

Mobile and Portable Hospitals

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Abstract

Access to medical care is one of the fundamental needs of every individual. Hospitals mostly provide services in buildings located in city centers. However, mobile hospitals are needed to provide health services in special situations such as wars and disasters or in regions that do not have access to hospitals. Today, mobile hospitals provide services on land, at sea and even in the air. In this study, mobile and portable hospitals used today and in the recent past are examined.

1. Introduction

The word “hospital” comes from the Latin word “hospes” which means “a welcomed stranger” or “a guest” (Skeat, 1893). The related Latin word “hospitium” comes from the same root and means “hospitality” which describes the relation between guest and shelter supplier. Early usage of the word “hospital” was used to signify a place to house and maintain the needy people. By time this word diverged into two branches, first one is hostel and the other one is hospital as we understand today.

The modern meaning of the word “hospital” describes a healthcare institution which provides patient treatment with healthcare staff by using specialized health science and medical equipment (WHO, 2023). The general hospitals usually have an emergency room, services that specialize in various fields and intensive care units. The majority of hospitals are fixed-site hospitals. But in special cases such as wars, disasters and epidemics or in hard-to-reach regions mobile or portable hospitals are needed (Khanna & Narula, 2016).

Mobile and portable hospitals are equipped enough to perform a surgical operation and are practical enough to be quickly installed in a desired area.

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First portable hospitals were military tents looking after injured soldiers at wars. We see many examples of these kind of military hospitals since ancient civilizations. By the development in medical sciences and transportation technologies the mobile and portable hospitals also developed. Today we have various kinds of mobile and portable hospitals at ground, sea and air.

This study focuses on the mobile and portable hospitals. In the study initially, a brief history of portable and mobile hospitals has been narrated. Then types and structure of portable and mobile hospitals have been discussed. And finally, some recent disasters and function of the portable and mobile hospitals in that urgent situations have been examined.

2. On The Land

2.1. Field Hospitals

Treatment of injured soldiers during the war emerged by a natural need. Besides being a wounded human needing help, the injured soldiers affect the mood of the whole army. In the front lines injured ones slows down the health soldiers and by inevitable pain sounds they put the healthy ones in fear also. Thus, medical evacuation is a crucial need not only for the injured soldier but also for the whole army. But transporting the injured soldiers to rear general hospitals usually increase the mortality risk or it is not possible or too costly in many cases. For this reason, we see the military field hospitals are placed near the front lines and continuously serving.

The field hospitals are in use from ancient times to modern times. The field hospitals usually consist of portable tents housing the medical crew and equipment. By the World War I and World War II we see the development of the MASH (mobile army surgical hospital) units in US army (King & Jatoi, 2005). The first MASH units were including only a single division formed for emergent surgical operations. By time the divisions of the MASH units are increased and they transformed into all-purpose hospital with 200-300 bed capacity (Woodard, 2003).

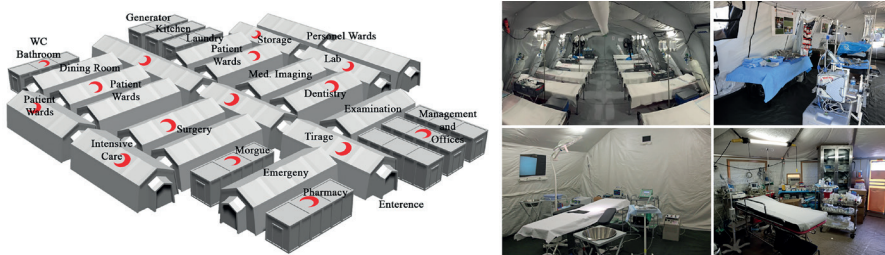


Figure 1. All-purpose Field Hospital. (LiveScience, 2020)

Plan of the field hospital changes depending on the size and purpose. A modern all-purpose field hospital includes tirage room, emergency unit, medical imaging unit, surgical operation rooms, pharmacy and laboratory, intensive care unit, dental and eye units, kitchen, supply and storage units as shown in Fig-1.

