 50y PT; e06 46y PT).</td><td>Drink cold water
(♂<40y FG)</td></tr>
</table>

Table S5. Ethnoclassification taxonomy of Cancer (3rd in combined group rankings).
Quotes in roman are translated from Tok Pisin (dual transcripts retained), quotes in italics were spoken as written. Attributed texts without quotation marks are from patient histories summarised by PNG research technicians.

<table>
<tr><td>Names</td><td colspan="2">“Susu cancer”
Breast cancer (♂≥40y Focus group [FG])</td><td>“cancer bodi insait”
Cancers inside body (♂≥40y FG)</td><td colspan="2">“Sik bilong ol mama”
Cervical cancer (♀<40y, ♀≥40y FGs)</td></tr>
<tr><td>Who</td><td colspan="4">Allot of us / We don’t know
“Now a lot of us living here have cancer… we don’t know ourselves… when we go to the hospital… in order to get medicine or something… the doctors… they will say “you have cancer”” (♂≥40y FG)</td><td>“Mothers, older women, younger women”
(♀≥40y FG)</td></tr>
<tr><td>When</td><td colspan="5">“It arrived in 2014 in the communities around here” (♀<40y FG)</td></tr>
<tr><td>Cause</td><td>“No sure”
(♀<40y FG)</td><td>Meat and Fish
“Eating meat or that kind of thing… you don’t dry the meat properly… sometimes this can cause some illness or cancer inside, it’s like, there’s water from fish and you take it and you boil it and you eat it” (♂≥40y FG)</td><td>Smoking
“This cancer that tends to be with a cough… sometimes… smoke a lot then cancer will occur” (♂≥40y FG)</td><td colspan="2">Betelnut
“OK chew a lot of betelnut… then cancer will occur” (♂≥40y FG)</td></tr>
<tr><td>Signs and symptoms</td><td colspan="2">“We don’t know ourselves… we find out from the doctor”
"Now a lot of us living here have cancer… we don’t know ourselves, we don’t know if we have cancer like this but… when we go to the hospital in order to get medicine or something, when the doctors check us or when they check our blood… now they will say “you have cancer” … so we find out from the doctor” (♂≥40y FG)</td><td>Cough
“it tends to occur with a cough and illness inside it tends to occur again inside” (♂≥40y FG)</td><td colspan="2">Patient is red
“They will look like blood” (♀≥40y FG)</td></tr>
<tr><td>Treatment</td><td colspan="5">“Only the hospital will treat” (♀<40y FG)
Hospital treatment not always successful, particularly if patients flee treatment
“OK cancer if it occurs, there is no way to stop this, sometimes we go to the doctor and the doctor is able to cure the cancer, it will finish… suppose we tell them about our illness and we go and stay in the hospital, it’s like the cancer can be stopped but if we are afraid of the injection or something and they get the needle out and we run away, sometimes the cancer will not stop and the cancer will still sit on the body and after you become an old man… you can die from this” (♂≥40y FG)
Absent Aid Post for referrals, hospital attendance to delayed
“my mother and his wife. She – she got the cervical cancer, she got that sick maybe for two years… if Wanang have a small haus sik there then easy to get a report and then move to the general hospital in Madang and easy to get treatment. But because of no haus sik there, the mother… herself she think that she is OK but the sickness is inside the body…, so we all never know what is with her, so after, the sick is like to stage – stage 4, then we all surprised then we took it to the hospital, and go to the x-ray and they said “oh, cervical cancer and it’s like in 50-50” so we try two hospitals here in Madang, and it cannot work as they said no medicine, we move her to the highlands, to Kundiawa General Hospital, and we went there and she passed away. So, that’s happened to like my mother and his wife…” (Key Informant)</td></tr>
</table>

Surfaces_WanangHealthNeedsSupplementary_CA16

Table S6. Ethnoclassification taxonomy of *"Grile"* (Tinea imbricata) (4th in combined group rankings). Quotes in roman are translated from Tok Pisin (dual transcripts retained), quotes in italics were spoken as written. Attributed texts without quotation marks are from patient histories summarised by PNG research technicians.

Names	***"Grile"*** (Tok Pisin: ♂≥40y, ♀<40y, ♀≥40y, ♂<40y Focus Groups [FG])		***"Kavnam"*** (Local language: ♂≥40y, ♂<40y FG)	***"Pukpuk"*** "crocodile" (Tok Pisin: ♀<40y, ♂<40y FGs)
Who	**Everyone, particularly infants & children** ● **"**Everyone, all ages" (♂≥40y FG) ●"tends to occur in children, also people like us, and maybe some older men… [and] women as well, little girls too. Most of the time tinea occurs in babies, in younger and older men just occasionally" (♂<40y FG) ● "older people… middle aged people and some children as well. Maybe from small to older people" (Key Informant [KI])	**Children** ● "Most of the children have this disease" (KI) ● "*[Q] You say most of the children here [have Grile], how many children do you have in the school? [A] I have 186."* (KI)	**Young men** "Grile common in young men" (Research Technician [RT])	**Older women, people are hiding it** "There's a lot of tinea. I've got it myself and I forgot about it! Severe tinea. A lot of us sitting down here have it… some people are hiding it so you can't see it" (♀≥40y FG)
When	**Anytime** ● *"It doesn't have seasons."* (KI) ● "Year to year. Mainly in the rain" (♂<40y FG) ● "Anytime" (♂≥40y FG)			
Cause	**Wet clothes** ● "You bathe… and keep wet clothing on you will get tinea very fast" (♂≥40y FG) ● "if you go walking in the rainy season… get wet in the rain, and you don't change your clothes, you keep it on, you sleep with the same things… these wet things will cause this tinea… you're walking along a long road…your shirt will be sweaty… you sit down rest, that will cause this" (♂<40y FG) ● "when you walk in the rain and you don't change your clothes" (KI)	**Contaminated rivers** ● "we bathe in the river, like bad swamp water, water that is not clean, not flowing… or another man is bathing upstream from you, in that way you can catch tinea." (KI) ● "Say I have tinea and bathe upstream and a man without tinea is bathing downstream, then these little "crocodile skin particles" … the water carries them and he can get them, you have different kinds of water, some won't have tinea, some will." (♂≥40y FG) ● "if a man with tinea washes something upstream from you and you wash something you will get it" (♂<40y FG) ● *"they use river for washing… it's caused by that and then the clothes they wear… During the sunny period… the fast-flowing rivers become small… algae grows… children like to jump into those rivers…those algae… give them bacteria, so they have Grile."* (KI)		**Touch and sharing clothes [and differing body-type susceptibility]** ● **"**friend of yours uses [wet] clothes, sleeps with everything on, sleeping in bed and if I sleep alongside him, I touch him while sleeping, still I will get tinea in this case, both of our bodies touch so it can move across, but if my body is not the right kind to get tinea from him, it will not want to… and if my body is the same type as his, I will catch Grile…" (♂≥40y FG) ● "If a man has this tinea and you use something of his, it will… spread to you. The same clothes, if they have tinea in them, you wear your clothes, you will get it." (♂<40y FG) ● transmitted from person with Grile… transmitted from other boys (patient histories)
Signs and symptoms	**● Skin like crocodile ● scratching ● pain** ● "Skin like crocodile. You might get it on your arm or leg… A man with tinea will scratch, a woman also, the skin will be painful" (♂≥40y FG) ● "They will be scratching… it's like all over the body, that's what this tinea is" (♂<40y FG) ● Some people are hiding it so you can't see it" (♀≥40y FG) ● *"Itchy all the time and they tend to scratch it all the time. [Q]: So they're itching, this could be other conditions so how do we know it's Grile? [A]: Itchy and… it just go on their skin… by looking at them you can see that they have Grile."* (KI)			
Treatment	**"we are not able to cure… we make forest medicine, we buy medicines [but]… it just comes back."** (♂<40y FG)			
	Traditional treatments		**Hospital/Pharmacy**	
	Plant-based ointments from the forest	**Placing skin inside banana tree**	**Grile cream** [Tolnaftate]	**Grile tablet** [Terbinafine]
	Lime, pepper, and tree bud paste / **Seeds of "sigwal" tree** / **"Moder" [Papaya blood]** ● "take kambang [lime powder used when chewing betelnut], daka [pepper chewed when chewing betelnut], and the bud from this tree flower… try to mix them with kambang." (KI) ● "There's a tree with… green leaves and yellow flowers, it's found in sandy areas around large bodies of water [local name: "sigwal"]… say you're walking along the road you see it, it bears… yellow fruit,… unripe ones will be green… you just take a strainer, it will get the seeds… and you can just close them within a leaf and… heat them in the fire and when they've been heated a bit, take them out and you rub them… One thing is papaya – grate it, the papaya fruit, when you've grated it a lot, this… black blood that they have, you will take this and you scratch your tinea and you rub it in… find the place where it is… the pain." (♂<40y FG)	**"**Medicine I use… removes tinea from people, take a knife and make a hole in a banana plant – any banana plant – when it's opened, put the skin infected with tinea inside… now it ends their tinea is cured… there is no spoken words or anything… Nowadays all of us don't use this method" (♂<40y FG)	● **"**In the town one gets medicine like ointment… liquid medicine, to just rub in, and this OK… Something like that… this medicine people tend to use Panadol type – tablet" (♂<40y FG) ● Grile cream; Grile tablet; most cases of past Grile cream treatment used; diagnosis was by self (patient histories)	● "Occasionally. If a man has "double" tinea all over the body, all the medicine won't be able to stop it… you just need to go to the hospital and you go to the chemist and buy medicine specifically for tinea and you drink it and this, will recover" (♂≥40y FG) ● *"I encourage them "if your parents going to town, tell them to buy, go to chemist and buy their tablets and soap there"* (KI) ● Grile tablet from pharmacy (patient histories)
	Effectively, No treatment *"There is no treatment. Looking at them I always encourage them …"when you go into town go to chemist and buy some medicine". But looking at their number most have Grile. Especially my school children."* (KI)			

Reporting checklist based on 'Appraising studies in health using rapid assessment procedures' [13]

This checklist is provided in line with the following statement in our protocol: 'The article will reference this protocol noting changes in method, and include a filled-in reporting checklist based on criteria for appraising studies in health using RAP' [4]. All changes are noted in the manuscript under the subheader 'Changes from our published protocol' in the methods section. Criteria in '_' are quoted from [13].

