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Real-World Global Evidence of Field Hospitals During the COVID-19 Pandemic

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ABSTRACT

Disease pandemics have spawned the extensive use of field hospitals for disease outbreaks in modern history. The objective of this paper is to examine the characteristics, roles, and challenges facing field hospitals in battling the COVID-19 pandemic and to offer some policy recommendations for improving the performance of field hospitals. Using online academic databases, a literature review of COVID-19 field hospitals was conducted for six regions from 2020 - 2021: the Western

Pacific, South East Asia, the Eastern Mediterranean, the Americas, Europe, and Africa. The findings reveal that field hospitals are rapidly established and they represent an effective low-cost method of treating COVID-19 patients. Most field hospitals have provided low acuity care and performed multi-purpose roles, including quarantine, referral, and recovery. Field hospitals have encountered various challenges which revealed weaknesses in existing health care systems. Field hospitals offer an efficacious means of dealing with pandemics. This study advances several recommendations to improve the performance of field hospitals. Future researchers could examine the key performance indicators of field hospitals, by using both qualitative and quantitative methods.

Keywords: *Field hospitals; COVID-19 Pandemic; health care; public health; patients*

INTRODUCTION

Field hospitals are temporary hospitals or mobile medical units, which are established during crises, such as natural disasters (tsunamis, earthquakes, floods, tornadoes, fires, and the like), wars, and disease outbreaks, where mortality rates are often high (WHO, 2013). Under these circumstances, existing hospitals are typically full of patients, and field hospitals can thus play an important role in relieving overloaded hospitals.

In general, field hospitals typically comprise tents, makeshift stations, mobile medical units, or even sophisticated medical units equipped with advanced medical services in converted existing facilities and buildings, like sports stadiums, army camps, car parks, and schools (Chen et al., 2020; Fang et al., 2020), There is extensive use of field hospitals in fighting the outbreaks of infectious disease, including the COVID-19 pandemic.

Despite the positive health care support that field hospitals can provide, various problems are reported in the deployment, operation, and management of field hospitals. These include delays in site operations, coordination and communication problems, adhering to professional standards of care, accountability, and exit strategies (Finestone et al., 2014;

Gerdin et al., 2013). Various studies have found that field hospital performance is typically dependent upon previous experience with health crises (Naor, 2019).

There is burgeoning literature on the characteristics and performance of conventional hospitals (Johnston et al., 2015; Brand et al., 2012). However, the characteristics and functions of field hospitals differ substantially from conventional hospitals. Moreover, field hospitals differ considerably in terms of size, type, and capabilities depending on the degree of a disaster (WHO, 2013). Thus, the characteristics, functions, and challenges of field hospital warrant empirical investigation.

This study seeks to contribute to the scholarly literature on field hospitals by examining their role in battling the global COVID-19 pandemic using real-world examples. Following the World Health Organisation (WHO)'s classification, we focus on six regions: (a) the Western Pacific, (b) South East Asia, (c) the Eastern Mediterranean, (d) the Americas, (e) Europe and (f) Africa, to examine the performance of field hospitals. From these real-world empirical studies, we distil some broad policy recommendations for improving the performance of field hospitals. In particular, the objectives of the paper are to (a) examine the characteristics of conventional hospitals and field hospitals for COVID-19, (b) examine the roles of conventional hospitals and field hospitals for COVID-19, (c) identify the problems and challenges faced by COVID-19 field hospitals, and (d) suggest policy recommendations for key performance indicators of field hospitals.

This paper is divided into five main parts. Part 2 provides a summary of the literature review of field hospitals. Part 3 outlines the methodologies employed, while Part 4 discusses the results and policy recommendations. Part 5 concludes the paper.

LITERATURE REVIEW

Field hospitals are unique and different in terms of type, venue, the number of beds, duration of completion, ownership, facilities, usage, and finance in the world (WHO, 2013; Johnston et al., 2015; Brand et al., 2012). Field

hospitals operate as one-stop, flexible, referral, community, and training (Chen et al., 2020; Noar, 2019; WHO, 2013). However, not all field hospitals can carry out all of these functions. Moreover, some field hospitals only offer limited services due to the limited human and financial resources. The roles of field hospitals are reportedly different across the countries.

