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Analyzing the Maharashtra Ambulance service "108": The prospect and challenges

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Abstract

The utilization of digital health has played a crucial role in enhancing healthcare services by transitioning from the current inadequate public health structure to an enhanced patient-centric system. The digital health system in India involves the use of various digital tools, such as electronic health records (EHRs), telemedicine, mobile health applications, health information exchange systems, and other technological advancements to improve access, efficiency, and quality of healthcare delivery. This study aims to investigate the current challenges and prospects of the digitized healthcare facility of the Maharashtra Emergency Medical Services (MEMS). Utilizing 38,823 MEMS call details recorded during November 2022, this study investigates the current status of service delivery mechanisms across the state of Maharashtra. Further, through spatial analyses this study explores the causes behind the call demand and the challenges of the service. The findings suggest that since the launch of MEMS in 2019, emergency care has drastically improved across the state. However, various urban and healthcare infrastructure factors, as well as socio-cultural challenges, presently impact the MEMS service delivery mechanism. Implementation of the digitized MEMS system allows the authors to analyze the factors that influence the service, thereby assisting policymakers and health administrators to identify and improve key sectors to enhance the service.

Keywords: Digital health, health system technology, Maharashtra Emergency Medical Services (MEMS), challenges, prospects, India

Introduction

Emergency medical conditions can be triggered by abrupt occurrences affecting the body or mind, such as injuries, infections, obstetric complications, chemical imbalances, or even ongoing neglect, in the case of chronic diseases.[1] This context introduces the notion of "emergency medical services" (EMS), which includes treatment of these ailments through: rapid assessment, timely provision of appropriate interventions, and quick transportation to the nearest healthcare center by the best possible means. The goal of EMS is to improve rates of survival while limiting disability, stress, and morbidity levels. In India, EMS have evolved in the past few decades from in-hospital treatment during the arrival-to-stabilization period to recent holistic prehospital care facilities.[1]

Emergency medical care is required in diverse circumstances in urban, peri-urban and rural tracts. There is an urgent need to analyze existing service quality and to formulate further strategies to meet the range of diverse needs through upgrading EMS and innovating and reorienting public health planning.

Global literature has pointed out the importance of EMS to lifesaving and providing comfort for citizens in distress.[1-4] Very often these services are regarded as prehospital medical care and/or reaction to emergency response. However, these services can be regarded as a part of a continuum with the hospital facilities when an individual, particularly one residing in geographically secluded areas or in areas with limited services, especially during odd hours, seeks immediate medical attention.

Globally, developed and developing nations have adopted varying models of emergency healthcare systems. While centralized systems have been implemented by some developed nations (including the United States, United Kingdom, and Canada), Japan has adopted a decentralized system. However, emergency medical services still remain a serious issue in populated developing nations like India. Although some nations, such as Bangladesh and the Dominican Republic, have developed a centralized standard telephonic contact-based service, a systemized and organized framework remains vague.[2] Furthermore, use of traditional techniques, lack of personnel shortage and inefficient EMS coverage remains an obstacle to the development of EMS in other places, such as China and Brazil.[3,4] Globally, the delivery of emergency medical services or pre-hospital care services have either been categorized as "Franco-German" and "Anglo-American" models or differentiated, according to the level of care provided, into "Basic Support" and "Advanced Life Support".[5] The Franco-German model, which focuses on a "stay and stabilize" philosophy, has been adopted in Germany, France, Greece, Malta, and Austria.[6-10] The Anglo-American model, based around a "scoop and run" philosophy, is followed in the United States, Canada, New Zealand, the Sultanate of Oman and Australia.[11-15] While terms like "The Golden Hour" and "Platinum Ten Minutes" are used in

EMS across the world, the state of medical assistance for pre-hospital patients varies widely from developed to developing nations like India.

Although India has extensively developed its healthcare sector, it is yet to create a single, comprehensive EMS system that can be accessed throughout the country. The existing fragmented system has failed to meet the demands of the nation. In some parts of India, "102" is the emergency telephone number for ambulances. However, different states can have different numbers. Under the Government of India's National Health Mission (NHM), "108" is a toll-free number assigned to emergency services in the state of Maharashtra.

With the advent of digital technology in developing health informatics across nations, India has been involved in digitizing health records. The digital health system in India aims to streamline healthcare processes, empower patients, enable remote consultations, facilitate data sharing among healthcare providers, and ultimately improve health outcomes for the population. Maharashtra is one of the pioneer states in the Indian subcontinent to develop a completely digital facility for 108, which is officially called the "Maharashtra Emergency Medical Services" (MEMS). The digitization has significantly improved health outcomes by improving access to goods and services at the time of need. The data, central to health systems, are monitored and managed using artificial intelligence and big data management tools.

This research focused on the following objectives: (i) Presenting, for the first time, the service delivery mechanism throughout the state of Maharashtra; (ii) Shedding light on the diverse triggers (causes) that have led to demand for this service, particularly in the Indian context; (iii) Highlighting the existing referral system for healthcare delivery in Maharashtra. Furthermore, it identifies the current challenges and future prospects of the 108 service in different districts of Maharashtra.

Literature Review

A plethora of global literature has been published on medical emergency calls, with a focus on access, emergency priority levels, and temporal and seasonal variations in emergency calls to medical emergency dispatch centers.[16] Most of these data-driven researches have concluded that unclear problems, medical challenges, intoxication, and accidents are the primary causes of urgent calls. The Chinese cities of Jinan and Hangzhou identified drastic increases in the number of daily emergency calls and ambulance dispatches attributed to central nervous system breakdowns during a severe air pollution event in 2013 and during the Covid-19 era, respectively.[17,18]

Another body of literature focuses on investigating the reasons behind medical emergency calls across different nations. A study conducted in Spain elucidated that elevations in particulate air pollution increase medical emergency calls for cardiac or respiratory challenges.[19] A study by Linderoth[20] explored the challenges in recognition and initial treatment of out-of-hospital

cardiac arrest in the capital region of Denmark. Most of these studies utilized closed-circuit recordings (CCTV), audio recordings, records from medical emergency control centers, data regarding the number of daily emergency calls, ambulance dispatches, and rescues to investigate the current situation of medical emergencies across the world.

