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Addressing health care disruption in rural Mozambique due to extreme climate events: mobile units tackling cyclones, vaccine-preventable diseases, and beyond

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Floods, and cyclones are occurring with increasing frequency and intensity worldwide due to global warming. Mozambique is very susceptible to these extreme events due to its geographical location. In the last ten years, four of the most severe extreme climatic events have been observed in this country, leading to widespread destruction of infrastructure and the displacement of inhabitants. Cyclones Dineo in 2017, Idai and Kenneth in 2019 and recently Freddy in 2023 affected in total over two million people impacting food and water security, causing cholera outbreaks and damage to health facilities. The mobile health units, known as *Brigadas Móveis* (BM), are crucial to the Mozambican health system as they provide people in the most remote areas with vaccinations, and antimalarials, and other interventions. The BM activities in five districts of Inhambane province in the south of Mozambique are run by the NGO Medicus Mundi Italia in collaboration with the local health authorities. Cyclone Freddy flooded the province of Inhambane, affecting road accessibility and the BM's planned operations in all five districts with a loss of 37.8% of BM outreach activities. The temporary absence of the BM service resulted in rural communities having no access to health care, including routine vaccine administration. Adaptation strategies need to be implemented to address the healthcare challenges associated with extreme climate events. As described in our experience in Inhambane, BM restored outreach activities immediately after the cyclone, improving access to care after challenging situations.

KEYWORDS

cyclones, floods, climate-induced disasters, healthcare disruption, Mozambique, public health, mobile health units, vaccines

1 Introduction

Despite their differences, floods and heavy precipitations, heatwaves, prolonged droughts, and cyclones are some of the extreme events that the Intergovernmental Panel on Climate Change (IPCC) states are becoming increasingly frequent and more intense worldwide due to global warming. The increased occurrence of these extreme weather events poses a persistent threat to health systems and individual well-being, especially in low- and middle-income countries (LMICs) (1). Millions of people have been exposed already to acute food and water insecurity, with the largest adverse impacts in many vulnerable communities. Moreover, exposure to such events results in immediate disruptions of services, increased risks of infectious diseases including water-, food- and vector-borne diseases and non-infectious diseases including mental health consequences, physical trauma and long-term effects (2).

Due to its geographical location, Mozambique is highly susceptible to floods and cyclones.

In the last ten years, four of the strongest cyclones ever registered in the South-West Indian Ocean area, have been observed in Mozambique (3). No cyclones or floods have been recorded from 2008 until 2017, but after cyclone Dineo, the climate crisis exacerbated the frequency and intensity of cyclones, leading Mozambique to be ranked 1st out of 180 countries in the Global Climate Risk Index for 2019 and resulting in widespread destruction and displacement (4).

Cyclone Dineo struck Mozambique in 2017, causing significant damage in the Inhambane province, affecting approximately 130,000 people (3). Cyclone Idai hit the central region in 2019, directly affecting 2.1 million people and causing food and water insecurity and cholera outbreaks (5). Cyclone Kenneth followed soon after, caused further cholera cases, infrastructure damages and displaced around 3,500 people (6). In 2023, cyclone Freddy impacted eight out of eleven regions in the country, affecting over a million people (7).

In this context we analyzed the performance of healthcare outreach activities conducted by the non-governmental organization *Medicus Mundi Italia* (MMI) during cyclone Freddy, which affected the province of Inhambane in February 2023. We analyzed indicators related to the number of routine vaccinations administered and the number of outreach activities performed during the observation month (March 2023), comparing it to the same month of the two previous years (March 2022 and 2021). The results obtained may shed light on the impact of natural climate-induced disasters on disruptions in healthcare services. Through this perspective, our objective is to underscore the urgent necessity of introducing, integrating, and reinforcing flexible strategies capable of reaching isolated populations during and after environmental disasters and providing the necessary healthcare support.

2 Mozambique healthcare system

The healthcare system in Mozambique comprises central and provincial hospitals, rural healthcare facilities, healthcare centers. Despite this decentralized organization, half of the rural population

has limited access to care and only for 53.6%, the nearest health center is less than 45 minutes walking (8). In response to low access-to-care and low vaccination rates among the population, the *Brigadas Móveis* (BM) service was introduced in 1979 by the Ministry of Health (MoH) (9).

