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Are Standard Surge Capacity Guidelines Feasible for all contexts? The Case of the Gaza Health System Struggling to Survive in Conditions of Siege and Armed Conflict

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Abstract

Background and Objectives: In emergencies and disasters, the expansion of a health service beyond its routine clinical care capacity can be defined as surge capacity. This study aims to provide a comprehensive description of the surge capacity (material, staff, structural, spatial and systems) of the health system in Gaza under siege and the concept of 'siege surge capacity.

Methods: In this study, a document review was conducted based on news and reports published on the institutional websites of OCHA Occupied Palestinian Territory and the World Health Organization between 7 October and 7 December 2023.

Results: Between 7 October and 07 December, 42 WHO and 138 OCHA news items or reports on Gaza were published. In particular, the study found that: (1) humanitarian supplies and personnel were prevented from entering and leaving Gaza; (2) limited medical evacuation from Gaza, acute fuel shortages and shortages of medicines and medical supplies affected health facilities and ambulances; (3) northern Gaza was evacuated at gunpoint; (4) lack of WaSH facilities in health facilities and shelters led to infectious diseases and outbreaks; and (5) lack of routine surveillance systems affected public health problems and surge capacity.

Conclusion: Our findings show that the health system in Gaza has collapsed. Furthermore, the concept of surge capacity, which promotes preparedness for emergencies and disasters, was found to be inadequate. Therefore, it is recommended that the concept of siege surge capacity should be studied in a multidimensional way in order to protect the surviving health system.

Keywords: Surge Capacity, Health System, Gaza, Conflict, Siege

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1. Introduction

Surge capacity, an essential aspect of disaster medicine, refers to a health service's ability to extend its capabilities beyond the usual scope to cater to increased demands in clinical care. It's a crucial component in disaster readiness and should be incorporated into the early stages of emergency planning. This concept underscores the need for prehospital and hospital emergency medical services to be adaptable and responsive in times of crises, ensuring that patient care can be maintained even under extraordinary circumstances.

Gaza's health system faces a critical challenge in surge

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↑*Question* *To provide a comprehensive description of the surge capacity of the health system in Gaza under siege.*

Findings *The study revealed challenges in Gaza: restricted humanitarian access, limited medical evacuation, forced northern Gaza evacuation, inadequate WaSH facilities, and surveillance system gaps affecting public health readiness.*

→*Meaning* *The study highlights Gaza's collapsed health system and inadequate surge capacity. Recommendations include studying siege surge capacity multidimensionally for health system protection.*

capacity preparedness, exacerbated by a protracted humanitarian crisis. The UNRWA's (United Nations Relief and Works Agency) updated oPt Flash Appeal in November 2023 highlights the unprecedented magnitude of this crisis, requiring an urgent response to meet the critical needs of approximately 1.6 million people in Gaza and around 150,000 in the West Bank (1, 2). The severe lack of crucial medical and trauma supplies, vital medications, fuel, and electricity is severely impacting the operational capabilities of all hospitals, including the responsiveness of ambulances. Health services are being significantly hampered, and medical equipment is becoming increasingly inoperative, which is adversely affecting both diagnostic and treatment capabilities. All these adverse conditions have also collapsed the surge capacity of an already fragile health system, making it impossible to provide the necessary medical care response to the forcible displaced people and the extraordinary patient and injury load in war conditions.

In the context of the Middle East, the escalation of conflict has led to increased targeting of healthcare, compromising the achievement of Sustainable Development Goals related to health and peace. The loss of medical neutrality, marked by non-interference with medical services in armed conflict, has profound consequences on health systems and local populations. Military strikes on health facilities and strategic interruptions of essential services like electricity and water drastically reduce healthcare delivery capabilities. The fear of violence leads to the exodus of healthcare professionals and reduced care-seeking behavior among the population. To address these challenges, strengthening compliance with international humanitarian law, improving data collection on conflict events, and investing in local health systems are essential (3).

