


Geographic and occupational mobility of small-scale fishers of Lake Malawi: an exploratory study of water, sanitation, and hygiene access, Malawi

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ABSTRACT

The livelihood of small-scale fishers on the world's freshwater lakes cuts across the Sustainable Development Goal (SDG) 6, which covers water and sanitation, and SDG 8 on economic growth. The aim of this study was to examine the nature and extent of fishers' mobility patterns and access to improved sanitation facilities, safe drinking water, and handwashing practices while at work and home for two fishing camps in Malawi. The study used key informant interviews, questionnaires, water quality testing, and an observational checklist, followed by interviews on fishers' occupational migration. Many fishers (85%; 51/60) live and work in fishing camps with their families. Most fishers only went on day trips, but 8% of their working days were away from the fishing camps. Only eight fishers had safe (0 cfu/100 ml) drinking water at home. Most fishers reported drinking (97%) from and going to the toilet (92%) in the lake during fishing. Historical trends in cholera cases did not correlate with higher periods of migratory behavior of fishers observed in this study. Improving the livelihoods of small-scale fishers requires attention to their culture, the economics of the industry, and geographic criteria while at work and within fishing communities along the shores of Lake Malawi.

Key words: Fisher, Lake Malawi, Migration, Occupation, Sanitation, Water

HIGHLIGHTS

- Examination of small-scale fishers' occupational mobility and access to improved sanitation facilities, safe drinking water, and handwashing.
- Most fishers went on day trips year-round.
- Fishing communities lacked universal access to water, sanitation, and hygiene.
- Public health models need to consider cultural, economic, and geographic criteria of fishers.

INTRODUCTION

The livelihood of fishers on the world's freshwater lakes cuts across the Sustainable Development Goal (SDG) 6, which covers water and sanitation, and SDG 8 on economic growth (United Nations, 2019). Globally, fishing carries occupational health hazards, including accidents, injuries, chronic physical problems, lifestyle factors, and exposure to contaminants affecting the people associated with fishing and their communities (Woodhead *et al.*, 2018), but occupational health issues related to basic access to toilets and safe drinking water are not often considered. The existing literature on small-scale fishers' occupational mobility focuses on ocean-based operations (Aburto *et al.*, 2009; Crona & Rosendo, 2011; Binet *et al.*, 2012; Wanyonyi *et al.*, 2016), with limited research on freshwater lakes (Nunan, 2010; Nunan *et al.*, 2012). However, the African Great Lakes are known to have waterborne disease outbreaks, such as the spread of cholera in water stemming from poor access to water, sanitation, and hygiene, in their shoreline fishing communities (Oguttu *et al.*, 2017; Kaponda *et al.*, 2019).

Lake Malawi is a large African freshwater lake (28,750 km²). In the 1870s, Lake Malawi was a major part of the migration route for Central Africa, with a transition to fishing as an occupation for the economic expansion of Malawi by the 1930s (McCracken, 1987). Today, the lake remains an economic stronghold for rural communities living along its shoreline, especially for employment in the small-scale fishing industry (Malawi Government, 2005, 2017). Currently, more than 50,000 fishers, mostly male, operate on Lake Malawi as gear owners and

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crew members (Malawi Government, 2017). Fish are consumed at the household level, and some are sold. The most common fishing craft for small-scale fishers is the dugout canoe (Malawi Government, 2017). Migration is an occupational necessity for the fishers (Russell & Dobson, 2011). Shoreline communities along Lake Malawi are characterized by sandy soils, where rural households place pit latrines for human excreta, but latrine collapses and shifting floors are an environmental challenge (Cole *et al.*, 2012). Furthermore, drinking water access is complex; shoreline communities may not have universal access or may choose not to use the available improved sources (Kaponda *et al.*, 2019; Malawi Government, 2019). This challenge for access to improved sanitation facilities and safe drinking water for shoreline fishing communities living along Lake Malawi is further evidenced by high fecal bacteria contamination in the zone up to 15 m from the shore (Tyner *et al.*, 2018). However, Malawi has a National Water Policy (Malawi Government, 2005) advocating for acceptable quality and satisfactory quantities of water for drinking and the environment in addition to a National Sanitation Policy (Malawi Government, 2008) promoting toilet and handwashing use and infrastructure. Yet neither of these national policies address the unique circumstances of the well-being and vulnerabilities of small-scale fishers at work on the lake and in their communities.

This work builds on other recent studies on the gaps in access to water, sanitation, and hygiene in the Malawian fish distribution chain, among local vendors in the open-air markets, and the balance of food safety and hygiene within the economies of low- and middle-income countries (Morse *et al.*, 2018; Lazaro *et al.*, 2019; Samikwa *et al.*, 2019; Kalumbi *et al.*, 2020). The aim of this study was to examine the nature and extent of fishers' mobility patterns compared with historic cholera case trends and the associated access to improved sanitation facilities, safe drinking water, and handwashing practices while at work and home for two fishing camps in Malawi. The key question is: How do the occupational mobility patterns of fishers impact their access to water, sanitation, and hygiene? The results of this study are then used to propose a targeted public health model in fishing communities to improve the health of small-scale fishers working in Lake Malawi and their communities.