In general, wide portable tents are used for living areas at the field hospitals. These tents may have their pre-installed air ventilations and electric cables. Besides tents metal containers are also used at the field hospitals. The generators, water treatment and other supply equipment are usually placed in to the containers. These containers may have their own wheels or they can be carried trucks and placed with mobile cranes.

The field hospitals are also in service during disasters, epidemics and humanitarian crisis. We see many examples of field hospitals, operated by international aid organizations and armies of several nations, at major earthquakes such as İzmit (1999), Kashmir (2005), Haiti (2010) and more (Talbot et al., 2012). In Syrian refugee crisis at 2015 Turkey set up many field hospitals and shelters at the Syrian border to help refugees (Köseoğlu & Çevikel, 2014). Most of these field shelters are still in use. During Covid-19 China and some other countries deployed their mobile field hospitals to slow down the spread of the virus and quarantined patients (Chen et al., 2020).

2.2. Mobile Medical Units

The multi division field hospitals require flat wide regions for set-up. And they usually need trucks for transportation and mobile cranes for setup. For small or single division needs motorized mobile medical units can be used. These units usually consist of a trailer pulled by a truck as shown in Fig-2. The trailer can be expandable to increase the interior area. When compared to field hospitals these units are more agile thanks for having their motorization.



Figure 2. Mobile Medical Unit (Matthews, 2023).

Depending on the medical application various equipment can be installed to the trailer. The services provided by mobile medical units may include public health, dentistry, ophthalmic surgery, general surgery, first aid and emergency, blood donation, disease testing and even medical imaging (Marques et al., 2011; Morano et al., 2014; Toppenberg et al., 2020). These mobile medical units can be in a routine for visiting people having low access (Khanna & Narula, 2016) or they can be put in charge in emergency and disaster situations (Taylor et al., 2007). In emergency and disaster situations with their agility and mobility these units usually give first response until bigger facilities being constructed.

3. At The Sea

It is predicted that dedicated ships to treat wounded soldiers are in use since ancient civilizations. When their names are examined, it is thought that the Roman ship Aesculapius and Athenian ship “Therapia” was one of ancient hospital ships. The earliest recorded British hospital ship was a vessel named as Goodwill, which is accompanied to Royal Navy (Sutherland Shaw, 1936). We see the invention and usage of the hospital ships were for mainly military purposes. But today we also have hospital ships owned by civilian organizations.

3.1. Military Hospital Ships

After 1700s it is known that almost every navy have used hospital ships at their fleets. These ships were carrying a special crew of health carers and medicines of their time and they were in use to house wounded and sick soldiers during naval wars or even in land wars. The ships of British Royal Navy HMS Grampus, HMS Dreadnought, HMS Caledonia and HMS Hamadryad can be given as examples for 1800s (Carradice, 2013). During World War I HMHS Aquitania, HMHS Mauretania, HMHS Britannic and HMHS Llandoverly Castle served for British Royal Navy (McCutcheon, 2015). Here the HMHS abbreviation means “Her Majesty’s Hospital Ship”. In Fig-3 pictures of HMHS Aquitania, HMHS Mauretania and HMHS Britannic is given.

The international laws on the hospital ships were first covered by the Hague Convention X of 1907 (Best, 1999). Depending on the convention the hospital ships were painting with red cross over white background to indicate that they are not armed. However even though the international laws, the HMHS Llandoverly Castle and some other ships were sunk by German submarines (Hunt, 1920; William Jr, 2012). Similar to British navy, every navy held its own hospital ships during the war. From these SS

Maheno and SS Marama serviced for New Zealand, SS Mexique and SS Flandre for France, HS Vpered and SS Portugal for Russia, HS Marechiaro for Italy and SS Ophelia and HS Tabora for Germany. These ships were equipped with medical devices and healthcare crew, they housed and treated thousands of injured during their use (Kludas, 1985).

