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## **BMJ Open**

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

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# 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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### 32 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
- 36 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).  $26 \ge 18y$
- 40 participated in sex-age stratified FGs (f < 40y; m < 40y;  $f \ge 40y$ ;  $m \ge 40y$ ). Five KIs were interviewed (1f,
- 41 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
- 55 demonstrated medical need sufficient to acquire funding to establish local primary care. In doing so, it
- 56 has aided Wanang's community to develop sustainably, without sacrificing their forest home.

### 57 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
- 67 ethnographic methodologies, and the breadth of health issues assessed reduced capacity to report
- 67 specific health burdens as accurately as single-disease focused research.

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### 69 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] 

### 79 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

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3 1	104	had been formed in 2001 when the logging frontier reached Wanang, and clans refused corporate
4 5	105	inducements and pressure, declaring most of their forest home as the Wanang Conservation Area.[3]
6 7	106	To make their initiative viable in the long-term they reached out to ecological researchers to access
8	107	development benefits. These have included research training and employment, a school,
9 10	108	transportation, and income.[3] The meeting in 2016 identified healthcare as 'the main missing service'
11 12	109	[9] to be developed in the collaboration's next phase.
13 14	110	In more industrialised countries, clinical interactions are commonly recorded electronically in
15 16	111	routinely collected patient data.[10] In contrast, in rural PNG aid post workers have traditionally
17	112	recorded total consultations and broadly what they were for on a single-sheet yearly form, but
18 19	113	generally do not keep patient data. Instead, individuals have been encouraged to obtain pamphlet-style
20	114	health books which they keep at home (figure 1 e and f), in which information is entered for reference
21 22	115	the next time treatment is sought. In principle this has been sensible given available resources.
23	116	However, health books are often scarce, and can deteriorate quickly in wet, humid rainforest
24 25	117	environments. Additionally, some hospitals require individuals have health books to receive treatment
26 27	118	(effectively making them care passports), so they are often surreptitiously shared and thus include
28	119	records of multiple individuals as though they are one person, making them inaccurate sources of
29 30	120	medical history.[11] During the design of this health needs assessment [12] community members
31	121	reported that few people had health books. With no aid post, summary information on burdens was
32 33	122	unavailable. This then was the clinical situation at Wanang: remote secondary care; no primary care
34 35 36	123	services in the community; sparse, unreliable, and dispersed patient data.

### 37 124 Aims

43

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?

### <sup>49</sup> 50 131 **METHODS**

### 51 52 132 Study design

53 We carried out a clinical and rapid anthropological assessment with parallel treatment of urgent cases, 133 54 55 134 in Wanang between 17-25 July 2018. It consisted of Key Informant (KI) interviews, Focus Groups 56 135 (FGs), individual clinical assessments by a general practitioner (with treatment and referral where 57 58 necessary), and ethnography (methodological flowchart, figure 2). This enabled rapid collection of 136 59 qualitative and quantitative data (at individual and community levels), and subsequent triangulation. It 60 137

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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  $\geq 18y$  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, 

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framework analysis[18] was conducted with matrixes generated in NVivo to enable ordering of themes and comparative analysis. To increase credibility: gualitative and guantitative 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 (<u>https://www.darwininitiative.org.uk/</u>) as part of a successful application to fund health
 service introduction into the Wanang Conservation Area. JM authored the resultant health service
 rlap (hear 1) in computation with other Co. Is with health compise healers and (CC. IAC. MI. SI Without Structure)

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

26 188 assessment).

### 28 29 189 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). 

### 4344 198 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**

### 55 204 Participants 56

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

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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 $\geq$ 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  $f \ge 40y$  or < 40y as a community health problem, but  $m \ge 40y$  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.



(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*". I "*Ai bilong pis*". ¶ "*Withold bilum bilong pikinini*". # "binatang eat the teeth", "*binatang kaikai tii*". 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, na *TB, all those – health education*". I "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*".

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3 4 5 6 7	262	Medical histories, clinical assessment, and urgent treatments
	263	Seventy-five participants (40m, 35f; 58.1%, n=129) were reported to have ever had "malaria"; 23
	264	(6f, 17m; 17.8%) "sotwin"; two (1f, 1m; 1.6%) cancer. Thirty-five (12f, 23m; 27.1%) had had
8	265	"grile", with other infectious skin conditions also highly represented: skin ulcers, 16 (6f, 10m;
9 10	266	12.4%); scabies, 11 (4f, 7m; 8.5%). No f<18y reported having children or problems during
11	267	pregnancy/birth. Of 30 f≥18y, 27 had given birth to live children: 128 in total (mean 4.7 per female
12 13	268	with a child, range 1–14), of which 15 (11.7%) had since died. Nine (33.3%) had experienced
14 15	269	problems during pregnancy/birth. Summary clinical results are illustrated in figure 3 and listed
15 16	270	(disaggregated by sex) against ICD-11 primary and specific codes in supplementary file (table S2,
17 18	271	p.4). Primary categories with the highest diagnoses were 'certain infectious or parasitic diseases' and
19	272	'diseases of the respiratory system' (each respectively with 41 diagnoses, 24.4% of the total 168),
20 21	273	followed by 'symptoms, signs or clinical findings, not elsewhere classified' (25, 14.9%). The next
22	274	largest grouping was 'well', an evaluation given to just 11 of 113 examined (9.7%). The five most
23 24	275	common diagnosed specific conditions were acute upper respiratory infection (URI)' (25, 22.1% of
25 26	276	those examined), tinea imbricata (15, 13.3%), lower respiratory tract infection (LRTI) (10, 8.8%),
20 27	277	malaria (9, 8.0%), and confirmed or suspected tuberculosis (9, 8.0%). GC noted a wide spectrum of
28 29	278	malaria severity, and <i>Plasmodium falciparum</i> and <i>vivax</i> were both present (mixed in some cases). A
30	279	greater proportion of females had URI (16, 31.4%) than males (9, 14.5%), in contrast to tinea
31 32	280	imbricata (11m, 17.7%; 4f, 7.8%) (supplementary table S2). Many diagnoses were only made in one
33	281	or two individuals (29.2% of total illness diagnoses, 49 of 168). Sixty-two villagers received urgent
34 35	282	treatments (30f, 32m), 31 (15f, 16m) were referred to Madang hospital for further investigation. ICD-
36 37	283	11 has a 'diseases of the skin' primary category, but many infectious skin diseases are categorised
38	284	elsewhere, mainly as 'certain infectious or parasitic diseases'. Figure 3 compensates by outlining in
39 40	285	red infections or parasitic conditions primarily affecting the skin (30 diagnoses, 17.9% of
41	286	morbidities). In addition to tinea imbricata (the second most diagnosed illness overall), tropical ulcers,
42 43	287	scabies, yaws, and post-traumatic wound infections were diagnosed. Multiple participants reported
44 45	288	these substantially affected their life because of itch, pain, disruption of sleep and inability to walk.
43 46 47	289	Concordance
48	290	There was generally strong concordance between diagnoses most frequently made following
49 50 51 52 53 54 55 55	291	assessment, medical histories, and the health issues the community identified as being most important.
	292	For example, three of FGs top four ranked health issues ([a] "malaria"; [b] "sotwin"; [c] "grile".
	293	Ethnoclassification taxonomies, supplementary tables S3-6, supplementary file, p.6-9), translated to
	294	the five biomedical conditions we diagnosed most ([a] malaria; [b] URI, LRTI, TB; [c] tinea
	295	imbricata. Figure 3). These three FG ranked health issues were also highly represented in declared
57 58	296	medical histories ([a] 75 participants, [b] 23, [c] 35). The remaining of the FGs top four ranked health
59 60	297	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  $\geq$ 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:

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3 4 5 6 7 8	333	"you have to walk for a day sleep there, get treatment and then walk back [but it often
	334	doesn't have supplies as] whenever there is a lot of medicine everyone from Musak, Kibirai
	335	and Ramu, they all come the medicine tends to run out in one day" (KI).
	336	Combined with concerns about violence in the neighbouring area, this meant traveling to Madang
9 10	337	town in a Public Motor Vehicle or with Binatang Research Centre was often preferred. Maternal
11 12	338	mortality is high in PNG, but one KI reported that with road evacuation by Binatang Research Centre:
12	339	"in the last five years, not a single mother giving birth died in childbirth. Because we are
14 15	340	safe in the time since conservation work has been occurring, we have [Binatang Research
16	341	Centre] emergency vehicle tends to come and take us" (KI).
17 18	342	However, improvised stretchers were still required transport for ill/immobile individuals to the
19	343	roadhead. KIs and FGs discussed further barriers on reaching the provincial hospital, including that it
20 21	344	often didn't have sufficient supplies:
22	345	"hospitals are running out of medicines, normally they check the patient and send them
23 24	346	to go to the chemist to buy. So you'll see, when people don't have money how will they be
25 26	347	cured" (KI).
20 27	348	Illiteracy and unfamiliarity with institutions left some unable to navigate the hospital (spatially or
28 29	349	bureaucratically), deterring attendance:
30	350	"sometimes they afraid come to the hospital because most things are written in English" (KI)
31 32	351	"some older women/mothers, they don't tend to go, big hospitals have a lot of wards. When
33	352	you go inside, you will go back and forth looking over a lot of areas you will be
34 35	353	confused making you not want to go to the hospital" ( $f \ge 40y$ ).
36 37	354	Without an aid post, villagers lacked formal referrals. Given such barriers, participant medical
38	355	histories and KI reports indicated secondary care attendance was frequently delayed, and clinical
39 40	356	diagnosis and treatment bypassed by purchasing medicines from pharmacies for immediate/future use,
41 42	357	or simply by not seeking biomedical care despite wishing to do so.
43 44	358	Top four health issues identified by FGs as affecting the community
45	359	Ethnoclassification taxonomies for each of the top four health issues identified by FGs are in
46 47	360	supplementary tables S3-6 (supplementary file, p.6-9), including example quotes from KIs, FGs, and
48 49 50 51 52 53 54 55 56 57 58 59	361	patient histories on how the diseases are understood, who treats them, and how. Though the belief
	362	"sanguma poison" (sorcery) causes some illness was voiced in the m≥40y FG, they seemed in
	363	agreement that "malaria sores, "sotwin" or that kind of thingare not to do with this." All causes
	364	given by FGs and KIs for the top four diseases were biological, none mentioned sorcery as causal.
	365	However, two examined participants declared they thought sorcery explained their ailments
	366	("sotwin"; lower body pain), and two others attributed death of some of their children to sorcery.
	367	"Malaria" (table S3, supplementary file, p.6): FGs all used the Tok Pisin and English word
60	368	"malaria", saying everyone can be affected, though some KIs highlighted children and old people as

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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  $f \ge 40y$  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". 

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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 $\geq$ 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. 