Criteria	Page, line number
'1. Aim (Is the aim of the study clearly described?)'	5, 124–127.
'2. Subjectivity (Are the researchers' background, prior knowledge and relationship to the community, and cultural competence clearly presented and addressed?)'	Paper: 6, 157–162, 176–177; 21, 598–609. Sup. File: 3.
'3. Field research guidelines (Is there an adequate description of the field guide and the rationale and process of its development?)'	Fully detailed in published protocol, which also includes all recruitment materials, KI and FG topic guides, clinical data collection forms, pharmacy, etc.[4]. Paper: 5–6, 133–142, 154–156.
'4. Staff (Is the recruitment process and training of research assistants presented, and is it sound?) RAP studies usually use research assistants in the collection of primary data from the field. Many researchers establish specific criteria for selecting assistants and these should be communicated. Further, the training process and content should be presented.'	Detailed in published protocol. Fieldwork RAs were existing RTs and PNG nationals at in-country New Bintang Research Centre. Sup. File: 3.
'5. Data collection methods (Is the rationale for the data collection methods and types of information collected with each method clearly presented?)'	Detailed in published protocol. Paper: 6, 143–156.
'6. Selection of research sites (Is an appropriate sampling strategy for selecting the study area(s) or research site(s) described?)'	n/a – site (Wanang village) was studied as it was the community that had requested health service incorporation in their existing conservation area. See 4–5, 79–123; detailed in protocol paper.
'7. Informant selection (Is a systematic process of selecting informants used and is it adequately described?)'	Fully detailed in published protocol. Paper: 6, 145–148; 7, 190–194.
'8. Credibility (Is a strategy for assessing credibility established and presented?)'	Fully detailed in published protocol. Paper: 5, 136–137; 6, 164–165; 6–7, 175-181.
'9. Analysis (Is the analysis process adequately described and was it sound?)'	Fully detailed in published protocol. Paper: Fig 2; 6–7, 157–181; 7, 194–197. Sup. File: 3.
'10. Presentation (Are the findings and discussion clearly presented?)'	Paper: 7–19, 203–593. Table 1, Figs. 3 and 4. Sup. File: 3–9, Tables S1–S6.
'11. Ethics (Are ethical principles respected and is the process for informed consent described?)'	Detailed in published protocol (including recruitment scripts, consent forms etc.). Paper: 21, 613–621.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page & line
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 1–4; 2, 35–36
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 37–53
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4–5, 69–130. Additionally, extensive wider background and discussion of methodological rationale given in published protocol paper, relevant section sign posted in start of this paper (4; 76–78: 'Here we outline site-specific context, biodiversity and health issues in PNG and our methodological rationale are discussed in detail in our published protocol.[4]')
Objectives	3	State specific objectives, including any prespecified hypotheses	2, 33–34; 5, 124–130.
Methods			
Study design	4	Present key elements of study design early in the paper	4, 72–76; 5–6, 132–142; Figure 2 methodological flowchart.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Description of setting and location: 4–5, 79–123. Periods of recruitment and data collection, 5, 134; 6, 143–145. Exposure and follow-up n/a.
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Described extensively in published protocol paper. In manuscript: 6, 145–148; 7, 190–194. Follow up n/a.
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a, not a matched study.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6, 152–156, 163–173. Detailed in published protocol paper, and its supplementary file.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6, 143–156; Detailed in published protocol paper, and its supplementary file. Study consisted of one community, with assessment methods uniform across group.
Bias	9	Describe any efforts to address	7, 180–181.

		potential sources of bias	
Study size	10	Explain how the study size was arrived at	Paper: 6, 145–148; 7, 190–191. Protocol paper, Table 1'Study cohort and justification of participant numbers and composition'.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Paper: 6, 162–164; 7, 194–197; table 2. Paper's Supplementary File: 3, 'Generating combined all-group rankings'
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Only basic descriptive statistics reported: 6–7, 162–164; Paper's Supplementary File: 3, 'Generating combined all-group rankings'. (Note: See other attached reporting checklist re RAP studies, which covers wider methods used).
		(*b*) Describe any methods used to examine subgroups and interactions	6, 167–169
		(*c*) Explain how missing data were addressed	8, 214–215
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, 204–211; Figure 2.
		(b) Give reasons for non-participation at each stage	6, 146–147; 7, 191–194.
		(c) Consider use of a flow diagram	Figure 2
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	4, 79–93; 7, 205–211; Figure 2 Paper's supplementary file, Table S1
		(b) Indicate number of participants with missing data for each variable of interest	8, 214–215; paper's supplementary File, Table S2.
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	n/a
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were	Our main results are not of this type as our study is a combined clinical and rapid anthropological assessment. Main results are reported: 8–14, 216–444; Table 1; Figure 3; Supplementary file, Table S2–S6.

		adjusted for and why they were included	See other attached reporting checklist re RAP studies for more details.
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	See answer to 16a above.
Discussion			
Key results	18	Summarise key results with reference to study objectives	15, 446–467.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	3, 57–68; 15, 468–490; discussed in detail in our published protocol paper, with signposting in this manuscript 16, 478–480
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16–18, 491–577
Generalisability	21	Discuss the generalisability (external validity) of the study results	16, 491–508
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22, 639–644

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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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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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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Keywords: Primary care; Tropical medicine – anthropology, epidemiology; Qualitative research; Health services administration and management; Neglected diseases.

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 19y, range 1mo–73y), 113 had clinical assessments (51f, 62m; median 18y, range 1mo–73y). 26 ≥18y participated in sex-age stratified FGs (f<40y; m<40y; f≥40y; m≥40y). 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 concorded 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; medicine costs. Service introduction priorities were: aid post; vaccinations; transport; perinatal/birth care; family planning.

Conclusions: This study enabled service planning and demonstrated 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.

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.

INTRODUCTION

Papua New Guinea's (PNG) health-related UN Sustainable Development Goal indicators are worse than all but two nations outside Africa,[1] and its rainforests are threatened by commercial logging driven primarily by global commodity demands.[2, 3] 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.[4]

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'.[5, 6] In contrast, for Wanang villagers (such as co-authors JP and RU), the 80km 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.[7] 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,[7] staffed by health-extension officers and nurses, and operated by government, churches, NGOs, or commercial interests such as mines.[8] 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.[3] 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.[3] The meeting in 2016 identified healthcare as 'the main missing service' [9] to be developed in the collaboration's next phase.

In more industrialised countries, clinical interactions are commonly recorded electronically in routinely collected patient data.[10] 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 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.[11] During the design of this health needs assessment [12] 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 17–25 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;[4] here we give an outline and describe changes. A reporting checklist following 'Appraising studies in health using rapid assessment procedures'[13] is in supplementary file (p.2). JM designed the protocol in

discussion with its co-authors,[4] after consideration of participatory planning case studies archived at the Participation Resource Centre.[14]

Data was collected by a team from Brighton and Sussex Medical School in the UK (co-authors JM and GC) and Binatang Research Centre in PNG (co-authors MJ, JP, and SS) (backgrounds and capacity building, supplementary file, p.3). All residents of Wanang were eligible and invited for clinical assessments, those ≥18y for FGs. Recruitment for both was self-selecting, by attending the temporary research shelter after a village meeting. KIs ≥18y 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]<40y, males [m]<40y, f≥40y, m≥40y) in Tok Pisin (PNGs 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.[15] Part of the Aisian language group of the Trans-New Guinea family, Magi is largely mutually intelligible with neighbouring Aisi,[15] 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[16]). Our assumption when designing the study was that most potential participants would understand either spoken Tok Pisin or English, and we planned that RTs would arrange translation by key informants for those who only spoke a tok ples (presumed to be a small minority).[4] 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 supplementary file[17] includes: focus group and key informant 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 co-investigators 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 co-authors who are PNG nationals (FD, MJ, ML, JP, JP, WP, SS, 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 1.6.1 (QSR International, Melbourne) and analysed to produce three outputs. Firstly, sex-age FG rankings of health issues affecting the community and

service priorities (collected using nominal group technique[18]) were tabulated, compared, and contextualized with explanations from the wider data. Secondly, disease ethnoclassification taxonomies were created by coding data to pre-chosen higher order themes (e.g., perceived causes, symptoms, appropriate treatments) as per Scrimshaw & Hurtado.[19] Thirdly, 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[20] 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; co-author 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 (box 1) in consultation with other Co-Is with health service backgrounds (GC, JAC, ML, 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'[4] 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).[21] In addition to sex-age FG rankings of health issues and service priorities, we generated all-group rankings by adding inversely weighting ranks (supplementary file, 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 co-authors to national level public health responses delayed writing up for journal publication. In addition, inter- and intra- national

travel restrictions delayed further community health assessments with conservation communities elsewhere in PNG (specifically on Mount Wilhelm [4]).

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 design, including co-author JP from Wanang. Community members advised on research conduct and burden, aided recruitment, and co-authored 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 19y, range 1mo–73y) and 113 examined (51f, 62m; median 18y, range 1mo–73y) (table S1, supplementary file, p.3). Data from all were used in analysis. In our protocol[4] we reported a survey recording 189 individuals (89f, 100m). KIs did not consider there had been major population changes in the intervening two years. Based on this, medical history and examination data would represent 68.3% and 59.8% coverage respectively. Twenty-six ≥18y 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, table S2, supplementary file, p.4) there were no participants with missing data.

Disease burdens

Key informants and focus groups

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 (e.g., "*TB*"), (2) trackable to specific biomedical conditions (e.g., "*pukpuk*" meaning 'crocodile', a reference to body-wide skin scaling pathognomonic of tinea imbricata), and (3) naming signs/symptoms with unspecified aetiology (e.g., "*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"* (i.e., 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≥40y 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<40y and m≥40y 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≥40y or <40y as a community health problem, but m≥40y and <40y 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 (co-author 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 smoking tobacco wrapped in newspaper seemed very common amongst adults.

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

Ranked lists were produced using the nominal group technique [18], combined group ranks by reverse weighting (scores in brackets, method, supplementary file, p.3). Italic text is untranslated direct speech, Tok Pisin names/descriptions are given at first use left to right (transcripts retained). Ethnoclassifications of the top four ranked health issues (*"Malaria"*, *"Sotwin"*, Cancer, *"Grille"*) are summarised in the main text, and detailed with quotes in tables S3–6 (supplementary file, p.6–9).