The “golden hour theory” is an important concept in EMS. This theory suggests that morbidity and mortality are affected if patients do not receive definitive care within the first hour after an accident or traumatic injury.[21,22] However, EMS often fail due to functioning outside the golden hour time limit, leading to higher mortality. Therefore, it becomes necessary to investigate the current problems in EMS service delivery.

The current challenges in EMS across the globe involves the lack of system-status management, inefficient planning and management, inoperability, ineffective demand forecasting, delayed response times, high workload, location allocation problems, and failure to handle predictable and unpredictable changes in demand and travel times. The major components that comprise the entire system of emergency care are prehospital care, transportation and hospital care. Lack of timely, simple, efficient, and sustainable prehospital care often leads to higher mortality rates.

Resource unavailability, including inadequate funding to make round-the-clock coverage possible, are established reasons behind ineffective pre-hospital care. Insufficient emergency care, especially limited access to quality hospital care, is a significant factor contributing to high maternal and child mortality rates in the majority of low- and middle-income countries across Africa, Asia, and Latin America. In such contexts, it is crucial to prioritize resource integration instead of maintaining separate systems for injuries and obstetric emergencies. Another reason is lack of access to trained personnel, as unavailability of trained lay responders and trained paramedical personnel often leads to increased on-site or in-hospital severity, trauma burden and, at worst, deaths.[23,24,25,26]

India has hitherto conducted little research on its emergency medical services. Babiarz[27] identified an association between ambulance services and neonatal and infant mortality rates in two Indian states, Andhra Pradesh and Gujarat. The study observed that Emergency Management and Research Institute (EMRI) ambulance coverage and in-ambulance service quality improvement was strongly associated with reduced mortality in both the states. Another study[28] analyzed the transport of pregnant women and obstetric emergencies across six Indian states, utilizing the ambulance service system data. A significant finding from this study was that only 9%-20% of pregnant women and obstetric emergencies utilized ambulance services for getting transported to medical healthcare centers, and these mostly belonged to rural and lower-income communities. The data confirmed that the ambulance traversed an average of 10-12 kms to reach patients, and that it took less than 2 hours from the call to reach hospitals. From a policy perspective, Sharma and Brandler[29] established that a public-private

partnership for implementing an organized pre-hospital care system in India may be instrumental in improving EMS in India. The quality of services provided by a publicly-funded ambulance program was investigated in Rajasthan, determining that around 70% of the surveyed emergency medical technicians (EMTs) met quality standards.[30]

Existing EMS research in the Indian context has revolved around policy recommendations and ambulance coverage and service delivery mechanisms in different states, but the lack of available data has restricted research in this area. A comprehensive investigation concerning the concept of digital health as utilized by the EMS in Maharashtra would aid in understanding the current situation and service delivery mechanisms. The paucity of detailed research in the EMS sector in India, the challenges and problems that have been identified in existing studies, and the lack of research on digital health all highlight the importance of a further comprehensive investigation on EMS in the Indian context.

Digital Technology in Health in India

In a 2019 study by Mitchell and Kan[31], the authors recognized the profound impact of digital health on existing healthcare systems. Digital technology in health systems has been instrumental in shifting the balance of power between provider and patient, aiming towards client-centered health care, especially in developing nations. With the advent of digital technology as the future of health systems, there has been a global-level push towards adopting digital health as an institutional and centralized framework.

In India, digital protocols followed by ambulance services have largely replaced the non-existent public systems. Singh[32] affirmed the importance of Ananya, a direct-to-consumer digital interface that uses digital health data informatics to address any health-related inquiry. With the help of the Adhaar program, which uses unique identifier numbers and biometric information, India has already progressed in generating simplified electronic medical record systems. Call-in services that link to ambulance systems are being implemented in different parts of India to improve health outcomes. The centralized private ambulance service, serving millions of people using digital technology, is considered a medical miracle in India. The Indian state of Maharashtra is one of the pioneers in maintaining digital records of individual patients who access state-run emergency services. These digital records include both the time of EMS service and patient and health condition details.

The MEMS 108 Ambulance Service

This research is focused on the “108 Ambulance Service” that is operational in the Indian state of Maharashtra. While India has a centralized National Emergency Response System to address emergencies (concerning health, fire etc.), several states also have their own operational and focused medical care and EMS schemes. Understanding the paramount importance of emergency medical care across the world, the home-grown public service project

of Maharashtra Emergency Medical Services (MEMS) was introduced in Maharashtra under its Commissioner of Health Services (CHS). The implementing partners of MEMS are Pune-based BVG Pvt. Ltd. and the London-based UKSAS. A total of Rs.15.34 crore has been sanctioned to MEMS till 2018 to facilitate the service.

MEMS is a publicly-funded, operational service of the Government of Maharashtra under NHM. Its toll free number, 108, is similar to 911 in the USA: it provides EMS free of cost at the point of use to the entire population in the state, serving urban, suburban, and rural populations. The "call on demand" ambulance service in Maharashtra also provides hospital-to-hospital service as well as responding to emergency calls. The objective of MEMS is to provide 24/7 pre-hospital EMS response across Maharashtra, including during disaster situations.

