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Oars of Hope: A Study on Boat-based Services and Public Health Equity among Char/Sapori populations in Lakhimpur, Assam

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Abstract

Public health care access in remote and riverine areas of India, specifically in Assam remains a vital concern, where geography severely restricts connectivity to healthcare. Characterized by its extensive river channels and dispersed char/saporis settlements (River islands) which accounts for a total of ten percent population of the state that is more than 30 lacs population resides in these islands (NHM Assam). These areas are frequently ravaged by the flood results into suffering and deteriorated health status of the inhabitants. Lakhimpur often renders road based emergency services which are still insufficient or altogether inaccessible for these areas With an intervention to transport patients from riverine and char areas for better health care facilities, boat ambulance and clinic services have been provided by Government of Assam under National Health Mission (NHM) which is also an integral component of Emergency Services named as 'Mrityunjoy'. This paper attempts to explore the role of boat-based healthcare services in Emergency Response in Lakhimpur through analysis of secondary data sources like Field documentation by NGOs such as the Centre for North- East studies (C-NES), NHM reports, case studies and media coverage, etc. This study presents a plight on scale, scope and limitations of these services. The findings emphasize the substantial role of boat clinics in providing preventive treatment, but they also additionally highlight attention to restricted reach, upkeep problems along with viability and integration of such models in broader public health domain. This paper concludes with recommendations and suggestions aimed at enhancing the responsiveness and dependability of boat-based healthcare delivery in remote areas.

Keywords

Assam, Boat clinics, Disaster resilience, Flood-prone areas, Health equity, Lakhimpur, Mobile healthcare, Public health access, Riverine communities

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Introduction

In India, where a sizeable population inhabits near rivers and witnessing surge in the flood-prone areas with time at the rate of 0.014 million hectares per year (Singh & Kumar, 2013), geographic remoteness remains a pressing challenge and crucial determinant in accessibility to healthcare services. Considering, specifically the case of Assam, According to Rashtriya Barh Ayog (RBA) 39.58% of the total land area comes under flood prone areas. Drawing conclusion from National Family Health Survey-5 data, which indicates that some of the vital health measures like NN (Neo-natal Mortality rate- 22.5/1000 live births), IMR (Infant Mortality Rate- 31.9/1000 live births) and (Under-five mortality rates 39.1/1000 live births) are in worse condition which bags Assam a place among highest top three particularly in North East. Around 46.9% of the total population is not visiting healthcare facility for their treatment due to absence of a nearby health care centre or physically inaccessible to residents of remote riverine villages (Saha, 2023).This data reflect a plight of the condition of the health facilities in Assam. Moreover, which worsens due to annual floods exposing them to waterborne and vector-borne diseases.

Lakhimpur, originated from the work Lakshmi (The goddess of prosperity) with approximately 1.2 million population[2] (Census Projections, 2024) one of the vulnerable districts as located on the North East corner of Assam and at the north bank of the River Brahmaputra (Saha, 2023). It is bounded on the north by Siang and Papumpare District of Arunachal Pradesh and on the east by Dhemaji District and Subansiri River. The river Brahmaputra along with Majuli District stands on the southern side and Gohpur sub division of Biswanath District is on the West. Acc. to NHM Assam Statistical Handbook 2024, Lakhimpur has 1 Medical College, 1 Sub Divisional Hospital, 154 Sub centre, 29 PHC and 3 CHC, Despite constant efforts and significant gains under the National Health Mission (NHM), rendering healthcare services in these ecologically sensitive zones remains hindered by limited connectivity and inadequate emergency response systems. During 2022-23 floods, data from Assam Emergency Management services reveals that a considerate proportion of individuals went unserved due to terrain inaccessibility and lack of functional boat ambulances. Adding to the structural vulnerability, Assam HDR (2014) indicates that while Lakhimpur has a HDI (Human Development Index) of 0.58 slightly above the state average of 0.557, health outcomes still remain challenged. Life expectancy is overall 60 years but drops drastically to 40 years among flood-affected populations.

The Maternal mortality ratio (MMR) of Assam stands at 328 (RGI, 2013), one of the highest in the country. These indicators demonstrate the cumulative effect of floods and inadequate healthcare systems on the survival of mothers and children, highlighting the pressing need for creative solutions like boat clinics to close the healthcare gap in Lakhimpur.