(a) Health issues affecting the Wanang community, identified and ranked by sex-age based focus groups

	Females <40y	Males <40y	Females ≥40y	Males ≥40y	Combined rankings
	Top five health issues, as ranked by sex-age focus group				
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"*	
	Health issues identified by all sex-age focus group, but not included in their individual top fives				
	(in top five)	(in top five)	*"Sotwin"*	(in top five)	
	Cough/cold	(in top five)	Cough/cold		
	(in top five)	Headache			
	Health issues identified by only three sex-age focus groups				
	Skin pain/damaged skin *"Skin pen"*				
	Back pain *"Baksait pen"*			Back pain	
	Diarrhoea *"Pekpek wara"*			Diarrhoea	
	(in top five)		Cancer ‡	(in top five)	
	Knee pain *"Kneepen"*		(in top five)	Knee pain	
	Stomach-ache *"Bel pen"*		Stomach-ache		
	Toothache *"Tit pen"*		Toothache #		
	Earache *"Ia pen"*		Earache		
	Loss of vision *"ai bilong mipela olsem i no save lukluk gut"* (*f*≥40y)				
	Sores *"Sua"*				
	Health issue identified by only two sex-age focus groups				
		Scabies *"Kaskas"*		Scabies	
	Health issues identified by only one sex-age focus group				
	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) Priorities for service introduction, identified and ranked by sex-age based focus groups

	Females <40y	Males <40y	Females ≥40y	Males ≥40y	Combined rankings
1	*"Transport"*	"Aid Post"			"Aid Post" (15)
2	Vaccinations *"Bebi sut"* *	Road *"Rot"*	Vaccinations	*"Family planning"*	Vaccinations (11)
3	*"Family Planning"*	*"Transport"*	Perinatal & birth care	Vaccinations	*"Transport"* (10)
4	Perinatal & birth care †	*"Awareness"*	Transport ‡	*"Awareness"* §	Perinatal/birth (7)
5	Fracture treatment ‖			Perinatal & birth care	*"Family planning"*(7)

(a) * "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<40y, cervical cancer, "*sik bilong Mama*"; f≥40y, breast cancer, *"Susu cancer"*; m≥40y, "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. Δ *"Animol sa kaikai"*. ◊ *"Kol sik"*. ** "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"*.(b) * For infants and children. † f<40y, **"**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≥40y, "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 tuberculosis, 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*".

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%) had 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<18y reported having children or problems during pregnancy/birth. Of 30 f≥18y, 27 had given birth to live children: 128 in total (mean 4.7 per female with a 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 supplementary file (table S2, p.4). 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 *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%) (supplementary 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";* [c]*"grile"*. Ethnoclassification taxonomies, supplementary tables S3–6, supplementary file, p.6–9), translated to the five biomedical conditions we diagnosed most ([a] malaria; [b] URI, LRTI, TB; [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 ethnoclassifications

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 ≥40y described preventing diseases through bathing, not eating rotten food, avoiding rain, and not "working too hard". Males <40y also mentioned care when walking in the forest and working with axes and knives. Females <40y 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 re-treating nets. Villagers said they learned 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 whilst 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<40y 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<40y).

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≥40y 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 traveling 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≥40y).

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

Ethnoclassification taxonomies for each of the top four health issues identified by FGs are in supplementary tables S3–6 (supplementary file, p.6–9), including example quotes from KIs, FGs, and patient histories on how the diseases are understood, who treats them, and how. Though the belief "*sanguma* poison" (sorcery) causes some illness was voiced in the m≥40y 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" (table S3, supplementary file, p.6): 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 (i.e., 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≥40y FG described treatments using steam from boiled plants and fruits. According to the m<40y 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.[22] A FG and KI described how hospital treatment was sometimes sought for severe cases, using Binatang Research Centre transport when available.

"Sotwin" (table S4, supplementary file, p.7)*:* This Tok Pisin word has a dual meaning as both sign/symptom (shortness of breath), and specific biomedical condition (asthma).[23] Given this, people were likely sometimes describing experiences of conditions beyond asthma (only one case diagnosed on examination). A KI emphasized 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≥40y (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 >5y 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 (table S5, supplementary file, p.8): 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≥40y 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 <40y were "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; table S6, supplementary file, p.9): 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 f≥40y 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 [24–26]). 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<40y 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 1 b shows FG identified priorities for service introduction. The highest scoring was aid post sited in Wanang, top for all but f<40y who thought it an unrealistic expectation from 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<40y. Transport was ranked first by f<40y, a priority by two other FGs. Pregnancy and birth care within the community was vocalised by female FGs and m≥40y, but not m<40y. Jointly scoring with pregnancy and birth care was family planning, identified by f<40y and m≥40y (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).

Whilst 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≥40y and f<40y 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 concorded 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 we diagnosed most ([a] malaria, [b] URI, LRTI, TB, [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 multi-day queue is likely to have biased the sample towards those with greater morbidity. In our protocol paper[4] 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'[27] (e.g., HIV, guinea worm[13]). 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 to 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 someway to making the relationship between the community and researchers a fair transaction, rather than one of dispossession and accumulation as West[28] 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 (i.e., 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 kisim em, tassel nau i **orait** gen' ('he had malaria, but now he's **well** again' [23]). 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'[29]), 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,[30] 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 socio-culturally understand concepts translatable to well-being or health, and how they relate to biomedical ideas (for example, see [31–33]). 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 co-authored 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.'[33] 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.[34] In 2021 PNG accounted for nearly 87% of malaria cases and 94% of associated deaths across the entire WHO Western Pacific Region.[35] This is an area of 37 countries and territories in which live 1.9 billion people.[36] Similarly, GBD 2019 ranks respiratory infection as the leading cause of all-age PNG DALYs.[37] 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 re 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),[38] whilst 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.[39] Treatment data from a large subset of health centres is in the process of being pooled nationally,[40] 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 is also unavailable for comparison.

Community perspectives and ethnoclassifications outlined in our study resonate with some voiced elsewhere in PNG (particularly Whittaker et al.[41]), however we caution against extrapolating beyond Wanang. PNG is hugely diverse culturally (it has more languages than any other nation on earth[42]) and biogeographically (lowland forests, peri-urban slums, swamplands, high mountains, island archipelagos), and its communities have markedly different levels of engagement with state, industry, and the money economy. The myriad eco-cultural 'entanglements' (in the sense used by

Nading[43] and Tsing[44]) 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 [38] asked women about difficulties accessing healthcare. Across Madang province 77% of rural women respondents 15–49y reported 'serious problems in accessing health care 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 [11] on relations within and around a hospital in Madang town.) In conclusion, whilst 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 policymakers

Wanang health service plan

Health needs assessments commonly make recommendations for clinicians or policymakers to act on identified needs. However, here 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.[45] 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 end of 2020, registered with the provincial health authority, and continues to be staffed by a full-time nurse (figure 4). Given PNG's health care 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 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[7]. 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, WP) have co-authored with colleagues a report assessing COVID-19 impacts on PNG's primary health services and public health infectious disease programs.[46] One key identified theme at a national level is especially relevant to the local findings and recommendations of our study. Newland et al. [46] 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 to 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).[46] Continuity of care amidst the pandemic was mainly possible because the nurses lived amongst 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 programs closed due to workforce re-tasking and restrictions on travel.[46] 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^2 to 150 km^2. 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[47]. The impacts of this work indicate simultaneously addressing health (SDG 3) and biodiversity (SDG 15) can be a successful 'synergy driver'[47] 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 pulmonary TB/tuberculosis.[48] Similarly, *"malaria"* may seem simple to translate; the Tok Pisin dictionary definition of *"malaria"* equals malaria in English.[23] However, in practice it is often used generally to mean fever.[41] This is clinically important as non-malarial febrile illnesses are widespread in PNG,[49] underlining the potential value of RDTs in determining when *"malaria"* is malarial, to avoid inappropriate treatment (which is common [50]). Translational issues between ethnoclassifications and biomedicine are particularly prevalent in PNG,[41, 51, 52] 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[45]). 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 [40]) 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.[53] The region has been key to developing integrated skin interventions to control scabies and reduce soft tissue infections.[54] Tinea imbricata, which is only found in a small number of populations worldwide but is highly distributed across Melanesia,[26, 55, 56] has been neglected as regards research and treatment [24]. An integrated skin intervention[57] 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.

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: (i) malaria treatment (including RDTs, appropriate medications, evacuation triggers), (ii) fracture management, (iii) off-road medical evacuation, (iv) 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, (i) Malaria: mosquito net audit, supply, and re-treatment; elsewhere ivermectin MDAs have reduced vector populations and thus human cases,[58] local trials may be beneficial, particularly combined with MDAs on neglected tropical skin diseases already including ivermectin (see iv). (ii) Respiratory issues: preventive child vaccinations; TB screening and referrals; RDTs should guide appropriate treatment given PNG wide shifts from bacterial to viral lung infections and pneumonia. (iii) Cancer: in addition to aid post referrals, preventive (both-sex) HPV 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.[59–61] (iv) 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.[62] (v) Family planning: facilitate Marie Stopes mobile clinic visit. (vi) 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.[63, 64] (vii) Health education: nurse-provided STD training sessions; exercises for youth to reduce sports related lower back pain. (viii) Mobile patrols: nurse-led patrols to reach villages across the aid post catchment area.

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STATEMENTS

Supplementary file: This file has been produced by the BMJ Publishing Group from an electronic file supplied by the authors and has not been edited for content.

Contributors: Author order is alphabetical by surname, except first and last. Co-Investigator backgrounds are detailed in the methods section, and in line with recommendations from Utarini et al.,[13] we also detail relevant prior experience of the fieldwork team (supplementary file, p.3). Contributions to this publication are outlined using the CRediT Contributor Taxonomy (https://credit.niso.org), and research assistants (RAs), technicians (RTs), and collaborators (C) flagged at first appearance. Conceptualization: JM, GC, JF, MGH, JI, HM, VN, MP, AJS, SLW, JAC. Data curation: JM, GC, AE(RA), RH(RA). Formal analysis: JM. Funding acquisition: JM, GC, JF, MGH, JI, ML, HM, VN, MP, WP, AJS, SLW, JAC. Investigation: JM, GC, MJ, JP(RT), SS(RT). Methodology: JM, GC, FD, JF, MGH, JI, MJ, CIJ, ML, HM, VN, MP, JP, WP, SS, AJS, SLW, JAC. Project administration: JM. Supervision: JAC, AJS. Visualisation: JM, JP(RT), JAS(C), VN. Writing—original draft: JM. Writing—review and editing: JM, GC, FD, AE, JF, RH, MGH, JI, MJ, CIJ, ML, HM, VN, MP, JP, JP, WP, JAS, SS, AJS, RU(RT), SLW, JAC. All authors reviewed the study findings and read and approved the final version before submission. JM is responsible for the overall content as guarantor, and attests all listed authors meet authorship criteria and no others meeting the criteria have been omitted.