### <sup>35</sup> 424 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</li>
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: 

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3 4	439	"they got no times for body to rest If they go over six, seven, eight, nine, and ten, that's too
5	440	much it's very expensive to buy clothes and school fee and for their safety, three
6 7	441	children to a father and mother, or four or five, it's enough" (KI).
8	442	Whilst not a combined top five, both male FGs ranked health education as a top five (specifically HIV
9 10	443	and TB awareness), but neither female FG did. Given opportunity only m≥40y and f<40y identified
11	444	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 

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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 threephases (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 selftreatment 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 fulltime 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 

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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<sup>2</sup> to 150 km<sup>2</sup>. Beyond the direct findings of our health needs assessment, this then has implications for policymakers and others looking to identify innovative ways to make progress on the Sustainable Development Goals (SDGs), which are mostly implemented individually[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). 

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### **Unanswered questions and future research**

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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. 

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### 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**

596 Supplementary file: This web only file has been produced by the BMJ Publishing Group from an597 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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were co-authors on our protocol paper but not subsequently involved in this study: Mohammad Yazid Abdad (Papua New Guinea Institute of Medical Research, PNG), Emilie Beauchamp (International Institute for Environment and Development, UK), Maxwell J F Cooper (Brighton and Sussex Medical School, UK), Caroline L Grundy (University of Sussex), Martina Konecna (University of South Bohemia), and Chrissy H Roberts (London School of Hygiene and Tropical Medicine). 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). Funding: University of Brighton provided support for open access publication. This work arose from a community consultation on the future of Wanang Conservation Area funded by the Waterloo Foundation (http://www.waterloofoundation.org.uk/EnvironmentTropicalRainforests.html), and was itself funded by Sussex Sustainability Research Programme (an internal strategic funding programme of the University of Sussex) (2016-023), and the Darwin Initiative (UK government aid funding) (26002). Funders had no role in design, operation, or reporting of this study. Competing interests: None declared. REFERENCES 1. Lim SS, Allen K, Bhutta ZA, et al. Measuring the health-related Sustainable Development Goals in 188 countries: a baseline analysis from the Global Burden of Disease Study 2015. Lancet 2016;**388**:1813–50. https://doi.org/10.1016/S0140-6736(16)31467-2 2. Shearman P, Bryan J. A bioregional analysis of the distribution of rainforest cover, deforestation and degradation in Papua New Guinea. Austral Ecology 2011;36:9-24. https://doi.org/10.1111/j.1442-9993.2010.02111.x 3. Novotny V, Toko P. Ecological research in Papua New Guinean rainforests: Insects, plants and people. In: Bryan JE, Shearman PL, eds. The state of the forests of Papua New Guinea 2014: Measuring change over period 2002–2014. Port Moresby, Papua New Guinea: University of Papua New Guinea 2015:71-85. 4. Middleton J, Abdad MY, Beauchamp E, et al. Health service needs and perspectives of remote forest communities in Papua New Guinea: study protocol for combined clinical and rapid anthropological assessments with parallel treatment of urgent cases. BMJ Open 2020;10:e041784. https://doi.org/10.1136/bmjopen-2020-041784 5. Thomas H. The Expedition as a Cultural Form: On the Structure of Exploratory Journeys as Revealed by the Australian Explorations of Ludwig Leichhardt. In: Thomas H, ed. Expedition 23 May 2023 - j.middleton@bsms.ac.uk

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3	807	113 Wanang villagers examined (51 females, 62 males), 168 diagnoses given (not including 11 classifications of
4 5	808	'well'). The proportion of each concentric circle relates to the proportion a diagnosis was given as part of the
6	809	total number of diagnoses, with categories arranged clockwise high to low. The inner circle shows ICD-11
7	810	primary categories, the outer circle ICD-11 specific conditions (or ICD-11 symptoms/signs/clinical findings)
8 9	811	with number of diagnoses given for each. Infections/parasitic conditions primarily affecting skin are outlined in
10	812	red * Developmental * Far/mastoid process * Factors influencing health status/contact with services &
11 12	813	Mental behavioural or neurodevelonmental disorders.   Sleen-wake disorders. ¶ External causes of
12	010	morbidity/mortality
14	014	moroidity/mortanty.
15 16	815	Figure 4. Phased health service introduction at Wanang.
17	816	Top: Examples of training provided, (left to right) fracture management, off-road vacuum-stretcher evacuation,
18 19	817	use of malaria RDTs. Middle: Wanang Aid Post (left) and nurse consultation (right). Bottom: Examples of
20	818	disease targets for proactive integrated interventions, specifically (left to right) tropical ulcer, yaws, tinea
21	819	imbricata, scabies mite and eggs. Images from Wanang, apart from Sarcoptes Scabiei microscopy (Credit: top
22 23	820	and bottom, JM; middle, Binatang Research Centre).
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**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].

139x138mm (300 x 300 DPI)



**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.

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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. II Sleep-wake disorders. ¶ External causes of morbidity/mortality.

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**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 scabiei* microscopy (Credit: top and bottom, JM; middle, Binatang Research Centre).

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### 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.

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# 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.
<sup>6</sup> 2. Subjectivity (Are the researchers' background, prior knowledge and relationship to the community, and cultural competence clearly presented and addressed?) <sup>6</sup>	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.
<sup>6</sup> 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. <sup>9</sup>	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.
<sup>6</sup> 7. Informant selection (Is a systematic process of selecting informants used and is it adequately described?) <sup>6</sup>	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.

23 May 2023 – j.middleton@bsms.ac.uk

# 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)

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1	Surfaces_Wan	hangHealthNeedsSupplementary_CA16			
2 3 4 5 6	<b>Supplementary Table S2. Diagnoses from clinical examinations in Wanang</b> Specific clinical diagnoses are listed in descending order and categorised as per <u>https://icd.who.int/browse11/l-m/en</u> ), followed by the relevant ICD-11 primary 'Certain infectious or parasitic diseases'. Diagnoses were recoded to ICD-11 by	y village the International Classification of Diseases 11th Evision Version code when appropriate. For example, 'Yaws' is lighted as a specific author JM and confirmed by author GC. Percentages are of examin	02/2022 (ICD- condition, and ned males/fem	-11, as a sub-ca ales/all, tota	tegory of ils are greater
7 8 9 10	than n as many of those examined had multi-morbidity. In this table, preserving categories. However, figure 3 in the main article shows full grouping by primar were only partially examined, due to non-compliance.	g order of individual conditions based on their frequency only allow y categories (but not break down by sex). Five your grid didren (all r	s partial group nale) of the 11	ing by ICD 3 individua	-11 primary ls examined
11	Conditions, as per International Classification of Diseases 11th Revision Version	ICD-11 Primary category (ICD-11 code) $\alpha \alpha \Box$	Males	Females	All
12	02/2022 (ICD-11) (ICD-11 code) [authors additional information]	[authors additional information]	N=62	N=51	N=113
13		ex Su	(%)	(%)	(%)
14	Acute upper respiratory infection, site unspecified (CA07.0)	Diseases of the respiratory system (ICD 12)	9 (14.5)	16 (31.4)	25 (22.1)
15	Other specified dermatophytosis (1F28.Y) [Tinea Imbricata]	Certain infectious or parasitic diseases (ICD 01)	11 (17.8)	4 (7.8)	15 (13.3)
16	Well *	요두 뜻	5* (8.1)	6* (11.8)	11* (9.7)
17	Lung infections (CA4Z) [lower respiratory tract] †	Diseases of the respiratory system (ICD 12)	4 (6.5)	6 (11.8)	10 (8.8)
18	Malaria	Certain infectious or parasitic diseases (ICD 01)	4 (6.5)	5 (9.8)	9 (8.0)
10	Tuberculosis, unspecified (1B1Z) ‡		4 (6.5)	5 (9.8)	9 (8.0)
19	Low back pain (ME84.2)	Symptoms, signs or clinical findings, not elsewhere constitued (ICD 21)	6 (9.7)	2 (3.9)	8 (7.1)
20	Anaemias or other erythrocyte disorders, unspecified (3A9Z) §	Diseases of the blood or blood-forming organs (ICD (2))	2 (3.2)	5 (9.8)	7 (6.2)
21	Stunting in infants, children or adolescents (5B53)	Endocrine, nutritional or metabolic diseases (ICD 05)	3 (4.8)	3 (5.9)	6 (5.3)
22	Tropical phagedaenic ulcer (EA40)	Diseases of the skin (ICD 14)	4 (6.5)	1 (2.0)	5 (4.4)
23	Osteoarthritis, unspecified (FA0Z)	Diseases of the musculoskeletal system or connective sisue (ICD 15)	2 (3.2)	3 (5.9)	5 (4.4)
24	Chronic obstructive pulmonary disease, unspecified (CA22.Z) ¶	Diseases of the respiratory system (ICD 12)	4 (6.5)	1 (2.0)	5 (4.4)
25	Presbyopia (9D00.3)	Diseases of the visual system (ICD 9)	5 (8.1)		5 (4.4)
26	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)
27	Pain in joint (ME82)	Symptoms, signs or clinical findings, not elsewhere cassified (ICD 21)	2 (3.2)	1 (2.0)	3 (2.7)
27	Excessive weight loss (MG43.5)	la n	1 (1.6)	2 (3.9)	3 (2.7)
20	Cough (MD12)	te		2 (3.9)	2 (1.8)
29	Fever of other or unknown origin (MG26)	с, re	1 (1.6)	1 (2.0)	2 (1.8)
30	Pityriasis versicolor (1F2D.0)	Certain infectious or parasitic diseases (ICD 01)	1 (1.6)	1 (2.0)	2 (1.8)
31	Yaws (1C1D) $\Delta$	<u>5</u> 2		2 (3.9)	2 (1.8)
32	Dysmenorrhoea (GA34.3)	Diseases of the genitourinary system (ICD 16)		2 (3.9)	2 (1.8)
33	Heavy menstrual bleeding (GA20.50)	s a		2 (3.9)	2 (1.8)
34	Thyrotoxicosis (5A02)	Endocrine, nutritional or metabolic diseases (ICD 05)	1 (1.6)	1 (2.0)	2 (1.8)
35	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)
36	Strain or sprain of wrist (NC54.6)	Injury, poisoning or certain other consequences of externa Bauses	2 (3.2)		2 (1.8)
37	Post traumatic wound infection, not elsewhere classified (NF0A.3)	(ICD 22)	2 (3.2)		2 (1.8)
57 20	Dislocation or strain or sprain of joints or ligaments of the knee (NC93) **	ан сан сан сан сан сан сан сан сан сан с	2 (3.2)		2 (1.8)
30	Strain or sprain of other or unspecified parts of knee (NC93.7)	lio	1 (1.6)		1 (0.9)
39	Strain or sprain of shoulder joint (NC13.5)	gra	1 (1.6)		1 (0.9)
40	Laceration without foreign body of ankle or foot (ND12.0)	q	1 (1.6)		1 (0.9)
41 42 43	23 May 2023 – j.middleton@bsms.ac.uk	//hmianan hmi.com/cita/ahout/cuidalinas yhtml			
11	For peer review only - http://	//bmjopen.bmj.com/site/about/guidelines.xntmi			

