Knowledge, Attitudes, and Practices Regarding Malaria Transmission and Prevention in an Indigenous Maijuna Community: A Qualitative Study in the Peruvian Amazon

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by

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ABSTRACT

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In 2018, the World Health Organization reported 228 million cases of malaria worldwide, which led to 405,000 deaths. Over 90% of incident malaria cases in Peru are localized in the Department of Loreto, and many who reside there live in rural, subsistence farming communities that are geographically isolated from existing healthcare services. Therefore, the emphasis on preventive behaviors, such as sleeping under an insecticide treated bed net, using indoor residual spraying in households, as well as early treatment-seeking is vital to decreasing transmission. However, the uptake of these behaviors is often dependent upon local malaria knowledge, beliefs, and the idea that malaria is embedded and unavoidable in society. This exploratory case study used semi-structured interviews to examine the knowledge, attitudes, and practices related to malaria prevention among the indigenous Maijuna people of Sucusari, Loreto, Peru. We interviewed 33 community members and performed 31 malaria rapid diagnostic tests. All test results were negative for malaria. Themes that emerged were confusion surrounding malaria transmission, knowledge of methods to prevent malaria, changes in malaria cases

over time, treatment-seeking as a common behavior, the belief that medications are effective, and the lifetime use of bed nets. These results should be used as a foundation for further studies among communities in the Peruvian Amazon that have limited access to health services, where culturally resonant, community-based health programming is essential to improving health.

BACKGROUND

Malaria is an acute, febrile illness caused by *Plasmodium* spp. parasites and transmitted to humans through the bite of infected female *Anopheles* spp. mosquitos. In 2018, there were 228 million reported cases of malaria worldwide, which led to 405,000 deaths (World Health Organization [WHO], 2019). Nearly half of the global population across 91 countries lives in areas at risk for malaria infection, the majority of which occur in Africa in areas north and south of the equator. *Plasmodium falciparum* and *Plasmodium vivax* are the most common of the five parasitic species that cause malaria (WHO, 2019). The parasite primarily responsible for malaria in the Amazon Basin is *P. vivax,* occurring at a ratio of 4:1 with the more fatal strain, *P. falciparum* (Ministerio de Salud del Perú*,* 2015; Rosas-Aguirre et al., 2016; WHO, 2015). The malaria parasite is transmitted perennially in the Amazon basin, primarily by the highly anthropophilic *Anopheles darlingi,* and less frequently by *Anopheles benarrochi* and *Anopheles albimanus* mosquitos (Newell et al., 2018; Rosas-Aguirre et al., 2016).

Clinical symptoms of malaria may vary by strain, but commonly include fever, headache, and chills. In severe cases, most often attributed to *P. falciparum,* untreated infections can cause severe anemia, respiratory distress, cerebral malaria, or death. Recommendations in the Amazon Basin for treating uncomplicated malaria, the common and less severe form of the disease, include chloroquine and primaquine combination

therapies since drug resistance levels are fairly low for this species (WHO, 2015). The recommended treatment for *P. falciparum* is an artemisinin-based combination therapy including artesunate and mefloquine paired with primaquine, which was adopted as a first-line treatment in 2015 to combat parasite drug resistance (Recht et al., 2017). While *P. vivax* malaria is less fatal than *P. falciparum*, the perception that *P. vivax* malaria is benign and therefore often neglected has changed in the last decade as reports of more severe *P. vivax* cases emerged, particularly in South America (Alexandre et al., 2010; Lacerda et al., 2007; Quispe et al., 2014; Recht et al., 2017; Rodriguez-Morales et al., 2015). In most countries with endemic malaria, people in low income groups with limited access to health facilities are disproportionately affected by the disease (WHO, 2015). In high malaria transmission areas, children who have not developed partial immunity to malaria, and pregnant women who experience decreased immunity during the pregnancy, are the populations most susceptible to infection, making up over two-thirds of all malaria deaths (WHO, 2019). However, as overall malaria transmission decreases in an area, over time there are less infections and, therefore, decreased protective immunity in the population, which leaves many adults susceptible to the disease (WHO, 2019).

Despite a global decrease in malaria incidence since 2010, there was a substantial rise in case incidence between 2014 and 2016 in the Americas, nearly half of which occurred in the Amazon Basin (Mitchell, 2016; WHO, 2017). Peru was one of four endemic countries in the Americas with a rise in malaria incidence since 2010 and accounted for 19% of the cases in the Americas (WHO, 2019). Incident cases in Peru nearly doubled between 2010 and 2016 (Pan American Health Organization

[PAHO]/WHO, 2016; Recht et al., 2017). In Peru, 11% of the population is considered to be at a high risk for malaria infection; however, 94% of Peru's malaria burden is localized in the region of Loreto (capital Iquitos), which has been listed as high risk since 1995 (Celis et al., 2003; Ministerio de Salud del Perú, 2015; Rosas-Aguirre et al., 2016; WHO, 2017). Between 2012 and 2017, the number of malaria cases in Loreto increased five-fold, to 55,000 cases in 2017 (Centro Nacional de Epidemiologia, Prevención y Control de Enfermedades, Ministerio de Salud del Perú, 2017). The increase may be attributed to changes in the human-environment interface related to deforestation or agriculture (Chuquiyauri et al., 2012; Lainhart et al., 2015; Parker et al., 2013), the occurrence of asymptomatic, undiagnosed or delayed diagnosis of cases (Reinbold-Wasson et al., 2012), the occurrence of major weather events (Pan et al., 2017), inadequate performance of health systems and control methods (WHO, 2015), and improved surveillance methods (Carlton, 2018; Lainhart et al., 2015; WHO, 2017).

While Loreto constitutes nearly a third of Peru's land mass, only 3.3% of the Peruvian population lives there, many of whom live in rural, subsistence farming communities representing a large group of people that are geographically isolated from existing healthcare services . These communities are located in areas that experience heavy rains and flooding, which create slow-flowing streams and swamps (WHO, 2019). Many of these swamps are dominated by the *aguaje* (*Mauritia flexuosa)* palm, that provides shade and nutrients to the surrounding water, creating ideal breeding sites for mosquitos and contributing to residual transmission of malaria throughout the region (Vittor et al., 2009). In remote communities that experience very low rates of malaria

transmission, the movement of individuals outside of their community, often to work, clear farm land, or hunt, can reintroduce the parasite and complicate efforts to eliminate malaria (Fraser, 2010; Rosas-Aguirre et al., 2015).

P. vivax can be controlled in these communities most effectively by vector control, since gametocytes often appear before a person develops symptoms and seeks treatment, meaning an infected person can transmit malaria before showing symptoms (da Silva-Nuñes et al. 2012; Lengeler 2004; Pluess et al. 2010). There are several malaria treatment and prevention initiatives directed by the Peruvian Ministry of Health and local non-government organizations (NGOs) that provide free bed nets and antimalarial drugs, and work to improve regional surveillance, early detection rates, and prompt treatment (Chuquiyauri et al., 2012; Herrera et al., 2012; Krisher et al., 2016; Mousam et al., 2017). In 2016, the Pan-American Health Organization announced a malaria elimination plan targeting the Amazon Basin, consisting of improved vector-control interventions, use of insecticide treated bed nets (ITNs), and indoor residual spraying (IRS) (Newell et al., 2018; WHO, 2015). There have also been several studies in the surrounding region on evolving mosquito behavior, malaria parasite species distribution, changing transmission patterns, insecticide and drug-resistance, and the uptake of preventive behaviors in urban areas (Conn et al., 2018; Lainhart et al., 2015; Mousam et al., 2017; Newell et al., 2018; Reinbold-Wasson et al., 2012; Rosas-Aguirre et al., 2015; Solano-Villarreal et al., 2019). However, despite these extensive research studies and indicated success of these interventions overall, very little research surrounding malaria knowledge, uptake of preventive behaviors, and treatment-seeking behaviors has been conducted in riverine

communities of the Peruvian Amazon, likely due to logistical challenges in accessing these remote populations (Iyer et al., 2019; Limaye et al., 2018; Newell et al., 2018).

The studies that exist, performed in urban and peri-urban areas surrounding Iquitos, have reported that the acceptability of preventive behaviors by individuals and communities can be affected by factors such as perceptions of malaria and its transmission, socio-economic status, gender, and beliefs about the value, safety, inconvenience and effectiveness of mosquito nets (Iyer et al., 2019; Newell et al., 2018; Rosas-Aguirre et al., 2011). Perceptions in these regions include the normalization of malaria symptoms and the idea that malaria is embedded and unavoidable in society, which acts as a major barrier to behavior change (Newell et al., 2018). More studies are needed to understand if these themes are also present among more remote populations of the Peruvian Amazon who experience different levels of risk and access to healthcare. One study conducted in the Peruvian Amazon attributed poor uptake of preventive measures to a lack of community engagement, lack of local malaria knowledge, and beliefs that vary by community and household (Westgard et al., 2018).