Ethics statement: 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 though 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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Data availability statement: All data relevant to the study are included in the article or uploaded as supplementary 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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FIGURES

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, D, E, and F, first author JM; B, co-author JP; G, Daniel Heuclin (SuperStock).

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. Role abbreviations: PC HCP, primary care health care professional (in this assessment a General Practitioner); RTs, research technicians; RF, research fellow.

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)

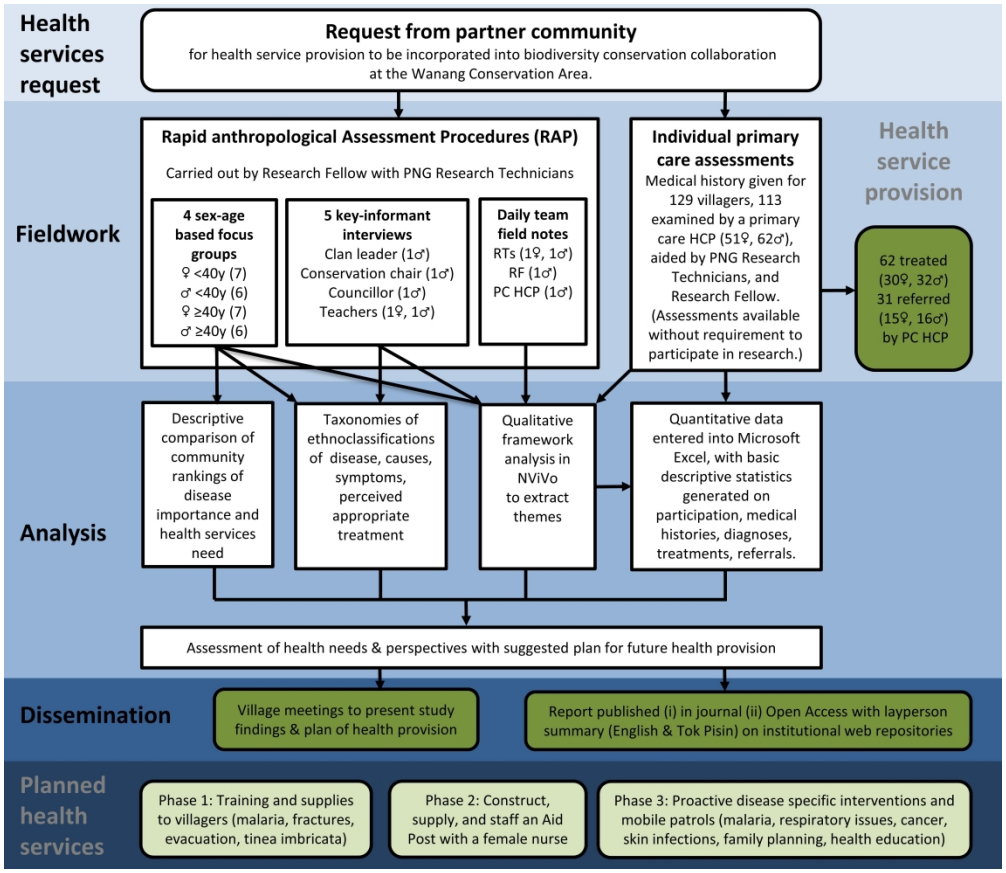
with number of diagnoses given for each. Infections/parasitic conditions primarily affecting skin are outlined in red. * Developmental. † Ear/mastoid process. ‡ Factors influencing health status/contact with services. § Mental, behavioural or neurodevelopmental disorders. ‖ Sleep-wake disorders. ¶ External causes of morbidity/mortality.

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 (*Casuarius 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, E, F and H, Wanang) apart from *Sarcoptes S*cabiei microscopy (H). Credit: A, D, E, F, and H, first author JM; B and G, co-author JAS; C, co-author VN. Photographic consents were provided by individuals pictured.

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, D, E, and F, first author JM; B, co-author JP; G, Daniel Heuclin (SuperStock), rights retained.

139x153mm (300 x 300 DPI)



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219x190mm (600 x 600 DPI)

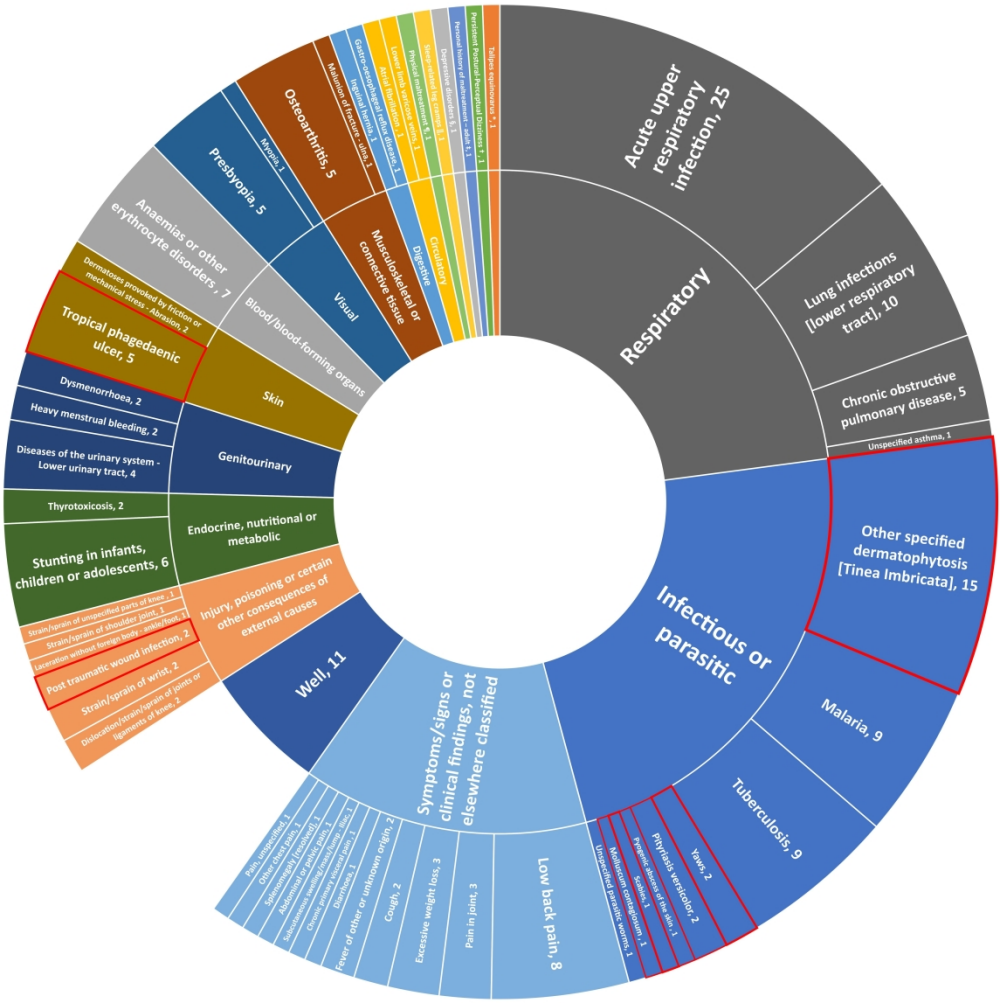

Figure 3 Clinical results of primary care assessments at Wanang. 113 Wanang villagers examined (51 females, 62 males), 168 diagnoses given (not including 11 classifications of 'well'). The proportion of each concentric circle relates to the proportion a diagnosis was given as part of the total number 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.

386x386mm (415 x 415 DPI)

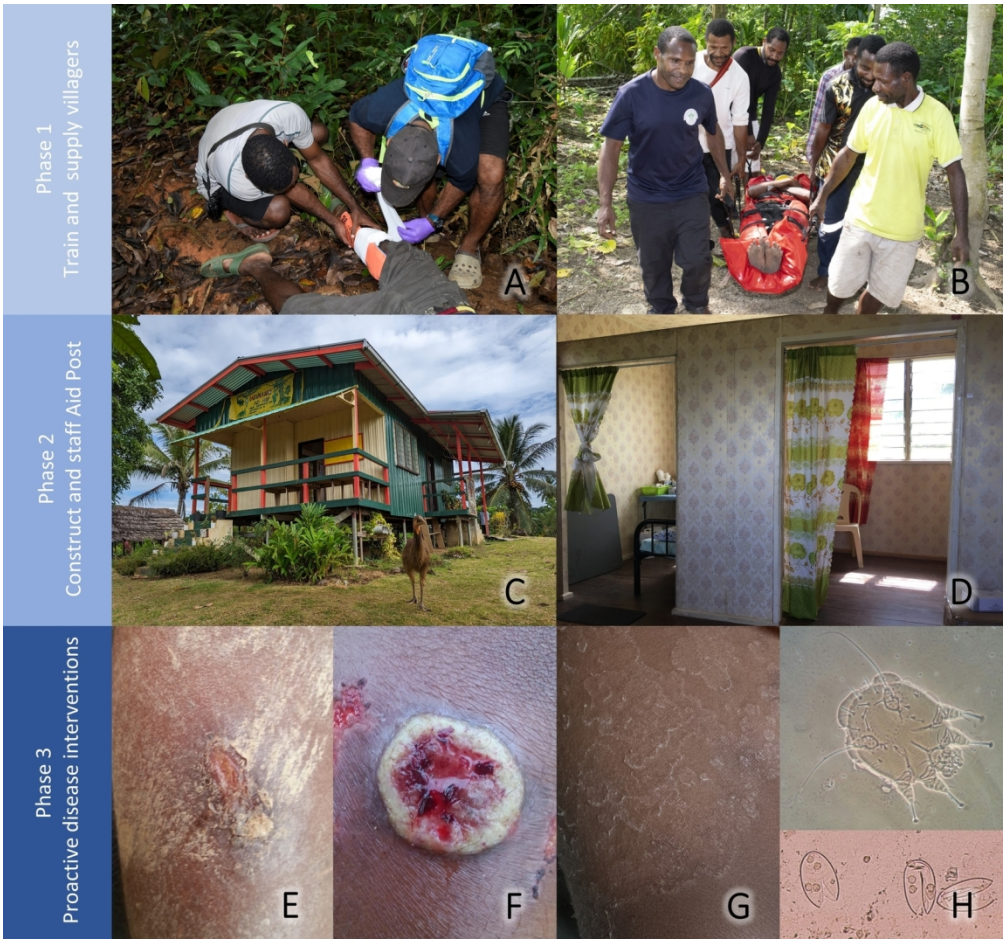

Figure 4. Phased health service introduction at Wanang. Examples of training provided: fracture management (A), off-road vacuum-stretcher evacuation (B). Wanang Aid Post, outside with a northern cassowary (*Casuarius unappendiculatus*) chick (C) and backrooms for nurse consultations (D). Examples of 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, E, F and H, Wanang) apart from *Sarcoptes scabiei* microscopy (H). Credit: A, D, E, F, and H, first author JM; B and G, co-author JAS; C, co-author VN.