MEMS functions with help of the state-of-art Emergency Response Center (ERC) that was developed in Pune under the CHS and is operated by a private body. ERC operates 24/7 and statewide, serving as the point of first contact for the toll-free emergency telephone number, 108, which can be dialed from any part of the state. This number also serves police- and fire-related emergencies.

Between its launch in 2014 and September 2019, MEMS received a total of 15.4 million calls and served 4,374,821 patients. Of these, 51.4% of calls were for generic medical emergency cases, and 23.21% for pregnancy/labor cases. MEMS has handled 300,000 cases of vehicle accidents, 900,000 pregnancy cases, and 30,000 child births to date, testifying to the necessity of the service.

The Emergency Response Center Physician (ERCP) provides on-line medical direction for doctors on ambulances during emergency calls. ERCPs also provide on-line pre-arrival instructions to callers and patients if needed. After timely pre-hospital care, patients are admitted to the most appropriate hospital as per their care needs.

MEMS operates 937 ambulances across the state, including 233 Advanced Life Support (ALS) and 704 Basic Life Support (BLS) vehicles. Bike Emergency First Responders are also available for immediate dispatch; they carry four kits: a trauma kit, a medical kit, an airway management kit and a delivery kit. The medical kit contains emergency medicines. The trauma kit contains equipment (such as air splints to stabilize fractures, bandages, antiseptic and analgesic sprays, etc.). AMBU bags for artificial ventilation, oxygen cylinders, suction machines and airways for respiratory emergencies and unconscious patients are included in the airway kit. The delivery kit contains equipment required for conducting emergency deliveries at home or in the ambulance.

While urban zones, including the hyper-dense city of Mumbai, have state-of-the-art services to save human life, in the state's rural areas, the free state-run ambulance service provides lifesaving facilities to cater to the needs of the people 24/7. However, despite the existence of these facilities, health reports from the Government of Maharashtra note that some rural communities still have poor access to these facilities. Furthermore, EMS for stroke, respiratory disorders, and other emergencies have often been reported to be unresponsive in both rural and urban areas.

Decisions regarding patient transfers to hospitals occur at two stages. First, based on the location and their initial assessment of a patient's health issues during the telephone call, medical officers at the ERC advise the 108 Ambulance medical team to transfer the patient to a particular healthcare center based on available infrastructure and proximity. Once the ambulance has reached the patient, the on-site medical team may modify the initial recommendation depending on their detailed assessment of the patient's condition. Cases of ambulance patients being rejected on arrival at hospitals are negligible, as the receiving hospitals are informed in advance.

The gaps in MEMS' 108 services made it essential to comprehensively investigate its current *modus operandi*, with a focus on its spatial coverage dimension.

Data and Methodology

The analysis of the data was conducted in two phases. Initially, a district-level spatial analysis was performed to examine socio-demographic characteristics, emergency and hospital-to-hospital transfer calls, and average MEMS episode times. This stage aimed in part to identify variations in MEMS episode times at district level. Next, the data were analyzed to identify district-level variations in disease patterns in the state. Python was employed to clean the data, while ArcMap 10.4 and Python were utilized to analyze and map call patterns and episode timing.

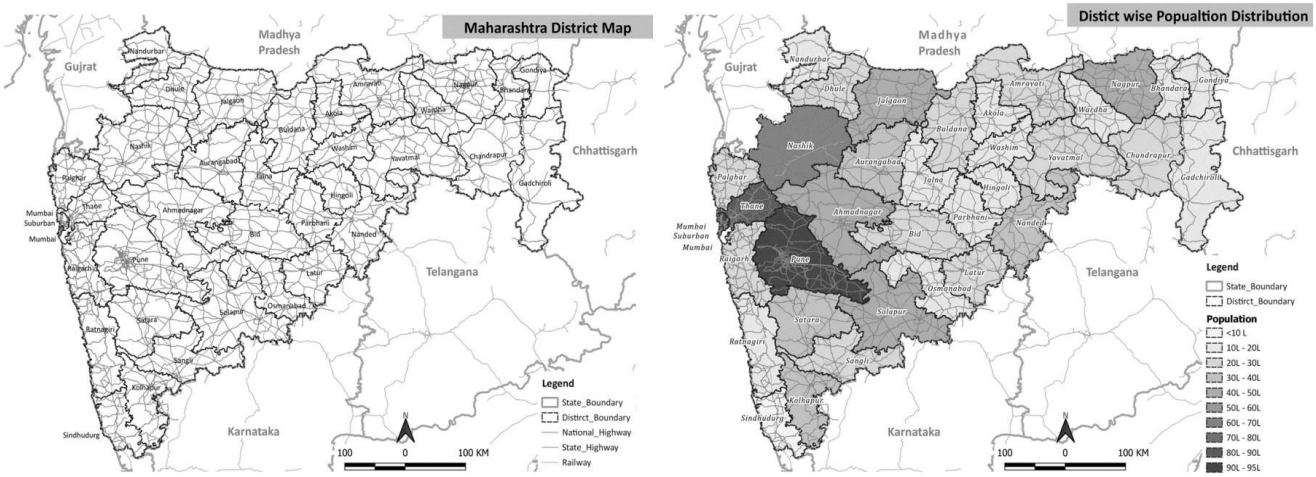
Study Area and Data

Given recent efforts for digitization and establishing mechanisms for data collection, storage and retrieval, the overall quality of data has improved substantially. Furthermore, the availability of the data with spatial characteristics made it possible to analyze and assess the impact of the service in all districts of Maharashtra.

Maharashtra, in the western peninsular region of India, is the second-most populous state in the country, with a population of 112,374,333 as per the 2011 Census of India. Geographically, Maharashtra, is the third largest state by area (307,713 km^2). Economically, Maharashtra is the most industrialized Indian state. Mumbai, the state capital, has been crowned the financial

capital of India. Figure 1 illustrates administrative boundaries of the districts within the state and the population distribution among the districts of Maharashtra.