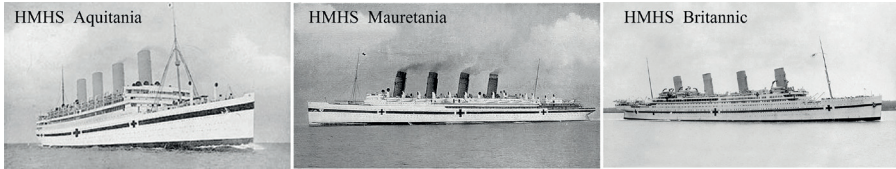


Figure 3. Hospital Ships of WWI (DeviantArt, 2019, 2022).

We see that before World War II British hospital ships were in majority. However, after World War II, hospital ships belonging to the US Navy came to the fore (Goodman, 2016). Today many of the navies includes modern hospital ships in their fleet equipped with emergency, surgery and intensive care units and their health personal.

3.2. Civilian Hospital Ships

3.2.1. Mercy Ships

It is estimated that 5 billion people around the world have no access to an affordable and trustable surgery (Meara et al., 2015). The Mercy Ships is a non-governmental organization aiming to supply healthcare supply and surgical treatment to poor countries and they are in service since 1978.

The first Mercy Ship was 1953 built Italian passenger liner “Anastasis”. Anastasis acquired by the organization in 1978 and used until 2007. The Anastasis was equipped with three fully-equipped operating rooms, a hospital ward, a dental clinic, a laboratory and an X-ray unit. In its 30-year service time Anastasis performed over 1 million healthcare operations. The second Mercy Ship was “Island Mercy”. It was a Newfoundland coastal ferry donated to the organization in 1983 and serviced until 2001. The Island Mercy supplied eye and dental services over 130 thousand people from Africa, South America and South Pacific. The third Mercy Ship was “Caribbean Mercy”. It is acquired from a Norwegian ferry company in 1994 and serviced until 2007. The Caribbean Mercy and his crew contributed more than 20% of Mercy Ships’ total missions in its 13-year service time. The crew was able to perform dental and eye surgeries on the ship. Besides

the surgeries the ship was also a medical school for local health-care workers (Mercy, 2023).

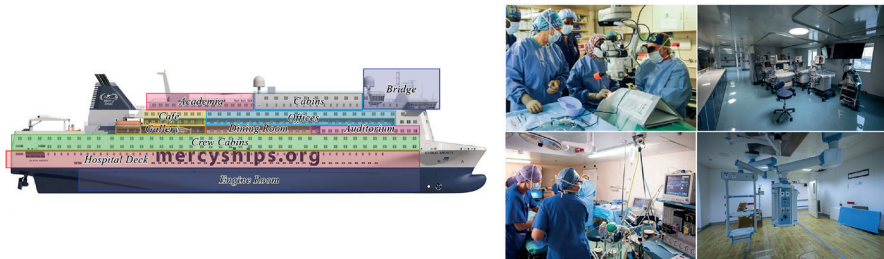


Figure 4. Global Mercy Hospital Ship (Mercy, 2023).

Today, Mercy Ships operates with two ships named Global Mercy and Africa Mercy. The Global Mercy is known to be the largest purpose-built civilian hospital ship. It is constructed at the Tianjin Xingang Shipyard of China and it is delivered to the organization in 2021. The Global Mercy shown in Fig-4 holds 7 intensive care units, 6 surgical operating rooms, 199 bed capacity and dental and eye services. The second active ship of the organization is the 152 m long Africa Mercy. After the Global Mercy, the Africa Mercy is the second largest hospital ship holding 5 surgical operating rooms, intensive care units and 82 bed capacity (Mercy, 2023).