This strategy was essential to implement vaccination campaigns aimed at reducing vaccine-preventable diseases and decreasing infant mortality. Routine vaccines include tuberculosis prevention (BCG), pentavalent vaccines against tetanus, diphtheria, pertussis, polio, *Haemophilus influenzae b* (DTaP-IPV-Hib), vaccines against hepatitis B (HepB), rotavirus (RV), pneumococcal conjugate vaccines (PCV), as well as vaccines against measles, mumps, and rubeola (MMR) (10).

Nowadays the BM system plays a crucial role in delivering different healthcare services, extending beyond vaccinations to rural areas (11).

Nevertheless, despite the efforts and achievements, the BM service is still underimplemented. Indeed, according to the *Brigadas Móveis* Report promoted by MMI in 2017, the BM system is present in only 115/141 (81.6%) districts of the country, despite governmental recommendations suggest coverage across all districts (12).

Each BM has a multidisciplinary team, ranging from 2 to 5 professionals, including at least one healthcare professional and a nurse with expertise in the mother and child health. Regularly, the BM reach each district from one to three times a month. During outreach activities, the BM always ensure vaccination service, in addition to other various activities such as babies growth control, vitamin A supplementation and anthelmintic drugs, health educational activities, prenatal visits, family planning counseling and other activities including TB or leprosy control programs, counseling and testing on sexually transmitted infections, and mental health (10). Moreover, considering the high frequency of extreme events, BM sensitize and alert communities about imminent dangers, helping them prepare and stay safe during extreme weather events (13).

The Government, in collaboration with the National Institute of Meteorology (INAM), has recently implemented a capillary system to enhance preparedness for climate-induced disaster (14). An early warning system reaches at-risk communities and mobile health units. In rural areas, community leaders, and community health workers receive notifications through BM service and through community radio communications, cell phone calls and/or SMS text messages to widespread information and to effectively inform the rural population.

As demonstrated by similar experiences, mobile health units are crucial in addressing emergency health responses in cases of conflicts and natural disasters, successfully delivering urgent aid to the most remote populations unable to reach health centers (15, 16).

When remote health care centers are damaged, and even if roads are disconnected, BM, using motorbike or off-road vehicles, are the only means to provide basic health assistance in those areas where people are not at walking distance from stable health centers.

Medicus Mundi Italia (MMI) is a non-profit NGO, specialized in health cooperation (12). It is officially recognized by the WHO

(WHO resolution EB63 R27) and is a member of the Medicus Mundi International network. Since 2008, MMI has been involved in the development of primary health care projects in the Inhambane province, starting from the Morrumbene District and subsequently expanding to other areas. MMI's focus has been on offering and enhancing the BM system in rural communities, with a community-based approach that ensures the service is sustainable and affordable for the communities.

As of 2023, MMI supports the BM system in 5 different districts within the Inhambane province (12): Morrumbene (pop. 136,980 inhabitants), Massinga (pop. 236,939 inhabitants), Funhalouro (pop. 44,140 inhabitants), Homoine (pop. 114,877 inhabitants), and Panda (pop. 43,968 inhabitants) (Supplementary Figure 1) (17). In the course of the year 2022, a total of 821 BM outreach activities were realized in the different rural communities, with MMI contribution.

3 Direct and indirect health impact

Extreme weather events cause both direct and indirect impacts on physical and mental health (2).

On the one hand, waterborne diseases (WBDs) are representative of direct impact. Biological, physical and chemical changes due to climate-induced natural disasters like floods and cyclones (18–20), along with inadequate sanitation practices, shortage of potable water and contamination of house water in cyclone-affected areas, significantly enhance the risk of microorganisms' replication and the transmission of WBDs, including cholera, dysentery, hepatitis A, typhoid fever and polio (21).

Cholera, caused by the bacteria *Vibrio cholerae*, is an acute diarrheal disease that can prove fatal within hours if left untreated (22). People usually get sick by swallowing contaminated food or drinking contaminated water with the cholera bacteria. This waterborne disease represents a global health challenge because in the last decades several outbreaks have been recorded worldwide and they mostly have been triggered by extreme events (20).

In Mozambique, several cholera outbreaks hit the country following cyclones, resulting in numerous cases and deaths. According to the weekly bulletins on outbreaks and emergencies published by the WHO African Region, as a consequence of Dineo 1,400 cholera cases with a case fatality rate (CFR) of 0.2% were reported (23). After Idai and Kenneth, 7,052 cholera cases were recorded including 8 dead in Sofala and Cabo Delgado province (24) where the CFR was 0.12% (5), while cyclone Freddy was responsible for over two million cumulative cholera cases in ten provinces of the country, with 129 deaths and a CFR over 1% in seven out of ten provinces (25).