139x130mm (300 x 300 DPI)

SUPPLEMENTARY FILE

Middleton, Colthart, Dem, *et al*. 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. Submitted to *BMJ Open* 2023.

CONTENTS

REPORTING

Reporting checklist based on 'Appraising studies in health using rapid assessment procedures' [13]
This checklist is provided in line with the following statement in our protocol: 'The article will reference this protocol noting changes in method, and include a filled-in reporting checklist based on criteria for appraising studies in health using RAP' [4]. All changes are noted in the manuscript under the subheader 'Changes from our published protocol' in the methods section. Criteria in '_' are quoted from [13].

Criteria	Page, line number
'1. Aim (Is the aim of the study clearly described?)'	5, 124–127.
'2. Subjectivity (Are the researchers' background, prior knowledge and relationship to the community, and cultural competence clearly presented and addressed?)'	Paper: 6, 166–171; 7, 185–186; 25, 686–699. Sup. File: 3.
'3. Field research guidelines (Is there an adequate description of the field guide and the rationale and process of its development?)'	Fully detailed in published protocol, which also includes all recruitment materials, KI and FG topic guides, clinical data collection forms, pharmacy, etc.[4]. Paper: 5–6, 133–142, 161–165.
'4. Staff (Is the recruitment process and training of research assistants presented, and is it sound?) RAP studies usually use research assistants in the collection of primary data from the field. Many researchers establish specific criteria for selecting assistants and these should be communicated. Further, the training process and content should be presented.'	Detailed in published protocol. Fieldwork RAs were existing RTs and PNG nationals at in-country New Bintang Research Centre. Sup. File: 3.
'5. Data collection methods (Is the rationale for the data collection methods and types of information collected with each method clearly presented?)'	Detailed in published protocol. Paper: 6, 143–165.
'6. Selection of research sites (Is an appropriate sampling strategy for selecting the study area(s) or research site(s) described?)'	n/a – site (Wanang village) was studied as it was the community that had requested health service incorporation in their existing conservation area. See 4–5, 80–123; detailed in protocol paper.
'7. Informant selection (Is a systematic process of selecting informants used and is it adequately described?)'	Fully detailed in published protocol. Paper: 6, 145–148; 7, 199–203.
'8. Credibility (Is a strategy for assessing credibility established and presented?)'	Fully detailed in published protocol. Paper: 5, 136–137; 6, 173–174; 7, 184–190.
'9. Analysis (Is the analysis process adequately described and was it sound?)'	Fully detailed in published protocol. Paper: Fig 2; 6–7, 166–190; 7, 203–206. Sup. File: 3.
'10. Presentation (Are the findings and discussion clearly presented?)'	Paper: 8–21, 219–681. Table 1, Figs. 3 and 4. Sup. File: 3–9, Tables S1–S6.
'11. Ethics (Are ethical principles respected and is the process for informed consent described?)'	Detailed in published protocol (including recruitment scripts, consent forms etc.). Paper: 25, 701–710.

METHODS

Fieldwork team backgrounds

BSMS: JM is a research fellow in public health with a background in pre-hospital emergency care, including in remote areas, and training in disease ecology and qualitative methods. GC is a general practitioner and experienced expedition medic with training in tropical dermatology. Both had prior field experience in Melanesia (PNG; Solomon Islands). BRC: MJ and SS were research technicians (RTs) with degrees in forestry science who were brought up in rural PNG villages, had previously worked with the community, and had pre-existing skills in social studies. JP is a RT from Wanang, where he continues to live with his family.

Capacity building for PNG staff

RTs were trained in study procedures by JM, provided the protocol [4] and [19] for reference in the field, and gained practical experience working alongside JM and GC who were present during all fieldwork. BRC staff were also given a lecture on conservation and health integration projects worldwide, and a certificated 3-day course on remote care and medical evacuation (taught by JM). FD, ML, JP, SS, and RU were additionally brought to the UK from PNG in 2019 and 2022. There they received training from Brighton and Sussex Medical School and University of Sussex (e.g., project monitoring and evaluation, eDNA, ecological and health analysis) and were taken on institutional visits nationwide (e.g., Millennium Seed Bank, University of Southampton, University of Oxford, London School of Hygiene & Tropical Medicine, Kew) to build their network of collaborators and co-plan future PNG-led work.

Generating combined all-group rankings

We generated combined all-group rankings of health issues and priorities for health service introduction by adding together inversely weighting ranks from sex-age focus groups. For example, two groups ranked malaria highest, another second highest, and the remaining as fifth highest: (1st=5) + (1st=5) + (2nd=4) + (5th=1) = 15. This was the largest combined score, so malaria was reported as the overall highest ranked health issue.

RESULTS

Supplementary Table S1. Primary care assessment participants.

		Medical History (n=129) (%)	Examined (n=113) (%)
Sex	Female	54 (41.9)	51 (45.1)
	Male	75 (58.1)	62 (54.9)
Age in years	0–9	50 (38.8)	45 (39.2)
	10–19	21 (16.3)	15 (13.3)
	20–29	9 (7.0)	7 (6.2)
	30–39	18 (14.0)	16 (14.2)
	40–49	10 (7.8)	9 (8.0)
	50–59	17 (13.2)	17 (15.0)
	60–69	2 (1.6)	2 (1.8)
	70–79	2 (1.6)	2 (1.8)
	Median (range)	19y (1mo–73y)	18y (1mo–73y)

Supplementary Table S2. Diagnoses from clinical examinations in Wanang village

Specific clinical diagnoses are listed in descending order and categorised as per the International Classification of Diseases 11th Revision Version 02/2022 (ICD-11, https://icd.who.int/browse11/l-m/en), followed by the relevant ICD-11 primary code when appropriate. For example, 'Yaws' is listed as a specific condition, and as a sub-category of 'Certain infectious or parasitic diseases'. Diagnoses were recoded to ICD-11 by author JM and confirmed by author GC. Percentages are of examined males/females/all, totals are greater than n as many of those examined had multi-morbidity. In this table, preserving order of individual conditions based on their frequency only allows partial grouping by ICD-11 primary categories. However, figure 3 in the main article shows full grouping by primary categories (but not break down by sex). Five young children (all male) of the 113 individuals examined were only partially examined, due to non-compliance.

Conditions, as per International Classification of Diseases 11th Revision Version 02/2022 (ICD-11) (ICD-11 code) [authors additional information]	**ICD-11 Primary category (ICD-11 code)** [authors additional information]	**Males N=62 (%)**	**Females N=51 (%)**	**All N=113 (%)**
Acute upper respiratory infection, site unspecified (CA07.0)	Diseases of the respiratory system (ICD 12)	9 (14.5)	16 (31.4)	25 (22.1)
Other specified dermatophytosis (1F28.Y) [Tinea Imbricata]	Certain infectious or parasitic diseases (ICD 01)	11 (17.8)	4 (7.8)	15 (13.3)
Well *		**5* (8.1)**	**6* (11.8)**	**11* (9.7)**
Lung infections (CA4Z) [lower respiratory tract] †	Diseases of the respiratory system (ICD 12)	4 (6.5)	6 (11.8)	10 (8.8)
Malaria	Certain infectious or parasitic diseases (ICD 01)	4 (6.5)	5 (9.8)	9 (8.0)
Tuberculosis, unspecified (1B1Z) ‡		4 (6.5)	5 (9.8)	9 (8.0)
Low back pain (ME84.2)	Symptoms, signs or clinical findings, not elsewhere classified (ICD 21)	6 (9.7)	2 (3.9)	8 (7.1)
Anaemias or other erythrocyte disorders, unspecified (3A9Z) §	Diseases of the blood or blood-forming organs (ICD 03)	2 (3.2)	5 (9.8)	7 (6.2)
Stunting in infants, children or adolescents (5B53) ‖	Endocrine, nutritional or metabolic diseases (ICD 05)	3 (4.8)	3 (5.9)	6 (5.3)
Tropical phagedaenic ulcer (EA40)	Diseases of the skin (ICD 14)	4 (6.5)	1 (2.0)	5 (4.4)
Osteoarthritis, unspecified (FA0Z)	Diseases of the musculoskeletal system or connective tissue (ICD 15)	2 (3.2)	3 (5.9)	5 (4.4)
Chronic obstructive pulmonary disease, unspecified (CA22.Z) ¶	Diseases of the respiratory system (ICD 12)	4 (6.5)	1 (2.0)	5 (4.4)
Presbyopia (9D00.3)	Diseases of the visual system (ICD 9)	5 (8.1)		5 (4.4)
Diseases of the urinary system, unspecified (GC2Z) - Lower urinary tract (XA34X0)	Diseases of the genitourinary system (ICD 16)	3 (4.8)	1 (2.0)	4 (3.5)
Pain in joint (ME82)	Symptoms, signs or clinical findings, not elsewhere classified (ICD 21)	2 (3.2)	1 (2.0)	3 (2.7)
Excessive weight loss (MG43.5)		1 (1.6)	2 (3.9)	3 (2.7)
Cough (MD12)			2 (3.9)	2 (1.8)
Fever of other or unknown origin (MG26)		1 (1.6)	1 (2.0)	2 (1.8)
Pityriasis versicolor (1F2D.0)	Certain infectious or parasitic diseases (ICD 01)	1 (1.6)	1 (2.0)	2 (1.8)
Yaws (1C1D) Δ			2 (3.9)	2 (1.8)
Dysmenorrhoea (GA34.3)	Diseases of the genitourinary system (ICD 16)		2 (3.9)	2 (1.8)
Heavy menstrual bleeding (GA20.50)			2 (3.9)	2 (1.8)
Thyrotoxicosis (5A02)	Endocrine, nutritional or metabolic diseases (ICD 05)	1 (1.6)	1 (2.0)	2 (1.8)
Dermatoses provoked by friction or mechanical stress (EH92) - Abrasion (XJ652)	Diseases of the skin (ICD 14)	1 (1.6)	1 (2.0)	2 (1.8)
Strain or sprain of wrist (NC54.6)	Injury, poisoning or certain other consequences of external causes (ICD 22)	2 (3.2)		2 (1.8)
Post traumatic wound infection, not elsewhere classified (NF0A.3)		2 (3.2)		2 (1.8)
Dislocation or strain or sprain of joints or ligaments of the knee (NC93) **		2 (3.2)		2 (1.8)
Strain or sprain of other or unspecified parts of knee (NC93.7)		1 (1.6)		1 (0.9)
Strain or sprain of shoulder joint (NC13.5)		1 (1.6)		1 (0.9)
Laceration without foreign body of ankle or foot (ND12.0)		1 (1.6)		1 (0.9)