Successful health interventions in other countries have been shaped around local culture to increase community involvement and effectively communicate intervention objectives (Erhun et al., 2005; Panter-Brick et al., 2006). In Loreto, one such successful intervention is the widespread use of ITNs, with a reported ITN ownership of over 98.7% of households (Lainhart et al., 2015). ITN use, in particular, may have been successful because it incorporated the intervention into the community's cultural background, and the use of ITNs became habitual and was passed down over generations. To understand

these behaviors among remote populations who are often at the highest risk for malaria with the least access to healthcare, further participatory research addressing human behaviors, local knowledge, and sociocultural attitudes related to malaria is crucial to develop effective control and prevention methods (Jones & Williams, 2004; Newell et al., 2018; Williamson et al., 2015).

To better understand the knowledge and behaviors surrounding malaria in remote, riverine communities, the objective of this study was to provide a knowledge framework for the development of location-specific, culturally appropriate intervention strategies to eliminate malaria in rural communities in the Peruvian Amazon. To create this knowledge framework, we assessed how local knowledge and sociocultural attitudes can influence malaria prevention behaviors and intervention uptake among members of an indigenous community in the Peruvian Amazon. We conducted semi-structured interviews with members of the Maijuna community of Sucusari to investigate understanding of malaria transmission, perceptions of causes, treatment-seeking patterns, and practice of preventive behaviors. We aimed to understand how local knowledge and attitudes toward malaria control strategies influence the uptake of preventive behavior and treatment seeking. The information from this study will contribute to the understanding of malaria health interventions in place, potential barriers to the uptake of preventive behaviors and treatment seeking, and areas where health communication to those in remote communities can be improved. This information can be used by the local government and NGOs that implement health interventions to build on existing health programs in the region and continue working towards the elimination of malaria in Peru.

Themes that emerged were confusion surrounding malaria transmission, knowledge of methods to prevent malaria, changes in malaria cases over time, treatment-seeking as a common behavior, the belief that medications are effective, and the lifetime use of bed nets. These results should be used as a foundation for further studies among communities in the Peruvian Amazon that have limited access to health services, where culturally resonant, community-based health programming is essential to improving health

METHODS

Research Questions

1. What are the local attitudes and knowledge about transmission, treatment-seeking, and prevention of malaria among the Maijuna community of Sucusari?

2. How do the knowledge and attitudes toward malaria impact the behavior of community members, including uptake of preventive actions, treatment-seeking, and malaria care?

3. What inhibits uptake of preventive behavior such as sleeping under bed nets and participating in indoor residual spraying among community members?

    3a. How can this be addressed using community-based and culturally relevant interventions to decrease malaria case incidence in Sucusari?

Study Population

This study was conducted in collaboration with the Maijuna, also known as the Orejón, an indigenous group that lives in the northeastern Peruvian Amazon (Gilmore, 2010). The Maijuna are a western Tucanoan people that reside in four communities: Puerto Huamán and Nueva Vida along the Yanayacu River, Sucusari along the Sucusari River, and San Pablo de Totolla along the Algodón River (Gilmore, 2010). With fewer than 500 Maijuna individuals in these four communities, they are one of the smallest and most vulnerable indigenous groups in Peru (Gilmore, 2010).

This study was conducted in Sucusari (Figure 1), located approximately 126 km by river from Iquitos in the Sucusari River basin, a tributary of the Napo River. The population of Sucusari is 172 people among 32 monofamilial or plurifamilial houses (Roncal et al., 2018). Around half of the individuals living in Sucusari are indigenous Maijuna, while the other half identify as mestizos, meaning they are of mixed Amerindian and Iberian descent (Coomes & Ban, 2004; Roncal et al., 2018). Sucusari community members hunt, fish, farm, and gather forest products for subsistence (Gilmore, 2010). To generate income, residents sell game meat, domesticated animals, agricultural products, and a variety of non-timber forest products in Iquitos and other local communities (Gilmore, 2010). Sucusari represents one of the many riverine communities in the Peruvian Amazon that are located over an hour boat ride from the nearest health post, and whose residents' subsistence strategies require frequent visits into the rainforest. These factors likely put members of the community at a higher risk of being infected with malaria than those in urban areas, and it is important to understand what level of health programming reaches these communities and how it impacts their knowledge, attitudes, and behaviors surrounding malaria.

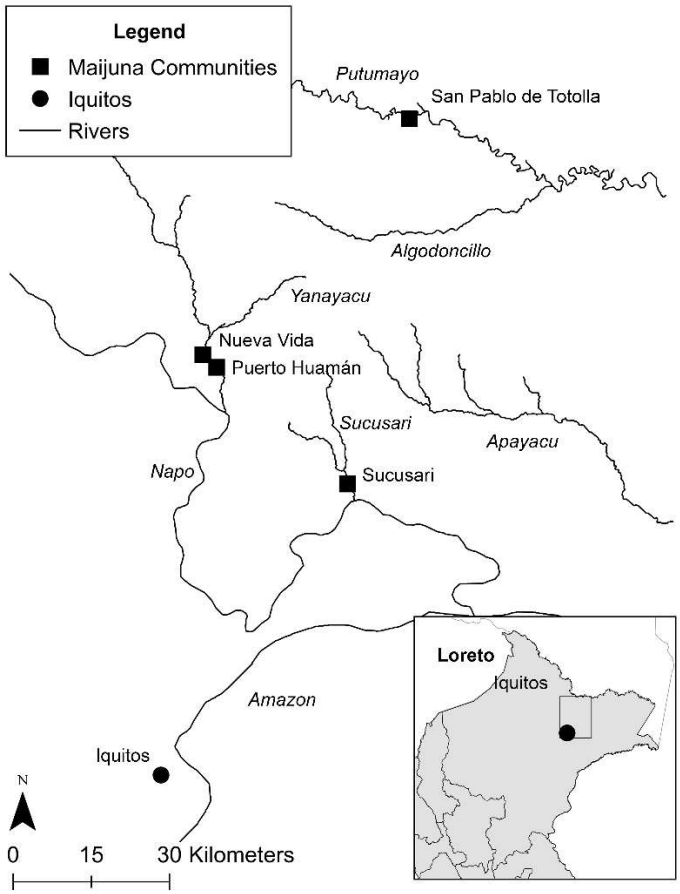

Figure 1 Map of the study site, the Sucusari Maijuna community

Study Area

The Department of Loreto is located in the northeast region of Peru, with ecological characteristics typical of the Amazonian lowlands and a population of 883,510 as of 2017 (Guarda et al., 1999; Instituto Nacional de Estadística e Informática, 2017; Mousam et al., 2017). The mean temperature ranges between 27°C to 29°C, and it is warmest between September and October, with relative humidity ranging between 87% to 93% (Guarda et al., 1999). The rural population of Loreto is clustered in riverine communities throughout the Amazon tributary system, with an economy relying mostly

on agriculture, fishing, logging, and commercial activities (Guarda et al., 1999). Malaria prevalence in Loreto depends heavily upon rainfall and water levels, with high rates of transmission typically occurring two months after the river level rises to its peak, and low rates of transmission typically occurring two months after the river levels are lowest (Guarda et al., 1999).

Study Design

This study was designed as an exploratory case study (Stake, 1995), which is used to provide meaning and understanding to experiences in a given context, and is particularly characterized by an absence of preliminary research or hypotheses (Harrison et al., 2017; Mills et al., 2010;). Because there is very little published research on the experiences of indigenous communities in Peru related to malaria, an exploratory study was used to fill this gap. An exploratory case study provides context to multiple bounded systems, in this case members of the community of Sucusari, that builds the researcher's understanding of the community members' narratives (Iyer et al., 2019; Newell et al., 2018; Stake, 1995). This study type also allows for flexibility in design, and the use of multiple sources of evidence for analysis, including interviews and document examination, providing comprehensive depth to the study (Harrison et al., 2017; Stake, 1995).

This exploratory case study was constructed using a qualitative Knowledge, Attitudes, and Practices framework, which is widely used to guide implementation of public health programs (Launiala, 2009; Muleme et al., 2017). The knowledge component assesses the participants' familiarity and awareness regarding a specific topic.

This knowledge often informs attitudes towards the subject or health program, such as agreement, motivation, perceived self-efficacy, and outcome expectancy. The attitudes towards the subject then impacts whether the participant practices a specified behavior.

To assess knowledge, attitudes, and practices of Sucusari community members related to malaria, this exploratory case study (Stake, 1995) consisted of semi-structured interviews (Newell et al., 2018) and examination of medical registers and documents. Rapid Diagnostic Tests (RDTs) (*CareStart*™ Malaria RDTs HRP2/pLDH (Pf/Pv)) were also performed to determine point prevalence in the community. Purposive and snowball sampling methods were used to select participants to ensure that diverse and information-rich (Frank, 2017) perspectives were considered. A purposive sampling method enabled us to learn about malaria through the perceptions and experiences of males and females of various ages, living in various locations within the community, with differing access to the community center and to health posts outside of the community (Palinkas et al., 2015; WHO/Stop TB Partnership, 2008).