METHODS

Study area

Our study focused on two fishing camps located along the shoreline of Lake Malawi at Tukombo in the Nkhata Bay District and Ngara in the Karonga District (Figure 1). Both are permanent camps with at least some small-scale fish processing units (smoking, drying, or parboiling) and with easy access to a paved main road (Malawi Government, 2009, 2013). Both Karonga and Nkhata Bay Districts have had suspected cholera cases periodically since 2003 (M'bangombe *et al.*, 2018; Kaponda *et al.*, 2019).

The Nkhata Bay District covers 4,182 km², with a population of 285,000 in the 2018 census (Malawi Government, 2019). There are 8,277 small-scale fishers in Nkhata Bay District, and the district has a low rate of households using an improved water source, 75% compared with 85% nationwide. Improved household sanitation in the district is 12%, compared with a national mean of 18% (Malawi Government, 2017, 2019). Handwashing stations with soap and water are also low at 9% for the Nkhata Bay District and nationwide at 11% (National Statistical Office (NSO) & ICF, 2017).

The Karonga District is north of the Nkhata Bay District and covers 3,416 km². The district had 365,000 people in the 2018 census. The Karonga District has a comparatively higher coverage of improved water sources (89%) and improved household sanitation access (23%) (Malawi Government, 2019). The rates of available household handwashing stations with soap and water (25%) are some of the best in the country (NSO & ICF, 2017).

Sample and recruitment

Thirty fishers were recruited from each fishing camp, and all were citizens of Malawi. The respondents, who were identified in consultation with the local Department of Fisheries Field Officer, were purposefully recruited from those who were in charge of devising when and where to fish in Lake Malawi and represented a range of socio-demographic characteristics.

Nine key informants were interviewed based on their link to the migration of fishers and public health work in the study area, including community leaders (2), local government Department of Fisheries field officers (2), local government Health Surveillance Officers providing frontline healthcare in the community (2), community health volunteers (1), and one female fisher (1). A representative of a local nongovernmental organization working on water and sanitation access in the fishing camp at Tukombo was also interviewed (1).

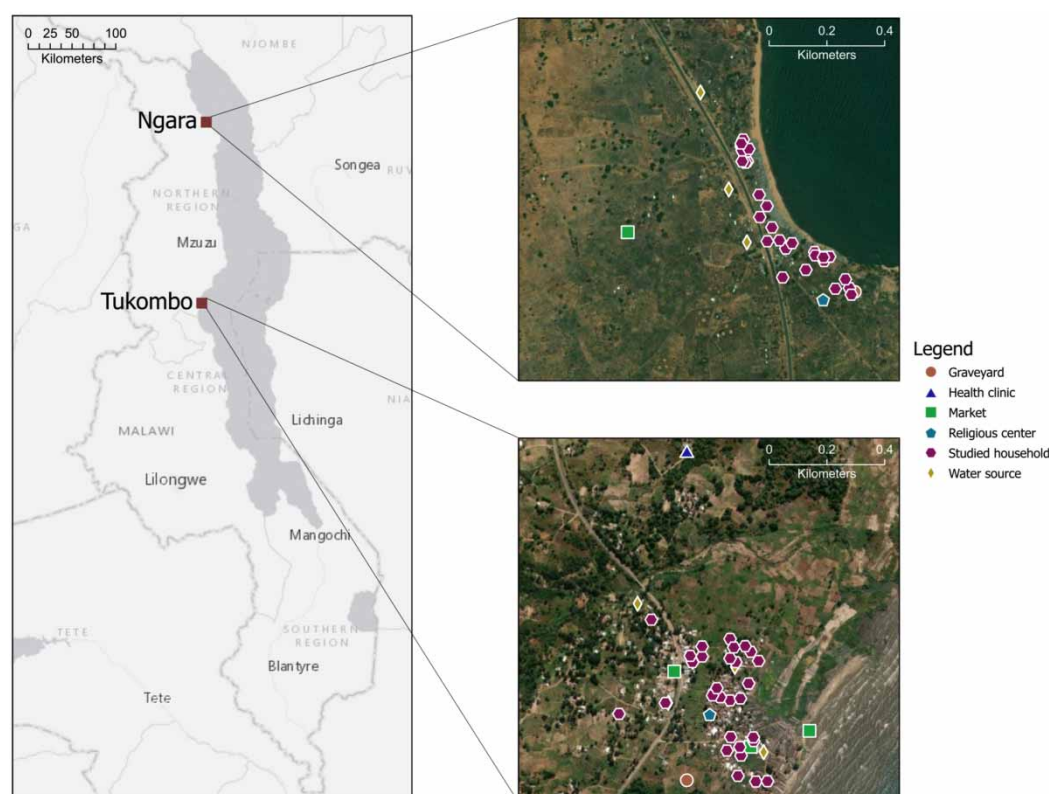


Fig. 1. | Study sites, Ngara in the Karonga District and Tukombo in the Nkhata Bay District, Malawi.