Currently, there is no standard classification or type of field hospital. Nonetheless, we use the foreign medical teams (FMT), which are generally employed in the aftermath of a sudden onset disaster (SOD) to shed additional insight into the field hospital analysis (WHO, 2013). The FMT refers to the groups of health professionals and supporting staff outside their country of origin and aims to provide health care specifically to disaster-affected populations. There are three categories of FMT namely: (a) outpatient emergency care, (b) inpatient surgical emergency care, and (c) inpatient referral care (WHO, 2013). Each type of FMT has its level of care, size, capacity, and capabilities to deliver the minimum standards of medical services in a SOD.

In general, the challenges faced by field hospitals are dimensional and cover various aspects such as human resources, facilities, finance, operations, management, utilisation, and construction, as reported in the literature. These challenges were not only encountered by field hospitals but rather represent a prolonged struggle faced by entire health care systems across the globe over several decades. Various studies have reported the problems endured by field hospitals during the 1918-1920 Spanish flu epidemic, the 1956-1958 Asian flu outbreak, the 1968 Hong Kong flu, the 2002-2004 SARS flu, the 2009-2010 H1N1 swine flu, the 2014-2016 Ebola outbreak and the current 2020 COVID-19 pandemic (Chen et al., 2020; Elmahdawy et al., 2017; WHO, 2013; Hsieh et al., 2007).

In common with the problems experienced by field hospitals in fighting large-scale disease outbreaks, similar challenges have also been reported in field hospitals dealing with natural disasters. These include problems encountered during rescue missions in nine countries by the Israeli Defence Force Medical Corps (Noar, 2019), operational problems in a multidisciplinary 100-bed field hospital treating tsunami patients in Banda Aceh, Indonesia (Riddez et al., 2005), financial problems in establishing field hospitals in Istanbul (Komurcu et al., 2020), equipment and connectivity problems in Israeli field hospitals deployed to earthquake sites

in Adapazari, Turkey, Port au Prince, Haiti and Minamisanriku, Japan (Finestone et al., 2014), as well as problems with the standard of medical care of 44 field hospitals operated by foreign countries in the 2010 Haiti earthquake (Gerdin et al., 2013).

It is thus clear that the characteristics, roles, and challenges faced by COVID-19 field hospitals are far from unique and share much in common with field hospitals used for other purposes, like natural disaster mitigation and healthcare systems in general (WHO, 2020c; Naor et al., 2019). The current COVID-19 pandemic is new and may provide additional insight into the existing literature of field hospitals. The literature gap between COVID-19 field hospitals and field hospitals of other large-scale diseases and natural disasters can be discovered in three aspects namely: characteristics, functions, and challenges.

Based on the above health care literature and WHO classification of FMT (WHO, 2013), we examine the characteristics of field hospitals from eight elements namely: type, venue, number of beds, duration of completion, ownership, facilities, usage, and finance. Meanwhile, we compare the roles of field hospitals against hospitals from six aspects which include: one-stop, flexible, referral, community, social and training centres. In terms of the challenges of field hospitals, we examine the human resources, facilities, finance, operations management, utilization and construction of field hospitals.

METHODOLOGY

In this study, we focus exclusively on field hospitals that are set up temporarily to treat COVID-19 patients. We conducted a thorough search by using keyword searches, such as ‘field hospitals’, ‘temporary hospitals’, ‘makeshift hospitals’, ‘tent hospitals’, ‘Fangcang shelter hospitals’ and ‘mobile medical units’ in different online academic databases. Following WHO (2013) and Chen et al. (2022), we examine the characteristics, functions and challenges of field hospitals worldwide in fighting the COVID-19 pandemic. We use general hospitals to shed additional insight into the analysis of the performance of field hospitals (Johnston et al., 2015; Brand et al., 2012). A general hospital is not the main focus of this paper and rather aids as a guideline to examine the performance of field hospitals.

We select field hospitals which were set up arising of the COVID-19 pandemic and from countries that have a high incidence of COVID-19 cases.