Figure 1. District-wise population distribution in the Indian state of Maharashtra (source: authors)



Overall, health infrastructure in the state is well established, although sporadic infrastructure gaps are still present.

MEMS data (including complete call records and the health conditions of patients at the time of call through the handovers to the respective hospitals) are maintained by the Emergency Response and Control Center in Pune. The data collection service integrates novel technologies, such as a voice logger system, GIS (Geographic Information System), GPS (Geographic Position System), AVLT (Automatic Vehicle Location System), and Mobile Communication System (MCS).

In this study we describe the *modus operandi* of MEMS by analyzing its data for the month of November 2022. The assessment of data pertaining in November effectively serves to determine an average demand placed on the emergency response service. The data were shared by the department with the authors after satisfying legal and ethical considerations. The data comprises details from 38,823 calls from all districts of Maharashtra.

The data comprises of two major kinds of incidents:

- Emergency calls (n=16,197; 42%)
- Hospital to hospital transfer calls (n=22,626; 58%)

In both emergency situations and hospital-to-hospital transfers, individuals (including hospital officials, patients, family members, or anyone nearby) dial 108 to request a service. The available data include information such as: the time and duration of the call, the response time of the ambulance, the time taken to transfer the patient onto the ambulance, and the overall duration of the journey to the healthcare facility. Additional details, such as the patient's health

condition, age, gender, level of consciousness, and severity of the disease, are documented by the MEMS control center and the medical officer at the scene before and after transferring the patient to the healthcare service. However, the data do not include any subjective or qualitative feedback from patients regarding the services provided.

Results and Discussion

Call details

The calls came from 944 base locations, with 11 locations having more than 100 calls. Overall, 41.7% of the calls were registered for emergency, while the rest for transfers. Of these, 55.8% of emergency and hospital-to-hospital transfer calls were from females. A close assessment of the data highlighted that the medical calls for 108's ambulance services were distributed relatively evenly within gender, with nearly 54.1% females calling for emergency services, and 57.1% females calling for hospital-to-hospital transfer.

Figure 2 showcases call occurrence (i.e., the total number of calls and spatial distribution among districts) of emergency calls (a,b,c) and hospital-to-hospital transfer calls (d,e,f) respectively. The highest call occurrence was recorded in Mumbai, followed by the Mumbai suburban and Pune regions, for both emergency and hospital-to-hospital transfer calls. This can be attributed to the high population density in these regions. However, the total number of calls was significantly high in Pune district. It is likely that the higher economic status and vitality of Mumbai mean its residents tend to choose other private emergency care alternatives over the free, state-run 108 MEMS service. The spatial distribution of call locations is higher in Pune and Kolhapur regions for both emergency and hospital-to-hospital transfer calls.

Figure 2. Call occurrence, district-wise total number of calls, and spatial distribution of emergency calls (a,b,c) and hospital-to-hospital transfer calls (d,e,f) respectively (authors' computation)