Data collection

Interviews were conducted in the local language of Chichewa, Chitumbuka, or Chitonga or in English by two research assistants, with the same research assistant for each camp for the full study duration. The responses were transcribed and translated into English for the data analysis.

Upon recruitment, a detailed in-person interview was conducted with each fisher on sociodemographic characteristics. One respondent declined to answer the question on education. Following this, the participant interviews were conducted orally, either face-to-face or by phone, on the occupational monthly migration patterns over 12 months. The questionnaire included the recall of daily information regarding whether they had fished, type of fishing gear and craft, names of beaches they visited, fish species caught, reasons why they did not fish every day, and when moving, whether it was alone for work or with their family. Due to the COVID-19 pandemic, comprehensive interviews on the fishers' occupational migration from August 2019 to July 2020 were only possible for 19 of the 30 respondents at the Tukombo camp and 22 of the 30 respondents at the Ngara camp.

Water-quality testing and an observational sanitary survey at the 60 fishers' homes were conducted between August and September 2019. The respondents' stored drinking water and linked drinking water sources in the fishing camps were tested for thermotolerant coliforms, pH, turbidity, and total dissolved solids. At the time of sample collection, the pH was determined using a Wagtech Hydrolite pH Sensor (Wagtech, UK), turbidity was determined using Jackson turbidity tubes, and total dissolved solids were determined using an EcoTestr TDS Low handheld meter. Additionally, the samples were analyzed in a field laboratory within 8 h of collection using the Wagtech Potatest Membrane Filtration Unit (Wagtech, UK) at 44 °C for 18 h to determine the thermotolerant coliform concentration. Using the same methodology, daily equipment blanks using boiled and cooled water were analyzed as negative controls, and all were found to be negative for thermotolerant coliforms.

At each fishing camp, GPS readings were taken at the graveyards, markets, religious centers, health clinic, and water sources. The map was created using ArcGIS Pro 2.5.2 (Redlands, CA, USA).

Historical data regarding the 2017–2018 reported cholera case rates in the Karonga and Nkhata Bay Districts were provided by the Malawi Government Ministry of Health (personal communication, May 18, 2018, and April 25, 2019). No cholera cases were reported during our study period at the two fishing camps.

Data analysis

Statistical analyses were conducted in the R environment (R Project 3.5.1, Vienna, Austria), and the default significance cutoff value was $p = 0.05$.

The water quality results were compared with the [World Health Organization \(2017\)](#) guidelines for drinking water. A wealth ranking was conducted and measured according to the fishers' reported ownership of a bike, car, cell phone, cookstove, radio, refrigerator, and/or television; poorer households own fewer assets. The fishers' access to improved sanitation facilities and safe drinking water were also ranked. No fishers had handwashing stations at home. The fishers were ranked as 'low' for having no toilet or a shared toilet and drinking water quality of >0 cfu/100 ml; ranked as 'medium' for a shared toilet and safe drinking water (0 cfu/100 ml) or for having a nonshared toilet (no one else outside their household used their toilet) and drinking water quality of >0 cfu/100 ml; and ranked as 'good' for a nonshared toilet and safe drinking water (0 cfu/100 ml). The interview data were analyzed using a thematic framework and approach.

Ethics

This study and its informed consent procedures were approved by the Republic of Malawi National Commission for Science and Technology (Protocol No. P.05/19/385). Written informed consent was obtained from each study participant.

RESULTS

Characteristics of fishers

Most fishers at Tukombo (90%; 27/30) and Ngara (80%; 24/30) lived and worked in the fishing camp with their partners and children. The respondents reported seven people as the mean number in their household the evening before the survey (eight in Tukombo and six in Ngara).

The respondents reported a mean of 15 years (15 years at Tukombo and 16 years at Ngara) in the fishing occupation. Approximately one-third (37%; 22/60) of the respondents relied solely on fishing as their occupation. The remaining respondents listed additional income generation activities, all of which would keep them off Lake Malawi for work: a fish transporter, farming, owning a small grocery store, informally selling fuel, carpentry and boat construction, a secondary school teacher, landlord, minibus operator, raising pigs, and selling second-hand clothes and shoes. Less than half (40%; 24/60) of the respondents participated in agricultural activities, which commonly included growing peanuts, maize, cassava, and rice, which could be dried and stored for household subsistence.

Among the respondents, one female at Tukombo was considered an active fisher because she entered the waters together with her crew members. She responded as follows when asked about her background and household income generation activities:

'I started fishing-related activities in 2007 when I was selling and transporting usipa {a local fish species} and transferred to Tukombo {fishing camp} in 2008, but then stopped all fishing activities when I moved to South Africa, where I worked for six years doing domestic work. I returned back to Malawi in 2014 and resumed fishing again at Tukombo site. In 2019, I started entering the water, going fishing together with my crew members, which {are} composed of all men. I am the first female to enter the waters at Tukombo {fishing camp}. Apart from going out fishing, I own and rent engines to other fishers, and I also transport and sell usipa.' (Female interviewee, October 2, 2019)

Asset ownership was used as an indicator of wealth, as poorer households had fewer assets. Having a cell phone (82%; 49/60) was the most common asset, followed by cooking stoves or electric hot plates (50%; 30/60), radios (48%; 29/60), televisions (32%; 19/60), refrigerators (25%; 15/60), bicycles (23%; 14/60), and cars (7%; 4/60). More than half (55%; 33/60) of the respondents would be classified as 'poor,' with zero to two assets, 28% (17/60) would be 'middle class' with three to four assets, and 17% (10/60) as 'upper class.' Only four respondents had none of the studied assets, and none had all seven assets. Financial facilities for fishers via mobile money options are available in both study areas.