Pain, unspecified (MG3Z)	Symptoms, signs or clinical findings, not elsewhere classified (ICD 21)	1 (1.6)		1 (0.9)
Other chest pain (MD30.1)		1 (1.6)		1 (0.9)
Chronic primary visceral pain (MG30.00)			1 (2.0)	1 (0.9)
Splenomegaly, not elsewhere classified (ME10.01) [resolved]		1 (1.6)		1 (0.9)
Diarrhoea (ME05.1)		1 (1.6)		1 (0.9)
Abdominal or pelvic pain (MD81)			1 (2.0)	1 (0.9)
Subcutaneous swelling, mass or lump of uncertain or unspecified nature (ME61) - Iliac region (XA0NH8)			1 (2.0)	1 (0.9)
Scabies (1G04) §§	Certain infectious or parasitic diseases (ICD 01)	1 (1.6)		1 (0.9)
Other and unspecified infestation by parasitic worms (1F90) ††		1 (1.6)		1 (0.9)
Molluscum contagiosum (1E76)		1 (1.6)		1 (0.9)
Pyogenic abscess of the skin (1B75.3)			1 (2.0)	1 (0.9)
Persistent Postural-Perceptual Dizziness (AB32.0)	Diseases of the ear or mastoid process (ICD 10)	1 (1.6)		1 (0.9)
Personal history of maltreatment (QE82) - adult (XT6S) [domestic]	Factors influencing health status or contact with health services (ICD 24)		1 (2.0)	1 (0.9)
Myopia (9D00.0)	Diseases of the visual system (ICD 09)	1 (1.6)		1 (0.9)
Talipes equinovarus (LB98.00)	Developmental anomalies (ICD 20)	1 (1.6)		1 (0.9)
Unspecified asthma (CA23.3)	Diseases of the respiratory system (ICD 12)	1 (1.6)		1 (0.9)
Sleep-related leg cramps (7A82)	Sleep-wake disorders (ICD 07)	1 (1.6)		1 (0.9)
Inguinal hernia (DD51) - Left (XK8G)	Diseases of the digestive system (ICD 13)	1 (1.6)		1 (0.9)
Gastro-oesophageal reflux disease (DA22)			1 (2.0)	1 (0.9)
Malunion of fracture (FB80.7) - Fracture of upper end of ulna (NC32.0)	Diseases of the musculoskeletal system or connective tissue (ICD 15)		1 (2.0)	1 (0.9)
Depressive disorders, unspecified (6A7Z)	Mental, behavioural or neurodevelopmental disorders (ICD 06)		1 (2.0)	1 (0.9)
Lower limb varicose veins, not further specified (BD74.1Z)	Diseases of the circulatory system (ICD 11)		1 (2.0)	1 (0.9)
Atrial fibrillation (BC81.3)		1 (1.6)		1 (0.9)
Physical maltreatment (PJ20) ‖‖	External causes of morbidity or mortality (ICD 23)	1 (1.6)		1 (0.9)
Totals of diagnosed morbidities *		**92**	**76**	**168**

*'Well' classifications (marked in green) were not included in the final calculations of total diagnoses of morbidities. The following individual diagnoses were classified by the examining primary care clinician (GC) as "possible" or "suspected": † Lung infections [lower respiratory tract], 3 of 10; ‡ Tuberculosis, unspecified, 8 of 9; § Anaemias or other erythrocyte disorders, unspecified, 5 of 7; ‖ Stunting in infants, children or adolescents, 3 of 6; ¶ Chronic obstructive pulmonary disease, unspecified, 2 of 5; Δ Yaws, 1 of 2; ** Dislocation or strain or sprain of joints or ligaments of knee, 1 of 2; †† Other and unspecified parasitic worms, 1 of 1; §§ Scabies, 1 of 1; ‖‖ Physical maltreatment, 1 of 1.

Table S3. Ethnoclassification taxonomy of *"Malaria"* (1st in combined group rankings).
Quotes in roman are translated from Tok Pisin (dual transcripts retained), quotes in italics were spoken as written. Attributed texts without quotation marks are from patient histories summarised by PNG research technicians at the time.

<table>
<tr><td>Names</td><td colspan="6">"Malaria" (Tok Pisin and English) (all)</td></tr>
<tr><td>Who</td><td colspan="3">Everyone
All Focus Groups [FG] agreed: "Everyone" (♂≥40y FG)</td><td colspan="3">Old People and young children
"It occurs a lot in young school children" (Key Informant [KI]) ● "Most of the time it's old people, and young children." (KI)</td></tr>
<tr><td>When</td><td colspan="3">All the time
● "malaria can occur at any time" (♂≥40y FG) ● "It's all the time. In the dry season, still there are mosquitoes, in the rainy season – same" (♂<40y FG)</td><td colspan="3">More in the rainy season
"Mostly in wet season. So if it rains more, you see more malaria?" (KI)</td></tr>
<tr><td>Cause</td><td colspan="6">Mosquitos [local name: "nagi"]</td></tr>
<tr><td></td><td>Animal blood
"They might bite our skin… in this way the skin has the same blood… they take it from pigs or dogs or whatever and come back and put it into men's skin." (♂<40y FG)</td><td>Mosquito eggs
"mosquito's eggs will stay inside them and that causes this" (♀<40y FG)</td><td>Sleeping in the open
● "Sleeping in the open" (♀<40y FG) ● "Not having a mosquito net" (♀≥40y FG) ● "maybe they don't sleep in a mosquito net" (KI)</td><td colspan="3">Environment
Bushy "It all grasses near their house." (KI)
Swampy "Swampy areas are a breeding place for mosquitos" (KI)
Rubbish "Tins and plastics… create a breeding place for mosquitoes" (KI)</td></tr>
<tr><td>Signs and symptoms</td><td colspan="6">● High fever ● shivers ● cold skin ● yellow skin ● strong head pain ● feel weak ● cannot walk ● dizziness ● vomiting ● joint pain ● cough ● tired
● "skin becomes yellow, they will be ill in the afternoon and morning. They sleep. They will be shivering" (♀<40y FG) ● "fever, shivers, headache, cough, cold skin" (♂≥40y FG) ● "they feel cold, their hairs will be standing on end, very weak" (♂<40y FG) ● "cold sickness" (♀≥40y FG) ● "Chill, when they are feeling chill, high fever, sometimes they feel dizzy, dizziness, and they tend to vomit regularly…we suspect that they have malaria, by looking at those signs." (KI) ● Strong head pain, very high fever, joint pain, vomiting, very weak (Parent [P] of 13y with confirmed malaria) ● Cough (P 7y, confirmed malaria) ● Head pain, high fever, weak (P 1y, confirmed malaria) ● Head pain, feeling cold, fever (P 8y, confirmed malaria) ● Can't walk properly (P 4y, confirmed malaria)</td></tr>
<tr><td>Treatment</td><td>Nothing/rest
● "In this community… they don't go look for treatment… they are sick they just stay in their bed rest until they… feel good, better… maybe two or three weeks after they become ill again, because the bacteria is in their body and it's not dead." (KI) ● "A lot of the time we just stay here, and the illness goes and, like it finishes on its own" (♂≥40y FG)</td><td>Pharmacy drugs
Chloroquine Paracetamol Amoxicillin
● "When you go to town or hospital they take them, and BRC sometimes sends supplies here" (♂<40y FG) ● "Panadol, bought from pharmacy" (P 4y, confirmed malaria) ● "Panadol, Chloroquine, Amoxicillin" (♀<40y FG)</td><td>Steam with medicine from the forest*
Papaya Grass Guava Ginger Citrus fruits
● "We… take grass smell, guava, citrus fruits, boil them, heat water really hot, go to bedside, cover them up, and steam" (♀ ≥40y FG) ● "We use steam - make hot water - cover them up with a bed sheet, find a large pot, stir it with a stick: Papaya leaves, grass leaves, grass smell, guava leaves, ginger, citrus fruits. Only a few people in the community know how to use it - he knows how to do that. Vines no… drinks no, only steam. When finished, we can wash them using cold water" (♂<40y FG) ● "We tend to use medicine from the forest - like tree leaves, papaya… You steam them, cook all of these tree leaves up and steam the body" (♂≥40y FG)</td><td>Hospital
● "the hospital will treat" (♀<40y FG) ● "when they get worse they call the Binatang people so when they have the trip coming up they will just go down to the hospital." (KI)</td><td>Comfort
"Rock cradle them allot" (♀<40y FG)</td><td>Private health care staff
Private doctor (P 7y, confirmed malaria)</td></tr>
</table>

*Similar community plant-usage for *"malaria"* has been reported elsewhere in PNG. For a useful summary (though one that does not evaluate effectiveness) see: WHO. Medicinal plants of Papua New Guinea. Manila: World Health Organization Western Pacific Region 2009.

Table S4. Ethnoclassification taxonomy of *"Sotwin"* (2nd in combined group rankings)

Quotes in roman are translated from Tok Pisin (dual transcripts retained), quotes in italics were spoken as written. Attributed texts without quotation marks are from patient histories summarised by PNG research technicians.