These databases consisted of Google Scholar, Ingenta, Science Direct, Web of Knowledge, Springer Link, Social Science Citation Index, Scopus, Emerald, Elsevier, PubMed, Ovid, WHO, and ProQuest. In this study, we restricted our analysis to journal articles and official governmental reports. We concentrated on studies dealing with the key characteristics, functions, and challenges faced by field hospitals in the COVID-19 pandemic. Social media coverage of the role of field hospitals in the COVID-19 pandemic was excluded from the study. In addition, we also excluded the hospital and other medical centres from the analysis. Although the medical standard of each country is different due to the variation in the endowment of resources, we seek to discover the common characteristics, functions, and challenges of field hospitals shared by these countries.

While field hospitals are used in dealing with COVID-19 cases worldwide, this study focuses on countries across six regions that have a high COVID-19 incidence to shed light on the performance of field hospitals. Based on the above criteria, our literature search yielded a total of 84 published articles, of which only 36 apply to this study. The selected studies were published from 2020 to 2021.

Sources and Regions

We examined six regions: (a) the Western Pacific, (b) South East Asia, (c) the Eastern Mediterranean, (d) the Americas, (e) Europe, and (f) Africa following the World Health Organisation (WHO)'s classification. Based on a search of field hospitals in these six regions, 33 countries reported the deployment of field hospitals to fight the COVID-19 pandemic. We only chose one largest field hospital from the selected countries to discover the common characteristics of the field hospital. Although the one-country one-field hospital selection method had its limitation, the selected number of field hospitals are adequate to represent the meaningful analysis of field hospitals. The list of field hospitals for six regions is summarised in Tables 1, 2, 3, 4, 5 and 6.

Table 1
List of selected field hospitals in South East Asia, 2020-2021

No	Region/ Country	Number of beds	Type/ Locations	Remarks	Authors/ Sources
	South East Asia				
1	India	10000	Sardar Patel COVID Care Centre, Delhi	Mega field hospital	Bharati et al., 2020
2	Thailand	308	Dormitory building, Klong Luang district	First field hospital in Thailand	Chalernpalanupap, 2020
3	Nepal	73725	School, campuses, hostels, hotels and other accommodating facilities, seven districts	Limited facilities and medical equipment	Dhimal et al., 2020
4	Sri Lanka	40	Building complex, Iranawila	Army forces completed the project within two weeks	Jayawardane, 2021
5	Bangladesh	2000	Bashundhara Convention Centre/ Dhaka	Built by Bashundhara group, country's leading private organization. 71 intensive care units (ICUs)	Islam et al., 2020
6	Indonesia	30	Makeshift ICU, Bekasi City Hospital	Surge of patients and demand for medical oxygen	WHO, 2021b

Source: Compiled by authors

Table 2
List of selected field hospitals in Europe, 2020-2021

No	Region/ Country	Number of beds	Type/ Locations	Remarks	Authors/ Sources
	Europe				
1	France	30	Field military intensive care hospital, Mulhouse	Treatment of critically ill patients	Danguy et al., 2020
2	Italy	90	Concert hall, Turin	Treatment of mild and moderate patients	Sacchetto, et al., 2020
3	Spain	5500	IFEMA Trade Fair and Exhibition Centre, Madrid	Completed in 100 hours	Valdenebro et al., 2021
4	Turkey	1000	Atatürk Airport grounds, Sancaktepe	Completed within 45 days	Simsek, 2020
5	Portugal	320	Concert hall, Porto	Provision of basic health care	Araujo et al., 2020
6	UK	4000	ExCel, East London	Mega field hospital	Bushell et al., 2020

Source: Compiled by authors

Table 3
List of selected field hospitals in America, 2020-2021

No	Region/ Country	Number of beds	Type/ Locations	Remarks	Authors/ Sources
	America				
1	US	252	Baltimore Convention Center Field Hospital, Baltimore	Longest-running US COVID-19 field hospital and cared for 543 patients since opening	Chaudhary, 2021
2	US	1000	Boston Convention and Exhibition Center, Boston	Deployed within 2 weeks and provide low-acuity care	Levy et al., 2020
3	US	500	Michigan Medicine Field Hospital, The University of Michigan	Provide low-acuity care	Bell et al., 2021
4	Brazil	6300	80 field hospitals, Brazil	Provide low-acuity care	Noronha et al., 2020
5	Peru	3000	Villa Pana-mericana, Lima	Deployment of military forces in fighting the pandemic	Ellis, 2020
6	Argentina	76	12 modular field hospitals, Buenos Aires suburbs	Treatment and advanced equipment in ICUs	Haldane et al., 2021
7	Mexico	12	Makeshift hospital, Matamoros	Health care treatment for hundreds of asylum-seekers	Reynolds et al., 2021

