Development and Challenges of Mobile Cabin Hospitals in China

Wenque Liu, Albert P. C. Chan*, Amos Darko, Man Wai Chan, Fan Zhang, and Goodenough D. Oppong

Hong Kong Polytechnic University, Department of Building and Real Estate, Hong Kong
Email: wenque.liu@connect.polyu.hk (W.L.); albert.chan@polyu.edu.hk (A.P.C.C.);
wai.88.chan@polyu.edu.hk (M.W.C.); amos.darko@connect.polyu.hk (M.D.); fan-2.zhang@polyu.edu.hk (F.Z.);
goodenough.de.oppong@connect.polyu.hk (G.D.O.)
*Corresponding author

***Abstract*—The COVID-19 outbreak occurred in 2019, which caused a catastrophic impact around the world. With the rapid and wide spread of the pandemic, there are increasing medical needs globally, which stimulates the development and upgrade of health facilities. Among these facilities, Mobile Cabin Hospitals (MCHs) are instrumental in responding to COVID-19. This study aims to provide an overview of current knowledge about MCHs. Its goals are to present a perspective of MCHs' construction patterns, their geographical distribution in China in the context of COVID-19, and underlying challenges. Results revealed the differences between two construction patterns of MCHs in terms of structural characteristics and application scopes. Also, through density maps, it was suggested that the geographical distribution of MCHs is closely related to the severity of the pandemic in China. Additionally, some potential challenges were identified in the planning, design, execution, operation, maintenance, and demolition phases respectively. The results can provide useful references for battling against public health emergencies like the COVID-19 pandemic.**

***Keywords*—mobile cabin hospitals, COVID-19, China, construction patterns, geographical distribution, challenges**

I. Introduction

In 2019, the COVID-19 pandemic swept the whole world. It was once described by António Guterres, Secretary-General of the United Nations, as the world's largest crisis since World War II. The adverse impacts of COVID-19 pandemic are devasting. There have been more than 691.23 million coronavirus cases and over 6.89 million deaths worldwide by July 1st, 2023, distributed in 189 countries and regions. In 2003, the Severe Acute Respiratory Syndrome (SARS) ravaged 29 countries and regions, causing over 8,000 infections worldwide. The COVID-19 pandemic and SARS are both regarded as major world public health emergencies. When public health emergencies occur, the demand for medical space will far exceed the capacity of healthcare facilities under normal operating conditions. Meanwhile, patients often fall into the double dilemma of strict flow control and insufficient medical resources. In particular, the outbreak of coronavirus disease (COVID-19) has become a catastrophic event, with global healthcare systems overwhelmed (Sun *et al.*, 2021). With the rapid and wide spread of the pandemic, there are increasing medical needs globally, which stimulates the development and upgrade of health facilities. Among these facilities, mobile cabin hospitals (MCHs) are instrumental in responding to COVID-19 (Evans *et al.*, 2023).

Mobile cabin hospitals are also called Fangcang shelter hospitals, community treatment facilities, community treatment centers, or hotel-based quarantine centers in China. The name of the mobile cabin hospital varies in distinct regions, as shown in Table I. Mobile cabin hospitals were derived from wartime field hospitals, which were originally built for refugees instead of infections (Li *et al.*, 2022). MCHs play a vital role in various emergencies. For instance, in 2014, MCHs were used to provide healthcare services to patients infected with the Ebola virus in West Africa. In China, two field shelter hospitals were applied to the medical treatment of the Wenchuan earthquake in 2008. Although there is a lot of experience with MCHs around the world, the widespread usage of MCHs in response to COVID-19 is still an unprecedented challenge for China.

TABLE I. Typical Provisions of Different Regions

Regions	Provisions	Data sources
Mainland China	Fangcang Shelter Hospitals	(Chen *et al.*, 2020)
Hong Kong SAR	Community Treatment Facilities	(Hospital Authority.(2022))
Macao SAR	Community Treatment Centers	(GCS, 2022)
Taiwan	Hotel-based Quarantine Centers	(Tsai, *et al.*, 2022)

Mobile cabin hospitals are a kind of healthcare facilities composed of a series of square cabins with different

Manuscript received September 27, 2023; revised November 11, 2023; accepted December 2, 2023; published January 29, 2024.

medical or technical support functions, including isolation, triage, basic medical care, frequent monitoring, rapid referral, and fundamental living guarantee (Shi *et al.*, 2022). They are well-suited to address public health emergencies like the COVID-19 pandemic, as they have three critical characteristics: rapid construction, massive scale, and low cost (Chen *et al.*, 2020). Zhu, *et al.* also illustrated that fast admission, low cost and alleviating public anxiety are the three major advantages of MCHs. The construction of MCHs is an effective way to enhance the resilience of healthcare infrastructure to respond to public health emergencies (Fang *et al.*, 2020). However, there are also various challenges in the whole life cycle of MCH projects.