Names	***"Sotwin"*** (all)						***"Umbang aul"*** (Local language) (♂<40y FG)
	Tok Pisin	**Symptomatic labelling beyond asthma**					
	'breath, to gasp for breath, to pant; 2. to have asthma' [23]	Given the dual meaning as biomedical condition and symptom (see left), people were likely sometimes describing experiences of other conditions beyond asthma, particularly when no individual clinical diagnosis had been previously available. ● *"I don't know what – is it TB or, we have TB or just asthma or, that's hard to know... If we have… medical report, like most – like at least medical patrol team they go to the Wanang and then they can inform us "you have TB or, just a cough""* (Key Informant [KI]) ● 50y patient (PT), complained of "Sotwin", diagnosed on assessment with TB.					
Who	**"Everybody/Everyone"**			**>5y, especially children**		**Middle-aged people and old-age people**	
	● "Everybody/Everyone" Focus Groups [FG]: ♀<40y; ♂ ≥40y; ♂<40y)* ● *"asthma is covering all the living people in Wanang, … from the kids up to the old people."* (KI) ● "cold/cough, "*sotwin*", they are very widespread inside Wanang… not just older men or women." (KI)			"especially like kids, but… young one is OK… maybe 5 to 16 years, then people up to like 30 years… and above… most of them are affected with the… coughing." (KI)		"*middle-aged people and old-age people… Not many young people.*" (KI)	
When	**All the time**						
	● "It's not seasonal - any time" (♂≥40y FG) ● *"No, all year round. Cough is all year round."* (♀KI)						
Cause	**Smoking**	**Chewing Betel nut**	**Meat, fish, cooking**	**Sex with women**	**Others**	**Rubbish and dust**	**The sun**
	● (♂≥40y FG) ● *"think the cause is… smoking… So most people around this place most of them are smokers"* (KI)	(♂≥40y FG)	● "Eating bloody meat… Fish, like blood so, you don't dry it" (♂≥40y FG) ● "you cook with fish and it has the smell of fish and you don't wash it properly and use it as a water container or water pot for drinking, this can cause *"sotwin"*. Fish… if you don't dry it properly and you cook it and someone eats it, it can cause "*sotwin*"" (♀<40y FG) ● "the women… cook, give to you and you eat it" (♂<40y FG)	● "a woman comes and… has sex with you, this will cause this "*sotwin*" to occur" (♂≥40y FG) ● "the women [unclear] your leg… Go with them" (♂<40y FG)	"I'm sitting down and they come round behind and use the same space where you were sitting" (KI)	" If the house is dirty and you sleep with rubbish, dust, then you will get" (♂<40y FG)	(♀<40y FG)
Signs and symptoms	**● Heavy breathing ● fast breathing ● difficulty during physical exercise ● coughing ● "*sotwin*" ● weakness**						
	● "When you walk up and down the mountain, you might call the "stretcher man"" (♀<40y FG) ● **"**If a man is breathing very heavily then we would know, he has "*sotwin*". Walking long distances…you will see… coughing a lot as well… when you go up a mountain you will need frequent rests" (♂≥40y FG) ● "The man might be coughing a lot. He will sit down, walk around and just rest… close to [the village]. He will not be able to climb up mountains… it's like, your breath will become locked and you will faint" (♂<40y FG) ● "*They tend to cough publicly, like openly. When they walk around you will see them coughing.*" (KI) ● *"everybody cough, but asthma is like times where you can cough cough cough, suddenly… it will come like very strong and you will like breathe very very fast…"* (KI) ● said had sotwin, described symptom as cough (55y PT, diagnosed on assessment with LRTI and COPD; Parent [P] of 1y, diagnosed on assessment with URTI) ● has no strength (39y PT, diagnosed on assessment with LRTI) ● Sotwin a lot (P of 11months, diagnosed on assessment with LRTI)						
Treatment	**Medicine from the forest**			**Pharmacy drugs**		**No treatment**	**Drink cold water**
	Banana drink	**Papaya leaf**	**Vine sap**	***Septrin***	**Amox**		
	● "banana… in a cup, strain it, give it to the child. You can heal it in the village (unlike malaria which is hard - for that you should go straight to the hospital). Papaya leaf" (♀<40y FG) ● "You get some sap from a vine, just sap from a vine, cut it [local name: "bamul"]" (♂<40y FG) ● "it doesn't have this kind of strong medicine from the forest. We have tried many times when *"sotwin"* has occurred and you take these kinds of medicines and just drink them, it will only help you for a short time… a day and tomorrow or the day after *"sotwin"* will occur again, OK some *"sotwin"* doesn't go on for very long, it can go away and stop, and some people if *"sotwin"* has already taken hold of them, they will try all kinds of medicine but it won't be enough, the *"sotwin"* will continue all the way until you become old… and they die" (♂≥40y FG) ● Bush rope (cut the rope and drink the white sap) (39y PT diagnosed on assessment with LRTI)			(51y PT, diagnosed on assessment with LRTI and COPD)	(55y PT, diagnosed on assessment with LRTI, COPD)	● "[Q: do people treat this illness?] "No. They just live with the kus, cough." (KI) ● Said had "Sotwin" but had had no treatment (P of 2y, diagnosed on assessment with URTI, LRTI; 48y PT (diagnosed on assessment with COPD; 50y PT; e06 46y PT).	(♂<40y FG)

Table S5. Ethnoclassification taxonomy of Cancer (3rd in combined group rankings).
Quotes in roman are translated from Tok Pisin (dual transcripts retained), quotes in italics were spoken as written. Attributed texts without quotation marks are from patient histories summarised by PNG research technicians.

<table>
<tr><td>Names</td><td colspan="2">“Susu cancer”
Breast cancer (♂≥40y Focus group [FG])</td><td>“cancer bodi insait”
Cancers inside body (♂≥40y FG)</td><td colspan="2">“Sik bilong ol mama”
Cervical cancer (♀<40y, ♀≥40y FGs)</td></tr>
<tr><td>Who</td><td colspan="4">Allot of us / We don’t know
“Now a lot of us living here have cancer… we don’t know ourselves… when we go to the hospital… in order to get medicine or something… the doctors… they will say “you have cancer”” (♂≥40y FG)</td><td>“Mothers, older women, younger women”
(♀≥40y FG)</td></tr>
<tr><td>When</td><td colspan="5">“It arrived in 2014 in the communities around here” (♀<40y FG)</td></tr>
<tr><td>Cause</td><td>“No sure”
(♀<40y FG)</td><td colspan="2">Meat and Fish
“Eating meat or that kind of thing… you don’t dry the meat properly… sometimes this can cause some illness or cancer inside, it’s like, there’s water from fish and you take it and you boil it and you eat it” (♂≥40y FG)</td><td>Smoking
“This cancer that tends to be with a cough… sometimes… smoke a lot then cancer will occur” (♂≥40y FG)</td><td>Betelnut
“OK chew a lot of betelnut… then cancer will occur” (♂≥40y FG)</td></tr>
<tr><td>Signs and symptoms</td><td colspan="3">“We don’t know ourselves… we find out from the doctor”
"Now a lot of us living here have cancer… we don’t know ourselves, we don’t know if we have cancer like this but… when we go to the hospital in order to get medicine or something, when the doctors check us or when they check our blood… now they will say “you have cancer” … so we find out from the doctor” (♂≥40y FG)</td><td>Cough
“it tends to occur with a cough and illness inside it tends to occur again inside” (♂≥40y FG)</td><td>Patient is red
“They will look like blood” (♀≥40y FG)</td></tr>
<tr><td>Treatment</td><td colspan="5">“Only the hospital will treat” (♀<40y FG)
Hospital treatment not always successful, particularly if patients flee treatment
“OK cancer if it occurs, there is no way to stop this, sometimes we go to the doctor and the doctor is able to cure the cancer, it will finish… suppose we tell them about our illness and we go and stay in the hospital, it’s like the cancer can be stopped but if we are afraid of the injection or something and they get the needle out and we run away, sometimes the cancer will not stop and the cancer will still sit on the body and after you become an old man… you can die from this” (♂≥40y FG)
Absent Aid Post for referrals, hospital attendance to delayed
“my mother and his wife. She – she got the cervical cancer, she got that sick maybe for two years… if Wanang have a small haus sik there then easy to get a report and then move to the general hospital in Madang and easy to get treatment. But because of no haus sik there, the mother… herself she think that she is OK but the sickness is inside the body…, so we all never know what is with her, so after, the sick is like to stage – stage 4, then we all surprised then we took it to the hospital, and go to the x-ray and they said “oh, cervical cancer and it’s like in 50-50” so we try two hospitals here in Madang, and it cannot work as they said no medicine, we move her to the highlands, to Kundiawa General Hospital, and we went there and she passed away. So, that’s happened to like my mother and his wife…” (Key Informant)</td></tr>
</table>

Table S6. Ethnoclassification taxonomy of *"Grile"* (Tinea imbricata) (4th in combined group rankings).
Quotes in roman are translated from Tok Pisin (dual transcripts retained), quotes in italics were spoken as written. Attributed texts without quotation marks are from patient histories summarised by PNG research technicians.

