Social Science & Medicine 365 (2025) 117631

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Tuberculosis treatment and undernutrition on Daru Island, Papua New Guinea: A qualitative exploration of a local foodscape

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ARTICLE INFO

Handling editor: Alexandra Brewis

Keywords:
Tuberculosis
Treatment
Food insecurity
Undernutrition
Foodscapes
Papua New Guinea
Qualitative

ABSTRACT

A substantial proportion of people with tuberculosis (TB)—one of the world's deadliest infectious diseases—live in resource-poor, food insecure settings. It is widely recognised that undernutrition significantly heightens vulnerability to TB, as well as contributes to poor treatment adherence and outcomes. However, more attention is needed to understand what shapes food insecurity and undernutrition in a particular setting. We use the concept of "foodscapes" to explore the distinct food environment on Daru Island, a recognised "hotspot" for multidrug-resistant TB in the Western Province of Papua New Guinea. Drawing on 128 qualitative interviews and 10 focus groups (conducted July 2019 and July 2020) with people with TB, family members, healthcare providers, community leaders and other stakeholders, we seek to elucidate the critical entwinement of food insecurity, people with TB, and their treatment experiences on Daru Island. We argue that potential solutions need to focus on the social and structural conditions that contribute to undernutrition in the first place, rather than on undernutrition itself.

1. Introduction

> *"[T]his is an island where nobody is eating"*—religious leader on Daru Island.

Despite the availability of effective medical treatments, tuberculosis (TB) remains one of the world's deadliest infectious diseases. Although mortality from TB has declined over the past decade, the World Health Organization's (WHO) strategy to end the global epidemic by 2035 is being challenged by sustained high TB transmission in certain settings in low- and middle-income countries (Jops et al., 2022; WHO, 2015, 2023). As a WHO-listed high burden country for TB and multidrug-resistant TB (MDR-TB), Papua New Guinea (PNG) is one such setting (WHO, 2023). The country's diverse geography, remote localities, and lack of adequate transport systems complicate the delivery of and access to TB prevention and care in this Pacific nation (Jops et al., 2022; Umo et al., 2021). Moreover, TB treatment is a challenging process. New treatment guidelines provide much needed hope recommending adherence to daily medications for six months in the case of MDR-TB. However, many settings, including PNG, still follow guidelines for between nine- and 18-months treatment (Jops et al., 2024). A substantial proportion of people with TB in PNG (>20%) are lost to follow up, with successful treatment completion rates reported to be around 55–72%, well below the global target of 90% (Aia et al., 2022; WHO, 2020; World Vision, 2024). This increases the risks of negative consequences for the individual, including treatment failure causing death or chronic lung disease, recurrence of TB disease and drug resistance, as well as wider public health risks of further transmission in the community (Diefenbach-Elstob et al., 2017; Jops et al., 2022; Umo et al., 2021). Improving treatment support to completion is a critical challenge in PNG

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https://doi.org/10.1016/j.socscimed.2024.117631
Received 7 August 2024; Received in revised form 6 November 2024; Accepted 10 December 2024
Available online 12 December 2024
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and attention to adequate nutrition, as noted previously with HIV in this setting (Kelly et al., 2011), is one major component of providing person-centred care to enhance outcomes.

Some regions of PNG are recognised as "hotspots" that have especially high TB incidence rates, including the South Fly District, Western Province, where our research took place, particularly Daru Island, the provincial capital (Morris et al., 2019). The proportion of TB cases in the Western Province is much higher compared to global and national rates, with 674 per 100,000 population in 2016 (Aia et al., 2018) versus 432 per 100,000 in PNG as a whole (Morishita et al., 2020; WHO, 2023). The TB case rate on Daru Island was 1031 per 100,000 in 2014, falling to 736 per 100,000 in 2017 (Morris et al., 2019). As we have shown elsewhere, specific socio-spatial "riskscapes" contribute to the elevated risk of TB disease and infection on Daru Island, including poverty, overcrowding, lack of water and sanitation, limited services, food insecurity and undernutrition (Jops et al., 2022). Building on these insights, we explore how these local conditions can potentially impact on the effectiveness and tolerability of TB treatment regimens in this setting, focusing specifically on food insecurity. Food insecurity is commonly defined as the lack of physical, social or economic access to sufficient food that meets the daily nutritional requirements for a healthy life (Balinda et al., 2019). It is widely recognised in the literature that food insecurity significantly heightens vulnerability to TB (Darnton-Hill et al., 2022; Duarte et al., 2018), as well as contributes to poor treatment adherence and outcomes (Ayiraveetil et al., 2020; Balinda et al., 2019). The RATIONS study in India clearly showed the benefits of nutritional support on reducing disease risk as well as improving outcomes (Bhargava et al., 2023a, 2023b).