The Global Mercy and Africa Mercy have performed out a wide range of surgeries like maxillofacial and plastic reconstructive surgery, tumour removal, cleft lip repair, palate repair, orthopedic operations, cataract removal, obstetric fistula repair, thyroid surgery and debilitating burn contractures (Cheng et al., 2022; Cheng et al., 2012; M’Pele, 2021). In addition to these services, they also provide basic medicine, dentistry, ophthalmology and other trainings as on-shore programs.

3.2.2. Esperanza del Mar and Juan de la Cosa

Esperanza del Mar and Juan de la Cosa are hospital ships under control of Spanish Ministry of Employment and Social Security. They hold intensive care units, surgical operating rooms and bed capacity of 10 and 15. These two ships serve for Spanish fishermen.

4. In The Air

We see first trials of the aeromedical operations occurred just after a few years of the invention of stable planes. The first of these trials was French Aerochir. By the time and developments in the aviation technology the use

of planes for healthcare purposes gained speed. Today there are dozens of military flying hospitals and even civilian hospital jets.

4.1. The Aerochir

The Aerochir is known for to be the first aircraft which carries a medical team and equipment to the war field. Aerochir was built on French Voisin-X airplane which was introduced at 1917 (Wikipedia, 2023). At Fig-5 a close-up photo and medical set-up near the plane is given. Two compartments under the wing were used for storage and transfer of the medical equipment of the time including an X-ray machine. The Voisin-X airplanes normally used to have two seats but in the available pictures of the Aerochir a crew of three is seen.



Figure 5. Aerochir (Airwar, 2022).

This crew was responsible for flying the plane, reaching to the war field and giving medical service at the field. For this a flat landing region and clean place for medical treatment was enough. The medical equipment of the Aerochir was portable. They used to set up at the field and, after the medical treatment, they removed to the storage compartments of the plane. It is known that Aerochir was in service between 1918 and 1920 in the French colonial wars (Lam, 2005).

4.2. C-9A Nightingale (1968-2005)

C-9A Nightingale is a modification of McDonnell Douglas DC-9 airplane to serve as aeromedical evacuation (Birtles, 2002). C-9A Nightingale is able to carry 40 patients unable to walk or 40 bedridden patients. The plane has an up opening wide door placed at the cabin and a hydraulic ramp to carry patients and medical equipment to the plane as shown in Fig-6 (AMCM, 2023). The interior of the plane is redesigned to contain patient beds, medical equipment, medical refrigerators, oxygen and vacuum supplies. Additionally, there were compartments for management, intensive care and quarantine. Depending on the needs the medical crew of the C-9A Nightingale was able

to give medical treatment during flight for urgent patients. More than ten C-9A Nightingale airplane were produced and they serviced from 1968 to 2005 for US air force and its allies (Drummer & Wilcoxson, 2001).



Figure 6. C-9A Nightingale (NaraArchive, 2023).

4.3. Boeing C-17 Globemaster

Previously Lockheed C-130 Hercules was in use as main cargo plane of US Airforce. In 1995 Boeing C-17 Globemaster started to take the mission of C-130s. The C-17 Globemaster has an enormous takeoff capacity of 74 tons and a large cargo deck with 27 m length by 5.5 m width by 3.76 m height (Taylor, 1996). C-17 Globemaster is in use in the air forces of United States, United Kingdom, Canada, Australia, England, India, United Arab Emirates, Qatar and Kuwait (Hoyle, 2017).

Besides cargo carrying these big airplanes are in use for medical evacuation of injured soldiers from the field. The wide cargo deck of the C-17 Globemaster makes it suitable for various uses and missions. During medical evacuation missions, thanks to its flexibility the cargo deck of C-17 can be rearranged depending on the status of the injured soldiers.