We aimed to perform around 25 to 30 semi-structured interviews, but, ultimately, determined the number of interviews based on availability of time, willingness of participants, and when the interviews reached a saturation point (Newell et al., 2018; Palinkas et al., 2015). Interviews (see Appendix I and II) were locally adapted and created using concepts and question structures from published survey instruments used in qualitative studies related to mosquito-borne diseases in Peru (Frank, 2017; Newell et al., 2018). We initially aimed to perform two focus groups as well, but, upon spending time in the community, realized that with the small community population, individual

interviews were preferred to provide more time for each individual to share their experiences.

Participants

To be included in this study, participants were required to be 18 years of age or older, reside in Sucusari at the time of the interviews, and speak Spanish. There were 13 females and 24 males that volunteered to participate in this study, all who resided in Sucusari. Participants' ages ranged from 18 to 74 years old.

Data Collection

The idea for this project was initially discussed with community leaders, and upon obtaining their prior informed consent (PIC), was introduced to all community members during a monthly community meeting, allowing time for anyone to ask questions or voice concerns. Members of every family in Sucusari were invited to participate in interviews and/or malaria testing. Given that indigenous communities are vulnerable populations due to historical social marginalization and exploitation, care was taken to conduct this study ethically following the principles of respect for persons, beneficence, and justice (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1978). This study was created as a response to previous comments from community members about the burden of malaria in Sucusari, and was performed with the intention of learning about this burden and ensuring the community was receiving resources to prevent and treat malaria. This study was designed to provide results that could be used to strengthen community-based public health intervention strategies, encourage adoption of preventive behavior, and promote a general

understanding of malaria transmission (Gumucio, 2011). Prior to each interview, the interviewers once again described the study and what was being asked of participants, answered any questions, and received PIC before continuing. Participants were also asked for consent before audio recording interviews, which were later transcribed. Each person was asked to participate in an interview and/or a malaria RDT. There were no incentives to enroll in this study, other than to share information that could be disseminated more broadly to improve public health, and participants could opt out of an interview at any time during the process.

Three pilot interviews were conducted in February 2019 with members of the community to ensure clarity and acceptability by participants (Newell et al., 2018). Following each pilot interview, the survey questions were adjusted, and a final survey was deployed for use during the rest of the interviews in February and March 2019. After interviews, researchers set up a workshop to thank the community for their participation, summarize the information that participants shared, and share information on how malaria can be effectively prevented and treated, answering any further questions community members presented.

Interviews were conducted by two interviewers. The primary interviewer was a graduate student studying Global Health with previous research experience studying malaria. This researcher spent one month in the community prior to beginning interviews, but was not fluent in Spanish. The second interviewer, who acted as the translator, had extensive knowledge of the community, lived there for six months prior to the start of the study, frequently interacted with community members and spoke fluent Spanish.

Interviews were performed in the participants' home or in the researchers' home in Sucusari, based on the participant's choice.

In the interviews, participants were asked about their sociodemographic information, health burdens in the community, knowledge of malaria, behaviors related to malaria, attitudes on encounters with health programmers or visiting doctors, and experiences having malaria, if applicable (See Appendices I and II). The Sucusari health promotor was also asked questions specific to their role in the community. Health promotors are voluntary, community-selected community members who are trained by the local government and/or NGOs, and primarily focus on managing cases of fever, malaria, diarrhea, first aid, and other common health issues with medications and tests provided by the government. Sucusari's health promotor was given the pseudonym of Martín for this study. The health promotor was interviewed using the same questions as the rest of the community, and, additionally asked specific questions related to their role in malaria testing, treatment, and recording (see Appendix I and II). Interviews lasted between 20 to 90 minutes, limiting the time commitment but ensuring the participant had sufficient time to share all the information they wished. All interviews were recorded and transcribed, and field notes were taken after each interview summarizing main points.

Analysis

Interviews were transcribed from Spanish to English by the researcher fluent in Spanish. All field notes that were taken during or following an interview were kept in one notebook throughout the project and transferred into individual files prior to analysis. Transcriptions of interviews were coded by the interviewer with malaria expertise using

processes and analysis methods outlined in Saldaña (2015). The transcriptions were first reviewed in a pre-coding process to build familiarity with the data (Layder, 1998), by highlighting quotes and passages that were related to the research questions and creating notes on tentative ideas for codes or patterns (Saldaña, 2015). Following the pre-coding process, the first cycle of coding included Attribute Coding of sociodemographic information, and Structural Coding for the remaining responses to interview questions, helping to categorize responses for further analysis (Namey et al., 2007; Stake, 1995). Attribute coding is a method that organizes essential information regarding participant and site characteristics, such as age, gender, ethnicity, location and education level for future reference and analysis (Saldaña, 2015). Structural Coding is a method used for categorizing the data to further examine similarities, differences, and relationships, and is often used for coding interview transcripts (Saldaña, 2015).

Next, we removed the names and other identifiable demographic information from the data. During the second coding cycle, we built on the information from the first coding phase using Structural Coding and Pattern Coding to group similar codes into clusters. Structural Coding assigns a conceptual phrase to a portion of data framed by a specific question of the interview (Saldaña, 2015). Structural coding is appropriate for categorizing large portions of the data for further analysis, and is useful for analyzing interviews driven by specified research questions (Namey et al., 2008). Pattern Coding is used to re-examine passages with similar codes and identify emergent themes or explanations found in the passages (Miles & Huberman, 1994; Saldaña, 2015). The themes that emerged through this process were then categorized into the knowledge,

attitudes, and practices framework to align with the research questions. Themes that arose that fell outside the scope of the research questions were not included in the results.

The validity of qualitative studies represents the degree of appropriateness and trustworthiness of the tools, processes, and data used throughout the study (Leung, 2015). Several steps were taken across all stages of this project, from the creation of research questions through the analysis stage, to maximize the appropriateness and trustworthiness of results and limit the impact of bias. This study was designed as an exploratory case study to provide meaning and context, within the knowledge, attitudes, practice framework, to experiences with malaria in a community where very little is known regarding this topic (Stake, 1995). Recording of interviews and field notes on observations during interviews were used to ensure descriptive validity, the factual accuracy of what the researchers report (Maxwell, 1992). Purposive and snowball sampling were used to improve internal generalizability, ensuring that experiences shared during interviews represented those of the community, and that participants included represented multiple age groups, different gender perspectives, and those who were and were not ethnically Maijuna (Maxwell, 1992). Interpretive validity, which focuses on understanding the meaning and intentions of reported events and behaviors, was addressed by spending prolonged time in the community to understand patterns of behavior, as well as through the inclusion of several questions about why a participant behaved in a specific way, or how they felt about a specific event occurring (Maxwell, 1992). It is also important to note that the researchers were raised within the United

States, and therefore acknowledge that their perspectives were shaped by Western views of science and medicine, which differ from those of the participants.

RESULTS

Thirty-three participants agreed to be interviewed (Table 1), 27 of whom volunteered to have an RDT done as well. Four community members did not wish to participate in an interview but volunteered to have an RDT done. There were no positive test results for malaria using the RDTs. The current health promotor, and a previous health promotor were included in interviews, and were asked supplemental questions related specifically to their role as a volunteer health worker.

There was a difference in the average reported number of malaria cases participants experienced in their lifetimes between males and females, with 23 male respondents reporting they had malaria an average of six times and six women reporting they had malaria an average of four times. Two women did not respond to this question. While there was a difference in the number of times a participant reported having malaria in their lives, there were no observed differences in themes that emerged by gender. Additionally, there were no observed differences in themes that emerged among those who were ethnically Maijuna versus participants who were not ethnically Maijuna.

Table 1. Interview Participant Demographics

Variables	N = 33 (%)
Gender	
Male	23 (69.7)
Female	10 (30.3)
Ethnicity	
Maijuna	17 (51.5)
Non-Maijuna	16 (48.5)
Age	
18-24	5 (15.2)
25-34	9 (27.3)
35-44	6 (18.2)
45-54	6 (18.2)
55-64	3 (9.1)
65-74	4 (12.1)
Highest Level of Education	
None completed	1 (3.0)
Some primary	11 (33.3)
Completed primary	9 (27.3)
Some secondary	7 (21.2)
Completed secondary	2 (6.1)
Some university	1 (3.0)
Unknown	2 (6.1)

Themes

The results from interviews assessed how local knowledge and attitudes surrounding malaria transmission, prevention, and treatment seeking impacted the uptake of preventative and treatment seeking behaviors. The interviews also sought to understand any factors that inhibited the uptake of preventive behaviors, such as using ITNs and participating in IRS, as well as how community-based interventions could decrease the burden of malaria in the community. The perspectives and themes that

emerged during interviews were grouped as sub-themes within the main knowledge, attitudes, and practices framework.

