RESEARCH PAPER

Design and Implementation of a Mobile Healthcare Dispensary for Remote Communities in Assam

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ABSTRACT

Access to public healthcare remains a critical challenge for populations in remote areas of Assam, India, where poor connectivity, inadequate transport, and limited medical facilities delay timely care. A simple health issue can become critical when transport is unreliable, pharmacies are hard to reach, and medical support is scarce. An ethnographic survey across four villages in Sonitpur district revealed persistent barriers to accessing essential medicines, particularly during the monsoon season. Although mobile medical units under the National Health Mission provide some relief, they remain insufficient to address localised healthcare gaps. This research focuses on designing and implementing a compact mobile dispensary and medical transport system tailored to narrow, flood-prone rural contexts. The proposed solution prioritises primary care delivery, medicine distribution, and emergency support rather than advanced diagnostics. The design emphasises accessibility, sustainability, and off-road capability, with potential for adaptation across similar low-resource regions.

Keywords: Healthcare Transportation; Context Specific Design; Rural Development; Sustainable Infrastructure and Development.

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INTRODUCTION

In many remote areas of Assam, people continue to struggle to access timely medical care, despite nearby urban areas benefiting from improved connectivity and on-demand services. Continuity of care is a key aspect of our healthcare system [1]. Although the Government of Assam has introduced mobile medical units under the National Health Mission (NHM) [2], the findings suggest that these efforts alone cannot meet the healthcare needs of remote communities. This research aims to implement, through design, a dedicated mobile medical transportation and dispensary system tailored to the needs of rural Assam. Such a solution can improve access to medicines, provide basic treatment, and support during emergencies. It also has the potential to be adapted for other developing regions facing similar challenges. Additionally, in various areas of Assam, approximately 1165 ambulances are actively providing emergency services [3]. Apart from that, 800 Mritunjoy Emergency Response Services are regularly operated by the Government of Assam. 793 units are regularly operated and are in daily service, and the remaining 15 (fifteen) are boat ambulances [4] for different riverine areas of Assam [5]. These boat ambulances are specifically designed for maternity and childcare emergencies in riverine areas. A total of 1226 government hospitals, excluding different community health centres (CHCs) and primary health centres (PHCs), were examined. Among CHCs, the majority of services are provided to more than 1,00,000 people.

All SCs and PHCs in a block were under the jurisdiction of the Block Primary Healthcare Centres (BPHCs) [6], and all cases that could not be treated in BPHCs were referred to the concerned CHCs, which are the uppermost tier of the rural public healthcare infrastructure. The population served by the Model hospitals is smaller, as they are the newest affiliates of the public health infrastructure. Despite the presence of public health infrastructure, systemic inefficiencies such as inadequate medical workers, long wait times, and limited resources hinder effective service delivery. Financial barriers, including low insurance coverage and high out-of-pocket expenses, significantly affect health-seeking behaviour, particularly among low-income households [7]. This indicates that the issue is not limited to an irregular ambulance; it is about a healthcare system that is failing those who need it most [8], [9]. To understand these challenges, an ethnographic survey was conducted across four villages in the Sonitpur district (Assam). In this regard, participatory rural Appraisal (PRA) approaches and tools were used by local communities to analyse their realities, develop an action plan, and evaluate and implement projects. In addition to the data mentioned here from the National Family Health Survey-III, it is reported that only 35 per cent of PHCs in Assam have adequate staff [10].

The study found that poor internet connectivity, inadequate transport, low awareness of medical emergencies, and limited pharmacy services continue to affect daily life. These problems worsen during the rainy season, when reaching a pharmacy is often impossible [10].

METHODOLOGY

The research emphasises the need for healthcare facilities in remote areas of Assam. In this context, Tim Brown of IDEO, an international design and consultancy firm based in California, argues that the design thinking methodology can help people understand the daily situations, challenges, and priorities of those living in remote areas. During the study in these areas, a group of people observed and identified what truly matters in their daily routines and listened to their needs. The method guided the design towards solutions that are sustainable, useful, and meaningful for the community, ensuring the outcome supports their lives in a simple and effective way. The stages of the Design Thinking Methodology are visually represented in Fig. 1 [11].

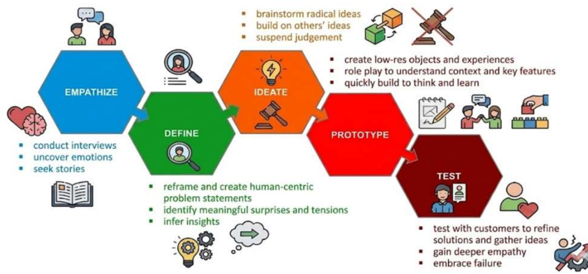

Fig. 1. Stages of the Design Thinking Process

Contextual Study: Localised Issues and Challenges

At the grassroots level, rural healthcare begins with sub-centres. These are the first point of contact between the community and the healthcare system. Sub-centres provide basic healthcare services, immunisation, maternal and child health services, and health education. To improve the quality of publicly provided rural health care services, it is necessary to manage human resources effectively and efficiently. Poor quality of public health care services can discourage people from using publicly provided services [12]. During the study, some of the people from the tea garden also studied. In tea gardens across Assam, more than 50 per cent (~56%) of workers are women. A recent maternal health incident highlighted the need for improved medical support at Deamoolie Tea Estate, Assam, as reported in a local newspaper in July 2025 (see Fig. 2). According to the article, a woman in critical condition faced delays in receiving timely ambulance services. Unfortunately, this resulted in her delivering a stillborn baby at home. While the Government of Assam provides ambulance services, improvements in medical transportation are needed to ensure that emergency services are accessible to all, particularly in rural areas. This incident serves as a reminder of the importance of strengthening healthcare systems to support mothers and ensure timely medical assistance during critical times [13]. In a previous study, it was also reported that tea garden labourers have nutritional deficiencies and suffer from several health-related problems due to low-calorie intake [14].

Fig. 2. Graphical Representation of Case Study 01 - Maternal Health Crisis in Deamoolie Tea Estate

LITERATURE STUDIES

Existing Mobile Medical Unit (MMU)

Mobile healthcare units are vehicles that deliver medical services to communities, namely hospital-on-wheels units that provide free consultations, lab tests, and medications in areas without physical clinics; however, this service is currently partially operational[15]. These mobile healthcare units address the challenges of health coverage in remote and underdeveloped areas, saving individuals significant time in seeking medical attention. Moreover, they play an important role during emergency responses and disease outbreaks.

Existing Healthcare Facilities in the local context

During a routine workday at Majnai Tea Estate (Sonitpur district, Assam), a worker collapsed suddenly due to a severe medical emergency. Unfortunately, no ambulance was immediately available, and emergency services responded with significant delay. By the time medical assistance arrived, it was too late to save the worker. The incident left the entire community shocked and deeply saddened, especially because the loss appeared preventable. As frustration and grief grew, workers gathered at the estate entrance in protest, halting operations and disrupting medical transportation services, as shown in Fig. 3.