[2] *NHM Statistical Handbook-2024, Government of Assam* *https://des.assam.gov.in/sites/default/files/swf_utility_folder/departments/ecostat_medhassu_in_oid_3/menu/document/statistical_handbook_assam_2024_0.pdf*

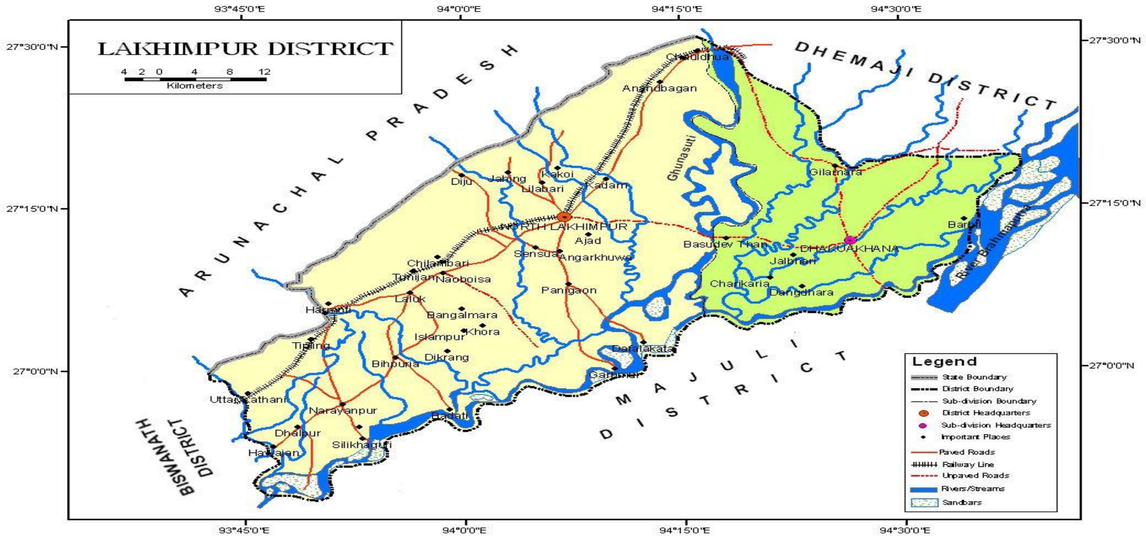

Figure 1 Map of study area

(Source:http://lakhimpur.nic.in/)

Background

The Brahmaputra valley of Assam is particularly vulnerable to flooding; districts such as Lakhimpur experience recurrent inundation, degradation of river banks, and population displacement almost every year. According to Assam State Disaster Management Authority (ASDMA, 2023 and 2024), approximately 50-60% area is affected annually by floods in the district which devastate homes, public infrastructure, including health facilities

Table 1 Flood Impact in Lakhimpur District, Assam (2023-24)

Parameters	2023	2024
Rainfall (Normal)	2031.8	2656.5
Rainfall (Actual)	1851.3	2551.8
Affected Revenue Circles	7	7
Affected Villages	250	379
Affected Population	124283	175031

In addition to isolating settlements and interfering with transportation systems, floods also create spikes in waterborne and vector-borne diseases such as diarrhoea, malaria, and skin infections, while simultaneously rendering many sub-centres and primary health centres non-functional. To address and mitigate these barriers, the Government of Assam launched the Boat Health services initiative in 2008 in collaboration with C-NES (Centre for North-East studies) with a dedicated aim to provide preventive and promotive services to populations inhabiting in remote and riverine regions aided with mechanized boats staffed by medical teams with focus on Curative Care, Reproductive and Child care, Family Planning Services and Basic Laboratory Services etc. Initially piloted in Dibrugarh, in partnership with the district administration then later expanded its services in other districts with UNICEF in picture. Currently, 15 boat clinics and 5 boat ambulances operates across Assam, including one boat clinic in Lakhimpur. The work of the boat clinics has led to remarkable results like catering to 18,000-20,000 people on an average per month in the districts who were earlier away from the reach of government programmes related to healthcare due to irregular visits by the medical personnel.[3] However, among the flood prone and char dwelling communities of Lakhimpur, despite expanding outreach of preventive medicine and treatment significant limitations persists in emergency responses, continuity of care and referral support. This paper attempts to highlight key role, performance and challenges of boat-based health interventions in the Lakhimpur district.

Displaced on the edge: Distribution of chars/saporis across the state highlighting social and geographic exclusion

Lakhimpur, where more than half of the total population comprise of foreign castes and majorly represented by the tribes including the Deuri, Misings, Sonowal Kachari and Khamti.[4] The Ahoms forms a large proportion of the total whereas the chutiyas are found in considerable numbers.[5] There are some areas which are surrounded by the course of river Brahmaputra and its tributaries where riverine populations reside known as 'chars'. These chars are formed when extremely braided channels of the river along with its suspended particles and bed load combine together during floods to give rise to "almond" shaped alluvial formations (Assam HDR, 2014).