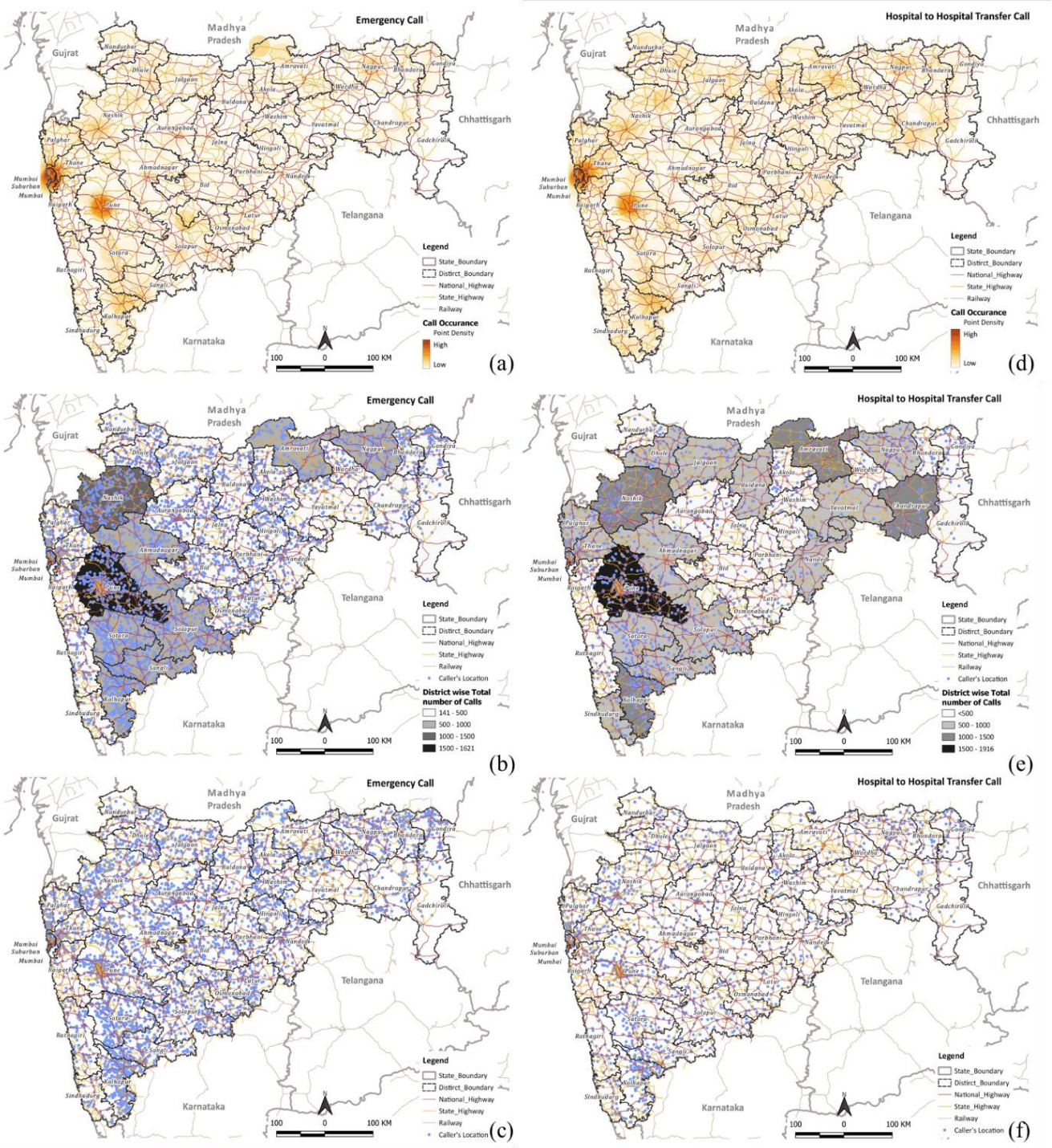


Figure 3 presents the distribution of ambulance service calls across the districts in November 2022. The largest number of emergency calls was received from the district of Pune (n=3524). This was followed by Nashik (n=2510), Mumbai (n=2120), Kolhapur (n=1923), and Amravati (n=1906) and others.

Figure 3. District-wise incident records, November 2022

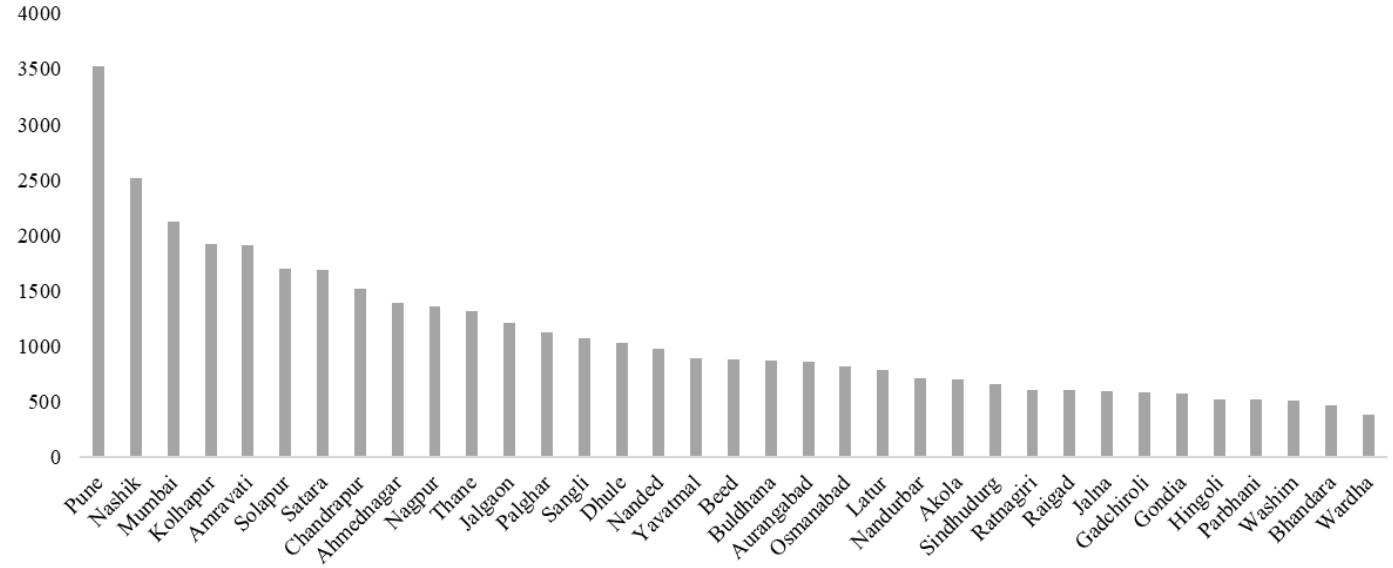
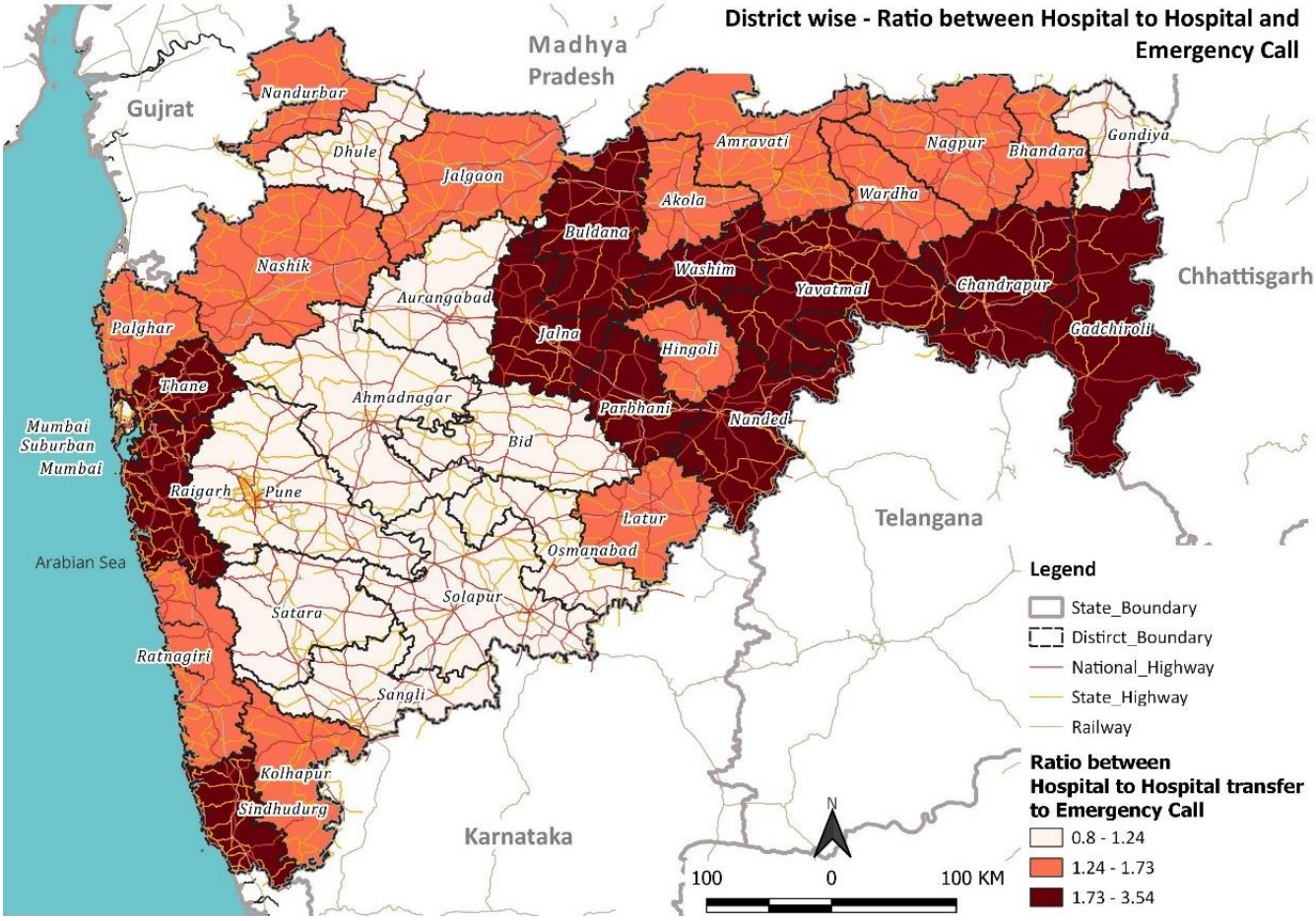