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Pain, unspecified (MG3Z)	Symptoms, signs or clinical findings, not elsewhere cessified (ICD 21)	1 (1.6)		
Other chest pain (MD30.1)		1 (1.6)		
Chronic primary visceral pain (MG30.00)	i g		1 (2.0)	
Splenomegaly, not elsewhere classified (ME10.01) [resolved]	g f	1 (1.6)		
Diarrhoea (ME05.1)	e o	1 (1.6)		
Abdominal or pelvic pain (MD81)	문 비명		1 (2.0)	1
Subcutaneous swelling, mass or lump of uncertain or unspecified nature (ME61) -	es solo		1 (2.0)	1
Iliac region (XA0NH8)	reic v			
Scabies (1G04) §§	Certain infectious or parasitic diseases (ICD 01)	1 (1.6)		
Other and unspecified infestation by parasitic worms (1F90) <sup>††</sup>	ed m 3.	1 (1.6)		
Molluscum contagiosum (1E76)	to en Do	1 (1.6)		
Pyogenic abscess of the skin (1B75.3)	te s		1 (2.0)	
Persistent Postural-Perceptual Dizziness (AB32.0)	Diseases of the ear or mastoid process (ICD 10)	1 (1.6)		
Personal history of maltreatment (QE82) - adult (XT6S) [domestic]	Factors influencing health status or contact with health services (ICD 24	)	1 (2.0)	
Myopia (9D00.0)	Diseases of the visual system (ICD 09)	1 (1.6)		
Talipes equinovarus (LB98.00)	Developmental anomalies (ICD 20)	1 (1.6)		
Unspecified asthma (CA23.3)	Diseases of the respiratory system (ICD 12)	1 (1.6)		
Sleep-related leg cramps (7A82)	Sleep-wake disorders (ICD 07)	1 (1.6)		
Inguinal hernia (DD51) - Left (XK8G)	Diseases of the digestive system (ICD 13)	1 (1.6)		
Gastro-oesophageal reflux disease (DA22)	ан сан сан сан сан сан сан сан сан сан с		1 (2.0)	
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)	
Depressive disorders, unspecified (6A7Z)	Mental, behavioural or neurodevelopmental disorders (IC) (16)		1 (2.0)	
Lower limb varicose veins, not further specified (BD74.1Z)	Diseases of the circulatory system (ICD 11)		1 (2.0)	
Atrial fibrillation (BC81.3)	J. J	1 (1.6)		1
Physical maltreatment (PJ20)	External causes of morbidity or mortality (ICD 23)	1 (1.6)		
Totals of diagnosed morbidities *		92	76	1

\*'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; ‡ Tuberculæris, unspecified, 8 of 9; § Anaemias or other erythrocyte disorders, unspecified, 5 of 7; I Stunting in infants, children or adolescents, 3 of 6; ¶ Chronic obstructive pulmonary disease, unspecified, 2 of 5;  $\Delta$  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; III Physical maltreatment, 1 of 1.

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 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.

Names	"Malaria" (Tok Pisin	and English) (all)					
Who	Everyone         All Focus Groups [FG] agreed:         "Everyone" (♂≥40y FG)		<b>Old People and young children</b> "It occurs a lot in young school children" (Key Informant [KI]) • "Most of the time it's old people, and young children." (KI)			[KI]) • "Most	
When	All the timeMore in the rainy• "malaria can occur at any time" ( $3 \ge 40y$ FG)• "It's all the time. In the dry season, still there are mosquitoes, in the rainy season = same" ( $3 \le 40y$ FG)• "It's all the season = same" ( $3 \le 40y$ FG)			<b>the rainy sea</b> m. So if it rai (KI)	<b>ison</b> ns more, you		
Cause Signs and symptoms	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) • High fever • shiv • "skin becomes yello FG) • "fever, shivers, very weak" (♂<40y FG)	Mosquito eggs "mosquito's eggs will stay inside them and that causes this" ( $\varphi$ <40y FG) vers • cold skin • y vo w, they will be ill in headache, cough, cc G) • "cold sickness"	Mosquitos [local name: Sleeping in the open • "Sleeping in the open" ( $Q < 40y$ FG) • "Not having a mosquito net" ( $Q \ge 40y$ FG) • "maybe they don't sleep in a mosquito net" (KI) ellow skin • strong head miting • joint pain • cou the afternoon and mornin old skin" ( $\Im \ge 40y$ FG) • " ' ( $Q \ge 40y$ FG) • "Chill, w	"nagi"] Bush "It all grasses i their hot (KI) d pain • fe ugh • tire ng. They s 'they feel c	En y S "Sw near area plac mos (KI ceel weak • c d leep. They v cold, their has ure feeling cl	vironment iwampy ampy as are a eding ce for equitos" ) annot walk vill be shiveri irs will be sta hill, high feve	Rubbish "Tins and plastics create a breeding place for mosquitoes" (KI) • dizziness • ing" (♀<40y anding on end, er, sometimes
	they feel dizzy, dizzing signs." (KI) ● Strong I malaria) ● Cough (P 7 feeling cold, fever (P 8	ess, and they tend to nead pain, very high y, confirmed malari By, confirmed malari	vomit regularlywe sus fever, joint pain, vomitin a) • Head pain, high feve ia) • Can't walk properly	spect that the ng, very we er, weak (P r (P 4y, cor	hey have ma eak (Parent [ 19, confirm firmed mala	laria, by look P] of 13y wit led malaria) ( aria)	king at those h confirmed • Head pain,
Treatment	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" ( $\mathcal{E} \geq 40$ y FG)	Pharmacy drugs Chloroquine • "When you go to town or hospital they take them, and BRC sometimes sends supplies here" $(\Im < 40y \ FG)$ • "Panadol, bought from pharmacy" (P 4y, confirmed malaria) • "Panadol, Chloroquine, Amoxicillin" ( $\Im < 40y \ FG$ )	• "We take grass sm guava, citrus fruits, boil heat water really hot, gg bedside, cover them up, steam' ( $\mathcal{Q} \ge 40$ y FG) • steam - make hot water them up with a bed shee large pot, stir it with a s Papaya leaves, grass lea grass smell, guava leavy ginger, citrus fruits. On people in the communit how to use it - he knows do that. Vines no drii only steam. When finisi can wash them using cc water'' ( $\mathcal{J} < 40$ y FG) • " to use medicine from th - like tree leaves, papay steam them, cook all of tree leaves up and steam body" ( $\mathcal{J} \ge 40$ y FG)	ell, l them, o to , and "We use - cover et, find a stick: aves, es, <i>ly a few</i> <i>y know</i> <i>s how to</i> nks no, hed, we old "We tend ne forest <i>a</i> You "these n the	<b>Hospital</b> • "the hospital will treat" ( $Q < 40y$ 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)	Comfor "Rock cradle them allot" (♀<40y FG)	t Private health care staff Private doctor (P 7y, confirmed malaria)

\*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.

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# 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)         Tok Pisin       Symptomatic labelling b         '1.out of       Given the dual meaning as biomedical conditioned breath, to         gasp for       asthma, particularly when no individual clinication available.         breath, to       available.         medical patrol team they go to the Wanang and have TB or, just a cough"" (Key Informant [K         [20]       complained of "Sotwin", diagnosed on assess	eyond asthma on and symptom (see left), people of other conditions beyond al diagnosis had been previously we have TB or just asthma or, port, like most – like at least of then they can inform us "you I]) • 50y patient (PT), ment with TB.	<b>"Umbang aul"</b> (Local language) (♂<40y FG)
Who	"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)	>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)	Middle-aged people and old-age people "middle-aged people and old-age people Not many young people." (KI)
When	All the t	time	OKD
Cause	• Th's not seasonal - any time" ( $\ge$ 240y FG) • "No, all year <b>Smoking</b> • ( $\ge$ 240y FG) • "think FG) • "think ( $\ge$ 240y the cause is FG) smoking So most people around this place most of them are smokers" (KI) • "Th's not seasonal - any time" ( $\ge$ 240y FG) • "No, all year <b>Meat, fish, cooking</b> • "Eating bloody meat Fish, like blood so, you don't dry it" ( $\ge$ 240y 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" ( $\bigcirc <40y$ FG) • "the women cook, give to you and you eat it" ( $\bigcirc <40y$ FG)	Sex withOtherswomen"I'm sitting• "a womandown andcomes andthey comehas sex withroundyou, this willbehind andcause thisuse the"sotwin" tosame spaceoccur"where you( $\eth \geq 40y$ FG)were• "the womensitting"[unclear] your(KI)leg Go withthem"( $\eth < 40y$ FG)	$\forall KI$ The sun and dustand dust( $\bigcirc <40y$ " If the house is dirty and you sleep with rubbish, dust, then you will get" ( $\bigcirc <40y$ FG)
Signs and	Heavy breathing • fast breathing • difficulty during	physical exercise • coughing • "s	otwin" • weakness
symptoms	• "When you walk up and down the mountain, you might call breathing very heavily then we would know, he has "sotwin". as well when you go up a mountain you will need frequent He will sit down, walk around and just rest close to [the vill like, your breath will become locked and you will faint" ( $d < 4$ <i>When they walk around you will see them coughing.</i> " (KI) • <i>cough cough, suddenly it will come like very strong a</i> sotwin, described symptom as cough (55y PT, diagnosed on a diagnosed on assessment with URTI) • has no strength (39y H (P of 11months, diagnosed on assessment with LRTI)	I the "stretcher man"" ( $Q < 40y$ FG) Walking long distancesyou will rests" ( $d \ge 40y$ FG) • "The man mig lage]. He will not be able to climb u looy FG) • " <i>They tend to cough public</i> "everybody cough, but asthma is like and you will like breathe very very J issessment with LRTI and COPD; F PT, diagnosed on assessment with L	• "If a man is see coughing a lot ght be coughing a lot. up mountains it's <i>licly, like openly.</i> <i>te times where you can</i> <i>fast</i> " (KI) • said had Parent [P] of 1y, .RTI) • Sotwin a lot
Treatment	Medicine from the forestBanan drinkPapaya leafVine 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" ( $Q < 40y$ FG) • "You get some sap from a vine, just sap from a vine, cut it [local name: "banul"]" ( $\mathcal{O} < 40y$ 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" ( $\mathcal{O} \ge 40y$ FG) • Bush rope (cut the rope and drink the white sap) (39y PT diagnosed on assessment with LRTI)	Pharmacy drugsNo treatSeptrinAmox• "[Q: d](51y PT,(55y)treat thisd ondiagnoassessmeassessmesed oncough."nt withassessSaid hadLRTI andmentbut hadCOPD)withtreatmerLRTI,diagnoseassessmeCOPD)URTI, LPT (diagnosecoupl.)"e06 46y	tmentDrink coldlo peoplecoldsillness?]waterey just( $\mathcal{J} < 40y$ r (KI) •fG)1 "Sotwin"had nott (P of 2y,ed onent with.RTI; 48ygnosed onent with50y PT;PT).