II. Construction Patterns of Mobile Cabin Hospitals

In China, there are two construction patterns for mobile cabin hospitals (Zuo, 2022). The first mode is the new construction of MCHs. In this mode, temporary healthcare facilities are built to meet the treatment standards for patients with COVID-19. The second one is the renovation and upgrading of large public buildings, including exhibition centers, stadiums, and commercial complexes. These buildings are transformed into large temporary healthcare facilities to supply substantial medical resources for infected individuals. From the perspective of structure, the overall structure of newly built MCHs is relatively complete and independent due to their integrated design, whereas that of converted MCHs, which are limited by the layout of the original buildings, is more complex and interdependent.

Furthermore, the two types of MCHs have different scopes of application. The newly built MCHs commonly have higher standards of infection control than the converted MCHs. The capabilities of anti-pollution and anti-proliferation are stronger in the first mode of MCHs. Hence, the newly built MCHs are suitable for light, ordinary, heavy, and critical patients, while the converted MCHs are appropriate for light, ordinary, and asymptomatic patients. Due to the higher standards of the first mode, the construction of new projects generally takes longer than that of renovation projects, and the construction cost per unit area of new mobile cabin hospitals is higher. However, the converted MCHs usually provide more beds than the new MCHs, which results in more capacity. Moreover, the second mode offers greater sustainability benefits. After the epidemic, the converted shelter hospitals can be quickly restored to their original state and continue to be used. If the newly built shelter hospitals are demolished, many resources will be wasted.

Regarding newly built MCHs, modular construction technology is widely adopted to meet the requirements of rapid construction. Notwithstanding, these modular hospitals are different from conventional modular buildings. Compared to general modular buildings, the modular construction technology for MCHs realizes the industrialized production of modular units with independent functions and quickly assembles independent units into buildings with larger spaces. This technology is helpful to improve construction efficiency, and shorten construction time. With respect to reconstructed MCHs, they are built based on the existing buildings, without the design of the foundation or the main structure. This mode is conducive to saving construction time.

III. Geographical Distribution of Mobile Cabin Hospitals

According to the National Health Commission (National Health Commission, 2022), as of April 25, 2022, there had been almost 400 MCHs built or under construction, totaling over 560,000 beds. Based on the latest data from various regions, this study counts the number of MCHs built and under construction and the total number of MCH beds in China during the COVID-19 epidemic, as shown in Fig. 1 and Fig. 2. Additionally, Fig. 3 showcases the average number of beds per MCH. All data are from official websites and news pages, which are presented in Supplementary Materials.xlsx.