While "food insecurity" is a ubiquitous term in the TB literature, it tends to be generic rather than specific, with little attention to untangling and elucidating the socio-spatial conditions that shape food insecurity in a particular setting. Given the epidemiology of TB on Daru Island, and the South Fly, it is critical to seek to understand challenges to daily treatment adherence from the perspectives of people who are involved with the local TB control program. Using the lens of "foodscapes" (Buttigieg et al., 2019; Kühne et al., 2023; Vonthron et al., 2020), we draw on qualitative interviews with people with TB, family members, local residents, healthcare workers, service providers and community leaders to explore the food environment on Daru Island and to uncover how it contributes to undernutrition and, in turn, negatively impacts the ability of people with TB to sustain and complete their treatment.

2. Background

2.1. TB and nutrition

The bidirectional nexus between TB and undernutrition is well-established: undernutrition is a major risk factor for developing active TB, while people with TB are commonly malnourished (Bhargava et al., 2023a, 2023b; WHO, 2013). Poor nutritional status also increases the risk of severe disease, drug malabsorption, poor recovery and mortality, and the disease itself often causes body wasting, leading to further clinical complications (Ayiraveetil et al., 2020; Darnton-Hill et al., 2022; Duarte et al., 2018). An important clinical benefit of adherence to TB treatment is a return to normal appetite, or even intensified hunger (Escott and Newell, 2007). However, a substantial proportion of people with TB live in resource-poor settings that are food insecure and so this may not lead to a return to sufficient dietary intake (Balinda et al., 2019). Moreover, TB itself can compound food scarcity, as the disease commonly causes significant financial strain on families, including in PNG (Aia et al., 2022; Viney et al., 2019). This is in large part because it impacts the ability of people with TB and caregiving family members to work and generate an income to buy food, creating a "vicious circle" of vulnerability (WHO, 2013; Escott and Newell, 2007).

Cross-cultural studies on TB treatment show that a lack of access to food can significantly impede treatment adherence and lead to discontinuation (Ayiraveetil et al., 2020; Balinda et al., 2019), including in PNG (Diefenbach-Elstob et al., 2017). It is widely recognised that nutritional support is a critical component of TB interventions, as recommended by the WHO 2013 *Guidelines on Nutritional Care and* Support *for People with Tuberculosis*. According to Darnton-Hill et al. (2022), however, the nutritional management of TB continues to receive inadequate prioritisation and action in TB control programs. The WHO guidelines state that the nutritional status of people with TB should be properly assessed, paying specific attention to acute malnutrition, and that they be provided with material support, such as food vouchers and meals (2022), ideally "locally available nutrient-rich or fortified supplementary foods as necessary to restore normal nutritional status" (WHO, 2013:23). But how to provide such food in a context of chronic food insecurity? This recommendation is futile unless we appraise the social and structural conditions that cause food insecurity and undernutrition in a particular setting, and how those conditions can be addressed. In short, we need to understand local foodscapes.

Foodscape – a melding of "food" and "landscape" – is a conceptual tool deployed since the mid-1990s by the social sciences and humanities, especially anthropology and critical geography, to examine the complex and synergetic relationship between human behaviour and food environments. There is no universal theory or definition of foodscapes. Rather, it is a polysemic term that has been applied, using a variety of methodological approaches, to a broad range of topics relating to the meanings, practices and ramifications of food systems from micro-levels to global scales, such as public health messaging, urban food networks, food trends, marketing, corporate food monopolies, sustainability, as well as food insecurity (Buttigieg et al., 2019; Kühne et al., 2023; Vonthron et al., 2020). Here, we use the term to denote the critical entwinement of people with TB, their treatment and the food situation on Daru Island.

2.2. TB care and treatment on Daru Island

Daru is the capital of PNG's Western Province. Daru is situated on a small island, also known as Daru, of only 14.7 km^2, which is located in the Torres Strait, less than 200 km from the Australian mainland. Daru serves as the local government area and administrative centre for the South Fly District, which covers a vast 31,864 km^2. Estimates from 2021 put the population on Daru Island at around 19,000 (National Statistical Office, 2021), but the population is often increasing sometimes two-fold as people move back and forth off the island for health, economic and socio-cultural reasons. Commentators have described the island as beleaguered by crumbling infrastructure, poverty, disease, a lack of public services (despite being the only place in the South Fly District with services) and a lack of employment or other income opportunities. Many people on the island reside in overcrowded informal housing settlements known as "corners" (Faa, 2020; Faiparik, 2020; Sil Bolkin, 2021). Fishing is one of few sources of income on the island (Mitchell, 2021).