Fig. 3. Graphical Representation of Case Study 02 - Death due to the Ambulance Delay during the emergency situation

Existing Healthcare Facilities in the Local Context

Guwahati Neurologist Research Centre (GNRC) Hospitals, a healthcare organisation in northeast India, provided Affordable Health Mission (AHM) services in 2012, which are now known as Medireach. It was designed to extend affordable and accessible healthcare services to underserved communities in North-Eastern India. It operates as a mobile hospital unit that delivers essential medical services directly to people in rural and semi-urban areas, overcoming barriers faced in remote locations. These challenges include a lack of awareness, long-distance travel, financial difficulties, and poor health-seeking behaviour. One of the facility's principal activities was to provide a bus service to remote areas, equipped with numerous medical diagnostic devices.

Fig. 4. Medireach Healthcare Unit Bus [16]

Guwahati Neurologist Research Centre (GNRC) operates as a mobile hospital unit under the Medireach brand, performing Electrocardiograms (ECGs), blood sugar tests, X-rays, and ultrasonography, while also offering basic curative care during its visits, as illustrated in Fig. 4. Its mobility arrangement helps people avoid long travel, lost wages, and transport costs by bringing services directly to their communities. Along with treatment, it conducts outreach activities that encourage early care-seeking and teach people how to manage chronic conditions more effectively. Under the AHM scheme, a Telehealth service was also added to connect patients with the GNRC medical team through calls handled by Swasthya Mitras using Android smartphones. This service supports remote consultations, home delivery of medicines, and guidance for local enquiries [16]. However, the program has stopped due to the unaffordability of the service. Fig. 5 shows how the Medireach unit provides services within the remote areas.

Fig. 5. Medireach unit services within different remote areas of Assam [16]

Solar Powered Vehicle: Local Issues Relevance

A solar-powered vehicle can aid a rural dispensary by transporting medicines, vaccines, and healthcare services to distant villages with unreliable electricity and transport. Solar energy cuts fuel expenses, reduces carbon emissions, and enables the continuous operation of medical devices, such as vaccine refrigerators and lighting. This enhances healthcare access, particularly during floods or power outages in rural areas of Assam. In addition, solar cars utilise PV technology to convert sunlight into electricity, which powers a motor to generate motion. A battery stores energy to ensure consistent power, particularly in low-light or no-light scenarios. The power management unit handles charging and discharging. Fig. 6 shows the diagram and components of a standard solar-powered vehicle.

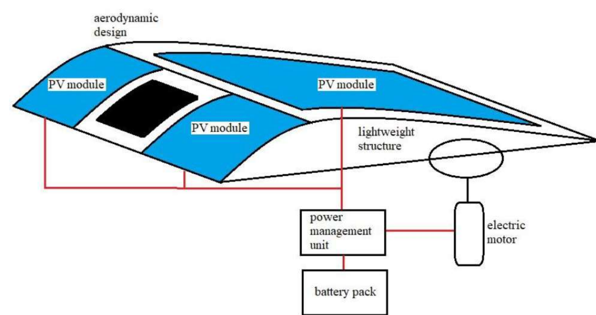

Fig. 6. Solar-powered vehicle Diagram and Components [17]

Implementation of Transport for Health Services in the Indian Context

a) Dr. LaBike's Portable Pathology Lab

LaBike (lab on bike) is a unique concept that combines mobility and healthcare. It is a laboratory on a motorbike equipped with essential diagnostic equipment, including a portable biochemistry lab, a digital microscope, a urine analyser, a BMI monitor, bio-waste management facilities, onboard power backup, and a GPS tracker, as shown in Fig. 7. Over 100 test types can be performed with LaBike. Accuster Technologies' innovative approach aims to bring diagnostics closer to people, especially in remote and underserved areas. The lab bike is built with portability and ease of use at its core, designed to fit into a single bag and requiring only a small area for setup. It is perfectly suited for rural or remote healthcare environments where space and resources are limited. It operates with very low energy consumption, using just 80W, and relies on solar power with a four-hour onboard battery backup, making it both economical and dependable in off-grid regions. Its robust design ensures stability across diverse environments, performing consistently in hot, cold, or humid climates. It has been tested to function effectively over a wide temperature range from 0°C to 50°C. Beyond its physical resilience, the lab bike also integrates digital connectivity, enabling real-time data synchronisation to the cloud via satellite and instant access to test reports via online Laboratory Information Management Systems (LIMS) software and portals, enhancing transparency and speed in diagnostics. The interface is designed to be simple and intuitive, allowing healthcare workers with minimal training to operate it effectively. With low maintenance requirements, affordable deployment, and scalability, it offers a cost-effective solution for extending diagnostic and healthcare services to underserved populations.

Fig. 7. LaBike for collecting diagnostic samples

It consumes approximately 80 watts of power, ensuring low energy and chemical use, and is highly cost-effective to deploy and operate at scale for rural healthcare. Its user-friendly interface requires minimal training to operate, and low maintenance needs ensure long-term reliability and convenience [18].
In this regard, a comparison between Medireach (Fig. 4) and LaBike (Fig. 7) is presented in Table 1.

Table 1. Across key parameters, including medicine dispensary, off-road capability, diagnostic services, awareness activities, and last-mile reach.

Parameters	Medireach	LaBike
Medicine dispensary	Not available	Not available
Off-road capability	Not available	Available
Diagnosis	Available	Available
Awareness	Available	Not available
Last mile reach	No	No

b) Sustainable amphibian ambulance for Rural People
A similar human-powered facility was also designed and developed by a doctoral research scholar of the Department of Design at the Indian Institute of Technology, Guwahati (IIT G), which operates on both land and water. This was particularly designed for flood-affected riverine areas, as shown in Fig. 8 [19]. The features of this transport system are:

Fig.8. Amphibian Ambulance designed at IITG

Human Factor Considerations for Vehicle Design

Human factor requirements include adherence to relevant ergonomics standards and the aim of meeting a range of context-specific needs [20]. Medical workers and patients can easily enter and exit the vehicle. Sitting arrangements are comfortable while moving. The user should have enough storage areas to bring fast-aid supplies and medical equipment. In this regard, anthropometric principles from the Indian Anthropometric Dimensions for Ergonomics Design Practices book were referenced, where common studies are conducted on the design for 95th and 50th Percentile people on workstation design.

Technology Transfer to Small Enterprise: Present Status
Transferring technology to small businesses supporting the Healthcare Dispensary in the Indian Context enhances healthcare access through affordable medical devices,

telemedicine, solar-powered solutions, and local production of medicines. This promotes employment, sustainability, and community health in rural regions. The World Health Organisation (WHO) states that technology transfer bolsters rural healthcare infrastructure and improves service delivery [21].