Participant Knowledge about Malaria

1) Confusion in what is known about malaria transmission

The most prominent theme involved the community's knowledge of malaria transmission. All but three participants referenced the role of mosquitos in transmission as represented below:

> *"They say it comes from the mosquitos, sometimes from water when you leave little pots outside and they fill with water, the mosquitos breed there and then they bite you and you have malaria."* [P01]

> *"Malaria comes from when you throw out your tins and they fill with water and that's where the mosquitos lay eggs. That's how the mosquitos grow and raise their young, then every time a mosquito bites you, you can get malaria."* [P02]

However, beyond the discussion of mosquitos, there was variation in the specific mechanism of transmission described, reflecting some confusion around this topic. The various modes of transmission mentioned included the bite of an infected mosquito, drinking contaminated water where mosquitos reproduce, drinking any contaminated water, and two participants associated malaria with a negative spiritual force. Additionally, one nuclear family who participated in interviews and was not ethnically Maijuna, all discussed the transmission of malaria being related to the consumption of water, with some also mentioning transmission through mosquitos.

One participant, as noted below, listed three different modes of transmission throughout the course of one interview:

> *"If you have malaria, and I don't, if a mosquito bites you and it has malaria then it bites me then I have malaria too. Then they told us that malaria was not going to go away if there was not clean water."* [P03]

> *"They say you shouldn't eat meat from the forest like from huangana [white-lipped peccary] or sajino [collared peccary] or sachavaca [tapir] because then you always get malaria."* [P03]

> *"But sometimes we go upriver, and for example I go to Belisario, and then you drink water from the forest, and I came back with malaria."* [P03]

Some community members attributed malaria transmission to specific locations, such as when they travelled working as loggers in remote areas for extended periods. When asked follow-up questions, they frequently did not specify why they thought that those locations had more malaria than their home village of Sucusari, but some people associated higher incidence with drinking unclean water in those locations. These thoughts are reflected below:

> *"Sometimes when we leave for other parts, we get it."* [P04]

> *"They say [malaria comes] from mosquitos, from water, and we don't know sometimes…I believe more in the water. Because sometimes when I went to*

the forest with my brother in law, we drank water from the aguajales and in the afternoon we had symptoms of malaria." [P05]

"Malaria comes from the water. Now everyone drinks clean water and there is no malaria. If you do not drink clean water everyone gets sick. Nobody can escape. Here, there are loads of aguajales, hundreds of them. When it is winter, the aguajales have water and the mosquitos are there. And what does the water there do? It gets yellow, like rotten water. The mosquitos live there, and there is the malaria. In winter when it rains, all of that water washes out and passes here, and when you drink that it causes harm and malaria. Diarrhea also comes from that." [P06]

In addition to attributing malaria transmission to specific locations, more than half of participants emphasized that malaria transmission was highest after the river rose. The remaining participants said that malaria incidence remained the same throughout the year. Both perspectives are expressed below:

"Yes, malaria always comes back when the floods come. For instance, last year when it flooded there were some cases. In July and August. Because the water has started to go down, but it stays in the lakes and the ponds. That's where malaria comes from. There are not many cases, but there are cases. This is every year, after the water comes. But when there are no floods there is no malaria [P07]

"No, it does not have exact times, it can grab you any time." [P08]

When asked where malaria comes from, many community members used phrases such as “they say” or “they tell us” before describing what they knew. When asked when and where they first learned about malaria, every participant responded that they first learned about malaria when they themselves were sick, or when they witnessed their family member get malaria. They frequently learned about the disease from the health practitioners who were treating them, or their families, but some participants also referenced health workers or doctors who visited and provided more information on malaria.

2) Varying understanding of the differentiation of malaria species

When participants were asked to relate what they knew about malaria, 18/33 (54.5%) specified the different types of malaria common to the region, including *P. vivax* and *P. falciparum.* Participants also often identified which type of malaria they had when discussing their own experiences, detailing the difference in symptoms, severity, mortality, and timeline between them. These differences between species are described below:

> *“If you say that you are shaking, they gave you the three pills for vivax. If you say that your whole body is hurting, they give you the pills for falciparum. But when they give you the wrong pills it does not do anything.”* [P03]

> *“Vivax gives you a headache, then you get shivers. You shake. When you shake a lot, you get cold, you get a fever. Then you know it is vivax. Falciparum, your body hurts, your eyes, your bones, everything. Then you*

know it is falciparum. It gives you a fever too. When it is more grave it makes you vomit, you don't feel like eating". [P04]

In addition to the commonly discussed *P. vivax* and *P. falciparum,* there were three participants who specified a third type of malaria as *maligna* (evil). While all agreed that this type caused the most severe symptoms, two of these participants referred to *maligna* in place of *P. falciparum*, while one participant referred to it as separate species discussed below:

"One is vivax, the other is falciparum, and the third is maligna. This is the strongest one that you can see here – maligna. Because it is a diabolical spirit." [P08]

3) Different understandings of malaria prevention

While some interviewees did not know or remember different ways to prevent malaria, many indicated several methods that they believed were effective. The most common response was to go to bed earlier and leave bed later, although the majority who discussed this also indicated that they did not typically follow this as described below:

"Yes, to prevent malaria you have to go to your bed at 5:30 pm, wear long sleeves, long pants with boots. But people here are not used to that so they do not do it." [P09]

"Lots of people say you can sleep early because at 6 the mosquitos come, that's what the doctor says. I do not do that." [P10]

In addition to going to bed earlier and leaving later, participants also discussed net use as a commonly adopted behavior to prevent malaria. They linked going to bed earlier, as indicated above, with the protection from mosquito bites that the nets provide. They also specified the use of ITNs, with insecticides to kill mosquitos as shown below:

> *"You can use your mosquito net. They have poison on them that kill mosquitos."* [P04]

When asked about other ways to prevent malaria beyond sleeping under bed nets, the theme regarding confusion about transmission also re-emerged, as a small portion of participants indicated that drinking clean water could keep them from getting malaria, as follows:

> *"To prevent these diseases, you have to drink clean water."* [P06]

> *"Now that we drink clean rainwater, we don't get it too often"* [P11]

Nearly half of participants also emphasized the importance of emptying containers with water to decrease the number of mosquito breeding sites, and indicated that health workers who visited the community for testing, treatment, and programming emphasized this, as discussed below:

> *"Take care of yourself. Don't let mosquitos bite you. Don't have containers outside the house where mosquitos can lay eggs."* [P12]

"They tell you not to toss out trash that can collect water, they say that the mosquitos reproduce inside there." [P13]

The health promotor and teachers in Sucusari discussed ways to prevent malaria which they learned while attending separate trainings and workshops provided by the Peruvian government and local NGOs. Below, one of the teachers in Sucusari shares what the workshops taught:

"The teachers used to participate in workshops to learn about malaria so that we can teach the children to prevent malaria as well. Do things like go to bed early, not keep containers of water around, don't toss trash outside because malaria can reproduce there, in containers of water they lay their eggs and reproduce." [P14]

Participant Attitudes about Malaria

1) Change in incidence of malaria over time

The most prominent theme in the attitudes of participants towards malaria was regarding their experiences of the change in malaria incidence over time, and their perceived reasons for this change. All but one participant mentioned that malaria had decreased in the community recently, after a long period of increased cases where many community members were sick. Some referred to a time before their families knew what malaria was, shown below:

"Before, my grandparents were dying in large quantities. They didn't know what was killing them. At that time, there wasn't any medicine." [P15]

For those that discussed more recent changes in malaria transmission, they attributed the decrease in incidence to many causes, including medicine, fumigation, drinking clean water, having a health promotor in the community, new health facilities nearby, and health worker visits to the community with tests and medications. When asked about how malaria has changed over time, many participants explained how the community was previously filled with cases of malaria. Perspectives of these changes are listed below:

> *"It has decreased. It has gone down a lot. But there was a lot in 2013-2014. The people here were all sick, truly. Everyone had it, kids, old people, everyone. And it was daily that people had malaria. This person has it, this person is going to the health post with malaria… and, up to now, we don't know, if the malaria has left, if it got tired of us, we don't know… there is malaria, but not like before."* [P05]

> *"There were times when the entire community, no lie, maybe except three or four people, had malaria. I say it comes from the water because we would drink water directly from the river."* [P06]

> *"We have medicine and treatment here, and close by in the health post that we can take to get better faster."* [P16]

Following the question about whether the incidence of malaria had changed in the community over time, participants were asked if they thought that there would be a time when malaria would not exist. There were mixed responses to this question, and

some participants indicated that if the health promotors, doctors, and fumigators continued to visit, then malaria might end, as indicated by the following statements:

> *"If there is more support for us from the government, in the future for our children, I believe that sometime in the future we don't have to suffer from malaria."* [P17]

> *"This depends on the health center, if they keep combating the mosquitos, fumigating and sending treatment. If they do, then the malaria could be finished."* [P13]

While those above felt it was the government's responsibility to eliminate malaria, some agreed that malaria elimination may be possible in the future, but that they also need to take responsibility to stop malaria. This perspective is represented below:

> *"Well for that I say it all depends on us because if we do not maintain our clean environment, we will get malaria again and the fevers will start again."* [P14]

Others who did not believe malaria would ever go away explained that mosquitos would never go away completely, and, therefore, malaria would always be around.