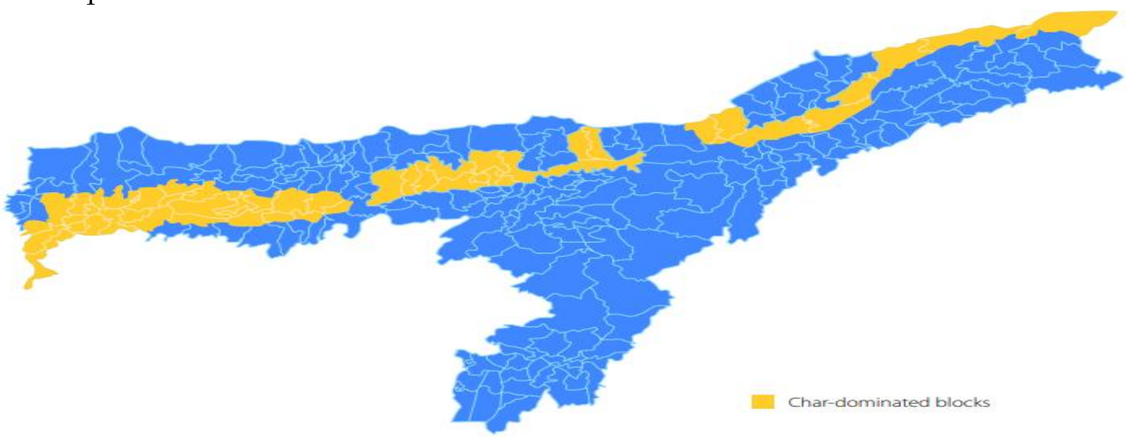

Figure 2 Map showing spread of char dominated blocks in the state

(*Source: Assam HDR, 2014)*

Besides the problems of accessibility and connectivity, life and livelihood of char-dwellers is challenged by several other uncertainties. The land of chars is favourable for agriculture production and their main source of livelihood, due to recurrent floods and large-scale erosion it is severely affected which give rise to considerable uncertainties

3 The Boat Clinics of the Brahmaputra https://cnes.org/programmes/boat-clinics/
4 https://databank.nedfi.com/districts-assam/lakhimpur-district
5https://books.google.co.in/books?hl=en&lr=&id=sXEoAAAAYAAJ&oi=fnd&pg=PA1&dq=boats+clinic+in+lakhimpur+assam&ots=8YQKrBh-ne&sig=5t8kO6RXrDifQ2wPzrJBLXORNoY&redir_esc=y#v=onepage&q&f=false

for the people living in char (Assam HDR, 2014). Forrey et al. (2008) mentions that the Chapori people are spatially isolated from basic amenities including social markets, energy supplies, health and educational facilities to a certain extent because of where they live. These natural calamities severely impact the lives and ability of Chapori people not only in terms of food but their health, water, sanitation and assets also. Due to their social marginalization and unstable living condition brought on by weather and climatic factors, they are exceptionally vulnerable. Lack of knowledge about their constitutional rights make this problem worse. The opportunity for social mobility is further limited by living on river islands, which also prevents access to social networks and capital.

According to UNICEF's case study of the Akha boat, the programmes and policies devised for the districts targeted at the whole of the geographic area, comprising river islands, but many interventions are yet to reach the chaporis. The development approach used for chaporis does not function as a culturally sensitive intervention or sufficiently address the specific disadvantages that the population faces. As a result, the impact of social and geographic exclusion significantly shapes their lives directly and indirectly. So, a tailor made and customized approach should be devised keeping their small numbers and shifting residential patterns due to inclement weather conditions in focus.

Powering remote healthcare: Integrating solar energy for operational sustainability

The Boat clinics needed to go on long night stay trips to conduct health check-up camps therefore required continuous and cost-effective power supply which results into noise pollution and costly fuel. To overcome this challenge, a cost effective and environmental friendly intervention was prerequisite to resolve the challenges faced by health workers on ground. So, team at SELCO foundation collaborated with C-NES to build sustainable energy ecosystem at the boat clinics of Brahmaputra[6] Boat clinics of Brahmaputra are state funded entities in Assam that have taken up the sustainable initiative of installing solar power plant to fulfil the energy requirements, end up saving electricity cost and benefit the environment by reducing the overall ecological footprint and pollution. Through the joint efforts of SELCO foundation and C-NES, boat clinics now have rooftop solar power plants to run their entire medical and diagnostic equipment along with fulfilling the entire lightning requirement 24 hours a day. Currently, the roof top solar power plants of the boat clinics are currently providing financial benefits of $480 per boat on yearly basis which was earlier spent on fuelling the kerosene based boats.