In 2014, the PNG National Department of Health declared the Western Province a "hotspot" for MDR-TB, prompting a multisector emergency response, with South Fly District as the main focus. A range of community-based measures were put in place, along with the scaling up of TB diagnostic and treatment services at Daru General Hospital. Although these measures were successful in stabilising the outbreak and improving outcomes, TB transmission levels remain high and unprecedented in Daru (Furin and Cox, 2016; Jops et al., 2022; Morris et al., 2019). Daru General Hospital provides diagnostics, registration and treatment for TB patients, including for MDR-TB, and is the only health services to do so in the whole of the South Fly District (Morris et al., 2019). The TB program on Daru Island provides a person-centred model of care and supports people to complete their MDR-TB treatment at community treatment sites. The administration of daily medication is provided at six community treatment sites called "Daru Accelerated

Response to Tuberculosis" (DART) sites across the island (Morris et al., 2019) along with psychosocial support and counselling (Adepoyibi et al., 2019). In 2016, when these sites were established, all MDR-TB patients began receiving food as material support during treatment. At the time of our study, both MDR-TB and DS-TB patients were receiving food vouchers and daily lunch at the DART sites. In addition, nutritional screening, assessment and supplementation was integrated in the TB program, especially for children.

Due to the centralisation of TB services on Daru Island, people who live in other parts of the district need to relocate from the mainland or other islands for the duration of their treatment, contributing to the overcrowding, pressure on resources and space, and widespread poverty. Although diagnosis and treatment of TB are free in Daru (and PNG more generally), getting there for people from remote and rural areas is both costly and lengthy, and transport is limited (Jops et al., 2023). The cost of living while staying on the island during many months of treatment can be onerous for mainland patients who are subsistence farmers or from low-income households (Jops et al., 2023). Residents, as well as people with TB and any accompanying family members, all subsist primarily on the island's staple diet of rice and sago (an edible starch made from palm stems), variably supplemented with tinned meat and fish, resulting in endemic undernutrition. In this article, we explore the assemblage of factors that creates Daru Island's food-scape and how it contributes to food insecurity, undernutrition and TB treatment challenges.

3. Methods

The specific findings presented here constitute one component of a larger qualitative study, which aimed to understand the diversity of socio-cultural and structural issues around the TB outbreak and response in South Fly District, with particular focus on Daru Island (Jops et al., 2022, 2023). In this article, we report on data collected between July 2019 and July 2020, including 128 semi-structured interviews and 10 focus groups with people undergoing TB treatment, caregivers and family members, service providers, healthcare workers, community members, religious leaders and other key informants. The snowball sampling method, the sample size, and interview schedules were all designed to elicit a broad range of lived experiences and perspectives on various dimensions of the local TB situation, including TB services and care in Daru, service accessibility and relocation, the TB treatment process, and structural, cultural, and environmental factors contributing to the spread of TB. We have systematically examined these different issues in respective articles (Jops et al., 2022, 2023, 2024). The present analysis examines the issue of TB treatment, with particular focus on food insecurity and undernutrition, which emerged as major themes in the participants' narratives in relation to treatment. Details of recruitment, sampling and data collection have been reported in full in previous publications by the research team (Jops et al., 2022; 2023).

Interviews and focus groups were conducted by Papua New Guinean social researchers between July 2019 and 2020 and took place at three South Fly locations; Daru Island and two mainland sites (Katatai and Abam). All interviews and focus group discussion were audio-recorded with participant consent and subsequently transcribed verbatim and, where applicable, translated from Tok Pisin and Kiwai into English by PNGIMR staff. Following an inductive thematic approach (Braun and Clarke, 2006), de-identified transcripts were coded in NVIVO 12 by a member of the research team in Australia, with emerging codes discussed and cross-checked for consistency by team members in PNG and Australia, drawing on their various disciplinary expertise and situated perspectives, a process which enabled further refinement of codes and identification of sub-themes (Jops et al., 2022; 2023).

The study received ethics approval from [the relevant institutions in Australia and PNG; details removed for the purpose of peer review]. Prospective participants were informed of the study and what participation involved by key informants working in outpatient and inpatient medical services in the study sites. Written consent was obtained from participants who were literate, while witnesses signed on behalf of those unable to read and write. Participants were also given the option of giving verbal consent if they were more comfortable doing so. Parental or guardian consent was obtained for participating adolescents on TB treatment. All participants were provided with refreshments and a small sum of money in appreciation of their time and contribution. Pseudonyms have been used in all study publications to protect participants' identity (Jops et al., 2022; 2023).

4. Findings

4.1. Un/healthy diets

There was broad consensus among the various participant groups that a key reason behind the ongoing TB outbreak in Daru is poor nutrition, making people more vulnerable to TB by lowering their immunity. The importance of a healthy and varied diet for people on TB medication was also widely recognised, and repeatedly emphasised by the TB service providers. "When you eat properly, it fights the disease, so these are some of the basic messages we give to the people", Wayne, a TB program coordinator, said. However, a similarly recurring theme was the difficulties of attaining a well-balanced diet for TB patients. Ezra, a participant in a focus group with community and religious leaders, said:

> We can keep on trying with our medicine; we will get exhausted and the medicine will run out and the sickness will still remain. We can continuously fund how many millions and the money will run out, but this sickness will still remain, because this is an island where nobody is eating … And when we are talking about balanced diet, we don't experience balanced diet in Daru.