On the other hand, public infrastructure's disruption, including healthcare facilities, reduces accessibility, availability, and quality of healthcare services, causing indirect effects on physical and mental health and vulnerable populations like older adults, pregnant women, and children are at higher risk (26). Furthermore, cyclones and floods can contribute to create internally displaced persons (IDPs) and worsening an already fragile health context

characterized by poor access to basic services and lack of resources (5).

These cascading effects disproportionately affect vulnerable communities and populations, leading to inequities in resource distribution during the recovery phase. A systematic review from 2012 found a 50% increase in the population mortality at all ages and a 40% increase in mental health disorders in the first year after a severe flood episode (27).

Cyclones Kenneth and Idai have caused severe damage to 113 health facilities in Mozambique, disrupting healthcare services and reducing population access to healthcare. Pozniak et al. explained how cyclone Idai disrupted in continuity of care for chronic diseases as the follow-up of people living with HIV (28). Travel time increases, accessibility coverage decreases, and geographical accessibility to healthcare declines in affected areas. In Idai-affected districts, the percentage of children under 5 years of age covered within 2 hours travel time to reach a healthcare facility decreased from 78.8% to 52.5%, implying that 136,941 previously covered children under 5 years of age lost timely access to care. Relative accessibility coverage in all Kenneth-affected districts decreased from 82.2% to 71.5%, corresponding to 14,330 children having lost access to the nearest facility within 2 hours travel time (29). Moreover, cyclones Idai and Kenneth created in 2019, respectively, 478,000 and 24,000 new IDPs. In this context, where overpopulation and low hygienic-sanitary conditions coexist, cholera outbreaks, along with other vaccine-preventable diseases such as measles, were more frequently reported (30).

Several studies in different geographical areas of the world reported a reduction of antenatal and postpartum care visits. These phenomena can be also related to a limited access to healthcare services (31). In particular, cyclone Idai in Mozambique caused widespread disruptions in the delivery of health services, specifically impacting maternal and child health. Immediately following the cyclone, there were significant and meaningful decreases observed in all aspects of maternal and child health services. Maternal health indicators showed immediate relative losses in March 2019, followed by a gradual recovery to pre-Idai levels by May. For instance, there was an 11.0% immediate relative loss in first antenatal care visits in March, with Sofala province experiencing a higher loss of 17%. Overall, the administration of BCG vaccines dropped by 10.0% (32). Although service delivery levels appeared to return to normal by May 2019, it is important to note that this recovery may not indicate a complete restoration, as there was a need to recover the losses incurred during the affected months. This is particularly relevant for indicators such as immunization, family planning, and antenatal care, where seeking timely care could have been delayed due to the cyclone's impact (32). Furthermore, other health effects indirectly attributable to the cyclone have been identified, as the devastation of crops has resulted in increased rates of malnutrition. In fact, 6 months after the cyclone Idai, Sofala province reported 600 cases of pellagra after decades with no episodes, suggesting Idai triggered the pellagra development in a population that already suffered from food insecurity and vitamin deficiency (33).

4 Impact of mobile units on healthcare access: the case of the Inhambane rural districts

In isolated contexts with weaker epidemiological surveillance, quantifying the impact of extreme weather events on health becomes challenging. Evidence identifies floods as a significant geographical barrier due to their acute onset, recurrent nature, and slow recovery process. This not only limits BM services, but also hinders patients' access to healthcare, isolating entire communities. These events have ripple effects on the supply-side of healthcare, leading to shortages in medical supplies and disruptions in the referral system (34). In fact, for people living in communities farther than 7 km from a primary health care center (HCC), BM often represent the only link to healthcare services.

During natural disasters roads can be impassable, therefore BM are not able to reach those communities. As a result, people should walk long distances to reach HCC, if these are still functioning after such extreme weather events. At the same time, once the roads are restored, BM are able to intensify interventions bringing supplies, recovering missed visits and administering vaccines. Otherwise, repairing the HCC damages it may take several weeks or months for becoming operational again on offering health services.

In late February and March 2023, the cyclone Freddy induced significant inundation in the Inhambane province, leading to compromised road accessibility and affecting the 53 scheduled outreaches activities of the BM in all the five districts. In particular a loss of 20 BM outreach activities were recorded (37.8% loss). Even though no cholera cases were officially registered in these rural areas, the absence of the BM service led to months without healthcare access for rural communities, forcing the population to walk around 7-15 km to reach another healthcare facility. As a consequence, the majority of users tend to stay at home and resort to traditional practitioners for their healthcare needs (35). Moreover, with a weaker surveillance, severe enteritis and potentially cholera cases could have been misdiagnosed and overlooked.