Outreach in isolation: Highlighting the role of Boat Clinics in Covid-19 Response

As per C-NES Annual Report, 2021-2022: During second wave of the pandemic, the daily life of Saporis/Char island dwellers was severely affected due to restrictions and maintaining isolation as per government advisory to ensure necessary precautions. Covid-19 was another add on to the hassle in addition to residing in insular locations with poor economic conditions and low literacy rates which ultimately led to their unwillingness to cooperate with the vaccination team's sincere efforts to get them vaccinated. Many misconceptions and

[6] *See at https://greenhospitalsindia.com/wp-content/uploads/2022/05/GGHH-Case-Study-Boat-Clinics.pdf*

rumours prevailing at that time along with minimal road connectivity and long distances were another contributing factors. In such scenarios, Boat clinic teams were unstoppable continuously mobilizing through the islands and taking steps to prevent any pandemic outbreak with regular health check-ups and Covid vaccination camps. In Lakhimpur, Covid vaccination camps organized in association with Bihpuria BPHC and Bhagora MPHC. With a target of vaccinating 400 island dwellers the camps were organized at Pavobhabhekeli and Kaniajan Villages which was also a part of media coverage[7]. The Boat clinic teams worked efficiently as front liners with dedication to prevent the outbreak of Covid in these areas and commitment to conduct regular awareness sessions regarding maintaining personal hygiene, physical distance, wearing mask and following hand washing practice. It was due to determined and constant endeavours of the Boat clinic teams which attempted to provide requisite healthcare facilities apart from preliminary check-ups and behavioural distinction was observed in their conduct after the awareness sessions regarding Covid from first wave to subsequent second wave, which marks the success of the pious efforts and instrumental role played by the boat clinic teams jointly.

Service Disruptions, Disease burden and Healthcare access via boat-based services

Impact of floods and variation in disease prevalence

In a study, on disease prevalence in flood-affected areas of Lakhimpur district, (Saha, 2023) found that percentage of fever cases was highest in both non-flood (28.4%) and flood periods (42.7%). The proportion of people suffering from skin infections was notably high (10.42%) during floods, while this illness was generally absent in non-flood times. Diarrhea and pneumonia ranked second (6.17%) in prevalence during non-flood periods; however diarrhea and dysentery cases increased to (7.29%) & (10.42%) during floods. Similarly, the population suffering from cough decreased from (4.93%) in non-flood times to (3.13%) in flood times. On, the other hand it was noted that the prevalence of chronic sickness rose in the majority of villages during the floods. Its rate of increase was highest in the char villages i.e., Na Ali Aunibari (35.29%) followed by Morton Chapori (28.57%)

Healthcare seeking patterns and service utilization in flood-prone areas of Lakhimpur district

On the basis of participant's responses, overall 62% of the individuals sought care from public health facilities, a higher proportion of treatment-seeking occurred with quacks and traditional healers. Among those suffering from acute illnesses, 61.5% sought treatment from public health facilities, followed by 23.08% who consulted informal providers. For chronic illnesses, 75% of respondents sought care from public health facilities, and 18.75% received treatment from boat clinics[8].During floods, the pattern shifted as about 38% of patients sought treatment from public health facilities, while 40% turned to quacks, traditional healers and pharmacies. Boat clinics served 13.68% of patients during floods, with notable variation between

[7] https://public.app/video/sp_x94xkqj24rg66

[8] *Public health facilities include community health centres, Primary Health Centres (PHCs), and Sub-Centres (SCs), while private health facilities comprised private hospitals and clinics. The category other referred to informal healthcare providers such as quack and traditional healers.*

villages- Na Ali Aunibari reported the highest use, with 52.94% of respondents seeking care from a boat clinic (Saha, 2023).

This shift not only raises concerns about the quality and safety of care but also underscores the vulnerability of communities when fixed health infrastructure becomes inaccessible. Moreover, the notable use of boat clinics specifically in the villages like Na Ali Aunibari- suggests their crucial role in delivering essential healthcare during flood times. However, the relatively low overall utilization of boat clinics suggests limitations in coverage, frequency, or awareness, highlighting the need for expanding and strengthing mobile healthcare services.

Inaccessibility and Dysfunction of Sub-Centres

In a study conducted in Lakhimpur district, (Saha, 2023) found that sub-centres in the char areas are in a worse condition compared to the sub-centres in the mainland village. These sub-centres lacks the basic infrastructure needed to operate and no residential facilities for the ANM so they mainly travel from urban areas to these sub-centres. Consequently, it was realized that the sub-centres are typically only open during vaccination and immunization camp as highlighted in the narratives of the residents of the study area. The narratives recorded in this study accounts for the disruptions in the services as non-availability and poor-quality of medicines, sub-centres being distant, unsure about the presence of any health-care professional at the sub-centre and limited time window which hinders the service delivery during emergencies.