This view was echoed by Sonia, a TB program counsellor: "I don't think we will be able to get that TB sorted out because the nutrition is the worst on the island". Priscilla, one of the hospital service providers, outlined the dilemma of providing health messages that conflicted with reality:

> You know, when we give the health education, it talks about eating good food: there's protein, there's vegetables, and there's carbohydrates, the three food groups. But on Daru Island, that is very hard, very hard. In the villages [on the mainland], that is much easier, but on Daru Island, it is hard for them to have a stable diet, a well-balanced diet because of the living condition here, it is very hard.

While undernutrition in Daru was a widely recognised problem, not all agreed on the cause. A minority of service providers presented different perspectives on the island's food situation, arguing that poor diets were not due to a shortage of food, but a choice driven by habitual ways of eating, a dislike of healthy foods, and a lack of knowledge how to prepare balanced meals, as purported here by Sylvia, a hospital healthcare worker:

> You see them; they will forever eat sago, sago, sago; dry sago with fish. That's their favourite food. I haven't seen them eat with greens and fruits, and all these types of food … they don't like greens … they still need to learn how to eat … peer educators have to teach them how to eat, cook and eat and educate them … It's all here in Daru, in the garden, in the sea, fish is here, banana is here, greens [are] here.

Daru residents were also described by some service providers as less concerned about their health than people with TB elsewhere, preferring to spend their money on tobacco and alcohol rather than on food, or ignoring medical advice, as Thomson, a hospital service provider, argued:

> [I]t's up to the patient now to take ownership of their life. We are in an environment where you know, people seem a little bit humbug. That gives a lot of challenges … unlike in other parts of the country,

people understand their life, they listen and they are very adherent with good nutrition support, whereas we have a lot of adult malnutrition. Once they run away from treatment, they come back very sick.

These views were exceptional rather than typical, yet they suggest that perspectives on undernutrition on the island might be shaped by different access to food and resources, based on people's social and economic position, indicating the concurrence of conflicting foodscapes. However, the most consistent theme emerging across the interviews, including among service providers, painted a far more complex picture of the food situation on the island for people with TB and their families than simply a matter of poor choices. "No, it's the availability of food", Walter, a TB project coordinator, said: "So, they do not have a choice, but they [just] have what they have". These narratives assembled a particular and intricate foodscape on Daru Island, one in which the environment, imported food, money, store monopoly, food vouchers, migration and family/social obligations converged, as we outline below.

4.2. Hunger and scarcity

Walter stated that the reason people on the island "do not have a choice" is "because the environment they have here is swampy, and the land is not good to grow different types of food … no good vegetables grow here". This description was echoed by other participants who noted that much of the available land on the island is not suitable for agriculture and home gardens, given most of it is scrubland, while the coastline consists largely of mud flats and mangrove swamps, and the soil is saturated with salt from the ocean tides. In addition, they emphasised that the island is small and consequently has insufficient land to grow a variety of foods, let alone additional space to expand production to provide for the influx of people with TB and their families over the past decade. Mathias, one of the Christian pastors, exclaimed: "There's no food. This is an island; where are we going to make gardens? Where are we going to get food?" And, according to Larry, a TB program coordinator, those who have the ability and space to make a garden soon give up, because "there's a lot of stealing going on".

Given the limited scope to grow food on the island, people "live on the store food", as Gamena, a TB training coordinator, observed. Service providers, people with TB and community members alike reiterated that most people are dependent on sago, rice and tinned fish from the main store on the island, while vegetables and garden greens are primarily imported from the mainland and irregularly sold at the local market, along with locally sourced fish. "Everything cost money here in town", a participant said in one of the focus groups with young men living on the island, some of whom had family members with TB. The price of imported food was described as expensive, making it difficult for both local residents and mainland patients to afford to buy enough food each week. Victoria, one of the TB support workers explained:

> I would say the access to food is difficult for the entire population in Daru … Most of the people in Daru can't grow their own food here, it comes from the mainland, so that means that you need money to buy the food and there's not many sources of income here. So, I don't know how people survive here.

Hunger was a recurring theme, a core feature of the local foodscape described by participants. It posed particular problems for people with TB who are instructed by healthcare workers to "eat plenty" because the medicines "are very strong", as Justin, a mainlander with MDR-TB, put it. Justin, along with other people with TB, mentioned that they sometimes go days without food, drinking only water, because they felt too fatigued or unwell to venture outside to look for food or access the free lunch. This made them reluctant to go to the community treatment (DART) sites and take their medication, knowing that the medication was likely to make them even hungrier. One of the TB counsellors, Sonia, commented:

> [W]hen the patients come and you ask them, "when was your last meal?" They will say, "my last meal was two days ago or three days ago". So, in that time, they haven't been eating anything. So, when you give them medicine, they will say, "I will have to find food [first], because there is nothing in my stomach".