Pilot Study: Field Visit and Findings

After reviewing the literature, it was found that some pilot studies require knowledge of the villages' actual demographics and anthropology. A pilot study was conducted in four villages of Sonitpur district, Assam. After conducting an ethnographic study of residents in remote areas (see Fig. 9), it was observed that villagers face various issues with local transportation and healthcare facilities. In this regard, they have to visit city hospitals, which are more than 10 kilometres away from the village. The economic background of the people is predominantly agriculture-based, with small-margin businesses, rickshaw riders, and other similar occupations. During the survey, the research team identified the following pain points:

Fig. 9. (a) Field visit in one worker's home from Monai Tea Estate, (b) Field visit in Gotaimari No. 01 village, and (c) Field visit in Niz-Basti village, a flood-prone locality

Fig. 10. Captured pictures of Monai Tea Estate during the field study

Finding 1: The people of the village (Fig. 11) of Gotaimari (Sonitpur District, Assam) face several crucial challenges that make daily life and emergencies difficult. The roads are in deplorable condition and become almost unusable during the rainy season, making it difficult for heavy vehicles, such as buses or ambulances, to reach the area. Most residents are uneducated, and they have limited access to basic health awareness, which adds to their vulnerability. Internet connectivity is very weak, and telephone connectivity does not work properly.

Fig. 11. Captured Road pictures from Gotaimari village during the field study

Finding 2: The village's roads are generally manageable in normal weather, but they frequently flood during the rainy season, slowing travel and making it unsafe (Fig. 12). The nearest health centres, located in Jamuguri and Kusumtala, both towns under Sonitpur District (Assam, NE India), are approximately 10 kilometres away. It takes about 30 minutes to reach them by four-wheeler, yet doctors are not available around the clock. The closest fully functional 24/7 healthcare facilities are nearly 70 kilometres away, causing critical delays during medical emergencies. Transport during emergencies remains a major concern, and many villagers have faced poor ambulance services when they needed support most. While the nearest health centres stock the required medicines, many villagers are still not fully aware of basic illnesses or common treatments, which limits their ability to respond to health issues in a timely manner.

Fig. 12. Captured pictures of Niz-Basti village during the field study

***Finding 3*:** The villages continue to struggle with very poor road conditions, which slow travel and make it risky, especially during emergencies. When someone needs urgent care, they often rely on the Tea Estate medical facility, but outsiders are only accepted if a permanent estate member takes responsibility. Although doctors are available around the clock at the estate hospitals, they frequently refer patients to Phulbari Hospital (Sonitpur Hospital), which in turn sometimes sends them on to Tezpur, resulting in additional delays. Estate vehicles are available for emergencies, but overall transportation remains unreliable and limited. Villagers need to contact nearby doctors;

however, they lack basic medical knowledge, hindering their ability to make timely decisions. In critical situations, many still rely on makeshift methods to transport patients, and even obtaining a single medicine requires long, exhausting travel due to distance and poor road conditions (Fig. 13).

Fig. 13. Captured pictures of Bihaguri village during the field study

Finding 4: Most villagers in Tezpur (Assam) rely on government hospitals for treatment, while a smaller group turns to private clinics to avoid long queues. Although the village is close to Tezpur, the main challenge is overcrowded facilities and limited availability of doctors, not travel distance. Ambulance services are available but often respond slowly, especially at night or in narrow areas. Rising costs in private hospitals make quality care unaffordable for low-income families. Many people still depend on local pharmacists because they lack awareness of preventive care and early detection. Frequent power cuts also affect the use of basic devices for elderly patients. Women often delay addressing their own health needs due to household responsibilities. Despite these challenges, villagers are willing to participate in health awareness programs to improve coordination between local health workers and hospital authorities.

Summary of the Field Study

The diagram summarises findings from a rural healthcare survey of more than 150 respondents. It highlights factors affecting healthcare accessibility, awareness, and service quality, which collectively shape emergency healthcare experiences.

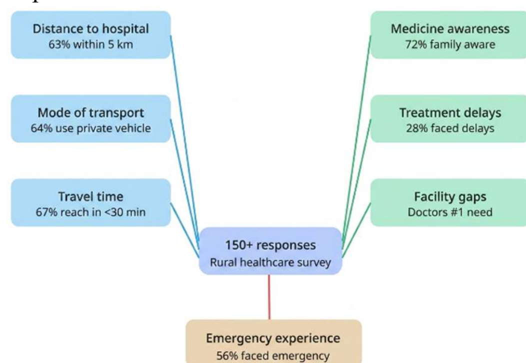

Fig. 14. Analysis of the field study

Observation of Local Medical Shops

It was observed that in many medical shops, shopkeepers commonly sort and store medicines in small plastic containers based on criteria or disease categories. Incorporating a similar organisation, such as local pharmacies, into the staff work faster and more efficiently than in traditional setups, as shown in Fig. 14.

Fig. 14. Organised small boxes of medicines in local medicine shops

Design Brief: Opportunities and Concept Developments

The design brief proposes a dedicated mobile medical transport and dispensary system for the remote areas of Assam, Northeast India. It should provide timely access to medicines, basic treatment, and emergency support when conventional infrastructure is inadequate or unavailable. Addressing the specific challenges in the Sonitpur district, where narrow, flood-prone roads and the absence of reliable transport compel villagers to use improvised methods called bookie Jugar (carrying on one's back), this solution proposes a rugged, off-road mini-truck chassis capable of reaching doorsteps at locations inaccessible to standard-sized ambulances. The design features of the proposed ambulance are:

- The design emphasises self-sufficiency and inclusivity by providing a compact cabin of 5.91 ft × 7.87 ft.
- Attachment of solar panels to ensure autonomy in power supply.
- Arrangement for storage of essential medicines and oxygen.
- Accessibility features such as modular ramps and assist steps to help the elderly and the physically challenged get in or out.
- Separate, uninterrupted service in areas with low levels of digital connectivity.

Opportunities

During the literature review, contextual study, and pilot study across various villages, the study team met with medical professionals, mobile healthcare workers, laboratory technicians, and other support staff to gain a clearer understanding of the ground realities. These discussions revealed that a high-tech healthcare facility will

not effectively address the daily challenges faced by people in remote areas. Most of them struggle with basic access rather than advanced treatments. Based on their feedback, we decided to focus on a compact mobile healthcare dispensary to address everyday needs, including basic check-ups, first aid, minor tests, and immediate care. The unit would be smaller than a regular ambulance, making it easier to navigate narrow roads, uneven terrain, and crowded village routes. This approach aims to bring essential medical support closer to people who often wait too long or travel too far for even simple healthcare services.