In the shadow of prolonged conflict and economic blockade, the Gaza Strip's healthcare system faces unparalleled challenges. This research article delves into the critical issue of surge capacity preparedness within Gaza's healthcare infrastructure amid armed conflicts. The prolonged Israeli blockade, now spanning over 18 years, has not only constricted the economic vitality of Gaza but has also systematically eroded the foundational aspects of its healthcare system. This erosion manifests in restricted access to essential medical supplies, limitations on patient movement, and a depleted healthcare workforce, further exacerbated by recurrent military incursions.

1.1. Background

In October 2023, the escalation of hostilities led to substantial casualties and infrastructural damage in Gaza. More than 18,205 Palestinians have been killed in Gaza, including about 7,729 children and 5,153 women; In total, over 1,200 Israelis and foreign nationals have been killed in Israel and 60% of Gaza's housing stock was destroyed or damaged, leading to the displacement of about 1.93 million people or 85% of the population (1). The West Bank, including East Jerusalem, also witnessed a significant deterioration in conditions, with large-scale Israeli military operations, increasing fatalities, injuries, and arrests, and intensified settler violence, causing additional displacement and restriction of access to basic services (4). 64% (46/72) Primary health care facilities and 50% (18/36) hospitals are not operational in Gaza. Average hospital occupancy rate is 126% (1).

Dr. Ben Thomson, at the press conference held by North America Medical Doctors on December 10, 2023, shared the following striking information (5):

[We are reaching the point of no return, where blatant disregard for international humanitarian law scars our collective consciousness. 283 health care workers in Gaza have been killed. The last two months has been the deadliest conflict in United Nations history, with 133 of their staff members killed. There have been 212 attacks on Gaza health care facilities since October 7th. This includes 24 different hospitals that have been bombed by Israel. Over a hundred ambulances that have been put out of service. Israel has arrested dozens of doctors. Their whereabouts remain unknown. The head of the main hospital, Shifa Hospital in Gaza City, Mohamed Abu Salmiah, has been under Israeli arrest since November 22nd. Many other senior doctors have continued to be held by the Israeli military for almost two weeks with no charges and no one knows their whereabouts. Al-Rantisi Pediatric Sub-Specialty Hospital, bombed. Al-Nasr Pediatric Hospital, bombed. Gaza's Only Eye Hospital, bombed. Gaza's Only Mental Health Hospital, bombed. Wafa Rehabilitation Hospital, bombed. The seniors facility immediately adjacent to Wafa Rehabilitation Hospital, bombed. Al-Jura Children's Hospital, targeted with prohibited white phosphorus, October 12th. Indonesian Hospital, the only hospital currently operating in the north, still trying to treat patients while being bombed. Shifa Hospital, bombed. The two medical schools in Gaza. Islamic University of Gaza, bombed. Al-Azhar University Medical School, bombed. Médecins Sans Frontières Ambulance Convoy, bombed. Red Cross Ambulance Convoys, bombed. Of 35 hospitals in Gaza as of this morning, 26 are non-functional, 9 remaining only partially functional, but they are operating at more than double their capacity with critical shortages of basic supplies and fuel. These facilities are also providing shelter to thousands of internally displaced people. Palestine Red Crescent Society yesterday announced that operations of their ambulances in northern Gaza has stopped. Due to depletion of fuel, hospital closures, it is now impossible to evacuate wounded people in the north. Instead, those patients are left to die. Massively overcrowded United Nations shelters have become havens to spread infectious diseases, including a hepatitis A outbreak, multiple meningitis outbreaks, lice, skin infections, and multiple diarrheal illness outbreaks. The United Nations Human Rights Office has declared on December 5th The pattern of attacks that target civilian infrastructure raises serious concerns about Israel's compliance with international humanitarian law and raises the risk of atrocity crimes. There have been immeasurable numbers of violations of special protection to civilians, children, and medical personnel, and widespread violations of international humanitarian law.]

The ongoing conflict has not only led to an immediate health crisis but has also amplified long-term challenges in healthcare delivery. Furthermore, the crisis in Gaza has had

a ripple effect in the West Bank, exacerbating vulnerabilities and healthcare demands, particularly among Palestine refugees facing movement restrictions, violence, and economic hardships (6).