Finding food was a daily struggle for people with TB, hospital healthcare worker Sylvia noted: "How can they look for food at the same time as they are sick?" For many, the daily lunch provided at the DART sites was their only regular source of food. While it was much appreciated, it was not considered adequate for peoples' daily nutritional needs. Annemarie, one of the young women in the community, remarked: "The patients are only given one-time lunch … but, in the evening, there is no one [who is] going to provide for them. Where are they going to find [food]?" Hunger was one of the main reasons that people with TB discontinued their treatment and mainlanders returned home, according to several services providers, including Larry, TB a program coordinator: "they feel hungry, and they want to go home … So, these are some of the hindrances where they don't stay [to] take medicine".

4.3. Longing for home

Food insecurity and undernutrition clearly emerged as an issue for people in Daru on the whole. However, people with TB from the mainland were having a decidedly tough time surviving on the island, especially those diagnosed with MDR-TB, considering the many months they have to stay for their treatment, often with little family support and with few opportunities to generate an income in a situation where resources are already severely strained. "[O]ne of the things that comes up a lot for the patients who are here from mainland is having access to accommodation and to food", TB support worker Victoria said. She explained that some stay at the sub-acute TB ward at Daru General Hospital, but most have to find a local family—so called "house people"—willing to provide lodging. House people do not receive any funding or subsidies from the government; they are "wantok" (relatives, kin, friends) who have some form of connection to the person with TB and who will take them in as part of kinship custom. Some mainland patients, especially children, have family members with them, making it even harder to find accommodation: "that's a lot to ask; to stay in someone's place that might already be overcrowded for eight months or so", Victoria remarked. Perhaps unsurprisingly, tension between mainlanders and house people was a common theme. In a focus group with people with TB, the following statement by Cecilia was typical among the stories by mainland participants:

> [W]e are all coming from faraway places or villages just to get treated over here, and when we are here we face these kinds of problems, all of us here … house and water and food. And sometimes that's why some patients are running away and they are not faithful to their medicines because of house problems and food side. They do not want to continue staying in this kind of suffering and sleeping out [side] the house when the house owners are not happy with them. That's why they give up and run away … back to the village to get good support there with food.

The same issues were raised by service providers who noted that the challenges of finding food and a place to live compelled some patients to discontinue their treatment and return to their mainland villages where "they have their family and everything", as Walter, a TB project coordinator, pointed out: "They have their own house … they have their own garden". This was a common refrain among mainland participants who often spoke longingly about the abundance at home, including Naomi who was staying in Daru with her grandchild, who was being treated for MDR-TB, and the child's mother. She explained:

> When you stay in the village, you have everything there. You make garden, you eat good food there like greens and fish. Everything is there, but when you come to Daru and you want to [eat] fish, you

> buy it with money, you want to eat good food, you buy it with money. But the thing is, we are not working. Where will we earn money to do that?

Brad (MDR-TB) and Paias (DS-TB), both from the mainland, said that if there were health services closer to their home villages, it would make TB treatment so much easier. "[If] I was living in my village, I would be alright", Paias said. Brad saw it as a solution both to the island's seemingly intractable situation and to enable patients to successfully complete their treatment:

> [J]ust set up DART sites in the village to stop all these problems with house and food and [house] people complaining … We will just be in the village and getting free food and staying in our own houses and getting our treatment until it is finished. So, these problems will be solved only by setting up DART sites in the villages.

Mainland participants tried to find other solutions to their struggles, such as arranging for family members back home to send food (a possibility only for those from nearby villages), or, like Clara, requesting to be provided with a few months' supply of TB medication for her teenage daughter Lorraine (MS-TB) so that they could return to their village where life would be far less demanding. Clara was deeply worried about her unattended house and garden back home, and how to feed herself and her daughter for six months without an income:

> I told the sister [nurse], "This advice about eating plenty, I find it hard to look for food here … [You] give us the [medication] supply and [we] go back to Balimo where there is [a] surplus and it would be easy for me to get what food [my daughter] wants. Any quantity and kinds of protein that she may want to eat are all there" … And they refused by saying, "we won't give you supply. You will stay for six more months and we personally will administer the medicines". [I said] "if that is the case, then you people must also give enough food; not just two flours in the morning [fried dough balls] and two spoons of rice during the day, [it] is not enough".