Source: Compiled by authors

Table 4
List of selected field hospitals in Eastern Mediterranean, 2020-2021

No	Region/ Country	Number of beds	Type/ Locations	Remarks	Authors/ Sources
	Eastern Mediterranean				
1	Iran	80	Revolutionary Guard Corps	the speedy spread of the coronavirus and lack of beds	Monfared et al., 2020
2	Pakistan	10000	Expo centre, Karachi	Established by the Pakistan army	Noreen et al., 2020
3	Occupied Palestinian territory	84	field hospital, Rafah Crossing	WHO supported the delivery of lab testing kits, personal protective equipment and goggles. 6 ICUs	WHO, 2020
4	Morocco	700	Near Morocco's International Fair of Casablanca	Completion of field hospital within 2 weeks	Oualla et al., 2020
5	United Arab Emirates	3000	Dubai	800 intensive care units	Hassan et al., 2021

Source: Compiled by authors

Table 5
List of selected field hospitals in Africa, 2020-2021

No	Region/ Country	Number of beds	Type/ Locations	Remarks	Authors/ Sources
	Africa				
1	South Africa	1000	Nasrec Expo Centre, Johannesburg	Low acuity care	Harris, 2021
2	Nigeria	674	Ten isolation and treatment centers, Lagos, southwest Nigeria	Treatment for mild and moderate COVID-19 cases	Osibogun et al., 2021
3	Ghana	68	Accra facility	Supported by WHO, 12 ICUs, and medical evacuation services	UN, 2020
4	Burkina Faso	30	Multi-purpose permanent structure, Dori	Supported by WHO	WHO, 2020
5	Chad	78	3 existing facilities	Supported by WHO	WHO, 2020
6	Morocco	700	Casablanca Office of fairs and exhibitions (OFEC)	Completed within 2 weeks	Oualla et al., 2020

Source: Compiled by authors

Table 6
List of selected field hospitals in Western Pacific, 2020-2021

No	Region/ Country	Number of beds	Type/ Locations	Remarks	Authors/Sources
	Western Pacific				
1	China	16000	16 Fangcang shelter hospitals, Wuhan	Treatment of patients with no or mild symptoms	Chen et al., 2020

Table 6 Continued

2	China	2600	Two newly built temporary hospitals, Wuhan	In accordance with pandemic prevention and control standards	Fang et al., 2020
3	Korea	500	Community Treatment Centers, Yongin	Provision of low-acuity care and advanced equipment for ICTs	Jung et al., 2020
4	Korea	3818	16 dormitories of vocational training centres, Daegu and Gyungbuk	Provision of low acuity care	Oh et al., 2020
5	Malaysia	604	Malaysia Agro Exposition Park, Serdang	Completed within 3 days. Provides quarantine and treatment for low-risk patients	Shah et al., 2020
6	Singapore	10,000	Resorts & convention centres and makeshift facility at a shipping terminal	Provision of low-acuity care	Lee and Ong, 2020
7	Laos	200	KM27 isolation facility, Houay Hong stadium and LaneXang stadium	mild and asymptomatic cases	WHO, 2021b

Source: Compiled by authors

RESULTS AND DISCUSSIONS

Characteristics of Field Hospitals for COVID-19

Based on the health care literature and list of selected field hospitals as above, we identified several common traits in general hospitals and field hospitals in dealing with COVID-19: type, venue, number of beds, duration of completion, ownership, facilities, usage and finance (WHO, 2013; Johnston et al., 2015; Brand et al., 2012). We only focus on the field hospitals which were assembled in fighting the COVID-19 pandemic, especially in the countries that had a high incidence of COVID-19 cases. The characteristics of general hospitals and field hospitals are summarised in Table 7, in line with the first objective of this paper.