Aim and Objectives

The primary objective of the project is to design a user-centric, affordable, and sustainable mobile healthcare dispensary system that addresses acute gaps in access and quality of care for low-income, isolated communities in rural Assam. Specifically, this will involve field studies to understand user pain points arising from poor road infrastructure and limited connectivity, analysing operational gaps in existing services where large vehicles cannot navigate narrow village roads, and integrating professional feedback to define medical needs. The project, therefore, also aims to ideate and develop a rugged, off-road-capable solution on a mini-truck chassis, complete with solar power and accessibility features for individuals with physical challenges, to ensure continuous healthcare delivery in locations where conventional infrastructure is unavailable.

User Study

A qualitative survey was conducted among students to gain a basic understanding of the medical facilities available to boarders at Tezpur University (a central university in India) and to local people near the university, and to examine emergency healthcare conditions, as shown in Fig. 15 (a, b, c, d, e, f, g, h & i). This study aimed to understand the availability, accessibility, and challenges of emergency medical services in rural areas through students' first-hand experiences and observations.

The pie chart in Fig. 15(a) shows the age distribution of the survey respondents.

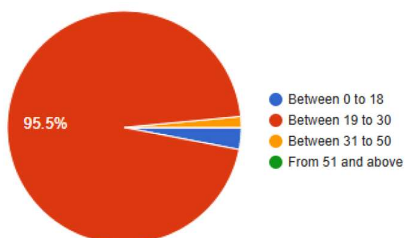

Fig 15 (a): Age Group

The pie chart in Fig. 15(b) shows the gender composition of the respondents in the study.

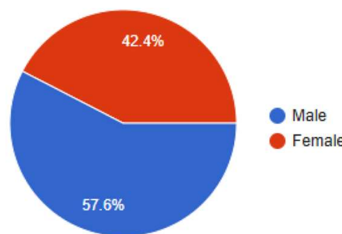

Fig 15 (b): Respondents' Gender

The pie chart in Fig. 15(c) shows whether respondents or their family members experienced a medical emergency in the past 2 years.

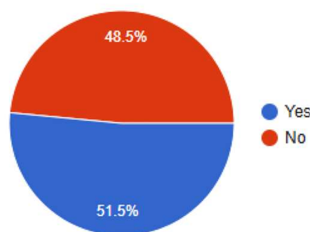

Fig 15 (c): In the past 2 years, have you or your family faced a medical emergency?

The pie chart in Fig. 15 (d) below illustrates the different types of medical emergencies reported by the respondents.

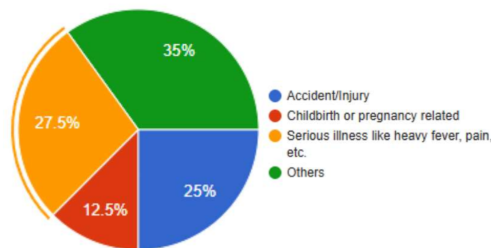

Fig 15 (d): If yes, what type of emergency was it?

The pie chart in Fig. 15(e) shows the approximate distance to the nearest hospital or health centre from the respondents' locations.

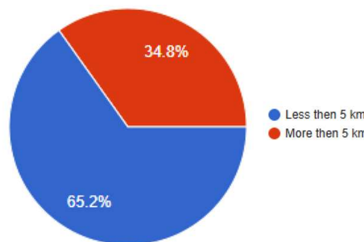

Fig 15 (e): How far is the nearest hospital/health centre?

The pie chart in Fig. 15 (f) shows the usual mode of transport respondents use to reach the nearest hospital or health centre.

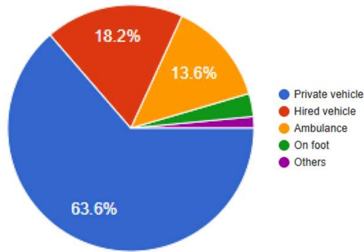

Fig 15 (f): What is the usual mode of transport to reach the hospital?

The pie chart in Fig. 15(g) shows the time respondents typically take to reach the nearest hospital in the event of a medical need.

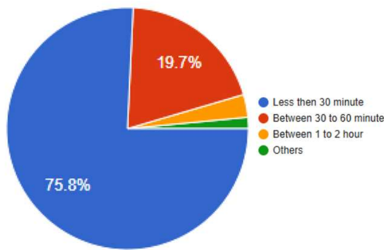

Fig 15 (g): How much time does it usually take to reach the nearest hospital?

The pie chart in Fig. 15 (h) shows respondents' views on whether their family members have adequate awareness of basic medicines and common diseases.

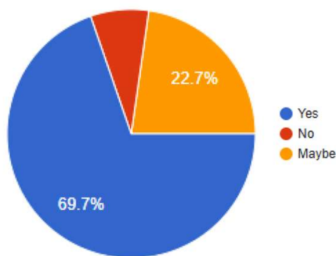

Fig 15 (h): Do your family members have proper awareness about different basic medicines and diseases?

The Pie chart in Fig. 15(i) shows whether respondents have ever experienced delays in receiving treatment during a medical emergency.

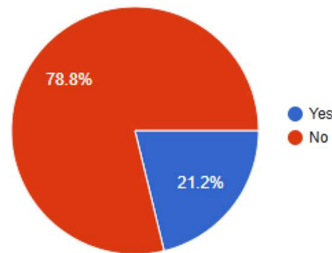

Fig 15 (i): Have you ever faced delays in getting treatment during an emergency?

Ideation Stage

The ideation stage began after a thorough understanding of the primary challenges faced by remote communities in Assam, particularly the lack of affordable access to healthcare. A range of ideas was explored to address these issues. Brainstorming sessions with local residents, medical staff, and field researchers helped clarify their needs and expectations. Several concepts were initially considered, including large mobile clinics, boats, and motorcycle-based units. However, these options proved too costly or impractical given the region's rough terrain and frequent flooding. After several rounds of discussion and feedback, the idea of a compact off-road mini-truck dispensary emerged as a practical, adaptable, and feasible solution for delivering healthcare directly to remote villages. The process adopted for the ideation stage is outlined in Fig. 16 below.

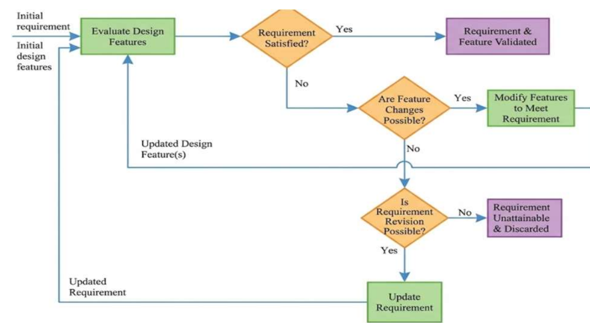

Fig. 16. Roadmap of the ideation process

Designing a ~ (8.5 ft. x 6 ft.) cabin for a mini-truck makes the unit easier to operate on rough and narrow roads, as these trucks excel at handling difficult terrain. Adding a solar power system also reduces operating costs and keeps essential devices running, reducing reliance on external electricity. A patient bed is necessary for cleaning, dressing, and basic procedures, and it can also be used to transport patients when needed.