The study aims to evaluate the current state of surge capacity preparedness in Gaza's healthcare system, a critical component for responding effectively to mass casualty incidents, which are tragically recurrent in the region. The adequacy of existing surge capacity guidelines is questioned, considering the unique socio-political and economic constraints of the Gaza Strip. The objective is to explore whether these guidelines are applicable and sufficient in the Gazan context or whether there is a pressing need to develop a new, context-specific framework.

This article, therefore, seeks to bridge the gap between generic surge capacity guidelines and the ground realities of a healthcare system operating under the strains of a protracted blockade and frequent armed conflicts. By comparing existing models and guidelines of healthcare surge capacity with the specific needs and limitations of the Gaza health system, this study endeavours to propose tailored strategies and recommendations. These strategies aim not only to enhance the resilience of Gaza's healthcare system in times of acute crisis but also to provide a model for other regions facing similar challenges worldwide.

2. Methods

2.1. Definition of terms

This study conducted a document review of organisational reports to determine the status of the Gaza health system in terms of surge capacity under the siege of Gaza. Preferred Reporting Items for PICOS and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines were used to strengthen the methodological underpinnings of the document review (7).

2.2. Information Source and Research Strategy

News and reports published on the websites of OCHA (Office for the Coordination of Humanitarian Affairs) Occupied Palestinian Territory and the World Health Organization were obtained between 7 October and 7 December 2023. In addition, publications from international news websites were consulted. The content of the reports was evaluated by researchers with expertise in disaster management, humanitarian aid, disaster medicine and public health.

In this study, a question was formulated to define the problem: What is the impact of the siege of Gaza on the surge capacity of hospitals? Within the framework of the defined question, the participants of the study are the hospitals (P), the factors affecting the implementation of surge capacity are the interventions (I), the analysis of these factors according to their characteristics constitutes the comparison (C), the findings obtained from the reports constitute the outcome (O), and the inclusion of all the studies constitutes the study design (S).

2.3. Qualifying criteria

2.3.1. Inclusion criteria

1. The report must deal with the siege of Gaza.
2. Must have a medical report.
3. It should include information on surge capacity.
4. Reports should be accessible.
5. The study had to be published in English.

2.3.2. Exclusion criteria

1. Literature that does not meet the inclusion criteria.

2.4. Study selection and data extraction

Reports were downloaded from the websites of the relevant institutions by entering the keyword 'Gaza, Occupied Palestinian Territory, Israel' in the search bar. The full texts of the reports were carefully and critically analysed by the authors.

As a guide for health systems, a survey tool was developed based on Chapter 5 "Surge capacity" of the World Health Organization (WHO) Hospital Emergency Response Checklist: An all-hazards tool for hospital administrators and emergency managers (8). The questionnaire contained thirteen key action items related to surge capacity, focusing on a) calculating baseline resources, b) estimating surge needs, and c) identifying gaps to be addressed. The reports were analysed to see if each item was applicable to Gaza hospitals in general, rather than to individual hospitals. Data on each item (staff, stuff, structure/space, systems) was extracted from the reports through content analysis using a form.

2.5. Quality Assessment and Risk of Bias

As the reports are produced by official institutions, the quality is considered to be high.

2.6. Data Synthesis and Analysis

Descriptive and content/thematic analyses were used to analyse the data. One author extracted the data from the included studies using a pre-developed form. The accuracy and completeness of the extracted data were checked by the other author.

2.7. Theoretical Framework of Surge Capacity of the Health System During Siege and Armed Conflict

The concept of "surge capacity" exists in the literature. However, this concept is inadequate for assessing health services under the pressure of embargo and armed conflict. For this reason, the process of the concept of surge capacity under siege and armed conflict has been studied:

- When a disaster occurs, national and international resources are expected to be mobilised to the disaster area quickly and in sufficient numbers. Staff affected by the disaster in the region are withdrawn to the safe area and new staff are deployed. Damaged or destroyed facilities are quickly replaced by field hospitals and space is expanded. As production continues in other parts of the country, the shortfall in supplies is expected to be made up quickly. The collapsed health system is being rebuilt with the help of external command systems, and recovery is being achieved quickly. This situation also applies to independent states at war. If you look at independent states in the world, almost all of them are in the neighbourhood of more than one country. This is an important factor in the delivery of humanitarian aid to the region through a second country in the

event of war. However, although Gaza has land borders with Egypt and sea borders with several other countries, it has been under siege by Israel for a long time and the embargo has turned it into a strip dependent on foreign aid with no production capacity. Such special situations require the discussion of a new concept in the literature, such as surge capacity under siege and armed conflict. In a normal war, the orange surge capacity volume in Figure 1 can be expected. However, under full siege, Gaza has (1) fewer places because its facilities have been hit, (2) fewer staff due to deaths, injuries, arrests, lack of salaries or staff fatigue, and the Palestinian National Health Capacity could not be mobilised due to lack of geographical integrity with the West Bank, (3) zero stocks due to lack of equipment and material aid, and (4) the health system has collapsed because the infrastructure and superstructure systems such as electricity, fuel and transport have been destroyed. Therefore, the surge capacity under siege and armed conflict is precisely the required capacity shown by the grey area in Figure 1. As the green area (staff, stuff, space and systems) is exhausted, the orange area expands into the grey area and the disaster surge capacity evolves into the concept of surge capacity under siege and armed conflict.

3. Results

Between 7 October and 7 December, 42 WHO and 138 OCHA news releases or reports were published in Gaza. Data from 13 news items were also used to provide more information in relation to the WHO guidelines. When the publications are analysed according to the WHO guidelines, 13 articles are assessed. These 13 items are generally related to the 4S concept. However, it can be seen that some of these items include all 4S (Table 1).

Staff. It is stated that health services and health workers are overstretched and their numbers are decreasing as they are exposed to more attacks under siege. In particular, attacks result in the injury and loss of life of health workers and the emigration of trained personnel. This means an increased workload and fewer staff in health facilities. To alleviate the burden, particularly in trauma and surgical care, efforts were noted to seek support from international medical teams (Table 1).

Stuff. Electricity has been cut off due to fuel shortages. This also means the closure of the internet and communications, the source of connection to the outside world. Hospitals and the community have run out of basic medical supplies, medicines, fuel, water purification systems, generators, food and water (Table 1).

Space: Medical facilities have been destroyed or demolished due to heavy bombardment, and medical space capacity has been reduced. As a result, patients are being treated on the floor due to reduced bed capacity. Morgues are full of bodies. Field hospitals and tents are being set up to increase capacity. In addition, hospitals have been filled with civilians who have nowhere to go under bombardment and are known as safe havens (Table 1).

Systems: The shelling of health facilities and ambulances, the disruption of the public health system and the problems of access to basic resources have led to the collapse of the health system. Forced evacuations of hospitals have further deteriorated the health system. Health services and medical equipment are increasingly out of order, affecting diagnostic and treatment capacity. As a result, each hospital has activated emergency protocols, affecting operations and access to health services. However, the damage to the Gaza Emergency Operations Centre and the emergency medical services has adversely affected coordination and communication. Nevertheless, it is important that medical evacuations and referrals are initiated both internally and externally (Table 1).

In Figure 1, the siege of Gaza is divided into two slices of the timeline: disaster surge capacity and full siege surge capacity. At the same time, as Gaza is under half siege during normal times, this period is taken as the 'disaster surge