Table 7
Key characteristics of general hospitals and field hospitals for COVID-19

No	Items	General Hospital*	Field Hospital*
1	Type	Planned and permanent	Sudden, ad-hoc, and temporary
2	Venue	Cities	Core areas: Sports stadiums, exhibition centres, university, and hospital buildings, gymnasiums, supermarket buildings, airports, railway carriages, mobile tents, manufacturing plants, and other large buildings
3	Number of beds	Several to hundreds	Several to thousands
4	Duration of construction	Several years, high-cost and large scale	Days to several months, low cost and massive scale
5	Ownership	Government	Government and partnership
6	Facilities	Complete	Range from basic to advanced equipment, depending on financial capacity
7	Usage	Medical care to in-patients and out-patients; normal to full capacity	Medical care to COVID-19 patients; scaled back, partially used, or remains unopened
8	Finance	High cost, depending on financial capacity	Range of costs, depending on the type and financial capacity

In general, there are three common methods of constructing field hospitals: converting existing facilities, building from scratch, and deploying mobile tent facilities. As we can see from Table 1 to Table 6, the first generic approach consists of field hospitals that are erected from the existing facilities. These facilities include *inter alia* sports stadiums, exhibition centres, universities, hospital buildings, gymnasiums, supermarket buildings, airports, railway carriages, and manufacturing plants. Some notable large-scale converted facilities include the Excel exhibition centre in London (Bushell et al., 2020), the Karachi Expo Centre in Pakistan (Noreen et al., 2020), the IFEMA exhibition complex in Madrid, Spain (Valdenebro et al., 2020) the Sardar Petel Covid Care Centre in Delhi, India (Bharati, et al., 2020) and the Wuhan Fangcang shelter hospitals in China (Chen et al., 2020).

The second generic approach consists of 'built-from-scratch' field hospitals on open blocks of land or playing fields. For instance, China built two largescale field hospitals - the Huoshenshan Hospital and the Leishenshan Hospital - by using prefabricated construction methods with 5G communications (Fang et al., 2020).

Finally, the third approach concentrates on tents and makeshift hospitals. For instance, a makeshift hospital was built for hundreds of asylum-seekers in Matamoros in Mexico (Reynolds et al., 2021). Similarly, the French government opened a 30-bed field military intensive care hospital in Eastern France (Danguy et al., 2020).

The size of field hospitals and the range of facilities available at field hospitals differs between countries, with field hospitals typically better equipped in advanced countries than in developing countries. The size of field hospitals extends from a few beds in a tent to thousands of beds in large centres. Some reported mega field hospitals with thousands of beds exist in Bangladesh, Brazil, China, India, Iran, Italy, Pakistan, Spain, the UK, and the US.

Facilities range from basic medical care to advanced intensive care units. For instance, field hospitals in South Africa, Nigeria, Ghana, Burkina Faso, Chad, and Morocco have been constrained by limited human, technical and financial resources (Harris, 2021; Osibogun et al., 2021; UN, 2020; WHO, 2020a) despite being deployed with the support from the WHO. By contrast, the Huoshenshan Hospital in China exceeds 60,000

m^2 and consists of 1,000 beds, 30 intensive care units (ICUs), medical equipment rooms, and quarantine wards. It provides medical care, emotional support, and social engagement to patients (Fang et al., 2020).

The time spent constructing field hospitals varies widely, ranging from a few days to several months, depending on the size of the hospital in question. Both the 1,000-bed Huoshenshan Hospital and the 1,500 bed Leishenshan Hospital were built in less than 14 days (Fang et al). Similarly, the 5,000 bed IFEMA Trade Fair and Exhibition Centre in Madrid, Spain, was established within 100 hours (Valdenebro et al., 2021). In Malaysia, the Agro Exposition Park - which can accommodate 604 patients - was established within 3 days (Shah et al., 2020). In Sri Lanka, a 40-bed makeshift hospital was completed within 14 days in an existing building complex (Jayawardane, 2021). In the UK, most field hospitals were completed in a timespan ranging from a few weeks to less than two months (Bushell et al., 2020).