Initial Sketches (Fig. 17)

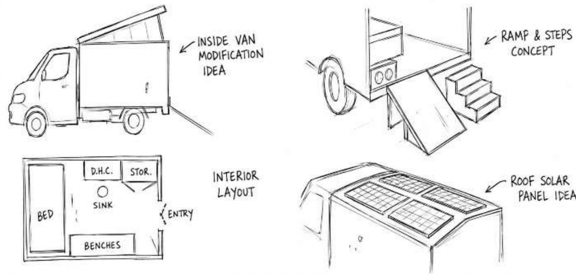

Fig. 17. Initial ideation sketches

Concept Development

After receiving professional feedback on the design, it was justified that lifting a patient through a side door is difficult due to the narrow opening. This limitation restricts movement and complicates safe handling. Additionally, it can force caregivers into awkward positions, increasing the risk of injury for both the patient and the medical team. It was also recognised that adding a side extension would widen the vehicle, making it harder to park along narrow village roads and leaving less space for other cars to pass safely. Fig. 18 shows a conceptual model of the dispensary trolley attachment cabin's overall structure. Rather than allocating space for diagnostic machines, it is more practical to focus on proper storage of medicines. Meeting basic healthcare needs is the priority in remote areas, and a well-organised medicine cabinet better supports that goal. Heavy machines can also create balance issues when travelling on uneven or poorly maintained roads, making them less suitable for this type of mobile unit.

Fig. 18(a): Conceptual model for the overall structure of the dispensary trolley (side view)

Fig. 18 (b): Quarter view and rear side view of the dispensary and internal spaces

Fig. 18 (c): 3-Quarter and perspective view of the mobile healthcare dispensary

Fig. 18. Concept Development followed by 3D views.

Following discussions with the user and medical professionals, several key design enhancements were identified and implemented. They recommended adding supportive lifting tools to assist physically weak patients when entering the unit, making the process safer and easier for both patients and caregivers. Additionally, they advised reducing the cabin size from (6.0 ft. × 8.0 ft.) to (8.0 ft.× 10 ft.) to create a more compact, practical layout that better suits the vehicle's mobility requirements.

Concept Finalisation: Application of Pugh Matrix

The decision-making tool used a Pugh Chart (Decision Matrix) to objectively compare conceptual designs for the newly designed Healthcare Dispensary service against predefined standards for the current '108' ambulance services in the Assam region. The conceptual designs were compared with the existing formulation to determine whether they were ‘better' (+) or ‘worse' (-) solutions for the existing needs of providing healthcare in rural areas, with a ‘neutral’ (0) assessment of the existing conditions. The evaluation relied on six critical parameters derived from field research (Table 2): *transportation capabilities, medicine distribution efficiency, healthcare dispensary functionality, diagnosis facilities, water system availability, and digital tool integration*. These pain points were identified and selected by villagers during the contextual study and addressed, such as the inability of standard large vehicles to navigate narrow, damaged roads and the frequent unavailability of essential medicines. The parameters prioritised practical utility and stability in harsh environments over complex, high-tech features that might be unsustainable in off-grid locations.

Table 2: Pugh Matrix

	Basic Ambulance	Concept
Transportation	1	1
Medicine Distribution	0	1
Patient Care	1	1
Diagnosis	0	0

Water System	0	1
Power	0	1
Digital tool integration	0	0
Total Score	*0*	*5 (Five)*

Final Concept

The concept was finalised through multiple rounds of feedback from professionals, including designers, medical officers, and laboratory technicians, as well as users of Tezpur University and local people, ensuring the unit performs well in real-world field conditions. The mobile healthcare cabin is powered by a solar panel system that supports essential internal functions, keeping the setup reliable in remote areas where electricity may not always be available. Inside the cabin, the layout includes organised cabinets and drawers of varying sizes to store medicines and medical supplies in a clean, accessible manner. A patient bed is placed at the centre for dressing, cleaning, and basic consultations, and it can also be used for short-term patient support when needed. Stools are provided for doctors, helpers, and attendants to maintain comfort during treatment.

Design Simulation using CAD modelling

To make the final concept more implementable in real life, various analyses and assessments are required. In this regard conducted different tasks. It aims to refine the concept and ensure its feasibility for application by identifying areas for improvement. The structural view of the final concept is shown in Fig. 19 below.

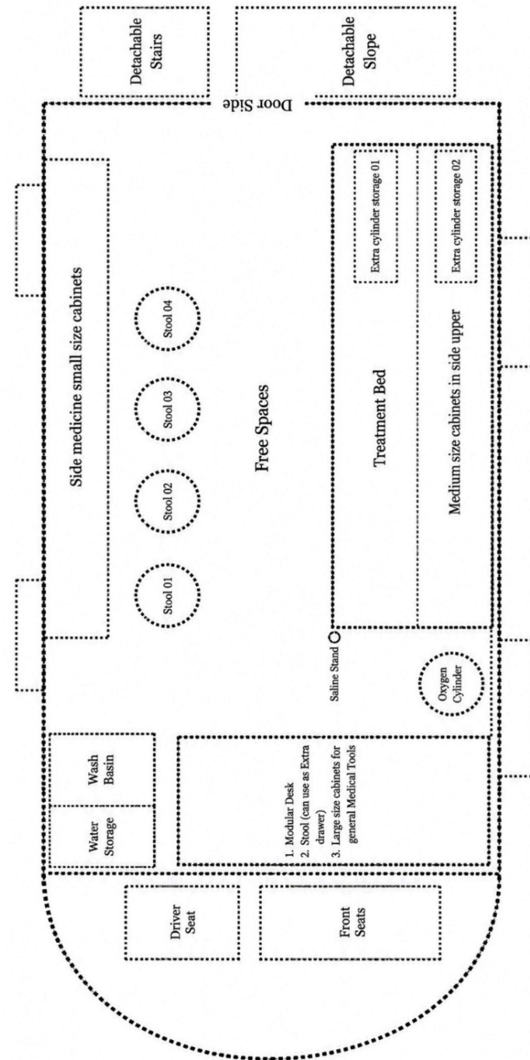

Fig. 19. X-ray view of the final concept

Factors Affecting Safety and Performance

The stretcher attached to patient compartments in the Mobile Healthcare Dispensary consists of several design issues that create unsafe working conditions for emergency medical service (EMS) providers. Because this serves as both transport and treatment spaces, providers often unbuckle their restraints to reach equipment, a major cause of injuries and fatalities. Key design problems include:

- Patient compartments in the Mobile Healthcare Dispensary have a variety of design flaws that affect the safety and efficiency of EMS professionals. Patient compartment seating and restraint systems, such as side-facing bench seating, rear-facing chairs, and CPR seats, enable EMS professionals to face and interact with patients but do not allow them to remain safely restrained during patient care. Side-facing seating increases the risk of serious neck injury during

accidents, and lap restraints, when used inadequately, provide little protection and are frequently not used.