'We Suffer, They don't Bother': A case study on primary healthcare vulnerabilities and gaps in boat-based health services amid floods in Assam

"In the last 35 years, I have seen so many ups and downs in this village. Many have died due to cholera, and people are still suffering from many diseases, but we have not been receiving minimal primary healthcare during and after floods from the state. We just suffer, but they don't bother"

Lamented by an elderly participant in the study, suggests that the community has faced repeated flood-induced health crises yet minimal primary healthcare support during or after floods. Although, communities primarily resort to traditional healers and religious rituals when PHC becomes non- functional after the floods, which may provide cultural comfort but often fail to address critical medical needs. The frustration was echoed in the participant's responses noting that appeals to the local MLA yielded no action, no post-flood PHC services remained inadequate (Sumesh & Gogoi, 2024).

"During post-flood, whatever medicine we receive from the government is all very faku dorob (useless medicines)."

Medicines provided were described as *faku dorob* (Useless medicines), leading residents to avoid PHC entirely. The narratives of research participants reveal not only logistical gaps but also the poor attitudes and substandard services encountered during floods. Significantly, the Government of Assam launched boat clinic services in 2008 to serve riverine communities of Brahmaputra having 15 operational units across Assam. Yet, despite their district's inclusion, none of the participants were aware of the scheme and its services.

"During floods, we have to provide healthcare services by boat, and sometimes we are unable to reach the patients due to the rising water levels."

Interviews in the study by (Sumesh & Gogoi, 2024) with healthcare workers further revealed that floods significantly disrupt the delivery of primary healthcare services. Even after having a boat clinic they fail to ensure continuous care through boat-based outreach during monsoon months despite the heightened need for medical attention during such crises. The presence of well-coordinated boat-based health services could bridge this gap by bringing accessible, timely and affordable healthcare to these isolated populations. The disconnect highlights a critical gap between policy intent and ground level-implementation which underscores the urgent need for consistent and well-coordinated boat clinic interventions in flood-affected riverine areas.

Methodology and Objectives

This study employs a descriptive and analytical research design based on review of secondary data sources. The approach incorporates quantitative data on health indicators and flood vulnerability with qualitative narratives from published reports and prior field based studies in Assam. The objective is to assess the role, performance and limitations of boat based health services or interventions in Lakhimpur district. Data sources comprises National Health Mission (NHM) Assam Annual Reports (2020-2024), Flood reports (2023-2024) from Assam State Disaster Management Authority (ASDMA) for rainfall, affected villages and population impact, Registrar General of India (2013) for maternal mortality ratios, Assam Human Development Report(2014) for district level human development indicators such as HDI, life expectancy, and mortality. Boat-clinic operations and service utilization figures were obtained from C-NES reports. Using the key words including "boat based health services", "mobile health units", "flood healthcare Assam" and "Lakhimpur health services" on Google Scholar peer-reviewed literature was accessed. The review spans the period 2008-2024, corresponding to the initial launch of the boat clinic program, and only reflected articles that provided statistical data, empirical evidence, evaluative insights on healthcare in flood-prone Assam; non-scholarly opinion pieces and unverifiable news sources were not included. While qualitative narratives from communities, health workers, and non-government organizations were compiled thematically under categories like service disruptions, reliance on traditional healers, disease burden during floods, and the role of boat clinics in emergency care, quantitative data like rainfall, population affected, IMR, MMR, and service utilization were tabulated and visualized to highlight patterns. For consistency, the results were cross-validated from multiple sources. Although, all sources have been cited properly to uphold academic integrity, ethical approval was not necessary as the study exclusively relied on secondary data and had no direct human engagement.

Findings

Pattern of morbidity across flood and non-flood periods in Lakhimpur District

In Figure 3, the comparative analysis of reported morbidity reveals statistically meaningful variations between flood and non-flood periods in Lakhimpur district. Fever constituted the predominant complaint during both periods, showing a rise from (28.4%) non-flood time to (42.7%) during floods. Diarrheal diseases also exhibited an upward shift from (6.2%) in non-flood periods to (7.3%) during floods, and dysentery reached (10.4%) whereas pneumonia shifted from (6.17% to 1.04%) in flood periods. The prevalence of cough decreased from (4.9% to 3.1%), along with stomach pain from (4.94% to 1.04%) and injury from (2.47% to 2.08%). Skin infections and urine problems were negligible during non-flood conditions, rose sharply to (23.96% and 2.08%) during floods respectively.

The steepest increase in chronic morbidity is recorded in char villages as Na Ali Aunibari reporting (35.3%) and Morton Chapori (28.6%) during floods (Saha, 2023). Collectively, these patterns underscore the susceptibility to water-borne and vector-borne diseases among riverine populations when fixed health infrastructure becomes inoperative.