> *"The mosquitos will always exist." [So, you're saying malaria will never stop?] "Yes."* [P12]

"It is going to keep coming because it can always come from another community. One person travels and gets infected, they come back here and a mosquito bites them and then bites me, and now I have malaria too." [P1]

2) Belief that health worker visits decreased malaria in Sucusari

As an extension of the theme of the incidence of malaria changing over time in Sucusari, there was an overall attitude throughout interviews that visits by health workers were instrumental to the decreasing number of malaria cases. Participants described a health brigade from the local health center that came to Sucusari for frequent check-ins when the number of malaria cases rapidly increased. Many participants explained that they would visit and test the whole community during a large outbreak, providing medications to those who were infected, and returning later to re-test. These experiences are described below:

"In the times when there was lots of malaria, they came to build capacity to make sure there weren't any containers of water open that fill with rain and then stay there. But this stopped because now [malaria] doesn't exist." [P08]

"The brigade of doctors came from Mazán to do the tests, but we didn't feel anything I felt healthy. But we all came out with malaria, the disease was living inside of us." [P16]

Beyond testing and treatment, community members also shared that health workers came to provide educational programming, distribute bed nets, and perform IRS in the community. Many interviewees referenced a health worker delivering bed nets

within the past year, however the times and frequencies for other visits varied more across all interviews. Some memories of health worker visits are shown below:

> *"There's always workshops that the health workers put on in the community if there is a new disease or on malaria*." [P12]

> *"The health worker from Mazán always used to come and he would explain what the symptoms of malaria are."* [P07]

The overall attitudes towards these visitors were positive, and, as discussed in the previous theme, many of the interviewees attributed the decrease in malaria to their visits. When asked if anyone came to the community, and about their impression of those who had, participants responded as follows:

> *"It was good, because they came here, and we did not have to spend the gas and time to go to Mazán. I think the brigade did good work because they kept coming and over time malaria has decreased. Now, we have a health post close too."* [P13]

> *"It [malaria] went down when the fumigators came. One big drop."* [P15]

> *"Good, it [fumigation] killed all of the insects. But it burned everyone's faces. You couldn't lean against the house. But all of the mosquitos and cockroaches died in the house."* [P19]

However, despite the overall positive attitude toward fumigation, all participants who discussed it specified that fumigations have not occurred since around 2016 when the

cases of malaria decreased. Some participants also mentioned that the health promotor can ask the government for fumigators to visit again and specified why they have not continued to spray, as shown below:

> *"Now that there is not much malaria they do not come. But the health promotor has the responsibility to go to the government once per year to ask them to come and here they don't do that."* [P17]

> *"After they saw that there wasn't much malaria in the community anymore, they stopped coming. Since a year ago. They can send a request for fumigation and they come."* [P20]

In other interviews, six community members specified that the community does not ask for fumigations anymore because previous fumigations killed bees that were being raised as part of a community-based beekeeping project, as described in the following statement:

> *"Now we don't want them to fumigate because we are raising bees. Last time they fumigated all of the bees ran off. I lost 4 hives of bees last time."* [P03]

Participant Practices Related to Malaria

1) Treatment seeking for malaria is common

The most prominent theme within practices related to malaria was a person's experience seeking treatment and care for malaria. Every participant reported having malaria at least once. When asked to describe both their first and most recent experiences having malaria, every person interviewed except for the youngest

participant, who was 18 years old, reported visiting a health center for at least one of their cases. The attitude regarding the importance of seeking care at a health post is shown below:

> *"You have to go to the health post otherwise it [malaria] doesn't leave you."* [P13]

The one person who did not visit a health center was tested and treated by the health promotor. Several other participants also reported visiting the health promotor instead of, or before, visiting the health post during their most recent experiences with malaria symptoms. Fewer participants reported being diagnosed and receiving treatment when the brigade visited Sucusari and tested each member of the community.

> *"The brigade of doctors from Mazán came and took my blood and it came out with malaria vivax. Then they gave me medicine."* [P16]

One community member indicated that the severity of their symptoms progressed as they waited for their test result from the brigade, who would test community members and come back later with results. This was a common theme, and reasons listed for waiting included thinking it was a different sickness that would pass, waiting for transportation or money for transportation, or being away from the community.

> *"One week. That's why I almost died, because they didn't come quickly. We had to go to Mazán. The post in Puinawa didn't exist yet, it is new."* [P15]

For many of the participants' first cases, which were often before the health promotor position had tests and medications in the community, there were more barriers to seeking treatment, often related to transportation or financial issues, as discussed below:

> *"There wasn't any money. We couldn't transport ourselves, buy gasoline."* [P15]

> *"We were in the forest, and because the river was low, it took a long time to get back."* [P01]

> *"I got it on a river outside of Mazán when I was up there with the loggers. It took us 15 days to get out and get to the health post in Mazán."* [P21]

Interviewees reported visiting three health posts near Sucusari, in Puinahua, Mazán, and Tamanco, to seek treatment. When the health promotor was given RDTs and malaria medications by the government, this provided another option for treatment seeking. Some participants discussed their considerations when deciding on which health post to visit. This decision appeared to vary over time, based on which health posts were open and accessible. Participants' discussions about their decision are shown below:

> *"If we want to know faster, we can go directly to Mazán. We went to Puinawa with symptoms of malaria, then they did the test, then they send the test to Mazán and after 3 or 4 days you get your results. So Mazán is a higher expense but your results are immediate."* [P08]

"Well, if we go to the health post we will have to wait in line for a long time, let's go to Martín's [health promotor] house and see if he has the tests." [P22]

Interviewees were also asked about how long they waited after the onset of symptoms before seeking care. Participants typically waited longer during their first time with malaria than their most recent because initially they did not know what it was. On average, the participants also waited less time to seek treatment for their children than they did for themselves, waiting an average of three days before taking their children versus nearly a week for their own cases. One parent discussed their experience when their child had malaria symptoms:

"He told us the symptoms one day and the next day we were on the way to the health post. Because malaria gets worse when you ignore it too." [P05]

2) Participants adopted several prevention and treatment behaviors

Since every participant had malaria at least once, they also shared their behaviors related to prevention and treatment. Nearly all participants stated that medication was effective at treating malaria. Participants emphasized the importance of taking medicine, receiving the correct medicine for the specific species of malaria, and completing the full dosage. They attributed their recovery to the medications. When asked if they finished their full treatment and why, participants responded with the following statements on their experiences with taking medications for malaria:

"Once you finish your treatment you recover fast." [P23]

"It seems like you're healthy. But you're not. The bugs don't all die. You have to take the whole treatment." [P15]

"Yes, because I wanted to get healthy." [P12]

"If you don't finish, you're going to go back to the health post because you are not going to get better." [P08]

All participants who said they did not finish the full course of treatment acknowledged that they had to complete the full dose to get rid of the parasite, but they either thought they were recovered, thought the pills were too bitter, or felt too sick or weak from the pills to complete. Two participants described their reasons for not taking a full course of medications below:

"Lots of people arrive but then don't take their whole treatment and they get malaria again. I am telling you these things, but sometimes I don't take my complete treatment either. Then I got malaria again. Sometimes I take 4 or 5 pills and I feel healthy, so I stop taking them." [P05]

"The pills are really strong; they make you dizzy and you walk like you are crazy." [P09]

Participants were also asked about their use of traditional remedies and how their parents previously treated malaria. There was a wealth of knowledge surrounding traditional remedies which varied by age. Traditional remedies discussed included grinding, boiling, and drinking the resultant liquid made from one of many possible

ingredients, including the shell of the yellow-footed tortoise (*Chelonoidis denticulata,* local name *motelo*), the bark of the *remo caspi* tree (*Aspidosperma* spp.), *Clavo Huasca*, the roots of the *huasai* tree (*Euterpe precatoria*), and the bark of the *abuta* vine (*Cissampelos pareira*). Even though participants were familiar with traditional remedies to treat malaria, as discussed below, they preferred to take medication.