- Ergonomic issues further aggravate dangers, as limited workspace forces EMS professionals into awkward positions and requires bending, stretching, and physical patient tasks such as Cardiopulmonary Resuscitation (CPR)- an emergency life-saving procedure and patient transfer, all of which contribute to permanent musculoskeletal harm. Unsecured equipment can become projectiles during rapid ambulatory motion or in accidents, posing a grave risk to both patients and EMS staff [22].

Key Requirements: Independent part design

According to the finalised concept design, mentioned below are a few key requirements that are important while detailing the concept according to the real world:

- Cabinet and other structure dimensions
- Specialised storage for required tools such as Oxygen cylinders, Medicines, etc.
- Patient care facilities
- Accessibility and Inclusivity for every type of patient and doctors
- Sustainable utilities like power supply
- Seating areas.

Designing essential parts of the cabinet

Small cabinets for medicine

Small boxes are kept in different cabinets. In Fig. 16, these small boxes need to be inserted into cabinets and organised by category or disease, making it easier to quickly access medicines. The estimated dimensions of each small cabinet are 1.0 ft (L) × 0.5 ft (B) × 0.35 ft (H). Fig. 20 shows a CAD model of the small medicine cabinets for the Mobile Healthcare Dispensary.

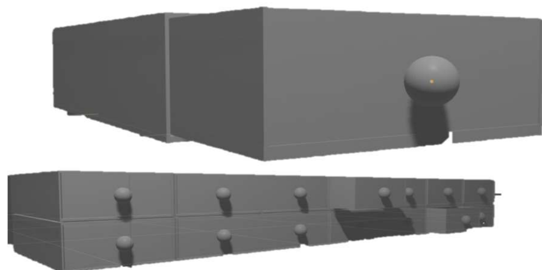

Fig. 20. CAD models of the small cabinets

Patient bed: Stretcher

The designed cabinet bed incorporates several key features. A separate storage area beneath the bed is provided primarily for storing various necessities; it also features two dedicated compartments for oxygen cylinders.

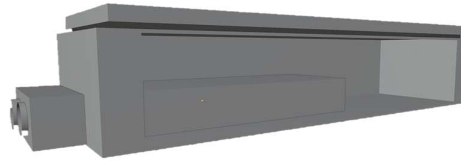

Fig. 21. CAD models of the patient bed cum stretcher for the cabinet

The covers of these compartments can serve as a secondary step for patients or medical staff. More importantly, the bed is fitted with a heavy, high-quality mattress to ensure ultimate patient comfort, as shown in Fig. 21. The estimated dimensions of the bed are 6 ft (L) × 3 ft (B) × 2 ft (H). Fig. 21 shows CAD models of the patient bed cum stretcher for the cabinet of the Mobile Healthcare Dispensary.

Wash basin

A wash basin is provided for basic hygiene and quick procedures.

Fig. 22. CAD models of a wash basin

Inside the cabinet, the wash basin is one of the most essential components. In any healthcare environment, frequent handwashing and access to clean water are critical for maintaining hygiene and preventing cross-contamination. Including a wash basin ensures that medical staff can follow proper sanitation protocols during examinations, treatments, or emergency procedures. It also supports tasks requiring immediate access to water, such as cleaning instruments, handling spills, or assisting patients with basic hygiene needs. The estimated dimensions of the wash basin are: 1.5 ft (L) × 1.5 ft (B) × 2 ft (H), and the bottom-line height from the base of the cabinet is approximately 0.65 ft.

Stool. Fig. 22 shows CAD models of a wash basin for the cabinet of the Mobile Healthcare Dispensary.

Dedicated slots are provided for an oxygen cylinder, with a separate space to store additional cylinders safely. There is also a secure area to place monitors and other essential devices in an emergency. A saline stand is mounted for quick access, and rapid test kits have their own storage section, along with space for other essential treatment items. To improve accessibility, a modular slope allows wheelchair

users to enter comfortably without additional assistance. Steps have been added for those who prefer regular access, and supportive handles are placed on both sides to help patients or those with physical challenges maintain balance while entering the vehicle. This setup aims to keep the unit functional, compact, and easy to use in challenging rural conditions.

Fig. 23. CAD model of a stool for doctors and nurses

In a medical cabinet, a stool (Fig. 23) is an essential functional element that can serve diverse purposes. It provides supportive seating for physicians during procedures or examinations, thereby supporting patient care. In addition to supporting patients who require more aid while seated or during transfers from one seated posture to another, it can also serve as a direct patient service from its placement in the medical cabinet. With these functions, it can be considered an element that greatly improves patient services in the healthcare setting. The stool features an adjustable height ranging from 1 ft. to 2 ft., and the seating surface has a diameter of 1 ft.

Medium-sized boxes/cabinets

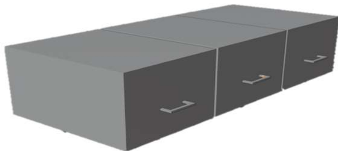

Fig. 24. CAD model of small-sized boxes

Medium boxes (Fig. 24) are attached to different divided small and large boxes to ensure efficiency and organisation in the storage cabinet. They provide storage for products that are too large for the small boxes but too small for the larger ones. The medium boxes help organise and divide medical materials such as bandages, gloves, basic kits, and drugs, thereby facilitating easier access during patient handling. They help organise health materials to increase efficiency and reduce clutter, ensuring a clean, organised health facility. The estimated dimensions of each box will be 1 ft on a side (Cuboid).

Large-size boxes/cabinets

The design fully utilises large cabinets (Fig. 25) measuring 2.0 ft. in height to meet the critical requirement of storing larger medical items that do not comfortably fit in shallow medicine drawers in a regular medical store. Tall, spacious storage boxes are placed at appropriate locations within the interior design to store larger medical requirements, such as crates containing sets of saline bottles, full dressing kits, and a standby stock of major medicines. At 2 ft, the design makes the most of the limited space in a 6 ft x 8 ft. vehicle, preventing displacement during off-road adventures and preserving a clean workspace for the doctor. The estimated height of the large-sized boxes is 2 ft., with 1 ft. in each length and width.

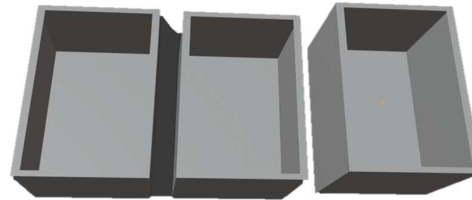

Fig. 25. CAD model of a large box cum cabinet

The cabinet is a functional, static, rigid cuboid designed to fit flush with the body of the off-roading mini-truck. The width, length, and height measure 6 ft (L) x 8 ft (B) x 7 ft, and within this cuboid, unnecessary aerodynamic lines have been reduced in favour of increased capacity for storing medical equipment and transporting patients. The design is kept short to avoid overhang and to facilitate the truck's passage through the village tracks without getting caught on vegetation. The design is topped with a roof suitable for solar panel installation as described in Fig. 6, and the sides are squared off to facilitate the ramp system. The estimated overall cabinet is shown in Fig. 26.