In terms of the small-scale fishers' education level, 68% (40/59) reported some primary school (8 years or less formal education), while 27% (16/59) of the respondents had some secondary school (between 9 and 12 years of

formal education), and 5% (3/59) had education beyond secondary school. The researchers observed that 11 of the 60 fishers could not read and write (in any language), with lower literacy in Tukombo.

Fishers occupational access to safe water, improved sanitation, and handwashing

Most fishers (97%; 58/60) reported drinking water from the lake while fishing in Lake Malawi. Similarly, when asked 'Where do you go to the toilet during fishing?' Most (92%; 54/59) reported using the lake.

At Tukombo, there is a public pay toilet along the shoreline, although it is in poor condition. At Ngara, while there is no public pay toilet along the shoreline, there is one toilet at the nearby open-air community market in poor hygienic conditions that is reportedly used by fishers. Neither fishing camp had handwashing facilities nor safe drinking water where the boats land at the community beach.

The results of this study indicate that there was nearly no access to safe water, improved sanitation, or handwashing for fishers while working.

Fishers' access to safe water, improved sanitation, and handwashing in their community

Neither fishing camp had access to piped water, but both fishing camps had access to a safe drinking water source, 0 cfu/100 ml, meeting the WHO (2017) guideline. At Tukombo, the shared community boreholes, an improved drinking water infrastructure, are open daily from 6 to 10 a.m. and are otherwise locked by committee members, and have a monthly fee of MK500 (USD\$0.68)/household. At Ngara, the boreholes are open continuously, and the water users do not pay for access.

Government health workers (Health Surveillance Assistants [HSA]) are in each community offering basic services for children under 5 years old, family planning for women, and community health education during daytime hours. Both HSAs emphasized the challenges in their work area related to water, sanitation, and handwashing access. Both study areas have some level of community-based organization working on the issues of water, sanitation, and hygiene access.

The HSA for Tukombo said about the fishing camp:

'The soils within the shores of the lake make it impossible for people to construct better toilets, and the toilets usually collapse soon after construction. Some people prefer defecating outside in bushes, because their toilets are nasty and poorly kept, plus the odor inside their toilets {are} awful due to poor hygiene practiced by the household.' (Male interviewee, August 29, 2019)

At Ngara, the HSA had a similar response:

'The sanitation is good at the clinic, but the pit latrines at the community or household level are poor.' (Female interviewee, October 9, 2019)

The community leader for Ngara similarly added:

'The lack of public toilets at our site {where the boats land} makes most fishers to use nearby toilets, which is not proper for household hygiene, that gives much more problems due to insufficient toilets for the incoming fishers....' (Male interviewee, October 8, 2019)

Beyond behavior, the environmental challenges were also echoed by the community leader for Tukombo, who sets community regulations to improve household sanitation and hygiene access:

'Most households lack pit latrines due to the sandy soil, that makes it difficult to construct a toilet. Toilets built in this area usually collapse; therefore, people tried constructing a nkhokwe {traditional reed fence placed along the walls of the below ground surface pit} to protect them from falling but this method has no effect during the rainy season.' (Male interviewee, October 1, 2019)

The village health volunteer for Ngara said further about the environmental challenges:

'So, at our beach, I can say 3–5 households share one toilet, because there is limited space where to build toilets for the incoming fishers who rent at the site.' (Male interviewee, October 9, 2019)

Beyond sanitation, challenges in safe drinking water access were similarly repeated at both fishing camps, but the general awareness that drinking from the lake caused exposure to waterborne disease was demonstrated. The community leader of Tukombo said:

'The other problem that has caused many health issues in this area is the unavailability of piped water, which results in people in the community using untreated water for domestic uses, hence making them vulnerable to waterborne disease.' (Male interviewee, October 1, 2019)

The community leader for Ngara similarly added:

'The main problem that we face at our site here is about lack of clean water, as most people drink water from the lake due to distances to draw water from the boreholes, but we are requesting for tap water.' (Male interviewee, October 8, 2019)

The results of this study indicate that there was limited access to safe water, improved sanitation, and handwashing for fishing communities due to a combination of behavioral and environmental challenges.