> *"You wouldn't drink that here because you're close [to the health post] but when you're out in the forest and logging, yes. This is what your parents teach you, from your grandparents."* [P05]

> *"They [parents] used this to cure themselves. But when you take it, it doesn't cure anything. One minute it would pass, then come back every bit."* [P15]

> *"Here, there are lots of plants that are medicines that they say you can take to get better, but you really have to go to the health post."* [P17]

There was also an association made during many interviews between the bitterness of the medications, which is a common complaint and reason many people do not finish a full course of treatment, and the bitterness of some traditional remedies such as those made from *abuta* and *remo caspi*. The association described below indicates that some community members believed the characteristic of bitterness was related to the effectiveness of the traditional remedies and/or medications:

> *"There is a vine that's called abuta, it's very bitter. You cook it because the malaria pills are also very bitter, it's the same as the vine."* [P07]

> *"Well, sometimes when you don't finish the pills and you get it again lots of people say that medicine from the abuta plant, it is really bitter, and it leaves your body clean and is good to stop malaria."* [P14]

Participants also discussed the common practice of nightly bed net use to prevent malaria. Every participant reported using a bed net each night, and the majority had used them for their entire lives. There were two families that more recently introduced this behavior into their routines when health workers provided everyone in the community with free nets. The following responses represent the perspectives shared by many of the interviewees, that sleeping under a bed net was ingrained in their daily lifestyles:

> *"No you have to sleep with one because how are you going to sleep outside with the mosquitos, and you can get cold"* [P01]
>
> *"The government donated some to us, but before that we bought them."* [P16]

Some common complaints about the nets provided by the government were that the mesh was too big to keep out mosquitos or that they were too hot or cold depending on weather. Some community members showed a different, thicker type of net with smaller holes that they purchased themselves, and typically used when it was colder. Additionally, the nets provided by the government, which were treated with insecticides, often caused rashes and burns on the skin. Because of this, the nets were sometimes washed or aired out before use to remove the insecticide, as indicated below:

"I like them, but sometimes at first they burn our faces. You have to wash it first and get all the poison out." [P24]

"When it's new it burns your face. [What do you do so it doesn't burn you?] *You hang it up and don't sleep under it for a while. Put it outside, so that the mosquitos smell it."* [P12]

Summary of Results

The results from 33 semi-structured interviews with community members provided an understanding of the knowledge, attitudes, and practices related to malaria in the Sucusari Maijuna community. Our participants indicated that despite several visits from health workers, individual trips to health posts to treat malaria, and having a trained health promotor in Sucusari who can test and treat malaria, there is still much confusion about how it is transmitted. Despite this confusion, preventive practices such as use of a bed-net each night are accepted and used by nearly the whole community and are embedded in the lifestyles of community members. Affirmative attitudes towards the effectiveness of antimalarial medications were consistent and the need to complete the full course of medication to treat malaria were common, but not always practiced. Barriers to seeking treatment were often distance, money for the transportation, or waiting to see if the symptoms were caused by something other than malaria. The belief that malaria would decrease or be eliminated in the future was common, but many participants stated that this outcome would rely upon continued outreach from the government as well as individuals within the community caring for themselves and their

families. In the following discussion section, we will use external context about malaria from published literature as an attempt to make meaning of this information, and guide future practice surrounding malaria in this area of Peru.

DISCUSSION

This exploratory case study examined the knowledge, attitudes, and practices surrounding malaria transmission, prevention, and treatment seeking in Sucusari, a riverine community in the Peruvian Amazon. Semi-structured interviews with community members provided information on how previous health programming resonated with the community, how local knowledge and attitudes impacted their behaviors related to malaria prevention and treatment seeking, and identified gaps in understanding about malaria transmission to inform future health programming.

Each major theme (knowledge, attitudes, and practices) contained several sub-themes. Three themes emerged within the knowledge theme including:

- confusion in what is known about malaria transmission,
- varying understandings of the differentiation of malaria species, and
- different understandings of malaria prevention.

Two sub-themes emerged within the attitudes theme including:

- change in attitudes regarding malaria over time, and
- belief that health worker visits decreased malaria in Sucusari.

Two final sub-themes emerged within the practices theme including:

- treatment seeking for malaria was common, and
- participants adopted several prevention and treatment behaviors.

Knowledge About Malaria Transmission

Results surrounding the knowledge of malaria transmission indicated confusion within the community regarding the source of malaria. While 26/33 (78.8%) participants reported that malaria transmission was in some way related to mosquitos, there were 15/33 (45.5%) that also mentioned contaminated water or water with mosquito eggs in it could cause malaria. This confusion is a historical problem, dating back decades to a survey in the Philippines with similar reports of transmission being caused by germs in contaminated water, as well as by mosquitos (Lariosa, 1986). These results suggest that previous community-based health programming may not have resonated culturally or reached all intended community members. The confusion surrounding the role that clean water plays in transmission could also be due to the timing of health interventions and educational programming in Sucusari. Several participants indicated that malaria incidence decreased when they began drinking clean water. This suggests that perhaps heath workers came to educate the community on malaria around the same time when water filtration systems were first introduced, making it difficult for community members to differentiate between the interventions. Alternatively, many health programs encourage emptying containers that might collect rainwater to decrease potential mosquito breeding environments and decrease the risk of malaria. This could be the reason that 17 participants mentioned when asked about malaria transmission and prevention that emptying containers filled with water is important to avoid drinking this

water and/or to decrease the numbers of mosquitos in the area. Despite the historical evidence of confusion surrounding how malaria is transmitted, similar confusion continues to exist and extend beyond Sucusari (Iyer et al., 2019; Newell et al., 2018). Therefore, it is vital for health workers to understand a community's context and local realities before presenting educational programing, as the malaria transmission cycle is quite complex and could appear by observation to be based on several phenomena (Control et al., 1991).

Relationship Between Knowledge and Preventive Behaviors

Confusion about malaria transmission and subsequent differences in knowledge of preventive practices were not directly related to the uptake of preventive behaviors. Everyone in the community reported sleeping under a bed net, and for most this was a behavior passed down from the previous generation. Additionally, some participants used the same word to describe their beds and their bed nets, suggesting that the use of bed nets is deeply rooted in their culture, as it is in many other communities in the Peruvian Amazon (Iyer et al., 2019; Newell et al., 2018). Since some participants report buying their own nets, and switching these with the government-provided nets depending on weather, it is important to note that while they do practice this behavior, it is potentially less effective than if they used the ITNs (Ngonghala et al., 2014). Previous studies have also suggested that changes in mosquito biting times present barriers to the effectiveness of ITNs, as it would decrease protected time spent under bed nets (Sokhna et al., 2013). However, based on the participant responses that people very rarely go to bed early to

avoid peak mosquito biting times, their risk may not change even if the mosquito biting times do shift, as these individuals were already exposed.

Species Differentiation

The theme of species differentiation emerged as a common topic, likely because the RDT that the health promotor in Sucusari tested with differentiated by species and treatments differ by species. The community members often discussed their experiences having both types of malaria, even though only 25% of malaria cases in the region are typically *P. falciparum* (WHO, 2015). This could be attributed to characteristics specific to *P. vivax,* such as how it frequently causes latent, asymptomatic phases and reoccurrence of malaria (Howes et al., 2016). If community members experienced these latent, asymptomatic phases, they would be less likely to seek treatment and therefore, might report experiences of *P. vivax* less. This explanation also aligns with the reports that community members were diagnosed with *P. vivax* when health workers tested everyone in Sucusari, even those without symptoms. Alternatively, these reports could be due to participant recall bias, because if participants had more severe symptoms during their experience with *P. falciparum,* which is typical, they may have been more likely to remember the experience and report it years later.

Treatment Seeking Behaviors and Attitudes

Results surrounding treatment seeking behaviors showed that seeking treatment and completing medication were perceived as necessary to combatting malaria. When asked if any traditional remedies existed, most participants discussed the use of the same plants and tortoise shell. Many indicated that they learned about the remedies from their

parents or others in the community. However, when asked how their parents treated malaria, the answer was often that their parents did not know what malaria was, and they died from it. This suggests that the remedies may have been used more broadly to treat the symptoms associated with malaria, such as fever and chills. This possibility also aligns with how some participants reported the use of these remedies to ease symptoms until you get to the health post. The fact that no one reported preference for traditional remedies over medications, despite having knowledge of them, reiterates the positive perception of antimalarial medication. Participants frequently connected the bitterness of pills to the bitterness of traditional remedies, which potentially contributed to the acceptability and adoption of medications.

Attitudes Towards Health Workers and Malaria Over Time

The theme that malaria incidence has changed over time was largely connected to the theme that health worker visits decreased incidence of malaria. The majority of participants agreed that the decrease in cases following a large surge of cases in 2014 was attributed to interventions provided by local health workers. This suggests that despite confusion surrounding the cause of malaria, the interviewees positively perceive visiting health workers and the malaria interventions they bring. Additionally, there appears to be a transition occurring from the belief that malaria is inevitable, which was recently discussed in a study in Peru (Newell et al., 2018), to a belief that malaria could end in the future. This is shown in the statements describing their parents, who died of malaria because they did not have medication, to then saying that an end to malaria "depends on us" and "depends on the health center." This suggests that health programming in

Sucusari is working, despite some identified gaps, and should continue to serve and support this community.