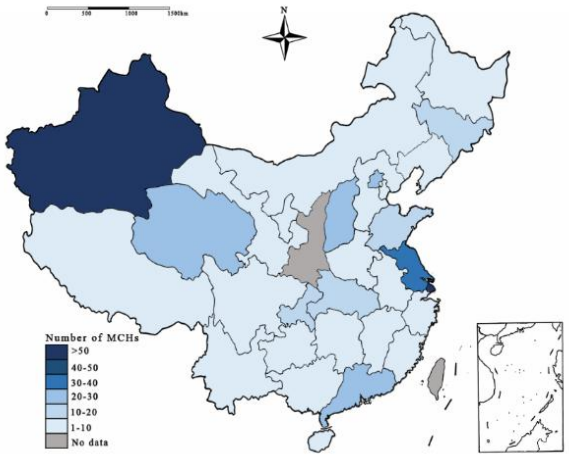

Fig. 1. Number of mobile cabin hospitals

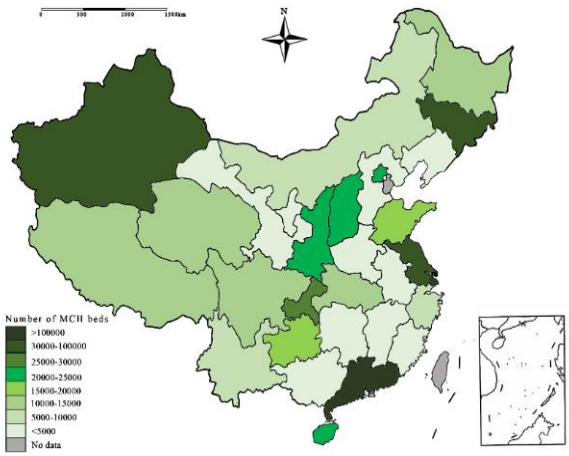

Fig. 2. Number of mobile cabin hospital beds

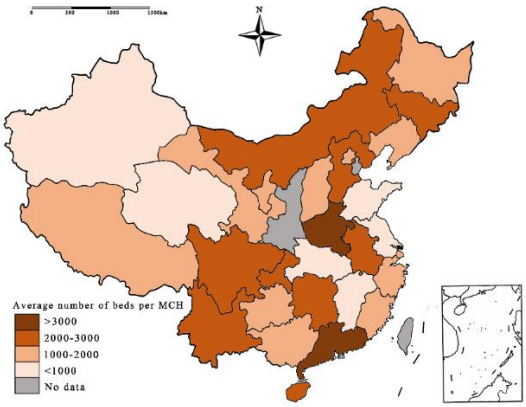

Fig. 3. Average number of beds per MCH

As observed from Fig. 1, there are fewer than ten MCHs in most regions. Xinjiang and Shanghai are the two regions that possess more than 50 MCHs. It can be seen from Fig. 2, the number of beds is roughly positively correlated with the number of MCHs. Shanghai is still in the lead in terms of the number of MCH beds. Besides, the total number of MCH beds in Guangdong province is beyond 100000. This phenomenon may be related to the severity of the epidemic and the number of infected individuals. As presented in Fig. 3, a conclusion can be drawn that the average number of beds in each mobile cabin hospital is considerable in Guangdong and Henan, indicating the large average capacity of medical supply there.

IV. Challenges of Implementing Mobile Hospital Projects

MCHs are usually constructed and initiated under circumstances when cities are in a closed or static state. The reasons for this situation are that there is a surge in the number of confirmed cases and that healthcare resources are seriously insufficient. Accordingly, a lot of large-scale MCHs need to be built quickly at the lowest cost, so as to control the epidemic efficiently. However, the resources of humans, equipment, and materials are limited, which makes the construction of MCH projects face huge challenges.

A. Challenges in the Planning and Design Stages

MCHs are health facilities integrating multiple functions, which require rigorous planning and design. It is essential to plan and design a reasonable spatial layout and traffic streamline for MCH projects, which is critical to implementing further procedures (Zhou *et al.*, 2022). The holistic layout should thoroughly consider the synergy of the medical processes, medical safety, functional requirements, and the storage and transportation of medical equipment and materials. Since the rapid transmission of the COVID-19 epidemic and its potent capacity to spread, the determination of the project location should strictly comfort to corresponding principles, comprising high security, low social influence, and good geological conditions. It is also vital to ensure the feasibility, flexibility, accessibility, and variability of the site to meet the needs of different situations. Besides, the time for design for MCH projects is limited, which places great demands on the compliance of the design. The design requirements of various systems affiliated with MCHs are also demanding, including heating, ventilation, and air-conditioning systems; water supply and drainage systems; electrical and intelligent systems; medical gas systems; and sewage treatment systems [10]. It is considerably important to maintain their effectiveness, efficiency, safety, and sustainability. In addition, there may be a phenomenon where design, modification, and construction are performed at the same time. It is an ordeal for the cooperation and coordination of all phases of design, procurement, and construction.

B. Challenges in the Execution Stage

During the execution stage, monitoring the MCH projects is pivotal because of the limited time. Besides, population-intensive activities are likely to raise the risk of infection. Hence, the difficulty in ensuring the safety performance of personnel in construction sites is expected to increase due to the impacts of COVID-19. Also, it is difficult to sustain the supply chain of a variety of materials smoothly in a short time. It is necessary to handle the entire production flow among the upstream, midstream, and downstream sections of the supply chain, which is troublesome in the epidemic. Another challenge is the construction technology of MCHs. MCHs embrace the characteristics of both modular buildings and hospitals, involving the installation of professional healthcare equipment, the construction of healthcare units and living infrastructure, and the modularization and integration of individual units. The uniqueness and complexity of MCHs highlight the high requirements of construction technology.

C. Challenges in the Operation and Maintenance Stages

MCHs consist of a series of healthcare units and living units, providing healthcare services and basic living security for residents there. Hence, improving user satisfaction is a focus during the operation and maintenance stages of MCH projects. However, most MCHs have obvious deficiencies, such as poor airtightness and poor sound insulation, which may make users feel uncomfortable. Besides, MCHs will encounter challenges in terms of the prevention and control of infection, operation management, and the security of supplies. The drainage and sewage capacity of reconstructed MCHs is usually insufficient when a large number of people live together. The security of supplies is also a prominent problem that MCHs should address. In the initial phase of the COVID-19 epidemic, shortages of supplies occurred frequently, which put medical professionals under enormous work pressure. As illustrated in Section A, MCHs are facilities with multiple complex systems, which increases the difficulty of inspection and maintenance. Establishing a sound management mechanism for operation and maintenance is also challenging due to MCHs' complexity.