Fishers' access to safe water, improved sanitation, and handwashing at their home

At Tukombo, most (90%; 27/30) fishers collected their household water from an improved drinking water infrastructure, a combination of public boreholes and private pumps. The respondents were observed to collect water and then store it prior to consumption in plastic containers, such as a bucket or bottle (90%; 27/30) or clay pots (10%; 3/30) (Figure 2). The stored water pH ranged from 5.94 to 8.11. The total dissolved solids ranged from 60 to 170 ppm, and the turbidity of all the stored water samples was less than 5 Jackson Turbidity Units (JTU). The thermotolerant coliforms were above the 0 cfu/100 ml guideline (WHO, 2017) for the drinking water for most households (90%; 27/30). For the four households with thermotolerant coliforms in their drinking water of >200 cfu/100 ml, the water was obtained from a mix of improved (3/4) and unimproved (1/4) sources and stored in a mix of plastic (3/4) and clay (1/4) containers before consumption.

At Ngara, fewer (70%; 21/30) fishers collected their household water from improved drinking water sources, while the other respondents (30%; 9/30) reported using Lake Malawi surface water for household drinking. The respondents stored water in their homes in plastic containers (67%; 20/30) or clay pots (33%; 10/30). The pH of the stored water ranged from 8.01 to 9.00, while the total dissolved solids ranged from 120 to 920 ppm. For each household, the turbidity was less than 5 JTU. The thermotolerant coliforms were above the 0 cfu/100 ml guideline (WHO, 2017) for drinking water for many households (83%; 25/30); however, only one household had thermotolerant coliforms >200 cfu/100 ml and was using an improved source and storing drinking water in a plastic bucket after collection.



Fig. 2. | Household drinking water storage in a covered traditional clay pot (a). Fishers at work (b). Household drinking water storage in a plastic bucket (c).

Only eight out of 60 fishers had safe (0 cfu/100 ml) drinking water at home. The household stored drinking water thermotolerant coliforms and water source thermotolerant coliforms were not significantly different (paired t -test, $p = 0.26$). However, the fishers' household thermotolerant coliforms were different between the study sites (Mann–Whitney U test, $p = 0.012$), with the mean values at the Tukombo and Ngara fishing camps of 45 and 14 cfu/100 ml, respectively. Although available in both communities, not all households used the improved water sources due to the distance from home or beach worksites or personal preference for drinking lake water.

Whether the respondent had a private toilet, a shared toilet, or no toilet at home did not necessarily impact the safe water in the fishers' homes (Kruskal–Wallis nonparametric ANOVA test, $p = 0.77$). For households with a private toilet, the mean thermotolerant coliform concentration was 35 cfu/100 ml ($n = 25$); for a shared toilet, it was 26 cfu/100 ml ($n = 34$); and for no toilet, it was 14 cfu/100 ml ($n = 1$). Furthermore, the thermotolerant coliforms in the stored household water did not differ from the number of assets owned as a wealth indicator ($p = 0.39$). These results indicate no link to wealthier fishers having better access to safe water at home. Furthermore, the household stored water quality conditions did not differ according to whether the fisher could read and write ($p = 0.59$).

The results of this study indicate a range of accessibility to safe water, improved sanitation, and handwashing at fishers' homes, despite a common occupation.

Fishers' temporal patterns

The respondents ($n = 41$) fished mostly at their fishing camps (Figure 3). The fishers were not highly mobile and were away from the studied fishing camp only 8% of the days to follow targeted fish species and better catches (815 migratory days away from camp/10,597 total days fishing during the study period). Some fishers did not migrate at all, and the maximum was 73% of the days studied. The majority (76%; 31/41) spent 95% or more of their days at their fishing camps. A Kruskal–Wallis rank-sum test of the total monthly days fishing indicated differences between at least 2 months ($p < 0.05$), with more days working and migrating commonly from April to July. However, the fishers' occupational patterns of migration from the community were inconsistent with the temporal cholera cases in the respective fishing camp districts, which have historically peaked in December and January (Figure 4).

At the Tukombo fishing camp, two fishers stood out with more total days of fishing. Classified as poorer in the household asset wealth indicators, each had access to a pit latrine but also had drinking water thermotolerant coliforms that did not meet the WHO (2017) drinking water guideline. In contrast, at the Ngara fishing camp, the total number of days fishing over the studied period was higher, with more fishers working daily, year-round, with a range of household asset wealth indicators and water and sanitation access. The most migratory fisher at Tukombo was not one of the individuals with more total days of fishing, whereas at Ngara, the most migratory fisher also spent more days fishing; and these high migratory fishers at Ngara were in the middle or upper class in the household asset wealth indicator category.

The fishers reported migrating primarily due to weather (rain or wind) and the availability of fish and did not necessarily have preplanned temporal patterns. Only one of the 41 respondents stated that they consistently migrated with their partner; the remaining respondents always, or mostly, left their family behind at the fishing camp.

The female fisher at Tukombo said about her choice of occupational migration patterns:

'Most times I fish here at Tukombo, but when the catches are low, here we move to other sites, which is still a challenge, but I make sure I am only gone for a day and rush back to be with {my son}. Although fishing is not considered as a female occupation, I intend to continue because I don't have the necessary papers for normal jobs because I stopped school in primary plus, unlike other jobs, I am good at it and it provides enough income for me and my son.' (Female interviewee, October 2, 2019)

The results of this study indicate that there was no clear positive effect of migration at the household level in terms of household wealth, access to water, sanitation, and hygiene, or providing wider universal community access. In addition, the periods of occupational migration did not follow the same temporal trends of the historical cholera cases in the area.