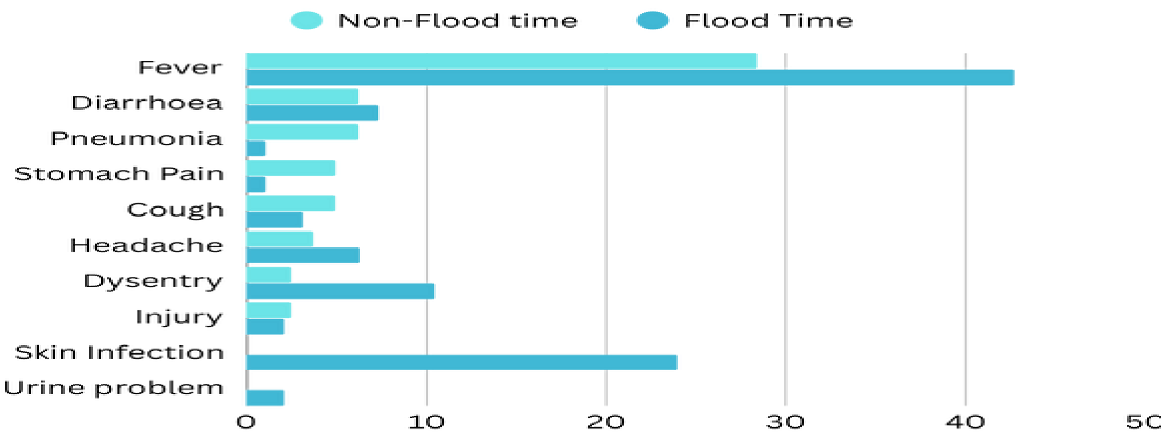

Figure 3 Prevalence of morbidities during non-flood and flood periods in Lakhimpur District

(Source: Compiled from Saha, 2023)

Community perspectives on boat clinic services and primary healthcare

As per the qualitative evidences gathered from local residents and frontline workers via in depth interviews reveals that there is pervasive dissatisfaction with the quality, dependability and responsiveness of basic healthcare services during frequent flood disasters in Assam particularly among riverine populations. Long term residents of these areas described decades of frequent health crises brought on by flooding, such as cholera outbreaks and other vector borne diseases, yet they regularly reported receiving minimal assistance from the state for primary healthcare during or after floods. Participants emphasized that several requests for action from locally elected officials, such as the Legislative Assembly member, had not resulted in any noticeable changes or sustained improvements in service delivery (Sumesh & Gogoi, 2024) Moreover, the prolonged closure of sub-centres during floods causes households to turn to community rituals and traditional healers, which provide cultural solace to an extent but are rarely successful in treating medical conditions. Medications provided by the government facilities were generally disregarded as *faku dorob* "useless medicines" which led to broken trust and discouragement in using public services. These findings underscore a clear disconnect between policy purpose and ground-level execution, bringing the focus on need for well-coordinated boat-based healthcare capable of continuous service and timely emergency referrals during monsoon phases.

Mobile health in Public Health Emergency: The Covid-19 Experience of Boat clinics

According to the data evidences from the C-NES Annual Report (2021-2022), during the second wave of Covid-19, the boat clinic program emerged as a critical first line of defence for isolated riverine populations. Residents of Lakhimpur's saporis (Char islands) encountered a number of obstacles, including low literacy, poor road access, geographic isolation, and pervasive vaccine rumours, all of which at first deterred them from taking part in governmental immunization campaigns. Boat clinic medical teams continued their outreach despite these challenges, visiting other islands to conduct normal health examinations and set up Covid-19 immunization campaigns.

Service utilization of Boat clinics in Lakhimpur (2020-21 vs 2021-22)

Boat-clinic outreach in Lakhimpur remained substantial and in several categories, expanded between the two reporting years, according to an analysis of C-NES service statistics. General health camps constituted the larger share of activity, rising from about 4,406 sessions in 2020-21 to nearly 4,701 in 2021-22, demonstrating the ongoing supply of routine therapeutic services.