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# 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.

Names	<i>"Susu cancer"</i> Breast cancer (♂≥40y Focus group [FG])	<i>"cancer bodi insait"</i> Cancers inside body (♂≥40y FG)	"Sik bilong ol mama"           Cervical cancer (♀<40y, ♀≥40y FGs)			
Who	Allot of us / "Now a lot of us living here have cancer to the hospital in order to get medicin "you have cancer"" (3>40y FG)	We don't know r we don't know ourselves who e or something the doctors the	"Mothers, older women, en we go younger women" y will say (♀≥40y FG)			
When	"It arrived in	2014 in the communities around	here" (♀<40y FG)			
Cause	"No sure" M (♀<40y FG) "Eating meat or th dry the meat prop cause some illness there's water from boil it and you eat	"No sure"Meat and FishSmokingBetel $(\bigcirc < 40 \text{y FG})$ "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 hoil it and you eat it" ( $\bigtriangleup > 40 \text{y FG}$ )This cancer that tends to be with a cough ( $\circlearrowright > 40 \text{y FG}$ )Betel "OK cher of betelm sometimes smoke a lot then cancer will occur" ( $\circlearrowright > 40 \text{y FG}$ )				
Signs and symptoms	"We don't know ourselves we find out from the doctor"CoughPatient is red"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"Cough "it tends to occur with a cough and illness inside it tends to occur again inside" ( $3 \ge 40y$ FG)Patient is red "They will look lid blood" ( $2 \ge 40y$ FG)					
Treatment	"C Hospital treatment not always succe particularly if patients flee treatm "OK cancer if it occurs, there is no way this, sometimes we go to the doctor and doctor is able to cure the cancer, it will finish suppose we tell them about our and we go and stay in the hospital, it's li cancer can be stopped but if we are afrai the injection or something and they get t needle out and we run away, sometimes cancer will not stop and the cancer will on the body and after you become an old man you can die from this" (♂≥40y F	Duly the hospital will treat" (\$<40	by FG) referrals, hospital attendance to delayed e. She – she got the cervical cancer, she got years if Wanang have a small haus sik report and then move to the general hospital get treatment. But because of no haus sik elf she think that she is OK but the sickness we all never know what is with her, so after, - stage 4, then we all surprised then we took to to the x-ray and they said "oh, cervical 0-50" so we try two hospitals here in work as they said no medicine, we move her diawa General Hospital, and we went there o, that's happened to like my mother and his )			

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**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 Focus Groups [FG])	≥40y, " <b>K</b> a	<b>vnam"</b> (Local langua ්>40v. ්<40v FG)	ige: "Pukp	<i>uk"</i> "crocodi ♀<40v. ♂<4	le" (Tok Pisin: 0v FGs)
				*7	011	
Who	Everyone, particularly infants & ch	ildren	Children	Young	Older wo	omen, people
	• "Everyone, all ages" $(0 \ge 40y \text{ FG}) \bullet$	tends •	Most of the	men	are	niding it
	to occur in children, also people like us	, and chi	Idren have this	"Grile	There's a	lot of tinea.
	maybe some older men [and] wome	n as dis	ease (KI)	common in	I ve got it r	nyself and I
	well, fittle girls too. Wost of the time the	nea •	[Q] You say most	young mon"	tinon A lot	of us sitting
	occasionally" ( $3 \le 40$ y EG) • "older pa	anle <i>Ib</i>	ne chilaren nere	(Research	down here	bave it some
	middle aged people and some children	as well ma	nv children do vou	Technician	neonle are	hiding it so
	Maybe from small to older people" (Ke	v ha	ve in the school?	[RT])	you can't s	$e it$ " ( $\bigcirc >40v$
	Informant [KI])	[A]	I have 186." (KI)	[[[[]]]	FG)	(+=10)
When	Anytime • "It doesn't have seasons." (	KI) • "Year to	year. Mainly in the ra	ain" (්<40y FC	G) ● "Anytim	e" (♂≥40y FG)
Cause	Wet clothes	Contamir	ated rivers	Touch	and sharing	clothes [and
	• "You bathe and keep • "we b	athe in the rive	r, like bad swamp wat	er, differin	g body-type	susceptibility]
	wet clothing on you will water th	at is not clean,	not flowing or	<ul> <li>"friend</li> </ul>	l of yours use	s [wet] clothes,
	get tinea very fast" another	man is bathing	upstream from you, i	n sleeps wi	th everything	on, sleeping
	$(3 \ge 40 \text{y FG}) \bullet \text{``if you go}$ that way	you can catch	tinea." (KI) ● "Say I	in bed an	d if I sleep al	ongside him, I
	walking in the rainy have tin	ea and bathe up	ostream and a man	touch hin	n while sleep	ing, still I will
	season get wet in the without	tinea is bathing	downstream, then	get tinea	in this case, t	ooth of our
	rain, and you don't change these fit	rrias them and	he can get them you	but if my	uch so it can	move across,
	on you sleep with the	ferent kinds of	water some won't ha	ve get tinea	from him it y	will not want
	same things these wet tinea so	me will " $(2>2)$	(0v FG) • "if a man	to and	if my body is	the same type
	things will cause this with ting	ea washes som	ething upstream from	as his. I y	vill catch Gri	le" (∂>40v
	tinea you're walking you and	you wash som	ething you will get it?	FG) ● "I	f a man has th	is tinea and
	along a long roadyour (3<40y	FG) • "they u	se river for washing	you use s	omething of	his, it will
	shirt will be sweaty you it's caus	ed by that and	then the clothes they	spread to	you. The san	ne clothes, if
	sit down rest, that will wear	During the sun	ny period the fast-	they have	e tinea in then	n, you wear
	cause this" ( $3 < 40 \text{y FG}$ ) • flowing	rivers become	small algae grows	. your clot	hes, you will	get it."
	"when you walk in the rain <i>children</i>	like to jump in	to those riversthose	e (∂<40y l	$FG) \bullet transm$	itted from
	and you don't change your algae	give them back	eria, so they have	person w	ith Grile tr	ansmitted from
0. 1	clothes (KI) Grile.	(KI)	a dila a sociatabilita a	other boy	s (patient his	tories)
symptoms	• "Skin like crocodile. You might get i will be painful" (♂≥40y FG) • "They y FG) • Some people are hiding it so you	t on your arm o will be scratchi 1 can't see it" (	or leg A man with ting it's like all over ♀≥40y FG) ● " <i>Itchy c</i>	inea will scratch the body, that's all the time and	n, a woman al what this tin <i>they tend to s</i>	so, the skin ea is" (♂<40y <i>cratch it all</i>
	the time. [Q]: So they're itching, this co	ould be other c	onditions so how do w	ve know it's Gri	ile? [A]: Itchy	, and it just
Tractment	go on their skin by tooking at them ye	forest medicin	we huy medicines	) [but] it just :	comes back	$^{\prime}(A < 40 \text{ y EG})$
Treatment	Traditional treatmen	of est meatern	Ho	nital/Pharma	v	Effectively
	Plant-based ointments from the fore	st Placing s	kin Grile cream	Grile f	ablet	No
	Lime. Seeds of "Moder"	" inside	[Tolnaftate]	Terbi	nafinel	treatment
	pepper, "sigwal" [Papaya	banana t	• "In the tow	n • "Occ	casionally.	"There is no
	and tree tree blood]	"Medicin	e I one gets medi	cine If a ma	in has	treatment.
	bud paste	use	like ointment	"doubl	e" tinea all	Looking at
	<ul> <li>"take kambang [lime powder used</li> </ul>	removes t	inea   liquid medici	ne, over th	e body, all	them I
	when chewing betelnut], daka [pepper	from peop	ble, to just rub in,	and the me	dicine	always
	chewed when chewing betelnut], and the	he take a kni	te this OK	won't	be able to	encourage
	bud from this tree flower try to mix	and make	a Something like	stop II.	you just	"when you
	them with kambang." $(KI) \bullet$ "There's a trac with group leaves and valles."	hanana nl	ant medicine neo	nle hospits	and you	go into town
	flowers, it's found in sandy arous arour	-any ban	and tend to use	go to t	he chemist	go thio town
	large bodies of water [local name:	nlant – w	hen Panadol type	- and bu	v medicine	chemist and
	"sigwal"] say you're walking along	it's opene	d, tablet" (♂<40	v specifi	cally for	buy some
	the road you see it. it bears vellow	put the sk	in FG) • Grile	tinea a	nd you	medicine".
	fruit, unripe ones will be green yo	u infected v	with cream; Grile	drink i	t and this,	But looking
	just take a strainer, it will get the	tinea insid	le tablet; most c	ases will re	cover"	at their
	seeds and you can just close them	now it en	ds of past Grile	(∂≥40	y FG) ● "I	number most
	within a leaf and heat them in the fire	e their tinea	is cream treatme	ent encour	age them	have Grile.
	and when they've been heated a bit, tak	e curedt	here used; diagnos	15 "if you	r parents	Especially
	them out and you rub them One thin	g is no spol	en was by self	going i	to town, tell	my school
	is papaya – grate it, the papaya fruit,	words or	(patient histor	(ies) them to	o buy, go to	children."
	when you've grated it a lot, this blac	k anything.	 . all	chemis	t and buy	(KI)
	blood that they have, you will take this	inowaday	5 all	their to	wiels and	
	and you scratch your tinea and you rub	US US US US	ι	• Grile	tahlet	
	it in the use place where it is the	use uns	1	- Onle	aurer	1
	nain " $(2 \le 40 \text{ y EG})$	method"		from n	harmacy	

# 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.
<sup>6</sup> 2. Subjectivity (Are the researchers' background, prior knowledge and relationship to the community, and cultural competence clearly presented and addressed?) <sup>6</sup>	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.
<sup>6</sup> 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. <sup>9</sup>	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.

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	Item No	Recommendation	Page & line
Title and abstract	1	( <i>a</i> ) Indicate the study's design with a commonly used term in the title or the abstract	1, 1–4; 2, 35–36
		( <i>b</i> ) 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	4–5, 69–130. Additionally, extensive wider background and

		being reported	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	<ul> <li>(a) Give the eligibility criteria, and</li> <li>the sources and methods of selection</li> <li>of participants. Describe methods of</li> <li>follow-up</li> <li>(b) For matched studies, give</li> <li>matching criteria and number of</li> </ul>	Described extensively in published protocol paper. In manuscript: 6, 145–148; 7, 190–194. Follow up n/a. n/a, not a matched study.
		exposed and unexposed	
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.