Study Limitations

One limitation of this study was that interviews were translated and transcribed, which presents the possibility that some of the narrative and experiences of interviewees were not fully conveyed (van Nes et al., 2010). Additionally, the researchers were raised within the United States, each with perspectives shaped by Western views of science and medicine, which differ from those of the participants. However, the person who translated and transcribed interviews lived in the community for six months prior to the interviews. Therefore, the translator was known by the community and knew the local vocabulary. Additionally, another researcher who lived in the community one year prior to the interviews was also asked to clarify any existing questions following the interviews.

Another limiting factor was that more males than females volunteered to participate in interviews, which reflected the larger proportion of males than females in the community, as well as women being less interested in participating in the interviews. During interviews, all household members were asked if they wished to participate, and the ratio of males and females included in the study was similar to the proportion of adult males to adult females in the community. While we originally aimed to perform around 25 to 30 interviews, we ultimately interviewed 33 participants based on the availability of time and the willingness of community members to participate and share information about malaria.

A final limitation is that studies investigating knowledge, attitudes, and practices often include a quantitative framework. However, this possibility was not feasible for this study due to the small population of the community. Additionally, the exploratory nature of this study lent itself to qualitative methodology, which aimed to understand community themes surrounding malaria in depth, rather than test a known hypothesis. Therefore, the results should be used to inform adjustments to health programming and further studies with a broader scope.

Implications for Future Practice and Research

Future Practice

These findings can be used to inform future health programming related to malaria in the region. The experiences of community members who participated in this study, along with the malaria case numbers in Loreto, indicate that efforts to eliminate malaria in the region are progressing. However, total malaria elimination in the Peruvian Amazon will be challenging and will require ongoing engagement from local, regional, and national government stakeholders with these communities to continue decreasing case incidence. The results of this study also show that there are gaps in the health communication that community members receive, which results in confusion about how malaria is transmitted. Future health programming in communities, at health promotor trainings, and at health posts should ensure that educational materials are culturally relevant, and that provider communication with patients is respectful and thorough.

Future Research

In addition to informing future practices related to malaria control in the Loreto region, the results from this study also emphasize the importance of continued qualitative malaria research among communities in the Amazon Basin living in high risk areas. Research that identifies gaps in knowledge, attitudes, or practices of those receiving health programming and care is necessary to inform future health interventions. As the landscape of malaria changes and efforts become more targeted, an understanding of the perspectives of communities such as Sucusari will become increasingly important. It is crucial to pair quantitative studies regarding malaria with studies that provide the perspective and depth of those experiencing malaria, who will be vital to malaria elimination in the region.

CONCLUSION

Despite decreasing global incidence of malaria in recent years, Peru remains one of the four countries in South America with endemic malaria where the incidence is increasing (WHO, 2019). Nearly all of the malaria burden in Peru occurs in the region of Loreto, largely due to the environmental characteristics of the Amazon Basin which are conducive to the *Anopheles* spp. mosquito that transmits malaria (Vittor et al., 2009). To continue progress towards decreasing malaria incidence in Loreto, it is vital to understand the knowledge, attitudes, and practices related to malaria of those living in this region that are at the highest risk of infection. Malaria elimination can only occur when these communities are involved and have the knowledge and resources to prevent, identify, and treat malaria cases. This exploratory case study provides an understanding of the Sucusari community's location and culturally specific knowledge, attitudes, and practices related to malaria. Using the narratives and experiences shared by this community, we saw what factors contributed to the uptake of preventive behaviors, what barriers existed to eliminating malaria, and how these can be addressed through culturally resonant, community-based programming. While these results are from one of many communities in the Peruvian Amazon, ideally, they will lay the foundation for further investigations into the health experiences of similar communities that have limited access to health services.

Declarations

Approval to conduct this study was granted by George Mason University's Institutional Review Board (IRB) under IRBNet ID: 1357277-1. All participants provided consent before participating as approved in the IRB protocol. Participants were assigned an individual identification number to prevent any personally identifiable information from being linked with the data. Interviews were recorded on a recording device and password protected cell phone, and all interview data was stored on a password protected laptop.

APPENDIX I

Semi-structured interview questions in English asked during individual interviews in the community of Sucusari. It is important to note that these questions served to generally structure the proposed interviews, but pertinent follow-up questions were asked based upon participant responses.

Sociodemographics

1. Name or pseudonym:
2. Date of interview:
3. GPS coordinates of household:
4. Gender:
5. Age:
6. Birthplace:
7. How long have you lived in Sucusari?:
8. Are you Maijuna?:
9. Do you speak any indigenous languages? If so, what languages?:
10. Marital status:
11. Number of children:
12. Number of people in household:
13. Head of Household:

14. How many years did you go to school?:

Interview Questions

1. What are some of the challenges in this community?
    a. What are some of the health challenges in this community?
    b. Is malaria a challenge?
2. Can you please tell me a bit about malaria?
    a. How do you get malaria?
3. Have you had malaria?
    a. How many times have you had malaria?
    b. When was the first time you had malaria?
        i. How did know you had malaria?
        ii. How did you feel when you had malaria this time?
        iii. When you had malaria this time, did you visit the health post?
            1) If yes, where did you go?
            2) How long did you feel sick before going to the health post?
                a. Why?
            3) Did you take a malaria test?
                a. Where did you take the malaria test?
                b. Was it an RDT or a microscopy test?
                c. What did the health provider say or do?
                d. Did you get medicine?
                    i. Did you take it all?

1. Why/why not?

e. If you did not go to the health post, why? What did you do?

c. When was the last time you had malaria?

i. How did know you had malaria?

ii. How did you feel when you had malaria this time?

iii. When you had malaria this time, did you visit the health post?

1) If yes, where did you go?

2) How long did you feel sick before going to the health post?

a. Why?

3) Did you take a malaria test?

a. Where did you take the malaria test?

b. Was it an RDT or a microscopy test?

c. What did the health provider say or do?

d. Did you get medicine?

i. Did you take it all?

1. Why/why not?

e. If you did not go to the health post, why? What did you do?

4. Have your children had malaria?

a. How many times have your children had malaria?

b. Did they take a malaria test each time?

5. Have you ever thought you had malaria but the test said you didn't have it?
    a. What do you think happened?
    b. Did your fever and chills go away?
6. Can you still work when you have malaria?
    a. If not, how long are you unable to work when you have malaria?
7. When your parents had malaria, how did they treat it? (*free-list)*
8. Are there traditional remedies for malaria that you know about or use?
9. Where did you learn the information that you know about malaria? Did someone teach you about it?
10. Is there a time of year where there is more malaria in the community? Why?
11. Does anyone get malaria more than others in the community? Why?
12. Since you've been in the community, have the number of malaria cases in the community changed? Why?
13. Can you prevent malaria?
    a. How?
    b. Do you do this? Why?
14. Do you own a bed net?
    a. Where did you get it?
    b. Does everyone in your house own one?
    c. Do you sleep under the bed net every night? Why?
    d. What time do you usually go to sleep? What time do you wake up?
    e. Does everyone in your family sleep under a bed net? Why?

f. When you leave the community (to hunt, to go to city) do you still sleep under a bed net? Why?

g. Are there any other times you don't sleep under it?

h. Does your bed net always stay up or do you hang it every night?

i. Do you use your bed net for anything else?

j. Has it ever gotten holes in it?

    i. Did you fix it?

k. Is there anything you don't like about the bed nets?

15. Has anyone come to community to talk about malaria?

    a. Who and when?

    b. What did they say?

    c. What did you think of what they said?

16. Have there been any community fumigations/spraying done in Sucusari?

    a. Who did this?

    b. Was it done just once? When?

    c. Where did they spray?

    d. Why was it done?

    e. Did it work?

17. Do you think sometime in the future people in Sucusari will stop getting malaria?

    a. Why?

    b. How?

18. Is there anything else you would like the share about malaria?

Health Promotor Questions

1. When did you become a health promotor in Sucusari?
    a. Were there health workers before you?
    b. How did you become the health worker?
        i. What organization organizes this?
    c. Did you go to a training?
        i. Where?
        ii. How long was the training?
        iii. What did you learn?
        iv. Are there multiple trainings?
        v. Did you teach everyone in the community what you learned?
2. Do you get paid to be the health promotor?
3. What do people in the community come to you for?
    a. Is it only for malaria?
    b. Do you keep records of people that come to you for malaria?
    c. What do you do with the records?
    d. About how many people have had malaria in the last year?
4. When someone comes to you and says they have malaria, what do you do?
    a. Do you do a test?
        i. What kind?
        ii. Can I see it?
        iii. Do you ever run out of tests?

1) If you run out of tests, what do you do?

a. Do they [the organization] bring you more, or do you have to go get them?

b. Do you have medicine?

i. When do you give it?

ii. Do people take all of the medicine?

iii. Do you ever run out of medicine?

1) If you run out of medicine, what do you do?

c. If you aren't here and someone is sick, what happens?

i. Can anyone else in the community give a test or give medicine?

APPENDIX II

Semi-structured interview questions in Spanish asked during individual interviews in the community of Sucusari. It is important to note that these questions served to generally structure the proposed interviews, but pertinent follow-up questions were asked based upon participant responses.