Figure 4 illustrates the district-wise percentage share of emergency and hospital-to-hospital transfer calls in Maharashtra. It highlights that most of the district have a higher share of hospital-to-hospital transfer calls than emergency calls. These districts (such as Nashik, Aurangabad, etc.) showcased higher hospital-to-hospital transfer calls compared to that of emergency calls. The lack of special medical care facilities or tertiary health centers in these districts likely drive the higher number of hospital-to-hospital transfer calls.

A few districts (such as Raigarh, Jalna, Chandrapur, etc.) had approximately 30-40% of calls for hospital-to-hospital transfer, indicating a higher share for emergency situations. One plausible reason might be that Raigarh district, which is on the Konkan belt, is the site of many accidents, including landslides during monsoon periods and highway road accidents, which increases the number of emergency situations.

Finally, some districts (such as Thane, Sindhudurg, Gadchiroli, Chandrapur, Nanded and Jalna) reported a similar number of emergency and hospital-to-hospital transfer calls. This demonstrates varying MEMS service delivery and requirements for different districts.

Figure 4. District wise ratios of hospital-to-hospital transfer vs. emergency calls (authors' computation)



Ambulance response time

It is also imperative to analyze the response time of emergency services, owing to its linkages with patients' criticality. Global literature has established that delays in response times lead to increases in patient mortality rates, thereby degrading the quality of emergency service delivery mechanisms.[32,33,34,35]

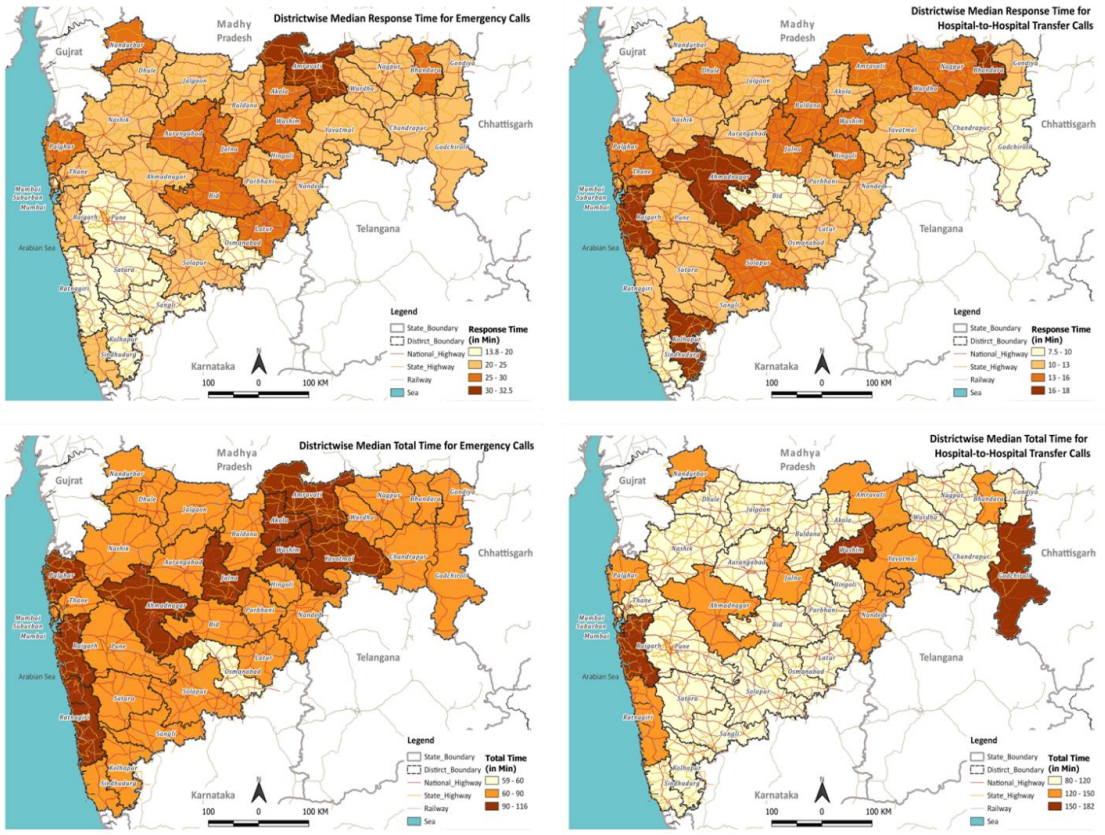
Figure 5 depicts the average response times of emergency and hospital-to-hospital transfer calls in the different districts of Maharashtra. The response time for an ambulance reaching to a scene varied from 7-30 minutes in which patient is given pre-hospital care. For emergency cases, the average response time was reported to range between 20-25 minutes. The Amravati district experienced the highest average response time of 32 minutes.