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		potential sources of bias	_ 0
Study size	10	Explain how the study size was	Paper: 6, 145–148; 7, 190–191.
		arrived at	Protocol paper, Table 1'Study cohort and
			justification of participant numbers and
			composition'.
Quantitative variables	11	Explain how quantitative variables	Paper: 6, 162–164; 7, 194–197; table 2.
		were handled in the analyses. If	Paper's Supplementary File: 3, 'Generating
		applicable, describe which	combined all-group rankings'
		groupings were chosen and why	
Statistical methods	12	( <i>a</i> ) Describe all statistical methods,	Only basic descriptive statistics reported: 6–
		including those used to control for	162–164; Paper's Supplementary File: 3,
		confounding	'Generating combined all-group rankings'.
			(Note: See other attached reporting checklist
			RAP studies which covers wider methods
			used)
		(b) Describe any methods used to	6 167–169
		examine subgroups and interactions	0, 107 107
		(c) Explain how missing data were	8 214-215
		addressed	0, 21+-215
		(d) If applicable, explain how loss to	n/2
		(a) If applicable, explain now loss to	II/a
		(a) Describe and constitution and have	
		(e) Describe any sensitivity analyses	11/a
Results	1.2*		7 204 211 5' 2
Participants	13*	(a) Report numbers of individuals at	7, 204–211; Figure 2.
		each stage of study—eg numbers	
		potentially eligible, examined for	
		eligibility, confirmed eligible,	
		included in the study, completing	
		tollow-up, and analysed	
		(b) Give reasons for non-	6, 146–147; 7, 191–194.
		participation at each stage	-0
		(c) Consider use of a flow diagram	Figure 2
Descriptive data	14*	(a) Give characteristics of study	4, 79–93; 7, 205–211; Figure 2
		participants (eg demographic,	Paper's supplementary file, Table S1
		clinical, social) and information on	
		exposures and potential confounders	
		(b) Indicate number of participants	8, 214–215; paper's supplementary File, Tab
		with missing data for each variable	S2.
		of interest	
		(c) Summarise follow-up time (eg,	n/a
		average and total amount)	
Outcome data	15*	Report numbers of outcome events	n/a
		or summary measures over time	
Main results	16	(a) Give unadjusted estimates and, if	Our main results are not of this type as our
		applicable, confounder-adjusted	study is a combined clinical and rapid
		estimates and their precision (eg,	anthropological assessment. Main results are
		95% confidence interval). Make	reported: 8-14, 216-444; Table 1; Figure 3;

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Page 2 of 3

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			Surfaces_WanangHealthNeedsSTROBE_3
		adjusted for and why they were	
		included	See other attached reporting checklist re RAP
			studies for more details.
		(b) Report category boundaries	n/a
		when continuous variables were	
		categorized	
		(c) If relevant, consider translating	n/a
		estimates of relative risk into	
		absolute risk for a meaningful time	
		period	
Other analyses	17	Report other analyses done—eg	See answer to 16a above.
		analyses of subgroups and	
		interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with	15, 446–467.
		reference to study objectives	
Limitations	19	Discuss limitations of the study,	3, 57-68; 15, 468-490; discussed in detail in
		taking into account sources of	our published protocol paper, with signposting
		potential bias or imprecision.	in this manuscript 16, 478–480
		Discuss both direction and	
		magnitude of any potential bias	
Interpretation	20	Give a cautious overall	16–18, 491–577
		interpretation of results considering	
		objectives, limitations, multiplicity	
		of analyses, results from similar	
		studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external	16, 491–508
		validity) of the study results	
Other information			1
Funding	22	Give the source of funding and the	22, 639–644
-		role of the funders for the present	
		study and, if applicable, for the	
		original study on which the present	
		article is based	

\*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

Jo Middleton<sup>1\*</sup>, Gavin Colthart<sup>1</sup>, Francesca Dem<sup>2</sup>, Alice Elkins<sup>3</sup>, James Fairhead<sup>4</sup>, Richard J Hazell<sup>3</sup>,
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**Keywords:** Primary care; Tropical medicine – anthropology, epidemiology; Qualitative research;

29 Health services administration and management; Neglected diseases.

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**ABSTRACT Objectives:** Determine community needs and perspectives as part of planning health service incorporation into Wanang Conservation Area, in support of locally driven sustainable development. **Design:** Clinical and rapid anthropological assessment (individual primary care assessments, Key Informant [KI] interviews, Focus Groups [FGs], ethnography) with treatment of urgent cases. Setting: Wanang (pop. c189), a rainforest community in Madang province, Papua New Guinea. Participants: 129 villagers provided medical histories (54 females (f), 75 males (m); median 19y, range 1mo-73y), 113 had clinical assessments (51f, 62m; median 18y, range 1mo-73y).  $26 \ge 18y$ 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.

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#### STRENGTHS AND LIMITATIONS OF THIS STUDY 7

- 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.
- 2 The mixed-method approach provided increased confidence in findings by triangulation of 3 qualitative and quantitative data.
- 4 Treating urgent cases was an immediate benefit to partner communities in advance of full 5 provision of health services.
  - 6 Rapid assessments can overlook nuances which may be picked up by more prolonged
- μ the bh rately as sin<sub>e</sub> 7 ethnographic methodologies, and the breadth of health issues assessed reduced capacity to report
- 8 specific health burdens as accurately as single-disease focused research.

# 69 INT 70 Papua

# 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]

# 77 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

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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. 

# 121 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
 the provide the provided 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?

# 128 METHODS

# 47 129 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 atthe 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  $\geq 18y$  for FGs. Recruitment for both was self-selecting, by attending the temporary research shelter after a village meeting. KIs  $\geq 18$ y 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 

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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 

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

211 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**

# 217 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  $\geq$ 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. 

# 45 233 Disease burdens

### 47 234 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 

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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 $\geq$ 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  $f \ge 40y$  or < 40y as a community health problem, but  $m \ge 40y$  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.

Review only

Table 1. Health issues affecting the Wanang community and priorities for service introduction, as

Ranked lists were produced using the nominal group technique [18], combined group ranks by reverse weighting (scores in

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

brackets, method, supplementary file, p.3). Italic text is untranslated direct speech, Tok Pisin names/descriptions are given at

identified and ranked by sex-age based focus groups

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(b) Priorities for service introduction, identified and ranked by sex-age based focus groups

	Females <40y	Males <40y	Females ≥40y	Males ≥40y	<b>Combined rankings</b>
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".  $\ddagger$  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".  $\blacksquare$  "Ai bilong pis".  $\P$  "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", "Helping ol mama long karim bebi". 1 "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".

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3 4	279	Medical histories, clinical assessment, and urgent treatments
5	280	Seventy-five participants (40m, 35f; 58.1%, n=129) were reported to have ever had "malaria"; 23
6 7	281	(6f, 17m; 17.8%) "sotwin"; two (1f, 1m; 1.6%) cancer. Thirty-five (12f, 23m; 27.1%) had had
8	282	"grile", with other infectious skin conditions also highly represented: skin ulcers, 16 (6f, 10m;
9 10	283	12.4%); scabies, 11 (4f, 7m; 8.5%). No f<18y reported having children or problems during
11	284	pregnancy/birth. Of 30 f≥18y, 27 had given birth to live children: 128 in total (mean 4.7 per female
12 13	285	with a child, range 1–14), of which 15 (11.7%) had since died. Nine (33.3%) had experienced
14 15	286	problems during pregnancy/birth. Summary clinical results are illustrated in figure 3 and listed
16	287	(disaggregated by sex) against ICD-11 primary and specific codes in supplementary file (table S2,
17 18	288	p.4). Primary categories with the highest diagnoses were 'certain infectious or parasitic diseases' and
19	289	'diseases of the respiratory system' (each respectively with 41 diagnoses, 24.4% of the total 168),
20 21	290	followed by 'symptoms, signs or clinical findings, not elsewhere classified' (25, 14.9%). The next
22	291	largest grouping was 'well', an evaluation given to just 11 of 113 examined (9.7%). This was a
23 24	292	clinical impression based primarily on self/parent declarations of no current illness, but also appraisal
25 26	293	of medical histories, conversation with the persons, and not observing signs of disease. The five most
20 27	294	common diagnosed specific conditions were acute upper respiratory infection (URI)' (25, 22.1% of
28 29	295	those examined), tinea imbricata (15, 13.3%), lower respiratory tract infection (LRTI) (10, 8.8%),
30	296	malaria (9, 8.0%), and confirmed or suspected tuberculosis (9, 8.0%). GC noted a wide spectrum of
31 32	297	malaria severity, and <i>Plasmodium falciparum</i> and <i>vivax</i> were both present (mixed in some cases). A
33	298	greater proportion of females had URI (16, 31.4%) than males (9, 14.5%), in contrast to tinea
34 35	299	imbricata (11m, 17.7%; 4f, 7.8%) (supplementary table S2). Many diagnoses were only made in one
36 37	300	or two individuals (29.2% of total illness diagnoses, 49 of 168). Sixty-two villagers received urgent
38	301	treatments (30f, 32m), 31 (15f, 16m) were referred to Madang hospital for further investigation. ICD-
39 40	302	11 has a 'diseases of the skin' primary category, but many infectious skin diseases are categorised
41	303	elsewhere, mainly as 'certain infectious or parasitic diseases'. Figure 3 compensates by outlining in
42 43	304	red infections or parasitic conditions primarily affecting the skin (30 diagnoses, 17.9% of
44 45	305	morbidities). In addition to tinea imbricata (the second most diagnosed illness overall), tropical ulcers,
45 46	306	scabies, yaws, and post-traumatic wound infections were diagnosed. Multiple participants reported
47 48 40	307	these substantially affected their life because of itch, pain, disruption of sleep and inability to walk.
49 50	308	Concordance
51 52	309	There was generally strong concordance between diagnoses most frequently made following
53	310	assessment, medical histories, and the health issues the community identified as being most important.
54 55	311	For example, three of FGs top four ranked health issues ([a] "malaria"; [b] "sotwin"; [c] "grile".
56	312	Ethnoclassification taxonomies, supplementary tables S3-6, supplementary file, p.6-9), translated to
57 58	313	the five biomedical conditions we diagnosed most ([a] malaria; [b] URI, LRTI, TB; [c] tinea
59 60	314	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.

# 317 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  $\geq$ 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: 

40337"we live in the forest so we have information about all little types of forest medicine... we4142338know to take sap from vines [for] coughs... Diarrhoea too can be treated by medicine from43339the forest... [but] lower abdominal pain doesn't have a forest medicine... you go out to the4445340hospital" (f<40y FG).</td>

47 341 Rituals were reported in a patient history and FGs:

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

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.