For family groups like Naomi's and Clara's, securing enough food for everyone while staying in Daru was particularly difficult. One of the TB counsellors, Sonia, stated that it was common for people with TB to share the lunch provided at the DART sites with family members: "they bring the family too, to eat the same lunch, so they go without food. It's [a] big problem here for our patients". This was not unique to those from the mainland, however. As we describe next, in this foodscape where undernutrition and poverty are widespread across the community, many people with TB felt obliged or pressured to share available resources.

4.4. Vouchers and sharing

Besides daily lunches provided at the DART sites, one of the non-government organisations distributes a monthly food voucher to support people with TB's nutritional needs. "[T]he program did recognise the fact that TB patients is to take quite a lot of medicine on an empty stomach, which is really not their choice, but because of the difficulty that the people go through here", Stavis, a TB program manager stated. The voucher also worked to incentivise patients to adhere to their treatment. Only those who were recorded as having attended a DART site every day of the month received a voucher, while those who missed a couple of days were not eligible for that month. "In order to qualify, you need to show effort that you really want to take the medicine and do it on a daily basis", Stavis explained. At the time of the interviews, people with MDR-TB received K150 (US$37), while those with non-MDR-TB received K100 (US$25). The voucher could only be used to buy food and only from a list of authorised items, purportedly to prevent the purchase of beer, or yeast and sugar to brew alcohol.

People with TB expressed genuine gratitude towards the non-government organisation for its support, but it came with provisos. The most commonly raised issue was that the voucher was not enough for a month, as Goretti, who was on treatment for MDR-TB said, "the shop is very expensive … so K150 it's, it's just only [for] one week". A few mentioned that a bag of rice cost around K45 (US$11), as an example. Another concern was that the voucher could only be spent at one supermarket on the island, not at the local market where fresh fruit and vegetables are sold. Suggestions were put forward to give half the voucher in cash to enable people on TB treatment to "buy garden food with that money", as Selina (MDR-TB), among other participants, said. While people on TB treatment were not permitted to sell the items they bought at the supermarket, it was a necessity for those who had no other way to obtain enough healthy food, as Justin (MDR-TB) described:

> [S]ometimes I sell those things or items I get from [supermarket], though it is not allowed. [The NGO] is not allowing any person to sell anything [bought] with the vouchers, but because I have nothing, I don't have anybody at the back of me who will help me financially, so I am doing this secretly. When I'm getting things, I sell some little bit of items like biscuit, noodles and lolly and that is how I live … [With] that cash money, we can … buy garden foods or fish or deer meat.

Adding to the difficulties of making the vouchers last a whole month, participants mentioned that relatives or house people often expected, or even demanded, a share of the purchased food. People with TB felt they had little choice but to agree to their request, either because of family obligations or because they wanted to avoid conflict with their house people and potentially lose their lodging. In a focus group with people with TB, Sonja, who was from the mainland, explained:

> So, when I get rice bag, I share with the house owner. In the past when patients get their vouchers, some of them they don't share their vouchers with [the house people] and then they started complaining, so that's why … I share it with the house people. If I didn't share my voucher with them, then they will gossip … and then I will [have to] look for another place to stay. So, to keep me staying in that house, I have to share my vouchers.

However, sharing was not always mutual. Ron, a man with TB who lived on the island with his father and brothers, said: "No, they don't support me, only myself … [but] when it's time to get the voucher … they'll all come and get what they want to get … But when I ask for money from them, they don't help me". Belinda, who had a baby she was still breastfeeding, said that she always shared voucher purchases with her house people, but when that food ran out, she would go hungry. "[T]hey [still] eat plenty. They use to just give me only little bit. It's not enough for my baby and me". Another person with TB from the mainland, Brad, elaborated on the invidious predicament for those at the mercy of others in a context of pervasive privation:

> [S]ometimes the house people don't feel good or don't think good about us. They tell us that, "We did not give you that sickness" or "we did not force you to get that sickness", and they don't share food with us properly or equally. But when we get voucher, that time, all those people are already happy and smiling for the food, so that's why we share it … And they tell us that, "You are another burden to us. This is town, we don't get food freely. It's money" … They say all sorts of words to us, but we have nowhere to go. We just think of our life and continue getting medicine, because life is important.

Given the general food insecurity on the island, it was troubling but not surprising to hear stories of relatives and house people congregating outside the store on voucher days. "[W]hen they hear that people are getting ready to get vouchers, there are already big crowds there; in front of that big shop there, or people are already there searching for [us]", said Thadelyn, a woman with MDR-TB from another island. Kopong, a TB program manager, also described the scene:

> I think most cases, when every month they go to get their items from the shelves in the shops, it's not the sick person going, but it's the

whole family going and selecting what they want, and not the patient selecting what he or she wants. It's the family doing the shopping for the family and it's not supposed to be.