D. Challenges in the Demolition Stage

As the COVID-19 epidemic eases, a batch of MCHs has entered the stage of retirement, with closure and

demolition. There are a set of problems in this process. The first nodus is how to properly dispose of waste and pollutants to avoid adverse effects on the environment during the demolition phase. Secondly, for reconstructed MCHs, it is hard and important to prevent the secondary spread of COVID-19 while not destroying the components and structure of the original buildings. Another point is related to the sustainability issue. A lot of manpower, material resources, and expenses have been invested in MCH projects. It is worth considering how to balance resource waste and reuse issues. Additionally, it is challenging to address problems like the storage of demolished objects, the risk of personnel infection, and the demolition schedule.

V. Conclusions and Recommendations

This study conducted an overview of mobile cabin hospitals based on the Chinese case. Firstly, this study illustrated the two construction patterns of MCHs in China, including newly built MCHs and converted MCHs. Subsequently, three maps were drawn to present the geographic distribution of MCHs during the COVID-19 pandemic, involving the number of MCHs, the total number of MCH beds, and the average number of MCH beds. Finally, potential challenges throughout the whole life cycle of MCH projects were summarized on the basis of the current development of MCHs in China. These findings could provide valuable experience and references for battling against public health emergencies such as the COVID-19 pandemic. Moreover, in the post-pandemic era, it may raise awareness about protecting the environment and provide a sustainability-related knowledge base both in practice and academia by illustrating the challenges in the demolition phase of MCH projects.

In the future, countermeasures to these challenges of implementing MCH projects should be further explored. Additionally, the sustainability issue of MCHs needs to be investigated in further research.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Wenque Liu conducted the research under the supervision of Albert Chan; Amos Darko, and Fan Zhang analyzed the data; Wenque Liu wrote the paper; Man Wai Chan and Goodenough D. Oppong reviewed and improved the write-up of the paper; all authors had approved the final version.

Acknowledgement

This study was supported by the Hong Kong Polytechnic University and the Research Grants Council (RGC) of the Hong Kong SAR (RGC General Research Fund: 15205421). It may consist of a portion of the PhD research related to MCHs. The authors acknowledge that this study may present a similar background with papers that may have been or may not have been published but with different research focus, research scope, research methodology, and research results. The original paper was submitted and presented in ICCPM-2023 and was modified in its current form for publication in JOAMS.

References

Chen, S., *et al.* 2020. Fangcang shelter hospitals: A novel concept for responding to public health emergencies. ***The Lancet.*** 395(10232): 1305-1314.

Evans, *et al.* 2023. Healthcare-associated infections in veterans affairs acute-care and long-term healthcare facilities during the coronavirus disease 2019 (COVID-19) pandemic. ***Infection Control & Hospital Epidemiology***, 44(3): 420-426.

Fang, D., *et al.* 2020. Large-scale public venues as medical emergency sites in disasters: Lessons from COVID-19 and the use of Fangcang shelter hospitals in Wuhan, China. *BMJ Global Health*. 5(6): e002815, 2020.

(GCS), G.I.B.(2022). Macao optimising preparations for large-scale community treatment centre. Available from: https://www.gov.mo/en/news/265260/.

Hospital Authority. (2022). Personal care for the elderly in geriatric zone of AWE. Available from: https://www3.ha.org.hk/ehaslink/issue119/en/cover_story-5.html.

Li, H., *et al.* 2022. Mobile cabin hospital compulsory quarantine for mild patients can serve as an alternative treatment for COVID-19: the Chinese experience. ***American Journal of Translational Research***, 14(5): 3132, 2022.

National Health Commission. (2022). Transcript of the Press Conference of the State Council Information Office on April 29, 2022. Available from: http://www.nhc.gov.cn/xcs/s3574/202204/96a54177c4f84f418cd5c1e86fe1ca2c.shtml.

Shi, F., et al. 2022. Emergency preparedness and management of mobile cabin hospitals in China during the COVID-19 pandemic. ***Frontiers in Public Health.*** 9: 763723, 2022.

Sun, S., *et al.* 2021. COVID-19 and healthcare system in China: challenges and progression for a sustainable future. ***Global Health***, 17(1): 14,.

Tsai, H. W., *et al.* 2022. Hotel-based quarantine center as a rapid response to COVID-19 outbreak, New Taipei, Taiwan, May to July 2021. ***J Formos Med Assoc***. 121(7): 1351-1353, 2022.

Zhu, W., *et al.* 2020. Establishing and managing a temporary coronavirus disease 2019 specialty hospital in Wuhan, China. ***Anesthesiology***. 132(6): p. 1339-1345, 2020.

Zuo, Z. 2022. Design and construction of modular hospitals in our country. ***Chinese Hospital Architecture & Equipment.*** 23: in Chinese.

Zhou, Y., *et al.* 2022. Automatic generative design and optimization of hospital building layouts in consideration of public health emergency. ***Engineering, Construction and Architectural Management.***