Various stakeholders are typically involved in building field hospitals, including national governments, state governments, local governments, private firms, international humanitarian organisations, domestic NGOs, and volunteers. For instance, in Latin America governments and military forces built field hospitals in a number of countries fighting the COVID-19 pandemic. These countries include Argentina, Barbados, Chile, Columbia, Ecuador, El Salvador, Guatemala, Mexico, Paraguay, and Peru (Ellis, 2020). In the US, the Army Corps of Engineers engaged private contractors to build emergency field hospitals around the country at a cost exceeding $660 million (Chaudhary, 2021). In Malaysia, the Health Ministry and other government agencies completed a makeshift field hospital at exhibition halls in the Malaysia Agro Exposition Park (Shah et al., 2020). In Britain, a 4,000-bed field hospital at the Excel exhibition centre was built with the assistance of soldiers from the Royal Anglian Regiment and the Royal Gurkha Rifles, working long shifts alongside NHS staff and contractors (Bushell et al., 2020).

Field hospitals typically receive certain types of patients, due to their limited human and capital resources. Most field hospitals provide some basic medical care for patients with mild symptoms, while some are equipped with intensive care units and professional medical teams. Most commonly, severe COVID-19 cases receive critical care at large

public hospitals. In Singapore, the Community Isolation Facility at D'Resort NTUC in Pasir Ris limits medical care to mild symptom cases (Lee & Ong, 2020). Other countries that provide medical care to mild symptom cases in field hospitals include Egypt, Malaysia, Saudi Arabia, and Thailand. In Britain, the Nightingale Education Centre was established to provide professional training to over 2,500 people from multiple healthcare and non-healthcare professions at the NHS Nightingale Hospital London to assist in fighting the COVID-19 pandemic (Bushell et al., 2020).

Funding for field hospitals typically derives from government agencies as well as donations from the private sector and international humanitarian organizations. It should be noted that information on the costs associated with field hospitals is not readily available. In the US, the federal government spent more than $660 million to establish field hospitals at various locations across the country (Chaudhary, 2021). Depending on the financial capacity of each country, developed nations allocated billions of dollars to responding to the consequences of the COVID-19 pandemic in their public health care systems and economies (WHO, 2020c).

Many field hospitals have closed in stages as the number of COVID-19 patients has fallen. For instance, many field hospitals have been scaled back, only partially used, or even remained unopened in the UK and the US. In Spain, the largest field hospital (at the IFEMA convention centre) was closed on 1 May 2020 after having treated more than 4,000 patients with a 98% recovery rate in 41 days (Valdenebro et al., 2021). In China, all field hospitals were shut down after the decline in COVID-19 cases (Chen et al., 2020).

Role of Field Hospitals

Field hospitals have played a significant role given the rapid surge in COVID-19 patients. The various roles played by general hospitals and field hospitals in the current pandemic are summarised in Table 8, according to the second objective of this paper. A general hospital is used as a comparison to distinguish the roles of field hospitals from the ones of the general hospital. In general, field hospitals operate as one-stop, flexible, referral, community, social, and training centres. Depending on their financial capacity, however, not all field hospitals carry out all of these

functions. Moreover, some field hospitals only offer limited services to mild COVID-19 patients as isolation and referral centres.

Table 8
Roles of general hospitals versus field hospitals in COVID-19

No	Items	General Hospital	Field Hospital
1	One-stop centre	Medical treatment for critically ill, severe, moderate, or mild patients, including COVID-19 patients	Isolation, treatment, and disease monitoring of patients with low and mild symptoms
2	Flexible centre	Flexible in admission and treatment capacity, depending on human resources and financial capacity	Flexible in admission and treatment capacity due to the large size of their public venues. Renovation, partition, temporary auxiliary tents, and installation of medical facilities increase the efficiency of field hospitals
3	Referral centre	Provide primary and secondary care	Identifying and transferring patients rapidly to general hospitals
4	Community centre	Limited role as a community centre. General hospitals provide universal medical care. Rural medical care services are also provided via mobile and modular hospitals	Relieving the burden on existing hospitals and lowering the spread of the virus within households and community transmission
5	Social centre	Basic essential living and social activities, such as food, recreation, and counselling activities	Limited essential living and social activities, such as food, recreation and counselling activities
6	Training centre	Recruitment and retraining of staff, training provision, research and development centres and teaching hospital	Not used as training centres. Existing doctors and nurses from general hospitals, retired medical staff, final year medical students, professionals and volunteers provide medical care and perform supportive roles