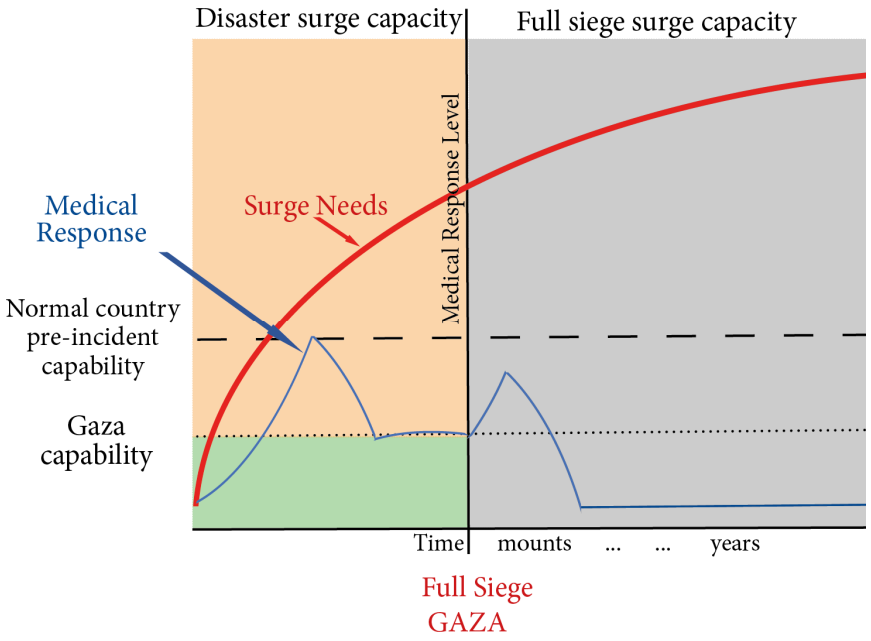

Figure 1. Disaster surge capacity and siege surge capacity

Table 1. Review of action items related to WHO's surge capacity under the concepts of "staff, stuff, structures/space and systems".

No	Recommended actions	Staff, Stuff, Structures/Space, Systems
1	Calculate maximal capacity required for patient admission and care based not only on total number of beds required but also on availability of human and essential resources and the adaptability of facility space for critical care.	Stuff: On 11 October, Gaza's only power station ran out of fuel and ceased operating, leaving hospitals reliant on back-up generators. Few areas now have any electricity supplies and communications are extremely challenging; internet access has been completely cut on three separate days. Hospitals are running out of essential medical supplies (6). Stuff, Structures/Space: Homes, schools, medical facilities, and other infrastructure have been damaged and destroyed… Israeli authorities have cut their water supply to Gaza, reducing an already scarce availability of potable water. And in accordance with the complete siege ordered by the Israeli Government on Gaza, access to electricity, food, and fuel have also been severed, inevitably worsening the already dire humanitarian situation. ... This hinders the ability of health facilities to function and treat those injured (9). Stuff, Structures/Space: Hospitals, overwhelmed with patients, are running out of medicine. Morgues are overflowing. Homes, schools, shelters, health centers and places of worship are under intense bombardment (10). Stuff: Gaza's health services, ... are being overwhelmed by the extreme challenge of meeting the healthcare needs of the rising number of wounded patients, all the while facing significant shortages of medical supplies, water and fuel (11). Structures/Space:... It was, therefore, overflowing with patients, including women and children. ... And the hospital was also hosting numerous internally displaced people who either had nowhere else to go or were sheltering there in the expectation, or at least perhaps the hope, that it would provide safety. And they were wrong. So far, reports indicate hundreds of fatalities, hundreds of civilians and health care workers … There have been many reports of health facilities sustaining extensive damage – indeed, the hospital itself had already been struck, as you know, on the 14th of October (11). Stuff:I am confident that this delivery will be the start of a sustainable effort to provide essential supplies – including food, water, medicine and fuel – ... (12). Stuff, Structures/Space, Systems:76 attacks on health care affecting 35 facilities and 24 ambulances. … The backup generators for many essential services, including hospitals and water desalination plants and food production are one by one coming to a halt because of the lack of fuel. The health system is