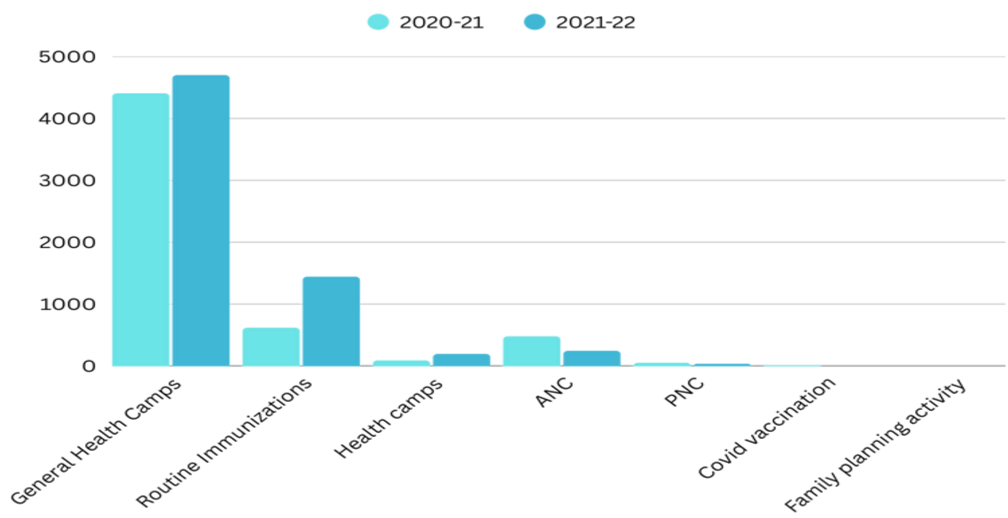

Figure 4 Comparative service utilization of Boat clinics in Lakhimpur, 2020-21 and 2021-22

(Source: C-NES Annual Report)

As a result of improved child health outreach and the restoration of basic preventive care, the number of routine immunizations sessions nearly doubled from about 618 to 1443, reflecting strengthened child-health outreach and recovery of basic preventive care. Specialized health camps also showed a proportional rise (from roughly 89 to 195), whereas antenatal care (ANC) visits declined from around 479 to 245, suggesting that pregnancy-related service uptake remained sensitive to mobility barriers and infection corners, Post-natal care (PNC) decreased from 51 to 36, where family planning activities remained negligible for both years, underscoring persistent challenges in delivering reproductive-health services during public health emergencies. Importantly, Covid-19 vaccination sessions, a service not previously provided, were incorporated in 2021-22, demonstrating the program's ability to quickly reorient activities in response to emergent needs.

Reconfiguration of Care-seeking during flood and non-floods periods

Participant narratives and utilization data (Saha, 2023) reveal a distinct redistribution of healthcare sources once flooding occurs. Although 62% of the respondents stated that they sought care from public facilities across the year, a significant portion of consultations were with informal providers, such as quacks, traditional healers, and neighbourhood pharmacies.

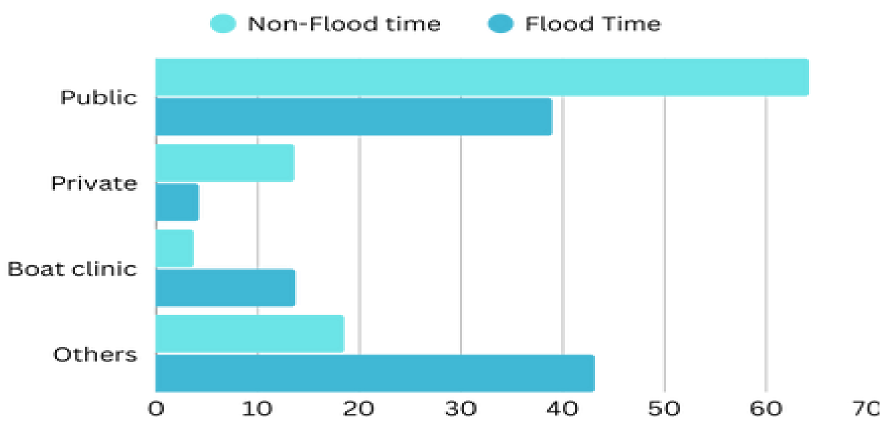

Figure 5 Distribution of health care seeking by provider type during flood and non-flood periods in Assam

(Source: Compiled from Saha, 2023)

While 23.1% resorted to unofficial practitioners, 61.5% relied on public facilities for acute ailments. The formal sector played a larger role in treating chronic conditions: 18.8% of patients sought care through boat clinics, and 75% of patients sought care at public facilities. During flood phases, the pattern shifted notably. Forty percent of patients relied on quacks, traditional healers, or pharmacies, while just 38 percent of patients continued to use public health facilities. Utilization of boat clinics rose to 13.7% reflecting their growing importance when road access was disrupted.

Discussion

In a setting of frequent floods, remote location, and long standing health inequalities, this study investigated the role, reach and constraints of boat-based health services in Lakhimpur district, Assam. Although, the boat-clinic model has been instrumental in expanding preventive and promotive care to previously underserved riverine populations, findings suggest that it is still not adequately incorporated into the emergency response framework and does not completely offset the shortcomings of fixed health infrastructure in times of crises.