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1

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2		
3 4 5 6 7 8 9 10 11 12 13	350	The ward councillor reported no aid posts, patrols, or health NGOs operated in the upper Ramu
	351	lowlands; an area he estimated to have c8000 persons. To reach the nearest post:
	352	"you have to walk for a day sleep there, get treatment and then walk back [but it often
	353	doesn't have supplies as] whenever there is a lot of medicine everyone from Musak, Kibirai
	354	and Ramu, they all come the medicine tends to run out in one day" (KI).
	355	Combined with concerns about violence in the neighbouring area, this meant traveling to Madang
	356	town in a Public Motor Vehicle or with Binatang Research Centre was often preferred. Maternal
14 15	357	mortality is high in PNG, but one KI reported that with road evacuation by Binatang Research Centre:
16	358	"in the last five years, not a single mother giving birth died in childbirth. Because we are
17 18	359	safe in the time since conservation work has been occurring, we have [Binatang Research
19	360	Centre] emergency vehicle tends to come and take us" (KI).
20 21	361	However, improvised stretchers were still required transport for ill/immobile individuals to the
22	362	roadhead. KIs and FGs discussed further barriers on reaching the provincial hospital, including that it
23 24	363	often didn't have sufficient supplies:
25 26	364	"hospitals are running out of medicines, normally they check the patient and send them
20 27	365	to go to the chemist to buy. So you'll see, when people don't have money how will they be
28 29 30 31 32 33 34 35	366	cured" (KI).
	367	Illiteracy and unfamiliarity with institutions left some unable to navigate the hospital (spatially or
	368	bureaucratically), deterring attendance:
	369	"sometimes they afraid come to the hospital because most things are written in English" (KI)
	370	"some older women/mothers, they don't tend to go, big hospitals have a lot of wards. When
36 37	371	you go inside, you will go back and forth looking over a lot of areas you will be
38	372	confused making you not want to go to the hospital" ( $f \ge 40y$ ).
39 40	373	Without an aid post, villagers lacked formal referrals. Given such barriers, participant medical
41	374	histories and KI reports indicated secondary care attendance was frequently delayed, and clinical
42 43	375	diagnosis and treatment bypassed by purchasing medicines from pharmacies for immediate/future use,
44 45	376	or simply by not seeking biomedical care despite wishing to do so.
46 47	377	Top four health issues identified by FGs as affecting the community
48	378	Ethnoclassification taxonomies for each of the top four health issues identified by FGs are in
49 50	379	supplementary tables S3-6 (supplementary file, p.6-9), including example quotes from KIs, FGs, and
51 52 53 54	380	patient histories on how the diseases are understood, who treats them, and how. Though the belief
	381	"sanguma poison" (sorcery) causes some illness was voiced in the m≥40y FG, they seemed in
	382	agreement that "malaria sores, "sotwin" or that kind of thing are not to do with this." All causes
56	383	given by FGs and KIs for the top four diseases were biological, none mentioned sorcery as causal.
57 58	384	However, two examined participants declared they thought sorcery explained their ailments
59 60	385	("sotwin"; lower body pain), and two others attributed death of some of their children to sorcery.

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"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 

 

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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 $\geq$ 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. 

# <sup>38</sup><sub>39</sub> 443 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</li>
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).

- 452 Child vaccinations ranked next highest, identified by three FGs, but not m<40y. Transport was ranked</li>
  453 first by f<40y, a priority by two other FGs. Pregnancy and birth care within the community was</li>
  454 vocalised by female FGs and m≥40y, but not m<40y. Jointly scoring with pregnancy and birth care</li>
  455 was family planning, identified by f<40y and m≥40y (the latter ranking it their second highest</li>
  - Page 15 of 32

456 priority). One KI stated people would welcome family planning services to enable increased birth457 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</li>
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. 

# 56 488 Strengths and weaknesses

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 489 Study strengths include its cost-effective time frame, and a mixed-method approach that increases
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 490 confidence in findings by triangulating qualitative and quantitative data. However, speed was also a

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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 

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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. 

# <sup>26</sup> 576 Implications for clinicians and policymakers

# 28 577 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 

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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 threephases (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. 

# 33 616 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. 

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# 633 *Integrating action on health and conservation*

As well as supporting the conservation community at Wanang, the establishment of an aid post powerfully demonstrated to surrounding communities the benefits of forest preservation, directly leading new clans to join the collaboration and commit to refuse secondary logging of regenerating previously selectively logged forest (expected to commence 2025). This has directly resulted in expansion of the conservation area from 100 km<sup>2</sup> to 150 km<sup>2</sup>. Beyond the direct findings of our health needs assessment, this then has implications for policymakers and others looking to identify innovative ways to make progress on the Sustainable Development Goals (SDGs), which are mostly implemented individually[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.

# 644 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 nonclinically corroborated prevalence estimates from community surveys) state more often how meanings encoded in local terms have been translated into biomedical categories (and vice versa).

# 2 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 nd acı ... 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. Onroad 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

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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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### 680 STATEMENTS

681 Supplementary file: This file has been produced by the BMJ Publishing Group from an electronic682 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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36	913	FIGURES
37 38	914	Figure 1. Study setting
39 40	915	A: Overgrown logging road on the way to Wanang. B: Wanang area. C: Mural honouring the role of aid posts in
40 41	916	PNG medicine on the wall of Madang Provincial Hospital. D & E: Examples of individual health books in-use
42 42	917	in-region at the time of this assessment. F: Traditional house in Wanang village. G: New Guinea common spiny
43 44	918	bandicoot ( <i>Echymipera kalubu</i> ). Credit: A, C, D, E, and F, first author JM; B, co-author JP; G, Daniel Heuclin
45 46	919	(SuperStock).
47	920	Figure 2. Methodological approach, participants, and resulting plan of health service provision
48 49	921	Green boxes are outputs: dark, delivered as part of this assessment; light, requiring additional funding for
50	922	provision. Role abbreviations: PC HCP, primary care health care professional (in this assessment a General
51 52 53	923	Practitioner); RTs, research technicians; RF, research fellow.
53 54	924	Figure 3. Clinical results of primary care assessments at Wanang
55 56	925	113 Wanang villagers examined (51 females, 62 males), 168 diagnoses given (not including 11 classifications of
57	926	'well'). The proportion of each concentric circle relates to the proportion a diagnosis was given as part of the
58 59	927	total number of diagnoses, with categories arranged clockwise high to low. The inner circle shows ICD-11
60	928	primary categories, the outer circle ICD-11 specific conditions (or ICD-11 symptoms/signs/clinical findings)

Page **31** of **32** 

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

- 0 933 Figure 4. Phased health service introduction at Wanang
- $\frac{1}{2}$  934 Examples of training provided: fracture management (A), off-road vacuum-stretcher evacuation (B). Wanang
  - 935 Aid Post, outside with a northern cassowary (*Casuarius unappendiculatus*) chick (C)) and backrooms for nurse
  - 936 consultations (D). Examples of disease targets for proactive integrated interventions, tropical ulcer (E), yaws
  - 937 (F), tinea imbricata (G), scabies mite and eggs (H). Images from Madang Province in PNG (specifically: A,
- 938 Baitabag; B, Nagada; C, D, E, F and H, Wanang) apart from *Sarcoptes Scabiei* microscopy (H). Credit: A, D, E,
- 939 F, and H, first author JM; B and G, co-author JAS; C, co-author VN. Photographic consents were provided by
  940 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)



#### 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.

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. Il 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.

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## 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.
<sup>6</sup> 2. Subjectivity (Are the researchers' background, prior knowledge and relationship to the community, and cultural competence clearly presented and addressed?) <sup>6</sup>	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.

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## 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)

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#### 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/browsel1/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	ICD-11 Primary category (ICD-11 code)	Males	Females	All
02/2022 (ICD-11) (ICD-11 code) [authors additional information]	[authors additional information]	N=62	N=51	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) $\Delta$	•		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)

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2					
3	Pain, unspecified (MG3Z)	Symptoms, signs or clinical findings, not elsewhere classified (ICD 21)	1 (1.6)		1 (0.9)
4	Other chest pain (MD30.1)		1 (1.6)		1 (0.9)
5	Chronic primary visceral pain (MG30.00)			1 (2.0)	1 (0.9)
5	Splenomegaly, not elsewhere classified (ME10.01) [resolved]		1 (1.6)		1 (0.9)
6	Diarrhoea (ME05.1)		1 (1.6)		1 (0.9)
7	Abdominal or pelvic pain (MD81)			1 (2.0)	1 (0.9)
8	Subcutaneous swelling, mass or lump of uncertain or unspecified nature (ME61) -			1 (2.0)	1 (0.9)
9	Iliac region (XA0NH8)				
10	Scabies (1G04) §§	Certain infectious or parasitic diseases (ICD 01)	1 (1.6)		1 (0.9)
11	Other and unspecified infestation by parasitic worms (1F90) <sup>††</sup>		1 (1.6)		1 (0.9)
12	Molluscum contagiosum (1E76)		1 (1.6)		1 (0.9)
12	Pyogenic abscess of the skin (1B75.3)			1 (2.0)	1 (0.9)
17	Persistent Postural-Perceptual Dizziness (AB32.0)	Diseases of the ear or mastoid process (ICD 10)	1 (1.6)		1 (0.9)
14	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)
15	Myopia (9D00.0)	Diseases of the visual system (ICD 09)	1 (1.6)		1 (0.9)
10	Talipes equinovarus (LB98.00)	Developmental anomalies (ICD 20)	1 (1.6)		1 (0.9)
17	Unspecified asthma (CA23.3)	Diseases of the respiratory system (ICD 12)	1 (1.6)		1 (0.9)
18	Sleep-related leg cramps (7A82)	Sleep-wake disorders (ICD 07)	1 (1.6)		1 (0.9)
19	Inguinal hernia (DD51) - Left (XK8G)	Diseases of the digestive system (ICD 13)	1 (1.6)		1 (0.9)
20	Gastro-oesophageal reflux disease (DA22)			1 (2.0)	1 (0.9)
21	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)
22	Depressive disorders, unspecified (6A7Z)	Mental, behavioural or neurodevelopmental disorders (ICD 06)		1 (2.0)	1 (0.9)
22	Lower limb varicose veins, not further specified (BD74.1Z)	Diseases of the circulatory system (ICD 11)		1 (2.0)	1 (0.9)
20	Atrial fibrillation (BC81.3)	•••	1 (1.6)		1 (0.9)
24	Physical maltreatment (PJ20) II	External causes of morbidity or mortality (ICD 23)	1 (1.6)		1 (0.9)
25	Totals of diagnosed morbidities *		92	76	168
26					

\*'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;  $\Delta$  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; III Physical maltreatment, 1 of 1.

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 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.