Service providers agreed that things needed to change. Kopong suggested that patients make a list of what they needed and that TB support workers do the shopping for them, keeping the food in a safe place to be distributed every few days, "so that patient benefits 100% or 99% or 95% or something like that, instead of family shopping for their own personal gain or need and the patient is suffering". Others emphasised the need for awareness programs to educate people about the importance of letting those with TB keep all of their voucher to enable them to eat properly while on treatment. But they conceded that it would be difficult to control considering the poor conditions on the island, as one training coordinator, Gamena, stated: "most of our people here, they are not working and they just live on anything that they find", including patient vouchers.

5. Discussion

Treatment for tuberculosis is a lengthy and, for many people, challenging process. Our findings from Daru Island identified multiple conditions complicating treatment adherence and completion, including centralised health services, relocation, the economic burden of being away from home, obligations to share and, significantly, inability to access adequate food and nutrition. These findings are resonant with Diefenbach-Elstob et al. (2017) research on TB treatment barriers in PNG, and more broadly with cross-cultural qualitative studies that show how a wide range of intersecting social and structural factors can negatively impact TB treatment (Munro et al., 2007). Our specific analysis of food insecurity found that all these factors were interconnected; one factor contributing to another within a broader context of poverty and an environment unsuitable for food production. In short, the Daru foodscape for people with TB emerged as an assemblage of co-constitutive conditions. Hence, we make the point that food insecurity cannot be considered in isolation, on its own, dislodged from the local foodscapes in which it exists.

In 2013, WHO emphasised undernutrition as a major risk factor for developing TB. Yet, a decade later, Darnton-Hill et al. (2022) claimed that undernutrition remains largely ignored by TB programs at both local and global levels. They argued that improving endemic TB in food-insecure and under-resourced settings will partly depend on "scaling up actions on addressing undernutrition" (p.6). The recent findings of the RATIONS study provide evidence from a randomised trial of the potentially positive impact of nutritional support for both the prevention and treatment of TB in a population in India where malnutrition is common (Bhargava et al., 2023a, 2023b). It is likely that the optimal and most cost-effective response is by tailoring to the needs and context of the specific population, with close attention to local foodscapes and riskscapes.

Studies in Haiti, Russia and Singapore have also shown a positive link between food provision and TB treatment adherence (Balinda et al., 2019). However, as Darnton-Hill et al. (2022) point out, supplementary nutritional programs for populations facing undernutrition are both "expensive and complicated to deliver" (p.7). It is also unclear whether food insecurity can be solved by food assistance alone, "perhaps because providing food is a temporary solution to a more profound problem" (Balinda et al., 2019:7). On Daru Island, food assistance is provided through lunches and food vouchers. While these are helpful and valued, they are not enough in meeting people's needs and do not resolve the constellation of underlying dynamics that contribute to food insecurity in that setting, as our research highlights. So how can undernutrition among people on treatment for TB on the island be addressed? We argue that potential solutions need to focus on the social and structural conditions that contribute to undernutrition in the first place, rather than on undernutrition itself.

As we saw, one solution raised by several participants was to make TB services more widely available in rural and remote communities, so that people can stay in their villages with easy access to healthy garden food while undergoing treatment (Jops et al., 2023). In other parts of PNG, decentralisation of TB services has been shown to improve treatment outcomes (Maha et al., 2019). While Daru Island already has a community-based model of care, this decentralisation from facility-based care is limited to the island. Efforts to extend and scale-up decentralisation and build the capacity of local health services across PNG are underway, and, in light of our findings, we strongly support this policy, specifically extending community-based treatment sites to the mainland and across the South Fly District. However, as we have noted in detail elsewhere (Jops et al., 2023), decentralisation of services for TB is one component of a broader strengthening of the national health sector, requiring a whole systems approach, and this is a slow process, encumbered by a significant lack of financial and human resources, given the scarcity of primary health services, remoteness and logistic challenges.

A more immediate solution raised by some mainland participants was the possibility of self-administered TB treatment, of being supplied with medication that could be taken at home, as is done for HIV. On Daru Island, health workers supervise the daily administration of TB treatment at the six DART sites. This globally common strategy is intended to ensure proper adherence throughout the course of the treatment, and thus enhance patient outcomes and prevent drug resistance (McLaren et al., 2016). But, in settings where TB services are centralised, such as the South Fly District, another outcome of this strategy is that people with TB in rural and remote areas have to relocate and significantly disrupt their lives, financially and socially, to access treatment. This arrangement, as we have seen, can cause people to discontinue their treatment because of hardship, thus increasing the risk of drug resistance.

With the rise of global commitments to promote people-centred models of care, supervised TB treatment has been questioned in terms of privacy, human rights and cultural considerations, but also its effectiveness versus self-administered treatment (McLaren et al., 2016; Ongugo et al., 2011; Zimmer et al., 2021). Whilst direct observation of TB treatment remains in PNG guidelines, recent WHO (2022) guidelines recommend community-based treatment support in the form of a healthcare worker or a properly trained lay person helping people with TB take their TB medications, and providing emotional support and medical intervention when necessary.