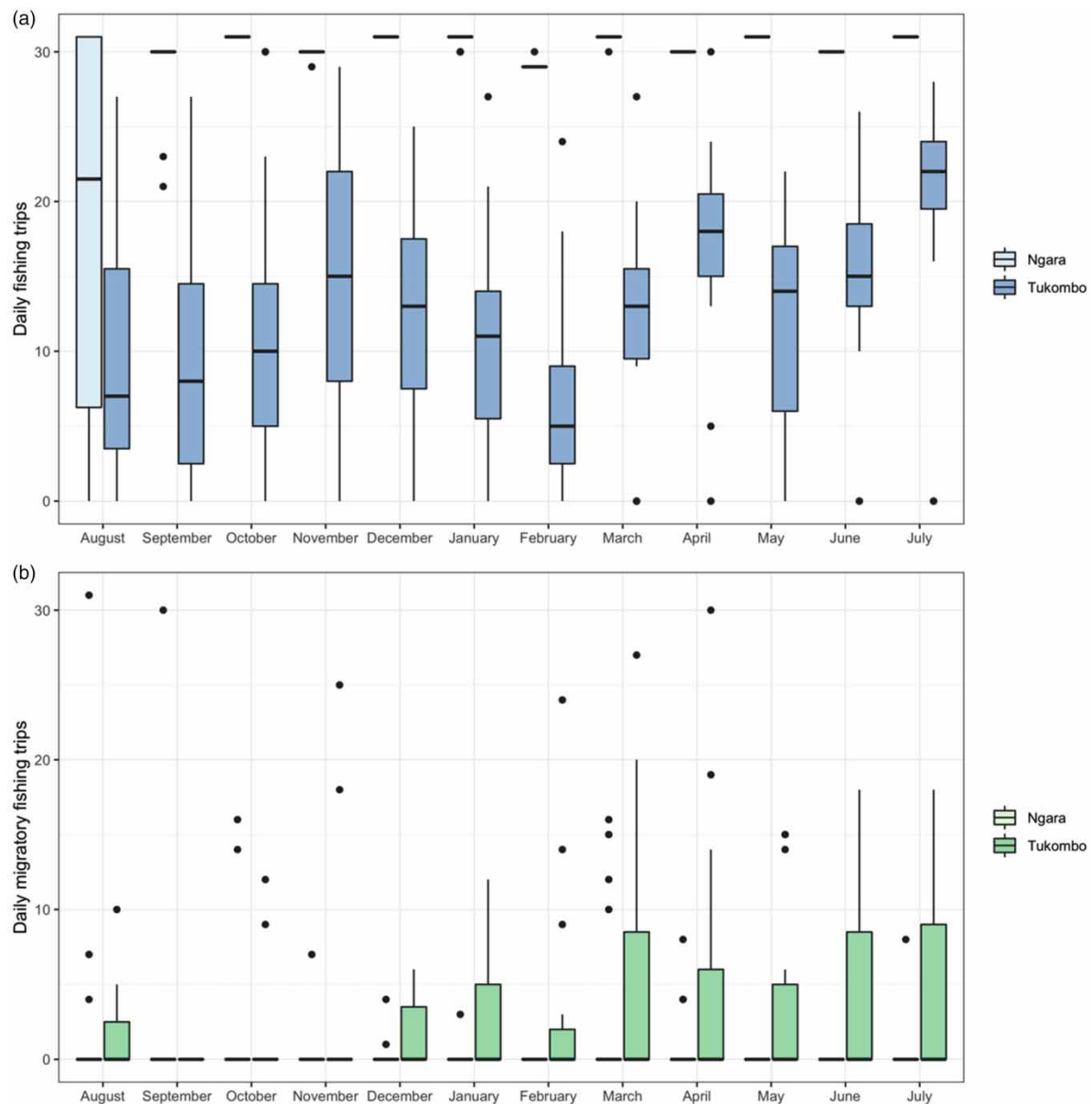


Fig. 3. | Effort distribution (total number of fishing trips) in the study area by month ($n = 41$); at Ngara, most fishers reported fishing trips each day of the month (a). Migratory effort distribution (total number of fishing trips away from their primary camp) in the study area by month ($n = 41$); at Ngara, most fishers reported fishing trips during the month only at their primary camp (b). Median, two hinges, two whiskers, and all 'outlying' points individually.