In particular, the Funhalouro district, situated inland within the Inhambane province, emerged as one of the districts most profoundly affected by the flooding according to the data collected by MMI. In March 2023, a mere 5 BM missions were executed, in stark contrast to the corresponding month in 2022 and 2021, during which 15 and 14 BM outreach activities were successfully completed in that month, respectively (65.5% loss). Considering that BM are the only health care services able to reach remote destinations, the absence of mobile health unit outreach activities have consequently resulted in a substantial decrease in the administration of vaccines to the population of those areas, which received 120 vaccinations doses as opposed to the 493 and 424 administered in the same month in the two preceding years (73.8% loss). Even if BM could be acutely and temporarily affected by heavy rainy events, they remain the only option when all other systems fail to provide aid. Using off-road vehicles, they constitute a significant

tool to restore safety health conditions in remote areas as soon as roads are drivable again.

Notably, starting from the subsequent month, the BM operations gradually reverted to a standard regimen, with an increase in both the number of outreaches activities (from 5 to 17) and vaccine doses administered (from 120 to 466) (Supplementary Figure 2).

The Panda district, located within the Inhambane province, also experienced significant ramifications due to the cyclone. In March 2023, a mere 3 BM outreach activities were conducted, a notable decrease (62.5%) compared to the 8 missions carried out during the same month in previous years. Consequently, the number of vaccine doses administered in the month affected by the flooding plummeted to 45 (79.5% loss), as compared to the 220 doses administered in March 2022. Parallel to the situation in Funhalouro, the BM service swiftly regained its operational capacity starting from the subsequent months, with 14 BM missions and 257 vaccine doses administered in April 2023. The adoption of a structured mobile health service, as that has been used in collaboration with MMI, is key given their ability to swiftly reach remote regions, particularly in situations where traditional healthcare facilities are non-operational. As evidenced in the aftermath of cyclone Freddy, BM successfully reinstated missed appointments once road access was reestablished.

This approach not only enhances healthcare availability in challenging geographical areas but also proves to be a resilient and adaptable tool after emergency situations, capable of tailoring its services to the needs of the population.

5 Conclusion

Extreme events related to the climate crisis act as a trigger for inequalities and disproportionately affect the most fragile countries with weak adaptation systems and populations in vulnerable situations.

The case of Mozambique is not unique and direct and indirect consequences on human health and social systems can be observed in other LMICs facing natural disasters.

Considering the escalating incidence of extreme climatic events in certain regions, like Mozambique, there is a pressing need to allocate additional resources to preparedness plans and population education in order to enhance adaptation. In this context a multi-sectoral approach involving healthcare systems, weather services including an implementation of early warning meteorological alert, and infrastructural interventions is most likely the most suitable approach. BM might represent a part of the solution as they proved themselves as a flexible strategy to improve access-to-care even after natural disasters.

As demonstrated also by Lien et al, health mobile units offer a diverse range of advantages since they could overcome barriers to health care access both in acute and in chronic situations, they could be quickly deployed in emergencies, they can assess population needs according to different situations (36).

As described in the five districts of Inhambane, the routine activities promoted by BM allowed to improve the health status of the most disadvantaged populations. Immediately after the acute

event they have recovered the number of outreach visits and the number of vaccine-doses administered.

In this perspective, we have discussed the adaptability of BM in reaching isolated populations within the specific context of a disrupted healthcare facility. However, further evaluation and effectiveness studies are ultimately necessary to maximize the impact of mobile clinics.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary Material](#). Further inquiries can be directed to the corresponding author.

Author contributions

BR: Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing. BF: Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing. CC: Data curation, Methodology, Writing – original draft, Writing – review & editing. NT: Data curation, Writing – original draft. RC: Data curation, Writing – original draft. FB: Data curation, Writing – original draft. BC: Supervision, Writing – original draft. LT: Conceptualization, Supervision, Writing – review & editing. FC: Conceptualization, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/ftd.2024.1328926/full#supplementary-material>

SUPPLEMENTARY FIGURE 1

Location of Inhambane province (bordeaux) in Mozambique with focus on the five districts (Morumbene, Massinga, Funhalouro, Homoine, and Panda) served by Brigadas Móveis with MMI's support.

SUPPLEMENTARY FIGURE 2

Number of BM outreach activities and vaccine-doses administered from March 2021 to March 2023, Funhalouro district.

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