Names	"Malaria" (Tok Pisin	and English) (all)					
Who	Everyo All Focus Groups [FG "Everyone" (♂≥40y F	EveryoneOld People and young childrenIll Focus Groups [FG] agreed:"It occurs a lot in young school children" (Key Informant [KI]) ● "Most of the time it's old people, and young children." (KI)					
When	• "malaria can occur a time. In the dry season season – same" (♂<40	All the time at any time" (♂≥40y a, still there are mose by FG)	FG) • "It's all the quitoes, in the rainyMore in the rainy season "Mostly in wet season. So if it rains more, you see more malaria?" (KI)				
Cause	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)	<b>Mosquito eggs</b> "mosquito's eggs will stay inside them and that causes this" (Q < 40y FG)	Mosquitos [local name: 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)	"nagi"] Bush "It all grasses i their hou (KI)	Env y Sv "Swa near area: use." breed place mosq (KI)	ironment yampy mpy e are a ling of for uitos"	Rubbish "Tins and plastics create a breeding place for mosquitoes" (KI)
Signs and symptoms	<ul> <li>High fever • shivers • cold skin • yellow skin • strong head pain • feel weak • cannot walk • dizziness • vomiting • joint pain • cough • tired</li> <li>• "skin becomes yellow, they will be ill in the afternoon and morning. They sleep. They will be shivering" (♀&lt;40y FG) • "fever, shivers, headache, cough, cold skin" (♂≥40y FG) • "they feel cold, their hairs will be standing on end, very weak" (♂&lt;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) • Head pain, high fever, weak (P 1y, confirmed malaria) • Head pain,</li> </ul>				• dizziness • ing" (♀<40y anding on end, er, sometimes cing at those th confirmed • Head pain,		
Treatment	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)	Pharmacy drugs Chloroquine • "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)	Steam with media from the forest from the for	ell, I them, o to , and "We use - cover et, find a stick: aves, es, <i>ily a few</i> <i>ty know</i> <i>s how to</i> nks no, hed, we old "We tend he forest <i>va</i> You T these n the	Hospital • "the hospital will treat" (Q<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)	Comfor "Rock cradle them allot" (♀<40y FG)	t Private health care staff Private doctor (P 7y, confirmed malaria)

\*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.

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Ethnoclassification	taxonomy of	"Sotwin"	'(2nd i	n combined	group ra	anking

Table S4. E ıgs) **Lable S4. Ethnoclassification taxonomy of "Solwin**" (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"
	1 ok Pisin Symptomatic labelling to '1 out of Given the dual meaning as biomedical condit	ion and symptom (see left) neor	(Local language) $(\mathcal{A} \le 40 \text{ v FG})$
	breath, to were likely sometimes describing experiences	s of other conditions beyond	(0 10) 10)
	gasp for asthma, particularly when no individual clinic	cal diagnosis had been previousl	у
	breath, to available. • "I don't know what $-$ is it TB or,	we have TB or just asthma or,	
	pant; 2. to that's hard to know If we have medical re-	eport, like most – like at least nd then they can inform us "you	
	asthma' have TB or. just a cough"" (Kev Informant II	$(1) \bullet 50v$ patient (PT).	
	[23] complained of "Sotwin", diagnosed on assess	sment with TB.	
Who	"Everybody/Everyone"	>5y, especially children	Middle-aged people
	• "Everybody/Everyone" Focus Groups [FG]: $\bigcirc$ <40y; $\bigcirc$	"especially like kids, but	and old-age people
	$\geq$ 40y; $\leq$ 40y)* • "asthma is covering all the living people in Wanang from the kids up to the old people "(KI) •	to 16 years then people up to	miadie-agea people
	"cold/cough, " <i>sotwin</i> ", they are very widespread inside	like 30 years and above	Not many young
	Wanang not just older men or women." (KI)	most of them are affected	people." (KI)
33.71		with the coughing." (KI)	
When	• "It's not seasonal - any time" (♂≥40y FG) • "No, all year	round. Cough is all year round	."(♀KI)
Cause	Smoking Chewing Meat, fish, cooking	Sex with Others	Rubbish The sun
	• ( $\partial \ge 40y$ Betel nut • "Eating bloody meat EG) • "think ( $\partial \ge 40y$ Eich like blood so you don't	women "I'm sitting	g and dust $(\bigcirc 40y)$
	the cause is FG) $dry$ it? ( $3 \ge 40y$ FG)	• a woman down and comes and they come	house is
	<i>smoking</i> So	has sex with round	dirty and
	<i>most people</i> has the smell of fish and you	you, this will behind and	you sleep
	around this don't wash it properly and use it as a water container or	cause this use the "sotwin" to same space	With rubbish
	them are water pot for drinking, this	occur" where you	dust, then
	smokers" can cause "sotwin". Fish	(∂≥40y FG) were	you will
	(KI) if you don't dry it properly	• "the women sitting"	get"
	eats it it can cause "sotwin""	[unclear] your (KI)	(⊖<40y FG)
	$(\stackrel{\circ}{\downarrow} < 40 \text{y FG}) \bullet \text{"the}$	them"	10)
	women cook, give to you and you get it? (A<40y FG)	(♂<40y FG)	
Signs and	Heavy breathing • fast breathing • difficulty during	physical exercise • coughing	• <i>"sotwin</i> " • weakness
symptoms	• "When you walk up and down the mountain, you might ca	ll the "stretcher man"" (♀<40y l	FG) ● "If a man is
	breathing very heavily then we would know, he has "sotwin"	. Walking long distancesyou	will see coughing a lot
	He will sit down, walk around and just rest close to [the vi	$(0 \ge 400 \text{ FG}) \bullet$ The man	might be cougning a lot.
	like, your breath will become locked and you will faint" ( $\mathcal{J}$	40y FG) • "They tend to cough	publicly, like openly.
	When they walk around you will see them coughing." (KI) $\bullet$	"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 very very very very very ver	ery fast" (KI) $\bullet$ said had D: Parent [P] of 1y
	diagnosed on assessment with URTI) • has no strength (39y	PT, diagnosed on assessment w	ith LRTI) • Sotwin a lot
	(P of 11months, diagnosed on assessment with LRTI)	, .	,
Treatment	Medicine from the forest	Pharmacy drugs No t	reatment Drink
	Banana drink Papaya leaf Vine sap	Septrin Amox $\bullet$ (51) PT (55) treat	Q: do people cold
	• "banana in a cup, strain it, give it to the child. You can	diagnose PT, "No	They just $(3 < 40y)$
	heal it in the village (unlike malaria which is hard - for that	d on diagno live	with the kus, FG)
	you should go straight to the hospital). Papaya leaf $(\ddagger 40)$ FG) • "You get some san from a vine, just san from a vine.	assessme sed on coug	gh." (KI) ●
	cut it [local name: "bamul"]" ( $3 < 40y$ FG) • "it doesn't	LRTI and ment but l	had Solwin
	have this kind of strong medicine from the forest. We have	COPD) with treat	ment (P of 2y,
	tried many times when "sotwin" has occurred and you take	LRTI, diag	nosed on
	help you for a short time a day and tomorrow or the day	COPD) asse	ssment with
	after "sotwin" will occur again, OK some "sotwin" doesn't	PT (	diagnosed on
	go on for very long, it can go away and stop, and some	asse	ssment with
	people if "sotwin" has already taken hold of them, they will try all kinds of medicine but it won't be enough the	COL	PD; 50y PT;
	"sotwin" will continue all the way until you become old	e06	46y PT).
	and they die" ( $3 \ge 40y$ FG) • Bush rope (cut the rope and		
	drink the white sap) (39y PT diagnosed on assessment with		
	LKII)		

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#### 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.

Names	<i>"Susu cancer"</i> Breast cancer (♂≥40y Focus group [FG])	" <i>cancer bodi insait</i> " Cancers inside body (♂≥40y FG)	<i>"Sik bilong ol mama"</i> Cervical cancer (♀<40y, ♀≥40y FGs)				
Who	Allot of us / We don't know"Mothers, older women,"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"Mothers, older women, younger women""true here cancer" $(2 \ge 400 \text{ FG})$						
When	you have cancer (0 240y FG)	2014 in the communities around he	re" ( $\bigcirc <40 \text{ y FG}$ )				
Cause	"No sure"Meat and FishSmokingBetelnut( $\bigcirc <40y$ FG)"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" ( $\bigcirc \ge 40y$ FG)Betelnut "OK chew a lot of betelnut 						
Signs and symptoms	"We don't know ourselves we find out from the doctor"CoughPatient is red"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""it tends to occur with a cough and illness inside it tends to occur again inside" ( $\partial \geq 40y$ FG)"They will look like blood" ( $Q \geq 40y$ FG)						
Treatment	(3≥40y FG) Hospital treatment not always succe particularly if patients flee treatm "OK cancer if it occurs, there is no way this, sometimes we go to the doctor and doctor is able to cure the cancer, it will finish suppose we tell them about our and we go and stay in the hospital, it's li- cancer can be stopped but if we are afrait the injection or something and they get to needle out and we run away, sometimes cancer will not stop and the cancer will if on the body and after you become an ole man you can die from this" (3≥40y F	Duly the hospital will treat" (♀<40y essful, Absent Aid Post for ref "my mother and his wife to stop that sick maybe for two ye the there then easy to get a ref in Madang and easy to get illness there, the mother hersel is inside the body, so we id of the sick is like to stage – so it to the hospital, and go to cancer and it's like in 50 Madang, and it cannot wo d to the highlands, to Kundi and she passed away. So, wife" (Key Informant)	FG) ferrals, hospital attendance to delayed She – she got the cervical cancer, she got ars if Wanang have a small haus sik port and then move to the general hospital treatment. But because of no haus sik f she think that she is OK but the sickness all never know what is with her, so after, tage 4, then we all surprised then we took to the x-ray and they said "oh, cervical 50" so we try two hospitals here in rk as they said no medicine, we move her awa General Hospital, and we went there that's happened to like my mother and his				