Sociodemographics

1. ¿Cuál es tu nombre completo?
2. Fecha de la entrevista:
3. GPS coordinates of household:
4. Sexo:
5. Edad:
6. ¿Dónde naciste?:
7. ¿Para cuánto tiempo has vivido en Sucusari?:
8. ¿Eres Maijuna?
9. ¿Hablas un idioma indígena? ¿Cuál es?:
10. ¿Estás soltero/a o casado/a:
11. ¿Cuántos hijos tienes?
12. ¿Cuántas personas viven en tu casa?:

a. ¿Cuántos adultos viven en tu casa?:

b. ¿Cuántos muchachos viven en tu casa?

13. ¿Quién es la cabeza de la casa?:

14. ¿Cuántos años asististe a la escuela?:

Interview Questions

1. ¿Qué son algunos de los problemas de salud en la comunidad?
2. ¿Me puedes contar un poco de la malaria?
    a. ¿Dónde proviene la malaria?
3. ¿Has tenido malaria?
    a. ¿Cuántas veces has tenido malaria?
    b. ¿Cuándo era la primera vez que tenías la malaria?
        i. ¿Cómo sabías que era la malaria?
        ii. ¿Cómo te sentías físicamente cuando tenías la malaria?
        iii. ¿Cuándo tenías la malaria, ibas a una técnica de salud?
            1) ¿Si no, por qué? ¿Que hacías?
            2) ¿Dónde fuiste?
            3) ¿Para cuánto tiempo te sentías enfermo/a antes que llegabas a la posta?
                a. ¿Por qué?
        iv. ¿Hacías la prueba de malaria?
            1) ¿Dónde hacías la prueba?
            2) ¿Era una prueba rápida o la lámina?

3) ¿Qué decía la técnica?

4) ¿Te daba medicina?

a. ¿Tomabas todo?

i. ¿Por qué no?

5) Si no ibas a la posta, ¿qué hacías?

c. ¿Cuándo era la última vez que tenías la malaria?

i. ¿Cómo sabías que era la malaria?

ii. ¿Cómo te sentías físicamente cuando tenías la malaria?

iii. ¿Cuándo tenías la malaria, ibas a una técnica de salud?

1) ¿Si no, por qué? ¿Qué hacías?

2) ¿Dónde ibas?

3) ¿Para cuánto tiempo te sentías enfermo/a antes que llegabas a la posta?

a. ¿Por qué?

iv. ¿Hacías la prueba de malaria?

1) ¿Dónde hacías la prueba?

2) ¿Era una prueba rápida o la lámina?

3) ¿Qué decía la técnica?

4) ¿Te daba medicina?

a. ¿Tomabas todo?

i. ¿Por qué/ Por qué no?

5) ¿Si tengas malaria de nuevo, irías a la posta de nuevo?

a. ¿Por qué/Por qué no?

4. ¿Tus hijos han tenido la malaria?
    a. ¿Cuándo era la última vez que uno de tus hijos tenía malaria?
        i. ¿Qué año era?
        ii. ¿Cómo sabías que era la malaria?
        iii. ¿Cómo se sentía físicamente cuando tenía la malaria?
        iv. ¿Hacia la prueba de malaria?
            1) ¿Dónde hacías la prueba?
            2) ¿Era una prueba rápida o la lámina?
        v. ¿Cuándo tenía la malaria, iban a una técnica de salud?
            1) ¿Si no, por qué? ¿Qué hacían?
            2) ¿Dónde iban?
            3) ¿Para cuánto tiempo se sentía enfermo/a antes que llegaban a la posta?
            4) ¿Qué decía la técnica?
            5) ¿Te daba medicina?
                a. ¿Tomaba todo el/ella?
                    i. ¿Por qué/ Por qué no?
5. ¿Alguna vez has pensado que tenías malaria, pero la prueba era negativa?
    a. ¿Cuántas veces?
    b. ¿Qué piensas pasaba?
    c. ¿Cuáles síntomas tenías durante esta enfermedad?

d. ¿Cuál enfermedad tenías?

e. ¿Como tratabas esta enfermedad?

6. ¿Todavía trabajas cuando tienes la malaria?

    a. ¿Cuándo tienes malaria, cuántos días demoran que no puedes trabajar?

7. ¿Cuándo tus padres han caído enfermo con la malaria, como la trataban ellos?

8. ¿Hay remedios tradicionales para la malaria?

    a. ¿Si hay, que son?

9. ¿Dónde aprendías la información que sabes sobre la malaria?

    a. ¿Cuándo la aprendiste?

10. ¿Malaria tiene una época en la comunidad?

    a. ¿Si hay, cuándo?

    b. ¿Por que es así?

11. ¿Hay alguna gente de la comunidad que caen enfermo con la malaria más que los demás en la comunidad?

    a. ¿Por que?

12. ¿Desde cuando llegaste en la comunidad, la cantidad de casos de malaria ha aumentado, ha bajado, o es igual?

    a. ¿Por que es así?

13. ¿Desde cuándo llegaste en la comunidad, alguien ha muerto de la malaria?

    a. ¿Cuándo era la última vez?

14. ¿Puedes protegerse de la malaria?

    a. ¿Como puedes protegerse de la malaria?

Transition: Thank you for sharing about your experience with malaria in your family and the community, now I would like to learn a little bit about bed nets.

15. ¿Tienes un mosquitero?
    a. ¿Cuándo empezaste a usar un mosquitero?
    b. ¿De dónde ha venido tu mosquitero?
    c. ¿Cuántos mosquiteros hay en tu casa?
    d. ¿Cada persona en tu casa duerme abajo de un mosquitero?
        i. ¿Por qué/Por qué no?
    e. ¿Hay veces cuando no usas un mosquitero?
    f. ¿Cuándo sales de la comunidad para andar en monte o a Mazan, por ejemplo, llevas tu mosquitero?
        i. ¿Por qué/Por qué no?
    g. ¿Hay algo que no te gusta de los mosquiteros que debe ser cambiado?
    h. ¿A qué hora duermes normalmente?
    i. ¿A qué hora despiertas normalmente?

Transition: Thank you for sharing about bed nets, now I would like to learn a little bit about how malaria is talked about and treated in the community by outside organizations.

16. ¿Ha venido gente a la comunidad para hablar sobre la malaria?
    a. ¿De cuál organización eran ellos?
    b. ¿Cuándo era la última vez?

c. ¿Han venido varias veces?

d. ¿Cuándo era la primera vez?

e. ¿Que decían ellos?

f. ¿Como te parecía lo que decían ellos?

17. ¿Había fumigado la comunidad alguna vez?

a. ¿Cuál organizacion hacía esto?

b. ¿Venían varias veces?

c. ¿Cuándo era la última vez que han fumigado a la comunidad?

d. ¿Cuándo era la primera vez que han fumigado a la comunidad?

e. ¿Dónde fumigaban?

f. ¿Cómo te parecía esto?

g. ¿Por qué han hecho esto?

18. ¿Crees que, un tiempo en el futuro la malaria no va a existir en Sucusari?

a. ¿Por qué/Por qué no?

19. ¿Hay algo más que quieres decir o compartir sobre la malaria en la comunidad?

Health Promotor Questions

1. ¿Cuándo te convertías en el promotor de salud en Sucusari?

a. ¿Había promotores de salud antes de ti?

b. ¿Cómo has convertido en el promotor de la salud?

i. ¿Cuál organización organiza eso?

c. ¿Has ido a algún taller?

i. ¿Dónde?

ii. ¿Cuánto tiempo demoraba el taller?

iii. ¿Qué aprendías?

iv. ¿Había muchos talleres?

v. ¿Has enseñado los demás en la comunidad lo que aprendías?

2. ¿Hay un pago por ser el promotor de salud?

3. ¿Para cuáles cosas vienen a ti los de la comunidad?

a. ¿Es solo para la malaria?

b. ¿Apuntas notas sobre los que vienen a ti para la malaria?

c. ¿Qué haces con las notas?

d. ¿Más o menos cuántas personas han tenido malaria en este año pasado?

4. ¿Cuándo viene a ti alguien que dice que tiene la malaria, qué haces?

a. ¿Haces una prueba?

i. ¿Qué tipo?

ii. ¿Me puedes mostrar la prueba?

iii. ¿A veces se acaba las pruebas?

1) ¿Si a veces se acaba las pruebas, qué haces?

a. ¿Se entregan más pruebas a ti, o tienes que ir a conseguir más?

b. ¿Tienes medicina?

i. ¿Cuándo das medicina a una persona?

ii. ¿Toman toda la medicina la gente?

iii. ¿A veces se acaba la medicina?

1) ¿Si se acaba la medicina, qué haces?

c. ¿Si no estés acá y alguien se enferma, qué pasa?

i. ¿Hay alguien más en la comunidad que puede hacer una prueba o dar medicina?

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