The patterns of morbidity witnessed during flood and non-flood times highlight how susceptible char-dwelling populations are to vector-borne and water-borne illnesses. The sharp increase in fever, diarrheal illnesses, dysentery, and skin infections during floods is consistent with patterns observed in other flood-prone areas of India and the world, where poor sanitation and limited mobility spike the risk of infectious diseases (Singh & Kumar, 2013). The cumulative effect of interrupted treatment and environmental treatment and environmental stressors on long-term health outcomes is further demonstrated by the notably high prevalence of chronic illnesses reported in Morton Chapori and Na Ali Aunibari. These results support the notion that emergency healthcare in these contexts necessitates consistent and ongoing service delivery rather than only episodic outreach. Secondly, in health care trends during floods, there is a noticeable movement toward informal suppliers. Under normal circumstances, public facilities continue to be the primary source of care; however during floods, their utilization drastically declines with quacks, traditional healers, and neighbourhood pharmacies taking their place. Although, these resources, could give quick access, they frequently deliver unapproved and inadequate care, which raises questions about patient safety. Their potential as a dependable substitute when road based services are interrupted is demonstrated by the increase in boat-clinic utilization during flood times, especially the high usage in Na Ali Aunibari. However, the low percentage of users overall also indicates coverage, frequency, community awareness, or trust problems. This is consistent with earlier assessments of mobile health programs, which emphasize that outreach on its own is inadequate in the absence of strong referral networks, community involvement, and consistent schedules (Forrey, D'Cruz, Gvetadze, & Goswami, 2008). Moreover, the narratives of workers on the front lines and community people reveal a recurring discrepancy between the goals of policies and their actual application. Following previous criticisms of health initiatives in Assam that lack culturally sensitive communication and participatory planning, a number of respondents were ignorant of the program's existence even though boat-clinic services were formally launched in 2008 (Assam HDR,2014). The idea that government-provided medications are "faku dorob" betrays a lack of trust and emphasizes how crucial it is to foster courteous, responsive service delivery addition to guaranteeing supply chain quality. Similarly, sub-centres sporadic operations and the lack of living facilities for auxiliary nurse midwives underscore structural obstacles that mobile units cannot surmount on their own. Further, the history of boat-based healthcare during public health emergencies shows its adaptability and fragility. The ability of boat clinics to reorient services toward emergent health needs- such as intensified immunization, disease surveillance and awareness generation highlights their potential as adaptable platforms for integrated primary healthcare in remote and disaster prone areas. The growth of preventative and promotional outreach is reflected in the rise in general and specialized health camps in recent years, indicating that mobile services may continue to provide treatment even in the case of disruptions to land-based systems. The limited scope of family planning and reproductive health activities, as well as the ongoing drop in prenatal and postnatal visits, reflect ongoing challenges in guaranteeing complete and gender response service delivery. In order to sustain critical health functions during emergency and non-emergency phases, these gaps highlight the necessity of regular operational planning, focused communication strategies, and committed human resources.

Conclusion and Recommendations

This study underlines that boat-based healthcare services play a pivotal role in extending essential healthcare to the geographically isolated and flood-prone communities of Lakhimpur district. As per the findings, these mobile units bridge the gap in the delivery of preventive and promotional healthcare, especially when frequent floods render conventional infrastructure unusable (NHM Assam, 2014). However, limitations still persist with coverage, emergency response readiness, continuity of care, and integration with the formal health system. The delicate nexus between ecology and public health in these areas is reflected in patterns of illness prevalence, which show increased susceptibility to water borne and vector-borne infections during flood and non-flood times (Saha, 2023). Similarly, systemic inequities and service interruptions that undermine public trust in institutional healthcare are revealed by changes in health-seeking behaviour towards informal providers during flood periods (Sumesh & Gogoi, 2024). Deficits in reproductive, chronic, and emergency care highlight the need more integrated and long-term approaches, despite the fact that boat clinics have shown flexibility in meeting urgent medical needs and sustaining outreach.

To enhance their long-term impact, boat-based services must be closely integrated with formal emergency care and referral systems in terms of establishing clear protocols for high-risk and maternal emergencies, develop systematic sensitization programs and participatory feedback mechanisms to strengthen public trust and understanding of available services (UNICEF,2019), Health education materials and strategies should be tailored for char and sapori populations, considering linguistic and cultural contexts to counter misinformation and improve health seeking behaviour (Forrey et al.,2008), The utilization of renewable energy solutions can be expanded such as solar power systems, to ensure consistent functioning and reduce operational costs (SELCO Foundation & C-NES,2022). To have a promising continuity and care of quality in both emergency and non-emergency phases, consistent staffing, training and medical supplies should be available, include community based monitoring to enhance program accountability and responsiveness. Mixed method and longitudinal approaches can be employed to assess long term health outcomes and capture the lived experiences of communities and providers, which will guide the adaption and development of mobile health models in comparable ecological environments.

In essence, by addressing these priorities, boat-clinic services would be more in line with the Sustainable Development Goals (SDGs), especially SDG 3(Good health and Well-being) and SDG 10 (Reduced Inequalities), and the National Health Policy (2017)'s vision of equitable, resilient, and sustainable health systems.

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