overrun, of course, and one third of the hospitals in Gaza have been shut down and two-thirds of the primary health care clinics have shut down due to the damage or to the lack of fuel (13). Stuff, Structures/Space, Systems:… the health care system is in tatters. Patients lie on the floors and in corridors. Surgeons are operating without anesthesia. Out of an estimated 50,000 pregnant women, 5,500 are due to deliver within the next 30 days. For the 1,000 patients dependent on dialysis and the 130 premature babies in incubators, life hangs by a thread as hospital backup generators run on fumes. Some 9,000 cancer patients are not receiving adequate care. … We are deeply concerned by allegations of military installations in the close vicinity of hospitals and the request by Israeli authorities for hospitals, including Al Quds and Shifa, to be evacuated – there is nowhere safe for these patients to go, and for those on life support and babies in incubators, moving would almost certainly be a death sentence. … In particular, [it is] urgent for us to replenish fuel supplies, which are vital for powering most essential services, including hospitals and water desalination plants, and to transport humanitarian relief inside Gaza (14). Stuff:We need to be able to provide the essentials for survival – particularly water, food, medicine and fuel – safely, immediately and at scale (15). Staff, Stuff, Structures/Space, Systems: Meanwhile, the backup generators that are essential for so many services, including hospitals, water desalination plants, food production facilities have been relying on to maintain power are one by one grinding to a halt as fuel supplies run out. The health system is overwhelmed with an influx of injuries, combined with severe shortages of supplies, personnel, electricity and water. Since the start of the hostilities, 40 per cent of hospitals in Gaza – that's 14 of 35, and nearly 71 per cent of primary health care clinics – that's 51 of 72 – have shut down (16). Stuff, Structures/Space: More than 23,000 injured people require immediate treatment within overstretched hospitals. … An entire population is besieged and under attack, denied access to the essentials for survival, bombed in their homes, shelters, hospitals and places of worship. More than 100 attacks against health care have been reported (17). Staff, Stuff, Structures/Space, Systems: Health facilities are overwhelmed, and medical stocks are in short supply as hospitals and health care are increasingly targeted by attacks. WHO has documented 102 attacks on health care damaging 39 health-care facilities and 31 ambulances. ... All operating hospitals and clinics are affected by the severe fuel shortages, leading to stringent rationing (18). Stuff: Provide fuel to key hospitals, primary health-care centres, and ambulance services to ensure that they can maintain access to essential services, in the absence of electricity reconnection (18).