In the case of hospital-to-hospital transfer calls, the median response time ranged from 10-16 minutes across the majority of districts. However, four districts (Raigarh, Kolhapur, Ahmednagar, and Bhandra) had higher average response times, ranging from 16-18 minutes.

However, in most of the districts, definitive care exceeded the international 'golden hour' rule. A comprehensive analysis of the median total time, which encompasses both response time and turnaround time, observed that only Osmanabad district achieved an average time frame of less than 60 minutes for emergency calls. The duration of hospital-to-hospital transfer calls within a district typically ranged from 80-120 minutes. Three districts (Raigarh, Washim, and Gadchiroli) had combined durations exceeding 150 minutes.

The phenomenon of delay in median total time for both emergency and hospital-to-hospital transfer calls can be attributed to various reasons, including lack of health infrastructure (in terms of trained medical personnel and emergency care essentials at the control centers for attending emergency situations or lack of ambulances located at the base), sparsely distributed patient locations in remote villages, lack of road connectivity and poor road infrastructure, early closure or lack of tertiary and specialized health care facilities in rural transects, and others. Another challenge is that MEMS, as a publicly-funded project, primarily caters to the public hospitals' clientele. Most private hospitals have their own ambulance services, the cost of which remains unaffordable to a major section of urban and rural populations.

Figure 5. District-wise median response and total time for emergency and hospital-to-hospital transfer calls (authors' computation)



Patients' health conditions

The top 10 reasons for which 108 ambulances were called included: pregnancy (32.52%), trauma/injury (13.32%), abdominal pain (8.19%), respiratory discomfort (6.37%), physical weakness (4.17%), head injury (3.61%), chest pain (3.32%), poisoning (3.02%), fever/infection (2.33%), seizure disorder (1.90%), and others.

Emergency medical personnel with 108 ambulance services document the level of consciousness of their patients. It was observed that during emergency cases, 92.5% of patients were alert, 1% were in pain, and 2.2% and 3% were in unconscious or unresponsive states, respectively. In hospital-to-hospital transfers, the stability of patients increased: 96.2% of patients were alert, 0.9% in pain, and 1.5% and 0.2% were in unconscious or unresponsive states, respectively.

The study also identified the number of deaths reported during either emergency or hospital-to-hospital transfer services. A slight difference was observed, with 2% (n=321) and 0.1% (n=23) death on arrival cases for emergency and hospital-to-hospital transfer, respectively. This can be attributed to the fact that the patients transferred within hospitals were already under medical care and attention, which reduced their mortality rates. For emergency cases, the rate is higher because prehospital care might fail due to lack of time or other reasons. These overall low rates highlight the success of patient transfers and handling capability of the 108 ambulance services.

Interviews conducted with medical officers at MEMS' Pune control center and other health professionals revealed contextual and socio-cultural reasons behind the long response times and total episode times of MEMS services. Socio-cultural reasons affecting health-seeking behavior, such as women waiting for their husbands to accompany them to healthcare centers even during emergency situations, were mentioned on the demand side; early closure of nearby health care centers and overloading of specialized tertiary centers were the primary supply-side reasons mentioned for delayed service.

Prospects and challenges

The importance of the transportation and logistics provided by emergency services to attaining universal health coverage—to achieve "health for all" as per the 1978 Alma Ata Declaration—is immense. The need and requirement to provide health services at patients' doorsteps is necessary for developing and densely-populated nations, like India, and all countries in the Global South. These services can provide much-needed access to high-quality care to all regardless of geographical remoteness, eradicating the divides between urban and rural and other socio-economic disparities. The MEMS service's effectiveness impact how people perceive healthcare and build faith in the service. Its availability, timeliness, and allocation are primarily based on digital technologies and virtual connections. Its goals are: first, ensure the

service 24 hours per day; second, reduce the financial burden of healthcare; third, ensure health personnel are available to provide continuous monitoring in ambulances to reduce risk.