In general, as we can see from Table 8, field hospitals are one-stop centres for the isolation, treatment, and disease monitoring of COVID-19 patients with mild symptoms. For example, the Fangcang field hospitals in Wuhan, China (Fang et al., 2020), resorts and convention centres in Singapore (Lee and Ong, 2020), and exhibition centres in the US (Levy et al., 2020) all concentrated on the isolation and treatment of mild COVID-19 patients. In Dubai, 800 intensive care units were established in field hospitals (Hassan, 2021). The number of ICUs at field hospitals was limited especially in the early stages of the COVID-19 pandemic, with severe cases typically referred to general hospitals.

In poorer nations, field hospitals provide only basic treatment to COVID-19 patients, while low and mild COVID-19 patients are usually isolated at home. In Mexico, a makeshift hospital was built for asylum seekers in Matamoros to provide healthcare facilities to reduce community transmission to uninfected residents (Reynolds et al., 2021). In rich nations, field hospitals are better equipped. For instance, in France, the Field Intensive Care Unit of the French Military Health Service (EMRSSA) had 30 ICUs and provided treatment to critically ill COVID-19 patients with high standards of care (Danguy et al., 2020).

In Britain, the NHS Nightingale Hospital London education centre was established to provide professional training to over 2,500 people from multiple healthcare and non-healthcare professions to work at the Excel Exhibition Centre in London (Bushell et al., 2020). In China, field hospitals performed five essential functions which included isolation, triage, basic medical care, frequent monitoring and rapid referral, as well as social engagement (Chen et al., 2020).

Challenges faced by Field Hospitals

Various challenges have been reported in both developed and developing countries, especially in poorer countries with weaker medical systems (WHO, 2020a; WHO, 2020c). These challenges include problems in human resources, facilities, finance, operations management, utilization and construction of field hospitals. The most common challenges reported in empirical studies are summarised in Table 9, in line with the third objective of this paper.

Most field hospitals in developing countries in the regions of South-east Asia, Africa, and the Eastern Mediterranean reported various challenges amidst the rapid surge of the pandemic. These countries faced various challenges in the operation and management of field hospitals. For instance, field hospitals and quarantine centres in India, Iran and Nepal encountered various challenges including limited human, equipment and financial resources (Bharati et al., 2020; Dhimal et al., 2020; Monfared et al., 2020). In addition to the high costs of fighting the COVID-19 pandemic, many countries have been afflicted by economic crises due to lockdowns and constraints on movement (WHO, 2020c).

Table 9
Challenges of field hospitals in the COVID-19 pandemic

No	Items	Problems/Challenges
1	Human resources	Shortages of professional and non-professional medical staff, re-training constraints and heavily stressed medical staff
2	Facilities	Inadequate facilities, ventilation problems and equipment shortages, poor ICUs, lack of facilities for sanitation and hygiene, weak medical care and social support, lack of nutritious food, shortages of beds and ICUs, shortages of emergency supplies, limited on-site pharmacy services, shortages of personal protective equipment (PPE), and wastage/shortages of medicine
3	Finance	Budget constraints, the financial burden on governments, and inadequate management of finance matters
4	Operation	Crowded, limited medical operations, interruptions, lower acuity care, heavy workloads, sterilization and infection risks, lengthy safety processes, and inadequate patient follow-up
5	Management	Bureaucratic procedures, managing and coordinating medical supplies, co-ordination and communication barriers across different levels of government, on-site management, clarity of responsibilities of various stakeholders, recruitment and re-training of staff, waste disposal, changing policies and procedures
6	Utilization	Generally, fully utilised, but some hospitals were scaled back, partially used, or remained unopened as field hospitals due to changes in the number of COVID-19 cases
7	Construction	Conversion problems in large-scale public venues to field hospitals, including power supply, architectural layout and partition, remodelling of ventilation and air conditioning, sewage, water supply, and drainage, fire safety, ICTs, and in the dismantling and closure of field hospitals