#### $Surfaces\_WanangHealthNeedsSupplementary\_PR4$

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	<b>"Grile"</b> (Tok Pisin: ♂≥40y, ♀<40y, ♀≥40 ♂<40y Focus Groups [FG])	)y, <b>"Kavnam</b> ∂≥40	r" (Local langua) )y, ♂<40y FG)	ge: <i>"Pukp</i>	<i>uk"</i> "crocodi ♀<40y, ♂<4	le" (Tok Pisin: 0y FGs)
Who	Everyone, particularly infants & child	ren Cl	hildren of the	Young	Older wo	omen, people
	• Everyone, an ages $(0 \ge 400 \text{ FG}) \bullet$ ter to occur in children, also people like us ar	d children	bave this	"Grile	"There's a	lot of tipes
	maybe some older men [and] women as	a disease"	(KI)	common in	I've got it r	nyself and I
	well, little girls too. Most of the time tinea	• "[0] Y	ou sav most	voung	forgot abou	t it! Severe
	occurs in babies, in younger and older mer	i just of the chi	ildren here	men"	tinea. A lot	of us sitting
	occasionally" (♂<40y FG) • "older people	e [have Gr	ile], how	(Research	down here	have it some
	middle aged people and some children as v	well. many chi	ldren do you	Technician	people are l	niding it so
	Maybe from small to older people" (Key	have in the	he school?	[RT])	you can't so	ee it" (♀≥40y
When	Informant [K1]) Anytime ● "It doesn't have seasons." (KI	[A] I hav • "Year to year.	Mainly in the ra	in" (♂<40v FC	FG G) • "Anytime	e" (♂≥40y FG)
Cause	Wet clothes	Contaminated	rivers	Touch	and sharing	clothes [and
Cause	• "You bathe and keep • "we bath	e in the river, like	bad swamp wate	er, differin	g body-type	susceptibility]
	wet clothing on you will water that i	s not clean, not flo	owing or	• "friend	d of yours use	s [wet] clothes,
	get tinea very fast" another man	n is bathing upstre	eam from you, ir	n sleeps w	ith everything	on, sleeping
	$(\bigcirc \geq 40 \text{y FG}) \bullet \text{``if you go}$ that way yo	u can catch tinea.	$(KI) \bullet (Say I)$	in bed ar	nd if I sleep al	ongside him, I
	walking in the rainy have tinea a	and bathe upstream	n and a man	touch hir	in this case h	ng, still I will
	rain and you don't change these little '	crocodile skin pa	istream, the	bodies to	in this case, t	nove across
	vour clothes, vou keep it water carrie	es them and he can	n get them, you	but if my	body is not f	he right kind to
	on, you sleep with the have different	ent kinds of water	, some won't ha	ve get tinea	from him. it y	vill not want
	same things these wet tinea, some	will." (♂≥40y FC	G) ● "if a man	to and	if my body is	the same type
	things will cause this with tinea w	vashes something	upstream from	as his, I v	will catch Gril	e…" (♂≥40y
	tinea you're walking you and you	u wash something	you will get it"	FG) ● "I	f a man has th	is tinea and
	along a long roadyour ( $3$ <40y FG	) • "they use rive	er for washing	you use s	something of l	nis, it will
	shirt will be sweaty you it's caused	by that and then t	he clothes they	spread to	you. The san	ne clothes, if
	sit down rest, that will wear Due to solve this? $(2 \le 40 \times \text{EG})$	ing the sunny per	algae grows	vour clot	thes you will	n, you wear
	"when you walk in the rain <i>children lik</i>	e to jump into tho	ulgue grows se rivers those	. your croi	FG) ● transmi	get II.
	and you don't change your algae giv	e them bacteria. s	so they have	person w	ith Grile tr	ansmitted from
	clothes" (KI) Grile." (KI			other boy	ys (patient his	tories)
Signs and	• SI	kin like crocodile	• scratching •	pain		
symptoms	• "Skin like crocodile. You might get it or	your arm or leg.	A man with ti	nea will scrate	h, a woman al	so, the skin
2 1	will be painful" ( $3 \ge 40 \text{ y FG}$ ) • "They will	be scratching i	t's like all over t	the body, that's	s what this tin	ea is" (♂<40y
	FG) • Some people are hiding it so you can the time $IOI$ : So they're itabing this could	n't see it'' ( $\neq \geq 40$ )	$(\mathbf{FG}) \bullet "Itchy a$	ll the time and	they tend to s	cratch it all
	go on their skin by looking at them you of	can see that they h	ave Grile." (KI	)	ile? [A]. Ileny	ana ii jusi
Treatment	"we are not able to cure we make fore	est medicine, we	buy medicines [	but] it just	comes back.'	' (♂<40y FG)
	Traditional treatments		Hos	pital/Pharma	cy	Effectively,
	Plant-based ointments from the forest	Placing skin	Grile cream	Grile	tablet	No
	Lime, Seeds of "Moder"	inside	[Tolnaftate]	[Terbi	nafine]	treatment
	pepper, "sigwal" [Papaya	banana tree	• "In the town		casionally.	"There is no
	and tree tree blood	"Medicine I	one gets medic	cine If a ma	an has le" tines all	Irealment.
	• "taka kambang [lima powder used	removes tinea	liquid medicin	doubl	e body all	them I
	when chewing betelnut] data [nenner	from people.	to just rub in.	and the me	dicine	always
	chewed when chewing betelnut], and the	take a knife	this OK	won't	be able to	encourage
	bud from this tree flower try to mix	and make a	Something lik	e stop it	you just	them
	them with kambang." (KI) • "There's a	hole in a	that this	need to	o go to the	"when you
	tree with green leaves and yellow	banana plant	medicine peop	ole hospita	al and you	go into town
	flowers, it's found in sandy areas around	– any banana	tend to use	go to t	he chemist	go to
	large bodies of water [local name:	plant – when	Panadol type -	- and bu	ly medicine	chemisi ana
	the read you see it it hears wellow	n s opened,	$FG) \bullet Grile$	y specifi tinea a	and you	medicine"
	fruit unrine ones will be green you	infected with	cream: Grile	drink i	t and this.	But looking
	just take a strainer. it will get the	tinea inside	tablet; most ca	uses will re	cover"	at their
	seeds and you can just close them	now it ends	of past Grile	(♂≥40	y FG) ● "I	number most
	within a leaf and heat them in the fire	their tinea is	cream treatme	nt encour	rage them	have Grile.
	and when they've been heated a bit, take	cured there	used; diagnosi	is "if you	<i>ir parents</i>	Especially
	them out and you rub them One thing	1s no spoken	was by self	going	to town, tell	my school
	1s papaya – grate 1t, the papaya fruit,	words or	(patient histori	ies) them to	o ouy, go to	<i>chilaren.</i>
	when you've grated it a lot, this black	anyunng Nowadaye all		cnemis their t	ablets and	
	and you scratch your tipes and you rub	of us don't		soan fi	here" (KI)	
	it in find the place where it is the	use this		• Grile	e tablet	
	pain." (d<40y FG)	method"		from p	harmacy	
	· · · /	(♂<40y FG)		(patier	nt histories)	

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#### $Surfaces\_WanangHealthNeeds\_PAPChecklist\_PR4$

# 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.
<sup>6</sup> 2. Subjectivity (Are the researchers' background, prior knowledge and relationship to the community, and cultural competence clearly presented and addressed?) <sup>6</sup>	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.
<sup>6</sup> 7. Informant selection (Is a systematic process of selecting informants used and is it adequately described?) <sup>6</sup>	Fully detailed in published protocol. Paper: 6, 145–148; 7, 199–203.
'8. Credibility (Is a strategy for assessing credibility established and presented?)'	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.

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	Item No	Recommendation	Page & line
Title and abstract	1	( <i>a</i> ) Indicate the study's design with a commonly used term in the title or the abstract	1, 1–4; 2, 37–38
		( <i>b</i> ) Provide in the abstract an informative and balanced summary of what was done and what was	2, 40–56
		found	
Introduction			
Background/rationale	2	Explain the scientific background	4–5, 72–130.
		and rationale for the investigation	Additionally, extensive wider background
		being reported	discussion of methodological rationale give
			published protocol paper, relevant section
			posted in start of this paper (4; 77–79: 'He
			we outline site-specific context, biodiversit
			methodological rationale are discussed in
			in our published protocol.[4]')
Objectives	3	State specific objectives, including	2, 35–36; 5, 124–130.
-		any prespecified hypotheses	
Methods			
Study design	4	Present key elements of study design	4, 75–76; 5–6, 132–142; Figure 2
		early in the paper	methodological flowchart.
Setting	5	Describe the setting, locations, and	Description of setting and location: 4–5, 8
		relevant dates, including periods of	123. Periods of recruitment and data collect
		recruitment, exposure, follow-up,	5, 134; 6, 143–145.
Participants	6	(a) Give the eligibility criteria and	Exposure and follow-up n/a.
1 articipants	0	the sources and methods of selection	paper. In manuscript: 6, 145–148: 7, 199–
		of participants. Describe methods of	Follow up n/a.
		follow-up	
		(b) For matched studies, give	n/a, not a matched study.
		matching criteria and number of	
		exposed and unexposed	
Variables	7	Clearly define all outcomes,	6–7, 159–165, 172–182.
		exposures, predictors, potential	Detailed in published protocol paper, and
		confounders, and effect modifiers.	supplementary file.
Dete serves of	0*	Give diagnostic criteria, if applicable	
Data sources/	8*	For each variable of interest, give	6, 143–165; Detailed in published protoco
measurement		methods of assessment	consisted of one community with assessm
		(measurement) Describe	methods uniform across group
		comparability of assessment	methods uniform deross group.
		methods if there is more than one	
		group	
Diag	0	Describe any efforts to address	7 188 100

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		potential sources of bias	
Study size	10	Explain how the study size was	Paper: 6, 145–148; 7, 199–200.
		arrived at	Protocol paper, Table 1'Study cohort and
			justification of participant numbers and
			composition'.
Quantitative variables	11	Explain how quantitative variables	Paper: 6, 171–173; 7, 203–206; table 2.
		were handled in the analyses. If	Paper's Supplementary File: 3, 'Generating
		applicable, describe which	combined all-group rankings'
		groupings were chosen and why	
Statistical methods	12	(a) Describe all statistical methods,	Only basic descriptive statistics reported: 6,
		including those used to control for	171–173; Paper's Supplementary File: 3,
		confounding	'Generating combined all-group rankings'.
			(Note: See other attached reporting checklist r
			RAP studies, which covers wider methods
			used).
		(b) Describe any methods used to	6–7, 176–178
		examine subgroups and interactions	
		(c) Explain how missing data were	8, 233–235
		addressed	
		(d) If applicable, explain how loss to	n/a
		follow-up was addressed	
		(e) Describe any sensitivity analyses	n/a
Results			
Participants	13*	(a) Report numbers of individuals at	8, 221–227; Figure 2.
1		each stage of study—eg numbers	
		potentially eligible, examined for	
		eligibility, confirmed eligible,	
		included in the study, completing	
		follow-up, and analysed	
		(b) Give reasons for non-	6, 146–147; 7, 200–203.
		participation at each stage	
		(c) Consider use of a flow diagram	Figure 2
Descriptive data	14*	(a) Give characteristics of study	4. 81–93: 8. 221–230: Figure 2
		narticipants (eg demographic	Paper's supplementary file Table S1
		clinical social) and information on	ruper s supprementary me, ruble sr
		exposures and potential confounders	
		(b) Indicate number of participants	8 233–235: naper's supplementary File Table
		with missing data for each variable	s?
		of interest	52.
		(c) Summarise follow-up time (eg	n/a
		average and total amount)	11/ u
Outcome data	15*	Report numbers of outcome events	n/a
Guicome uata	15	or summary measures over time	11/ a
Main results	16	(a) Give unadjusted estimates and if	Our main results are not of this type as our
	10	applicable confounder adjusted	study is a combined alinical and ranid
		apprease, contounder-adjusted	anthronological assessment. Main regults are
		estimates and their precision (eg,	antihopological assessment. Main results are
		95% confidence interval). Make	reported: 5–10, 250–400; Table 1; Figure 3;
		clear which confounders were	Supplementary file, 1 able S2–S6.

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		adjusted for and why they were	
		included	See other attached reporting checklist re RAI studies for more details.
		( <i>b</i> ) Report category boundaries when continuous variables were categorized	n/a
		( <i>c</i> ) 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		$\sim$	
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 deta 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			7.
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.