DISCUSSION

In this study, we used mixed methods to develop an in-depth understanding of fishers' occupational, community, and home access to water, sanitation, and hygiene along the shores of Lake Malawi. The availability of access to improved sanitation facilities, safe drinking water, and handwashing while at work and at home affects food safety and occupational factors for the fishing communities in Africa, yet this issue remains under-researched. [Maja & Ayano \(2021\)](#) noted the impact of increasing population growth in low-income countries impacting natural resources in response to climate change. [Limuwa et al. \(2018\)](#) determined that small-scale fishers in Lake Malawi have been increasing their fishing time as a result of their perceptions on climate change, including fishers' perceptions of extreme weather events and low fish catches, which our study respondents also reported as reasons for occupational migration. The following sections propose a public health model with special attention to fishers and occupational mobility with regard to cultural, economic, and geographic criteria to increase access

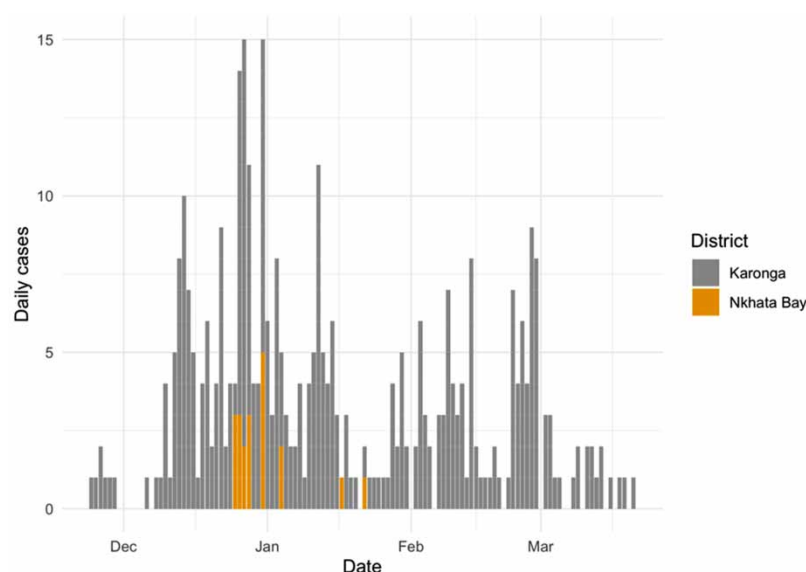


Fig. 4. | 2017–2018 cholera cases in the Karonga and Nkhata Bay Districts (data provided by the Malawi Government Ministry of Health).

to water, sanitation, and hygiene and improve the health of small-scale fishers in Lake Malawi and their communities.

Culture of fishers and their communities

Fishing is deeply ingrained in the culture of the fishing communities studied. [Mphande \(2015\)](#) writes about the lakeside Tonga culture in Northern Malawi:

‘Apart from marriage, fishing is a provider of local association and kindship bonds. Most fishing activities are centered on the village, whose men folk share one net-shelter (khumbi) which is also their mphara (men’s gathering place). It is also a place for moral instructions to the boys and also for learning how to be kind or share with others. Individuals who live inland may be regular visitors to some Khumbi, as the basis for friendship with one of the members of the lakeshore village. Here, they exchange with one another stories that take place within their related hamlets or villages. Fishing songs are often composed and reflect Tonga creativity.’ (p. 64)

Nearly a century ago, [Mackenzie \(1925\)](#) wrote about the Ngonde ethnic group in the Karonga District:

‘Fishing remains an important part of the year’s work for those living near river or lake. For river fishing, huts are built in the vicinity of the place where the traps are to be set, for the fishers live there for as long as the season lasts.’ (p. 142)

Similar to our study, [Kalumbi et al. \(2020\)](#) also found gaps in water, sanitation, and hygiene access within fishing communities; but variations in handwashing access especially may be attributed to the culture of fishing communities in the Tonga and Ngonde ethnic group in our study compared with the Yao ethnic group in the [Kalumbi et al. \(2020\)](#) study.

In our study areas, migration away from the fishing camp for more than day trips was limited. [Russell & Dobson \(2011\)](#) reported that the median length of residence in a Malawian fishing community was 4.5 years. Although there was a limited seasonal dimension to movement in our study, one might have expected the period of higher geographic mobility to match the historical peak reported cholera cases; however, this was not the case. Other studies have linked a cholera outbreak in a Ugandan fishing camp as being introduced by a visitor and spread by low access to community water, sanitation, and hygiene ([Oguttu et al., 2017](#)), indicating that migration within the community, not only fishers’ occupational migration patterns, may play a larger role in waterborne disease.

There were gaps across the water, sanitation, and hygiene access at work and at home in our study. [Bivins *et al.* \(2019\)](#) noted that 90% adherence to household water treatment is necessary for health gains, but this is difficult for our study respondents due to the number of workdays that the fishers are away from their homes or communities and the limited interaction with the HSA. The HSA may consider offering more flexibility in the services to coordinate with the fishers, tailoring health clinics to be held during the predicted times of poor weather, when fishers are not on the lake and are instead at the net-shelter. This can be further implemented without much cost or risk involved for either the fisher or the HSA.

Transformative community models for fishers and their communities should focus on using community advocates in a peer-to-peer oral approach or the use of local radio by experts outside the community rather than large community meetings or a single HSA clinic. In addition, for fishers at work, building pit latrines periodically along the shoreline with a focus on suitable technology for sandy soils could work well as a collaborative community effort. In our study, the results of one female respondent who had moved in and out of the fishing occupation visibly indicates that further research regarding female fishers is necessary. Public health messages should include targeting female fishers and their families and not assuming that fishing communities consist of only male fishers.