Fig. 26. CAD model of the outer side of the cabinet

Design Assembling: Prototyping

As this research progressed into the detailing phase of the finalised cabinet design, simulation began playing a critical role in verifying the spatial configuration and functionality of its interior features. A prototype had to be made for a physical analysis of the size ratio between this device and the essential tools needed for its functionality. Proper configuration of features such as patient beds, medicine cabinets, and oxygen containers was required to ensure a smooth workflow for both medical and physically

challenged patients. This further finalised the device's precise size at 6 ft x 8 ft and led to the incorporation of minute details related to its functionality to enhance performance, such as medical cabinets with sloped shelves and support handles, which could also be beneficial for physically challenged patients.

Ergonomic evaluation using human model simulations

Integrating these simulations from the human model software is imperative to confirm that the scaled interior environment of 6 ft x 8 ft is functional, allowing the doctor to navigate without hindrance or strain. It helps create an optimal environment that enables doctors and healthcare providers to access medications with ease. It also helps test accessibility across various groups using parameters such as ramps and handles.

Accessing the under-bed storage and the wash basin

This ergonomic simulation demonstrates its multifunctional aspect, allowing three people to coexist within the space without impeding major functions. This simulation confirms the required space for an ergonomically crouched staff member who also has direct access to the under-bed storage drawers while maintaining the patient's safety on the examination table. The simulation also confirms simultaneous functions, where the doctor is able to manoeuvre within the space, maintaining direct access to the wash basin, necessary for maintaining hygiene, without impeding the conduct of other tasks. This simulation verifies the functionality's feasibility in a real-world environment by maximising the use of the small space.

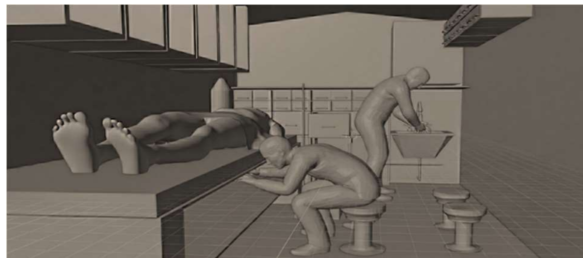

Fig. 27. CAD model of accessing under-bed storage and the wash basin

Using the steps

This 3D ergonomics simulation serves as an important entry point, allowing a doctor to use the step system to access the mobile dispensary cabinet efficiently. In this case, this simulation serves as a proof-of-concept to ensure the theoretical unit provides a safe working environment for health professionals.

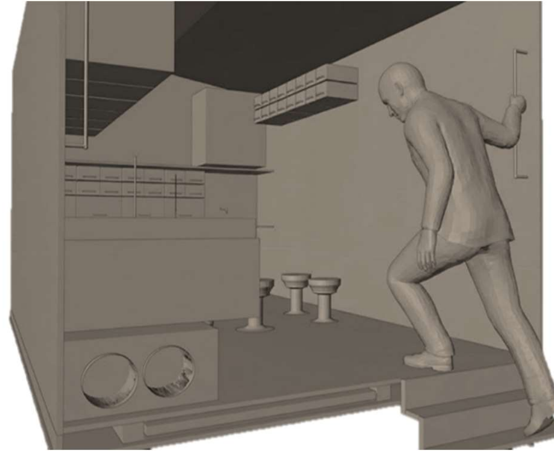

Fig. 28. CAD model of human models using the stairs and handles

Using the ramp

This 3D accessibility simulation has validated the design's inclusivity while visualising the critical process of transporting a wheelchair-bound patient into the dispensary via the deployable ramp. It confirms that the slope is manageable for a helper to push the wheelchair without excessive exertion and that the doorway has sufficient clearance for standard mobility aids. The model shows that the ramp and steps, when placed side by side, do not obstruct each other, allowing easy access for both walking and wheelchair users. This very useful scenario demonstrates the practical feasibility of the requirement for ‘accessibility and inclusivity, ensuring that physically challenged village people can safely access primary care facilities within the compact unit.

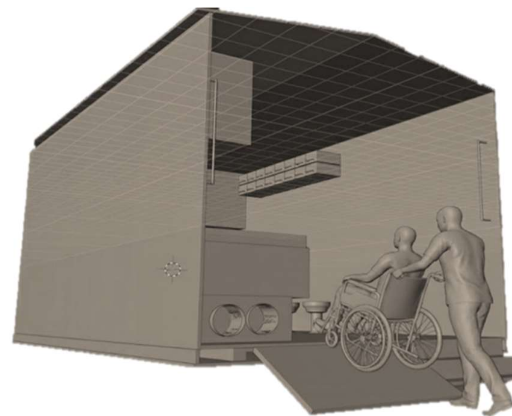

Fig. 29. CAD model of a patient using the slope to enter the cabinet

Accessing small cabinets

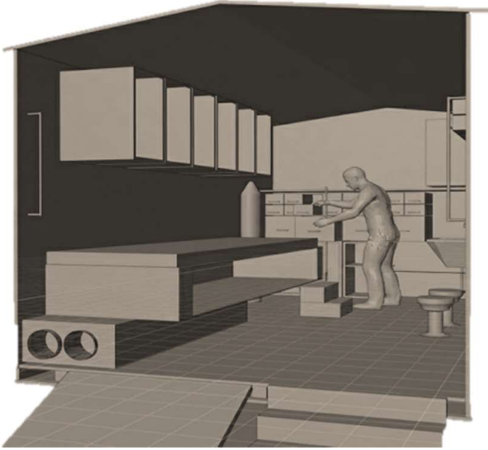

Fig. 30. CAD model of a doctor accessing the cabinets

The CAD model finds the positioning of the overhead compartments to ensure they are at ergonomic, anthropometric, and safe heights that allow the retrieval of non-portable medical supplies. Additionally, the CAD model finds that the stand aisle space from the patient bed to the cabinetry is adequate to prevent obstruction of the central path. The positioning of components maximises the use of airspace within the vehicle, ensuring that less frequently used but still critical items are not in the direct path of patient handling. This verifies the efficacy of the high-density storage system within the operational constraints of the mobile dispensary.

Using the ramp

The 3D ergonomic simulation of the healthcare dispensary shows the doctor performing critical tasks in the confined work area and helps validate the interior layout's efficiency. The CAD model shows that the practitioner can reach the top storage compartments while maintaining a neutral, comfortable posture, avoiding unnecessary strain.