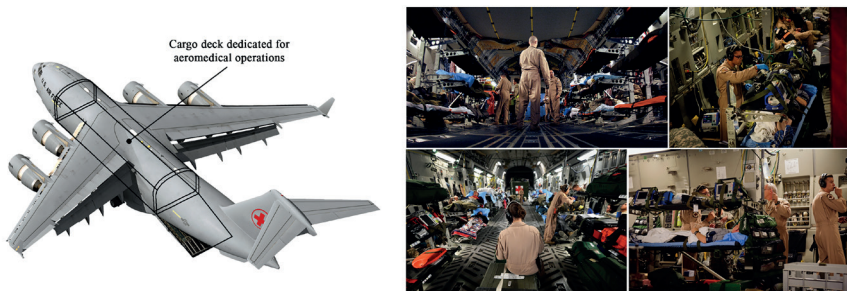


Figure 7. Aeromedical C-17 Globemaster (AFMS, 2019).

At Fig-7 illustration of C-17 Globemaster and photos of its medical deck is given. At its missions this plane can hold a fully equipped emergency unit or stacks bunk beds can be placed to carry bedridden patients (Upadhyay & Guru, 2016). It is known that C-17 Globemaster is used in many aeromedical evacuation missions around the world. But most of these missions were under control of US Airforce and they were for military purposes.

4.4. Orbis: The Flying Eye Hospital

Orbis project first envisioned by Dr. David Paton at 1960s. Dr. Paton was aware of the lack of eye care and ophthalmic teaching in developing nations. For people at developing countries, it was unreachable to have even an easy eye treatment. And these types of countries were too insufficient to graduate their doctors in enough numbers. The vision of Dr. Paton was to construct a charity organization to supply ophthalmic teaching and treatment for developing countries (Munsell & Frank, 2006).

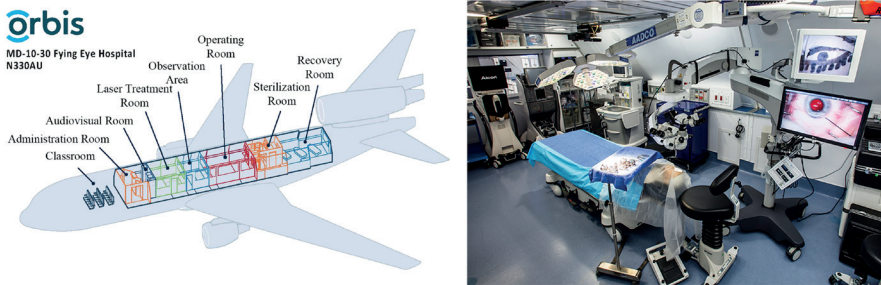


Figure 8. Orbis Flying Eye Hospital. (Orbis, 2023)

In 1980 United Airlines donated one McDonnell Douglas DC-8 airplane to the Orbis project. The plane was modified and equipped for ophthalmic teaching and treatment (Watts et al., 1998). In 1982 the Orbis plane flew to Panama for its first mission. Latterly FedEx donated a McDonnell Douglas DC-10 donated to the project. The old DC-8 airplane replaced with the DC-10. The interior design of the Orbis DC-10 is illustrated at Fig-8. Orbis holds latest medical equipment needed for eye-treatment and also audio-visual simulation systems for virtual training. Orbis have flew over 95 countries to give education and eye-treatment (Orbis, 2023).

5. Conclusion

In the study, mobile and portable hospitals serving on land, at sea and in the air were examined. When we look at the history of mobile and portable

hospitals, we see that they first emerged for the treatment of the wounded in wars. Today, mobile hospitals are used for both military and civilian purposes. The most common type of mobile hospital used on land is the field hospitals. On the other hand, motorized mobile health clinics are used for routine public health programs or to provide rapid support in emergency situations. Mobile hospitals used in maritime first appear as separate ships that support the war fleet. Besides navy medical ships, civilian hospital ships supported by charities provides health care support for poor countries. Mobile hospitals used in aviation became widespread later than the others and they are generally used for military evacuation operations. However, there are civilian initiatives to use airplanes to provide healthcare.

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