capacity'. These periods show how the surge requirement for the level of medical response changes according to the severity of the incident. The dashed line shows the pre-event medical response level of a normal country, while the dotted line shows the medical capacity of Gaza under siege and attack. The blue line shows the variation in Gaza's medical response to events. The red line, however, defines the demand capacity curve. The green area indicates that the 4S are partially adequate, but with the full siege, the reductions in the 4S move into the grey area. The orange area represents the higher level of medical response desired for Gaza

Table 1. Continued

No	Recommended actions	Staff, Stuff, Structures/Space, Systems
1	Calculate maximal capacity required for patient admission and care based not only on total number of beds required but also on availability of human and essential resources and the adaptability of facility space for critical care.	Stuff, Structures/Space, Systems: Eighteen hospitals have shut down and evacuated since the start of hostilities. Another five hospitals, including Shifa, are providing extremely limited services to patients who have already been admitted. These hospitals are not reliably accessible because of insecurity, do not have electricity or essential supplies, and are not admitting new patients (19). Stuff: Critical shortages of drugs, blood products and supplies (fuel at the hospitals is being severely rationed) (20). Systems: Shut down over 1/3 of the hospitals and nearly 2/3 of primary health care shut down [20]. Stuff: Critical shortages of drugs, blood products and supplies (Fuel at the hospitals is being severely rationed) (20). Systems: Evacuation orders All 13 hospitals still operational in Gaza city and Northern Gaza have received evacuation orders (20). Stuff, Systems: Acute shortage of essential medical and trauma supplies, essential medicines, fuel and electricity is affecting critical functions at all hospitals, as well as the ability of ambulances to respond. Health services and medical equipment is increasingly non-functional, affecting diagnostic and treatment capacities (21). Systems: Every hospital has activated emergency contingency protocols that impact operations and healthcare accessibility (21). Systems: Damage to the Gaza Emergency Operations Centre and emergency medical services has negatively impacted coordination and communications (21). Stuff, Systems: … The MoH in Gaza has been reallocating limited amounts of fuel to hospitals to keep them open and has asked people to donate their personal fuel supplies (21). Systems: Health Cluster partners estimate that mortality rates have been on the rise due to the extremely limited access to essential healthcare services (22). Staff: The ongoing hostilities have displaced most of the medical professionals in Gaza, forcing the hospitals to operate with less than one-third of their normal staffing levels, according to MoH in Gaza. Since 7 October, 130 health workers have been killed (22). Staff, Stuff, Structures/Space, Systems: Hospitals are facing an unprecedented level of devastation. Hospitals are on the brink of collapse due to the shortage of electricity, medicine, equipment and specialized personnel. In addition to the shortage of fuel, hospitals operations are undermined by the recurrent breakdown and malfunctioning of backup generators, which are not designed to operate uninterruptedly (22). Stuff: At Shifa Hospital, Gaza's main surgical facility, staff have reported a shortage of painkillers, leaving wounded patients screaming in agony. Pharmacies are running out of medicines… With a low stock of medicines and extremely limited access to clean water, the rate of anti-biotic resistance in Gaza is alarming (22). Staff, Stuff, Structures/Space, Systems: Hospitals are overwhelmed with the influx of trauma patients. There are shortages of some medical supplies essential for managing the injured. They are overstretched and healthcare workers overwhelmed by the caseload. Insecurity is hindering access to essential healthcare services for the population as healthcare workers and patients are unable to reach healthcare facilities, including pregnant women of which about 455 deliver every day. There is increased demand for fuel for ambulances. More than 4 800 patients in Gaza require access to lifesaving or life-sustaining healthcare on a daily basis- which is dependent on a constant supply of electricity. At least 300 of these patients are connected to lifesaving medical equipment such as ventilators, dialysis machines, incubators and aesthetic equipment (23). Systems: This facility was reportedly forcefully evacuated on 10 November by Israeli forces (24). Stuff, Systems: Functioning of health care facilities and ambulances is critically affected by acute shortages of fuel with lack of mains electricity, as well as depletion of medications and medical supplies. For hospitals remaining open, functionality is drastically reduced due to fuel depletion and limited supplies. Fuel has been rationed to maintain operating theatres, intensive care, and neonatal incubators. Stuff: Critical outages and shortages of essential medications and medical supplies, including those which are lifesaving for both acute and chronic care: e.g. saline, anaesthesia, pain medications, antibiotics, insulin, and cancer chemotherapy. A large proportion of medical equipment is non-functional, affecting diagnostic and treatment capacities (25). Staff: 34 attacks in the Gaza Strip have resulted in 11 fatalities of health care workers on duty, 16 injuries, and affected 19 health care facilities and 20 ambulances (23). Stuff: 1,559 trucks carrying humanitarian aid, excluding fuel, entered Gaza between 21 October and 23 November. Before the fuel crisis, an average of 500 trucks were entering per working day in 2023. An average of 46 trucks were allowed to pass daily (20).

(Figure 1).

In Figure 2, the red colours show the pre-siege situation of Gaza in terms of the 4S. The blue colour indicates that a capacity increase of at least 10% in the 4S is expected in the event of a disaster. This would involve the deployment of additional personnel, the use of pre-positioned supplies, the establishment of field hospitals and the establishment of an emergency operations centre. However, the black colour indicates that, due to the siege of Gaza, the 4S is much lower than the current situation and the expected structure. In Gaza, 34% of hospitals (structures/space) are unusable. As a result, only 34% of the existing staff can work, and there is some increase in staffing levels in the hospitals that are available. Since 34% of the hospitals are unusable, it can be said that at most 34% of the systems are usable.