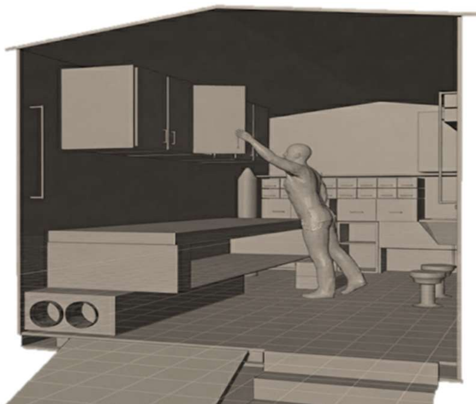

Fig. 31. CAD model of a doctor accessing the cabinets

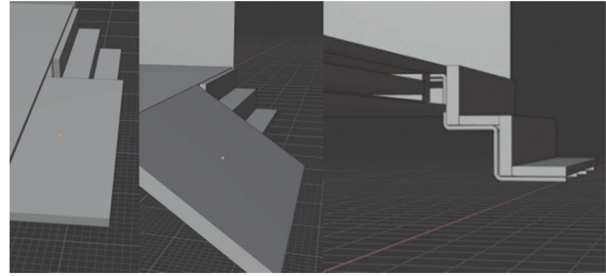

Fig. 32. CAD model of detachable steps and ramp for patients

Preferred load carrier

The Tata Yodha 2.0 has been shortlisted for its optimal dimensions and terrain resistance for the Mobile Dispensary vehicle design. Unlike common mini trucks, Yodha offers the widest cargo bed at 6.1 ft, which fits the 6 ft-wide cabinet perfectly without requiring an unstable overhang. The 8.7 ft. (2650 mm) cargo bed of Yodha allows easy accommodation of its 8 ft. (2438 mm) long cabins, along with sufficient room for mounting hardware on the chassis [23].

Fig. 33. Tata Yodha load carrier

The final design

In its final design, the sturdy truck chassis is repurposed as an autonomous mobile dispensary, specifically designed to traverse remote terrain. Accessibility is paramount, facilitated by a dual-entry system at the back, equally equipped with a ramp and stairs to cater to differently abled patients. Inside, it optimises space by incorporating an efficient work area with an examination bed, a doctor's station, and adequate overhead storage for medical supplies.

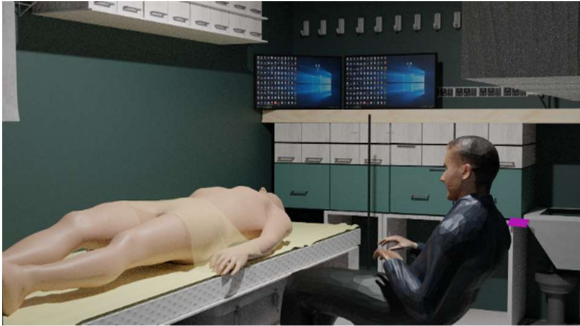

Fig. Workstation for medical workers inside the cabin of the dispensary.

To facilitate use in remote settings, it is equipped with solar modules on its roof that power its diagnostic and lighting equipment. Its clean, crisp design creates an ideal medical dispensary setting, with space-saving cabinets that enhance efficiency, as shown in Fig.35.

Fig. 35. Top view of the Mobile Health Care Dispensary with attached solar panels.

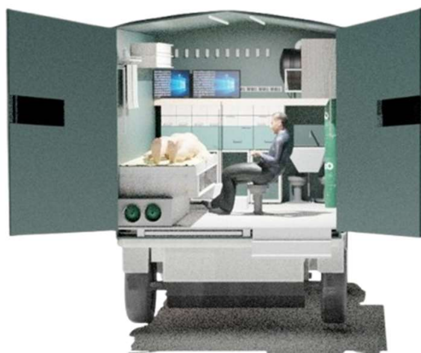

Fig. 36. Front view of the entry and exit to the Health Care Dispensary

This invention closes the gap between medical care and rural areas by providing necessary medical care facilities right at their doorsteps. A few adjustments have been made to the final design, following input from many experts, to improve the vehicle's functionality. To improve patient-doctor relations, the larger cabinets were moved to one side, while the smaller medicine boxes were moved to the other side for the same effect.

Fig. 35. 3-quarter rear side view

User testing

The research focuses on designing a mobile dispensary for remote regions of India, particularly rural and hard-to-reach areas of Assam, to address healthcare challenges. It highlights persistent barriers, including poor infrastructure, limited disease awareness, delays in seeking timely medical care, and the influence of superstitions, which continue to hinder public health progress. The study emphasises that any healthcare setup, whether mobile or hospital-based, requires adequate manpower, essential medicines for minor infections and non-communicable diseases, maternal and child healthcare services, basic diagnostic facilities, and a compassionate, preventive approach to community service. Over the past decade, maternal and child mortality rates in Assam have improved significantly through sustained efforts, and mobile medical services can further strengthen this progress. The mobile medical unit developed under the project is carefully designed to meet outpatient care needs in remote populations. A key feature is the inclusion of laboratory testing facilities, which are often absent from existing mobile units. With point-of-care testing, the unit can support screening for anaemia, sexually transmitted infections, vector-borne diseases, and non-communicable diseases, enabling early detection and timely intervention. The project is further strengthened by the active involvement of medical officers from existing mobile medical units, whose practical insights enhance its feasibility and operational effectiveness, ensuring better outreach and care for last-mile patients. The study also underscores the importance of preventive healthcare through community engagement on child and adolescent health, sexual and reproductive health, maternal care, family planning, and healthy lifestyle practices, including the provision of contraceptive options where appropriate. Drawing on months of field observations in remote regions, the research acknowledges the significant gap in healthcare access compared with urban settings and expresses hope for

a future in which even isolated communities can benefit from advanced diagnostic technologies such as X-ray, ultrasound, computed tomography (CT) scan, and Magnetic Resonance Imaging (MRI) through continued innovation and professional dedication.

CONCLUSION

One of the main goals of national planning is to ensure adequate healthcare services. To achieve this, there must be sufficient medical infrastructure and an adequate number of physicians, nurses, and other medical professionals [24]. The current study was conducted to address serious healthcare problems in remote areas of Assam. In many villages in the Sonitpur district, people often fail to reach hospitals on time because the roads are unsafe, floods are common, and there is no regular transport. The problem is not only a lack of medicines but also a lack of transport to get them. To address this, a healthcare transportation system is designed that includes a cabinet (6 ft. X 8 ft. x7 ft.) mounted on the back of a mini-truck, such as the Tata Yodha load carrier (Fig. 33), which is small, light, and strong, and can travel on narrow and difficult roads. There are storage facilities for medicines. In addition, solar power panels will be installed on the top of the healthcare dispensary to generate electricity, and other infrastructure, e.g., ramps, will be installed so elderly people and patients can easily enter. After user testing, doctors and health workers confirmed that the designed vehicle will be more practical and useful than the large ambulance currently used in different areas of Assam. The CAD simulation was completed, and prototype testing will be in scope for the product's commercialisation in the social context. In design and technology, individuals blend practical and technological skills with creative thinking to develop and produce products and systems that address human needs [25].

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