Data from a meta-analysis of comparative studies found little statistically significant difference between the two strategies (McKay et al., 2019). Alternatives to supervised TB treatment, including home delivery of treatment, multi-month dispensing, and family-supported and community-based strategies have been successfully used in some settings where daily facility-based treatment has been rendered impossible by conflict, war or pandemics (Zimmer et al., 2021), but also in settings with remote mountainous topography, poor transport services and inadequate health infrastructure, such as in the Gulf Province of PNG (Kurbaniyazova et al., 2023).

5.1. Strengths and limitations

Most available research on TB in PNG is epidemiological and quantitative (e.g. Morris et al., 2019; Aia et al., 2018), with very few studies using a qualitative approach. The kind of rich and nuanced data that qualitative methodologies enable constitute one of the major strengths of this study, by providing a situated perspective on the lived experiences and socio-structural dimensions of TB in this PNG setting. Our examination of food insecurity, undernutrition and TB treatment was one component of this larger study. Participants spoke to the issues they perceived as important to them, and while food insecurity and undernutrition was a crucial factor that frequently arose, the breadth of the study may have limited an in-depth discussion of each of the dimensions

related to TB, including the present topic. Additionally, the findings are highly contextualised and therefore not necessarily generalisable to PNG more broadly, nor should they be considered representative of the experiences of people with TB in other parts of the country.

6. Conclusion

The TB treatment program on Daru Island has, for all intents and purposes, been a success in terms of containing the outbreak, which likely reflects the community engagement, person-centred care and treatment support that have been sustained over the past decade. However, the persistent and composite food insecurity on the island risks undermining these efforts. Our findings highlight the need for decentralised community-based approaches, including the establishment of community treatment and care sites on the mainland, and for strengthening the person-centred care and support components. While more research is needed to confirm the outcomes of self-administered take-away TB treatment in PNG, both in relation to DS-TB and MDR-TB, this too could potentially provide a solution to the food insecurity and undernutrition on the island, and the challenges it poses to treatment adherence. We recommend that it be implemented in consultation with people with TB and providers as part of a comprehensive package of person-centred care and support.

We have used the concept of foodscapes to illustrate how food insecurity and undernutrition in the context of TB treatment on Daru Island is not solely a matter of food shortage, but a nexus of multiple co-constitutive conditions. This, therefore, suggests that solutions to undernutrition are more intricate than providing additional nutrition; it requires attention to the social, structural and environment conditions that shape and perpetuate particular foodscapes, highlighting the value of qualitative research in elucidating local perspectives and lived experiences in this setting and beyond.

CRediT authorship contribution statement

A. Persson: Writing – review & editing, Writing – original draft, Formal analysis. **P. Jops:** Writing – review & editing, Formal analysis. **J. Cowan:** Writing – review & editing, Supervision, Data curation. **M. Kupul:** Writing – review & editing, Supervision, Methodology, Data curation. **R. Nake Trumb:** Writing – review & editing, Data curation. **S. S. Majumdar:** Writing – review & editing, Funding acquisition, Conceptualization. **S. Islam:** Writing – review & editing. **H. Nindil:** Writing – review & editing. **W. Pomat:** Writing – review & editing, Funding acquisition, Conceptualization. **S. Bell:** Writing – review & editing, Funding acquisition, Conceptualization. **G. Marks:** Funding acquisition, Conceptualization. **M. Bauri:** Writing – review & editing. **S. M. Graham:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **A. Kelly-Hanku:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization.

Ethics approval

The study received ethics approval from the PNGIMR Institutional Review Board, the PNG National Department of Health's Medical Research Advisory Committee, and UNSW Sydney (HC180602). The study was endorsed by the Western Provincial Health Authority, PNG. Prospective participants were informed of the study and what participation involved by key informants working in outpatient and inpatient medical services in the study sites. Written consent was obtained from participants who were literate, while witnesses signed on behalf of those unable to read and write. Participants were also given the option of giving verbal consent if they were more comfortable doing so. Parental or guardian consent was obtained for participating adolescents on TB treatment. All participants were provided with refreshments and a small sum of money in appreciation of their time and contribution. Pseudonyms have been used in all study publications to protect participants' identity.

Financial disclosure statement

This work was supported by the National Health and Medical Research Council [grant number 1142715] (AKH). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Declaration of competing interest

The authors have declared that no competing interests exist.

Acknowledgments

The authors would like to thank the funders of this project, the National Health and Medical Research Council (NHMRC). We are also grateful to the people in Daru, Papua New Guinea, who participated in this study, and who generously gave their time and shared their stories with us.

Data availability

The data that has been used is confidential.

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