Due to limited resources and ICUs, most field hospitals worldwide have only provided low acuity care to COVID-19 patients. However, the pattern of care is mixed. For example, military field hospitals in Eastern France treated critically ill COVID-19 patients (Danguy et al., 2020), whereas Italian field hospitals provided treatment to mild and moderate COVID-19 patients only (Sacchetto et al., 2020). In Portugal, basic health care infrastructure in field hospitals provided treatment for mildly symptomatic and asymptomatic COVID-19 patients. The cabin hospitals in Wuhan, China (Yao et al., 2020), Malaysia's Agro Exposition Park (Shah et al., 2020), the makeshift isolation centre in Bekasi, Indonesia (WHO, 2021a), and Community Treatment Centres (CTCs) in Korea (Jung et al., 2020) limited medical services to the quarantine and treatment of mild COVID-19 patients.

We suggest five major policies to improve the performance of field hospitals, in line with the fourth objective of this paper. Firstly, the need for COVID-19 field hospitals arose from weaknesses in the public health systems of many countries (WHO, 2020c). This suggests an urgent need to improve existing public hospitals. The improvement of the public health system is important to ensure that welfare and access to medical services by the public are protected. Secondly, during the COVID-19 pandemic, the owners of many of the facilities used for field hospitals, like exhibition centres, stadiums, and parks, were denied income due to the closure of their businesses. Renting these facilities to governments as field hospitals thus assisted in keeping these businesses afloat and ensuring continuity of tax collection by the government. Thirdly, many field hospitals were left empty, scaled back, or partially used, given the containment of the pandemic (Fang et al., 2020; WHO 2020a; WHO, 2020c). The resultant excess medical equipment could be donated to poor countries with weak health systems to promote universal healthcare. Fourthly, in many countries, modular, mobile, or makeshift field hospitals could be relocated to rural areas as temporary primary health care clinics. Moreover, governments could provide financial and technical assistance to field hospitals to adopt remote forms of service delivery suited to rural areas. Finally, the digitalisation of medical services represents a promising way forward. During the COVID-19 pandemic, online sources have played a crucial role in enabling the public to seek advice on medical care and connect with local information networks. Future public funding could thus focus on the further digitalisation of medical

treatment and medical services to improve public health, especially in rural areas and developing countries.

CONCLUSION

In conclusion, field hospitals have been established worldwide to fight the COVID-19 pandemic. In this paper, we have identified eight common characteristics, six common functional roles, and seven common problems faced by field hospitals. Five major policy recommendations were suggested to improve the management and operation of field hospitals. Most field hospitals are used to treat mild symptoms of COVID-19 patients or operate as quarantine, referral, and recovery centres. Field hospitals are built or deployed largely due to the capacity constraints of existing healthcare systems.

Our findings contribute to the literature on the performance of field hospitals in health care systems. In particular, the characteristics, roles, and problems of field hospitals dealing with COVID-19 - as demonstrated in Table 7, Table 8, and Table 9 - could be used as a guide to developing common key performance indicators for field hospitals. More specifically, the key characteristics of field hospitals could serve as input indicators, their functional roles as process indicators, and their problems as output and outcome indicators (Zaboli et al., 2018; Johnston et al., 2015).

Our study has several limitations, including examining a comparatively narrow range of countries and field hospitals. Future researchers could include more countries and field hospitals to provide additional information on field hospitals. In addition, future researchers could focus on the performance of field hospitals at the individual field hospital and country levels, by using both qualitative and quantitative methods. In essence, our findings suggest that - depending on the type and size of field hospitals - field hospitals represent an effective low-cost method of treating mildly symptomatic COVID-19 patients.

CONTRIBUTIONS OF AUTHORS

The authors confirm the equal contribution in each part of this work. All authors reviewed and approved the final version of this work.

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CONFLICT OF INTERESTS

All authors declare that they have no conflicts of interest.

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