Prospects

- Geographical coverage: MEMS represents a step towards universal health coverage, especially for remote locations. This analysis shows that incidents are distributed across all districts of Maharashtra. At the same time, the number of calls can vary with respect to the population density of a given area, especially in urban towns and cities.
- Service for all: MEMS is provided free of cost, and provides equal opportunity to all socio-economic classes. This aids in reducing out-of-pocket expenses and other costs, primarily thanks to the transfer of patients from hospital-to-hospital, as well as saving lives in cases of emergencies and accidents.
- Identifying the nearest response team and ambulance: The state-of-the-art command and control center provides optimum allocation of services to calls for hospital-to-hospital services and emergencies. The availability of GPS in all ambulances enables a seamless allocation.
- Reducing first response time: Procuring further ambulances might augment and improve the availability of the service while reducing response time. Ensuring the availability of the attached medical personnel would also be critical.
- Reducing total episode time: The lack of road networks, especially in remote villages, often results in service delivery delays. Augmentation of existing road networks and improve in overall transport infrastructure is essential to reduce delays.
- Reducing travel time: Augmenting primary (as well as tertiary and specialized) healthcare centers further would enable handling larger volumes of patients across larger coverage areas and responding to emergency needs faster.

Challenges

- Maintaining data privacy and confidentiality in the digital system is a major concern. Prioritization of the criticality of and access to the data needs to be streamlined to reduce breaches.
- The operational efficiency of the MEMS depends on multiple sectors, such as road infrastructure, healthcare infrastructure, and the availability of required medical personnel. In the case of an emergency call, EMS transport the patient to the nearest appropriate government hospital. However, it is important to note that EMS may not have access to information regarding the availability of medical personnel on duty at the hospital. In the context of hospital-to-hospital transfers, EMS play a crucial role in ensuring the availability of beds at the receiving hospital. Most state and district hospitals in Maharashtra and India are overburdened and overstretched. The data analysis showed that the transfer time at certain hospital locations was around 30 minutes, primarily due to a lack of medical personnel. It was observed that the unavailability of a particular infrastructure often increased travel time, especially for emergency cases. Our field studies revealed that the quality and condition of the road network itself increased the travel time. It is to be noted

that the majority of the urban areas in the state are densely populated and often have congestion, leading to delays.

- As the MEMS service gains credibility in Maharashtra, one of the significant challenges will be to cater to growing demand. Substantial investment would be necessary to cater to all calls and improve the service's preparedness to deal with various diseases and emergency types. This requires investment in MEMS and in allied sectors as well. For example, the data showed that availability of medical personnel in healthcare centers and hospitals is pivotal to serving appropriately.

Conclusion

One of the major aims of this research was to look at the timeliness of the MEMS service with respect to the objective of saving the life of the patient based on the golden hour theory. The theory, also termed the "resuscitative" hour, suggests that a patient must receive definitive treatment within the first 60 minutes following the emergency. At the MEMS control center, around 80% of calls are non-emergency in nature. Operators are trained to answer these calls and provide necessary available information to caller. The overall framework of the MEMS service is digital; however, it uses manual entry of the data pertaining to patients' conditions.

Delays in service vary with respect to different districts, owing to the variability of the availability of health care infrastructure, road and network conditions, population density, socio-economic conditions and remoteness of the location. MEMS officers can connect with senior medical personnel at the control center for consultation and are trained to take measures as deemed appropriate.

This study's findings suggest recommendations that can aid in developing a more sustainable and efficient digital-based emergency medical system:

- **Efficient resource allocation:** Response times vary significantly among different districts in Maharashtra due to geo-spatial and other barriers. Population density, occupation patterns and per-capita income vary among the districts. The current MEMS service needs to calibrate the availability of its services based on the above. Attempts should be made to reduce the districts with excessive response times by optimizing the allocation of limited resources, such as personnel, equipment, and infrastructure. Instead of maintaining separate systems for injuries and obstetric emergencies, for example, combining resources allows for better planning and distribution, ensuring that critical care is available where and when it is needed most.
- **Comprehensive emergency care:** More data on the number and types of calls related to different diseases could provide valuable inputs to enable the provision of comprehensive emergency care services that encompass a wide range of medical needs. In less-developed districts, women and children often face health risks beyond obstetric emergencies, such as injuries, infectious diseases, and other acute conditions. An integrated system would ensure

that emergency care facilities are equipped to handle a broader scope of emergencies. Gender- and age-based profiling of needs is essential to improve the service. However, comprehensive outcome data is currently not available. One of the major recommendations would also be to track the outcomes to better assess the needs.

- **Strengthening healthcare infrastructure:** The overall travel time from the incident of emergency to the healthcare facilities also varied significantly among the districts. The major reasons ascertained here are lack of preparedness and the capacity of the nearest facilities. These cases highlight the dependency on tertiary, district and sub-district hospitals. Yet in most cases, these facilities are already overburdened and stretched, affecting also the handover time of the patients to the facility. Although a significant number of public and private healthcare services are available in Maharashtra, there is a need to integrate, upgrade and empanel these facilities to provide emergency services. This would greatly reduce the overall time slot needed for each patient. Strengthening the overall healthcare system's capacity positively impacts not only maternal and child health but also the general emergency care needs of the population.
- **Enhanced training and expertise:** One of the major features of MEMS is the availability of trained medical personnel in the ambulance. These personnel not only assess the criticality of the patient's condition, but also provide immediate aid (post consultation with the medical team at the command-and-control center) and decide on the destination facility. To ensure timely and correct assessment, enhancing the skills of these personnel at regular intervals is necessary. Multi-disciplinary medical professionals with competency in emergency care can contribute to better outcomes and reduced mortality rates.
- **Cost-effectiveness:** MEMS is funded by government agencies, and there is a need to improve the cost effectiveness of the service. Integrating resources could potentially lead to cost savings by eliminating duplication and streamlining services. Instead of investing in separate systems for certain regions and disease types, pooling resources allows for more efficient use of available funds, maximizing the impact of limited financial resources.

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