Names	***"Grile"*** (Tok Pisin: ♂≥40y, ♀<40y, ♀≥40y, ♂<40y Focus Groups [FG])		***"Kavnam"*** (Local language: ♂≥40y, ♂<40y FG)	***"Pukpuk"*** "crocodile" (Tok Pisin: ♀<40y, ♂<40y FGs)
Who	**Everyone, particularly infants & children** ● **"**Everyone, all ages" (♂≥40y FG) ●"tends to occur in children, also people like us, and maybe some older men… [and] women as well, little girls too. Most of the time tinea occurs in babies, in younger and older men just occasionally" (♂<40y FG) ● "older people… middle aged people and some children as well. Maybe from small to older people" (Key Informant [KI])	**Children** ● "Most of the children have this disease" (KI) ● "*[Q] You say most of the children here [have Grile], how many children do you have in the school? [A] I have 186."* (KI)	**Young men** "Grile common in young men" (Research Technician [RT])	**Older women, people are hiding it** "There's a lot of tinea. I've got it myself and I forgot about it! Severe tinea. A lot of us sitting down here have it… some people are hiding it so you can't see it" (♀≥40y FG)
When	**Anytime** ● *"It doesn't have seasons."* (KI) ● "Year to year. Mainly in the rain" (♂<40y FG) ● "Anytime" (♂≥40y FG)			
Cause	**Wet clothes** ● "You bathe… and keep wet clothing on you will get tinea very fast" (♂≥40y FG) ● "if you go walking in the rainy season… get wet in the rain, and you don't change your clothes, you keep it on, you sleep with the same things… these wet things will cause this tinea… you're walking along a long road…your shirt will be sweaty… you sit down rest, that will cause this" (♂<40y FG) ● "when you walk in the rain and you don't change your clothes" (KI)	**Contaminated rivers** ● "we bathe in the river, like bad swamp water, water that is not clean, not flowing… or another man is bathing upstream from you, in that way you can catch tinea." (KI) ● "Say I have tinea and bathe upstream and a man without tinea is bathing downstream, then these little "crocodile skin particles" … the water carries them and he can get them, you have different kinds of water, some won't have tinea, some will." (♂≥40y FG) ● "if a man with tinea washes something upstream from you and you wash something you will get it" (♂<40y FG) ● *"they use river for washing… it's caused by that and then the clothes they wear… During the sunny period… the fast-flowing rivers become small… algae grows… children like to jump into those rivers…those algae… give them bacteria, so they have Grile."* (KI)		**Touch and sharing clothes [and differing body-type susceptibility]** ● **"**friend of yours uses [wet] clothes, sleeps with everything on, sleeping in bed and if I sleep alongside him, I touch him while sleeping, still I will get tinea in this case, both of our bodies touch so it can move across, but if my body is not the right kind to get tinea from him, it will not want to… and if my body is the same type as his, I will catch Grile…" (♂≥40y FG) ● "If a man has this tinea and you use something of his, it will… spread to you. The same clothes, if they have tinea in them, you wear your clothes, you will get it." (♂<40y FG) ● transmitted from person with Grile… transmitted from other boys (patient histories)
Signs and symptoms	**● Skin like crocodile ● scratching ● pain** ● "Skin like crocodile. You might get it on your arm or leg… A man with tinea will scratch, a woman also, the skin will be painful" (♂≥40y FG) ● "They will be scratching… it's like all over the body, that's what this tinea is" (♂<40y FG) ● Some people are hiding it so you can't see it" (♀≥40y FG) ● *"Itchy all the time and they tend to scratch it all the time. [Q]: So they're itching, this could be other conditions so how do we know it's Grile? [A]: Itchy and… it just go on their skin… by looking at them you can see that they have Grile."* (KI)			
Treatment	**"we are not able to cure… we make forest medicine, we buy medicines [but]… it just comes back."** (♂<40y FG)			
	Traditional treatments		**Hospital/Pharmacy**	
	Plant-based ointments from the forest	**Placing skin inside banana tree**	**Grile cream** [Tolnaftate]	**Grile tablet** [Terbinafine]
	Lime, pepper, and tree bud paste / **Seeds of "sigwal" tree** / **"Moder" [Papaya blood]** ● "take kambang [lime powder used when chewing betelnut], daka [pepper chewed when chewing betelnut], and the bud from this tree flower… try to mix them with kambang." (KI) ● "There's a tree with… green leaves and yellow flowers, it's found in sandy areas around large bodies of water [local name: "sigwal"]… say you're walking along the road you see it, it bears… yellow fruit,… unripe ones will be green… you just take a strainer, it will get the seeds… and you can just close them within a leaf and… heat them in the fire and when they've been heated a bit, take them out and you rub them… One thing is papaya – grate it, the papaya fruit, when you've grated it a lot, this… black blood that they have, you will take this and you scratch your tinea and you rub it in… find the place where it is… the pain." (♂<40y FG)	**"**Medicine I use… removes tinea from people, take a knife and make a hole in a banana plant – any banana plant – when it's opened, put the skin infected with tinea inside… now it ends their tinea is cured… there is no spoken words or anything… Nowadays all of us don't use this method" (♂<40y FG)	● **"**In the town one gets medicine like ointment… liquid medicine, to just rub in, and this OK… Something like that… this medicine people tend to use Panadol type – tablet" (♂<40y FG) ● Grile cream; Grile tablet; most cases of past Grile cream treatment used; diagnosis was by self (patient histories)	● "Occasionally. If a man has "double" tinea all over the body, all the medicine won't be able to stop it… you just need to go to the hospital and you go to the chemist and buy medicine specifically for tinea and you drink it and this, will recover" (♂≥40y FG) ● *"I encourage them "if your parents going to town, tell them to buy, go to chemist and buy their tablets and soap there"* (KI) ● Grile tablet from pharmacy (patient histories)
				Effectively, No treatment *"There is no treatment. Looking at them I always encourage them …"when you go into town go to chemist and buy some medicine". But looking at their number most have Grile. Especially my school children."* (KI)

Reporting checklist based on 'Appraising studies in health using rapid assessment procedures' [13]

This checklist is provided in line with the following statement in our protocol: 'The article will reference this protocol noting changes in method, and include a filled-in reporting checklist based on criteria for appraising studies in health using RAP' [4]. All changes are noted in the manuscript under the subheader 'Changes from our published protocol' in the methods section. Criteria in '_' are quoted from [13].

Criteria	Page, line number
'1. Aim (Is the aim of the study clearly described?)'	5, 124–127.
'2. Subjectivity (Are the researchers' background, prior knowledge and relationship to the community, and cultural competence clearly presented and addressed?)'	Paper: 6, 166–171; 7, 185–186; 25, 686–699. Sup. File: 3.
'3. Field research guidelines (Is there an adequate description of the field guide and the rationale and process of its development?)'	Fully detailed in published protocol, which also includes all recruitment materials, KI and FG topic guides, clinical data collection forms, pharmacy, etc.[4]. Paper: 5–6, 133–142, 161–165.
'4. Staff (Is the recruitment process and training of research assistants presented, and is it sound?) RAP studies usually use research assistants in the collection of primary data from the field. Many researchers establish specific criteria for selecting assistants and these should be communicated. Further, the training process and content should be presented.'	Detailed in published protocol. Fieldwork RAs were existing RTs and PNG nationals at in-country New Bintang Research Centre. Sup. File: 3.
'5. Data collection methods (Is the rationale for the data collection methods and types of information collected with each method clearly presented?)'	Detailed in published protocol. Paper: 6, 143–165.
'6. Selection of research sites (Is an appropriate sampling strategy for selecting the study area(s) or research site(s) described?)'	n/a – site (Wanang village) was studied as it was the community that had requested health service incorporation in their existing conservation area. See 4–5, 80–123; detailed in protocol paper.
'7. Informant selection (Is a systematic process of selecting informants used and is it adequately described?)'	Fully detailed in published protocol. Paper: 6, 145–148; 7, 199–203.
'8. Credibility (Is a strategy for assessing credibility established and presented?)'	Fully detailed in published protocol. Paper: 5, 136–137; 6, 173–174; 7, 184–190.
'9. Analysis (Is the analysis process adequately described and was it sound?)'	Fully detailed in published protocol. Paper: Fig 2; 6–7, 166–190; 7, 203–206. Sup. File: 3.
'10. Presentation (Are the findings and discussion clearly presented?)'	Paper: 8–21, 219–681. Table 1, Figs. 3 and 4. Sup. File: 3–9, Tables S1–S6.
'11. Ethics (Are ethical principles respected and is the process for informed consent described?)'	Detailed in published protocol (including recruitment scripts, consent forms etc.). Paper: 25, 701–710.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page & line
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 1–4; 2, 37–38
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 40–56
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4–5, 72–130. Additionally, extensive wider background and discussion of methodological rationale given in published protocol paper, relevant section sign posted in start of this paper (4; 77–79: 'Here we outline site-specific context, biodiversity and health issues in PNG and our methodological rationale are discussed in detail in our published protocol.[4]')
Objectives	3	State specific objectives, including any prespecified hypotheses	2, 35–36; 5, 124–130.
Methods			
Study design	4	Present key elements of study design early in the paper	4, 75–76; 5–6, 132–142; Figure 2 methodological flowchart.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Description of setting and location: 4–5, 80–123. Periods of recruitment and data collection, 5, 134; 6, 143–145. Exposure and follow-up n/a.
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Described extensively in published protocol paper. In manuscript: 6, 145–148; 7, 199–203. Follow up n/a.
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a, not a matched study.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6–7, 159–165, 172–182. Detailed in published protocol paper, and its supplementary file.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6, 143–165; Detailed in published protocol paper, and its supplementary file. Study consisted of one community, with assessment methods uniform across group.
Bias	9	Describe any efforts to address	7, 188–190.

		potential sources of bias	
Study size	10	Explain how the study size was arrived at	Paper: 6, 145–148; 7, 199–200. Protocol paper, Table 1'Study cohort and justification of participant numbers and composition'.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Paper: 6, 171–173; 7, 203–206; table 2. Paper's Supplementary File: 3, 'Generating combined all-group rankings'
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Only basic descriptive statistics reported: 6, 171–173; Paper's Supplementary File: 3, 'Generating combined all-group rankings'. (Note: See other attached reporting checklist re RAP studies, which covers wider methods used).
		(*b*) Describe any methods used to examine subgroups and interactions	6–7, 176–178
		(*c*) Explain how missing data were addressed	8, 233–235
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8, 221–227; Figure 2.
		(b) Give reasons for non-participation at each stage	6, 146–147; 7, 200–203.
		(c) Consider use of a flow diagram	Figure 2
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	4, 81–93; 8, 221–230; Figure 2 Paper's supplementary file, Table S1
		(b) Indicate number of participants with missing data for each variable of interest	8, 233–235; paper's supplementary File, Table S2.
		(c) Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	Report numbers of outcome events or summary measures over time	n/a
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were	Our main results are not of this type as our study is a combined clinical and rapid anthropological assessment. Main results are reported: 8–16, 236–466; Table 1; Figure 3; Supplementary file, Table S2–S6.

		adjusted for and why they were included	See other attached reporting checklist re RAP studies for more details.
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	See answer to 16a above.
Discussion			
Key results	18	Summarise key results with reference to study objectives	16, 468–490.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	3, 60–71; 16–17, 491–535; discussed in detail in our published protocol paper, with signposting in this manuscript 17, 501–503
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18–21, 536–664
Generalisability	21	Discuss the generalisability (external validity) of the study results	18, 536–578
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26, 728–729

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.