Economics

Based on the wealth indicators of a phone, television, and/or radio reported in the 2018 census, the fishers in this study were better off than national averages ([Malawi Government, 2019](#)); however, fishing days or migration days were not linked to the highest access to assets or having good water, sanitation, or hygiene at home. In contrast, other studies have found that greater fisher migration has a positive effect on fishers and their communities, including improved access to assets and having a pit latrine ([Wanyonyi *et al.*, 2016](#)). [McCracken \(1987\)](#) noted that historically, Lake Malawi fishers, as labor migrants or part-time fishers, transitioned in the 1950s by moving from areas where they lacked access to land to shoreline communities for occupational fishing as a cash crop. [Nunan \(2010\)](#) also notes that for the Lake Victoria area, fishers staying in one place allow an investment in the 'home' camp infrastructure.

For most rural communities of Malawi, the economies of the households and their communities are focused on subsistence farming, which brings a single agricultural crop per year, typically around the months of May or June. As such, public health strategies for rural households in Malawi have typically avoided the harvest period when people are working, and instead focus on the months after harvest. Still our fishers were fishing for at least a portion of each month, indicating a year-round income. [Wanyonyi *et al.* \(2016\)](#) also note that fishers who have enough household wealth to own a mobile phone further allow communication with other fishers on occupational migration and mobile money transfers. Despite the wealth indicators, other studies have shown that the willingness to pay (cash) for a low-cost pit latrine remains low in shoreline communities ([Holm *et al.*, 2016](#)). Pit latrine sharing was commonly reported by both our study respondents along Lake Malawi and by [Kalumbi *et al.* \(2020\)](#) for communities along Lake Malombe.

A policy response for improving water, sanitation, and hygiene for fishers and their communities may include transformative economic models to focus on the self-investment of year-round income with steps building up to better access at home and work. However, acknowledging that many of our respondents had income beyond fishing, this confirms previous findings ([Nunan, 2010](#)) that other livelihoods, such as farming, are an important component of fishers' livelihoods similarly found on Lake Victoria. Using our study results, the approach could begin with no and low-cost options, such as building a noncollapsing pit latrine with grass walls for privacy and no roof, then adding a roof and a drop-hole cover; later stages could include other low-cost solutions, such as a handwashing station with soap and the practice of household water treatment.

Geographic

The results from our respondents indicate that geographic mobility outside the fishing camp is limited. This contrasts with fishers in Lake Victoria who are reported traveling up to several hundred kilometers within 1 year, and with variability in the patterns of direction of movement of fishers, even from the same fishing camp ([Nunan, 2010](#); [Nunan *et al.*, 2012](#)). The reported spatial distribution of fishing efforts for both coastal and freshwater fishers has been primarily based on a resource co-management-driven focus ([Aburto *et al.*, 2009](#); [Crona & Rosendo, 2011](#); [Russell & Dobson, 2011](#); [Nunan *et al.*, 2012](#)). [Binet *et al.* \(2012\)](#) advocated for regional level data sharing on fishers' migration, rather than for specific fishing camps. Such an approach in a transformative community

model for fishers and their communities would also be helpful in Malawi, including transboundary data sharing on fishers' migration with Mozambique and Tanzania.

Limitations

This study did not include a random sample. The results of this study are likely to date quickly based on the evolving migratory patterns and the impacts of climate change, and because the study data were collected during the COVID-19 pandemic. The study did not investigate the influencing roles on the migration of human, financial, physical, social, or environmental factors. The study design did not include menstrual hygiene management for female fishers while at work, which would require further study. Although Lake Malawi is bordered by the three countries of Tanzania, Mozambique, and Malawi, this study did not consider foreign migrants. Future research is needed to monitor small-scale fishers using GPS tracking.

CONCLUSION

Public health interventions, where there are a large number of fishers, cannot exclude the unique occupational impacts of access to water, sanitation, and hygiene while at work and at home. While it is not uncommon for the rural communities of Malawi to lack access to water, a place to go to the toilet, and handwashing facilities, fishers are unique for their long workdays lacking access to toilets and drinking water on Lake Malawi and the environmental conditions and cultural norms of their fishing communities. This study found that most fishers only went on day trips but fished many days of each month year-round. There was no clear positive effect of migration at the household level. Fishers are often portrayed as being particularly at risk, and that their migratory behavior contributes to higher waterborne diseases in fishing communities along the shores of Lake Malawi. This perspective stems from misunderstanding at the local level of occupational migration and that decades of underinvestment have left many fishing communities lacking in basic access to water, sanitation, and hygiene. The results of this study do not provide evidence to support such perceptions. Improving water, sanitation, and hygiene access for small-scale fishers and their communities requires attention to the culture of fishers, economics of the industry on households, and geographic principles to guide interventions along the shores of Lake Malawi.

ACKNOWLEDGEMENT

This work received financial support from Furman University.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

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First received 19 March 2021; accepted in revised form 18 May 2021. Available online 18 June 2021