Table 1. Continued

No	Recommended actions	Staff, Stuff, Structures/Space, Systems
1	Calculate maximal capacity required for patient admission and care based not only on total number of beds required but also on availability of human and essential resources and the adaptability of facility space for critical care.	Structures/Space: Approximately 64 per cent (46/72) of primary health care facilities and 34 per cent (12/35) of hospitals in Gaza are not functioning whilst 29 communities in West Bank have not had access to mobile clinics due to checkpoint closures and movement restrictions [18]. Staff: With casualties mounting, there is an urgent need to boost trauma and emergency care within the framework of the trauma care pathway (26). Stuff: Acute shortage of medical supplies –The number of casualties continues to grow, emergency, trauma, and surgical supplies are rapidly running out at hospitals and health partners' warehouses. There is a shortage of blood at hospital blood banks in the Gaza Strip. In the last 24 hours, there have been 15 admissions to ICUs and 106 surgeries, at hospitals in Gaza, which are already at capacity. Medicines for communicable and non-communicable diseases for the treatment of the sick are in short supply. Restrictions on movement are severely obstructing WHO and partners' ability to replenish dwindling stocks (27). Stuff: Acute shortage of medical supplies –The number of casualties continues to grow. Emergency, trauma, and surgical supplies are rapidly running out at hospitals and health partners' warehouses, with entry of humanitarian supplies still not possible. There is a shortage of blood at hospital blood banks in the Gaza Strip. Medicines for the treatment of communicable and more than 350,000 non communicable patients are in short supply (28). Stuff, Systems: Hospitals have reduced functioning to ration remaining fuel – Hospitals are relying on generators to maintain critical health services (28). Staff: The scale of bombardment is having a grave toll on mental health for all – health workers and other first responders have further been working long hours in difficult conditions (28). Stuff: Acute shortage of medical supplies – With the numbers of casualties rapidly growing, the consumption of medications is rapidly depleting. MoH reported that its daily consumption of medicine during the war is equivalent to its monthly consumption before the war started. Restrictions on movement and lack of humanitarian access severely obstruct WHO and partners' ability to replenish dwindling stocks (29). Stuff: All drugs are depleting not only those needed for emergency, trauma, surgical supplies but also those needed to treat 350,000 non communicable diseases patients, obstetric care, patients in need for kidney dialysis, cardiovascular diseases, and communicable diseases. There is a shortage of blood at hospital blood banks in the Gaza Strip (29). Stuff: Some medical equipment at the hospitals in Gaza is non- functional further affecting the ability of the hospitals to provide care to the patients and injured. Shifa Hospital is in need of diagnostic basic digital X-Ray and CT-Scan (29). Staff: Health workers and other first responders are facing exhaustion working long hours in difficult conditions. Specialist health workers, already in shortage in Gaza are now needed to help manage the complex cases of trauma and injuries (29). Stuff: Traumatic injuries: Rapid depletion of critical supplies to manage as daily use is equal to monthly consumption before the war (30). Staff: Health worker resources: Critical shortage, with medical staff capacity at 30% of requirements (30). Structures/Space: 50% 8 36 Hospitals not functioning (1). Stuff: Medicines and medical supplies: • anaesthetics • antibiotics • IV fluids • pain medications • insulin • blood and blood products; Medical equipment Increasingly not functional at hospitals, (e.g. monitors, ventilators, incubators, x-ray and CT, lab analysers, anaesthesia machines), which are dependent on electricity (1).
2	Estimate the increase in demand for hospital services, using available planning assumptions and tools.	Structures/Space: Homes, health centers and schools sheltering displaced families have been hit (31). Stuff: In their desperation, people have resorted to breaking into UN warehouses in search of food and water. Dehydration is an increasing concern, as is the possibility of the spread of disease and other health concerns due to unsafe water and breakdown in sewage treatment services (14). Structures/Space: … More than 1.4 million people are internally displaced in Gaza, and hundreds of thousands of children, women and men are crammed into overcrowded shelters and hospitals (14). Stuff, Systems: The inability to access potable water is driving people to rely on unhealthy water sources. The unsanitary conditions across Gaza, especially in heavily overcrowded IDP locations and the lack of availability of basic personal and domestic hygiene items, create a high-risk environment for public health. Of particular concern is an outbreak of infectious acute watery diarrhea (AWD); reports of escalating diarrhea cases, upper respiratory infections and skin diseases are already common. … Sanitation and solid waste management is currently extremely limited, sewage overflow is reported in many areas adding to the public health risk across Gaza (18). Stuff: There are around 540,000 women of reproductive age in Gaza, among whom 50,000 are currently pregnant, and over 5,500 women are expected to deliver in the next month; at least 825 (15 per cent) of whom are expected to experience a complication requiring emergency obstetric care. With lack of clean water and adequate sanitation facilities, pregnant and lactating women, as well as women who have recently given birth, face elevated threats; they also have higher daily water and caloric intake requirements (18). Stuff: Procurement of trauma and emergency care drugs, medical disposables, laboratory supplies, medical kits, and equipment which are in critical shortage which is hindering case management (18). Stuff: Electricity or fuel supplies at key hospitals and for ambulance services to continue providing lifesaving services (18). Staff, Stuff, Structures/Space: Existing health-care facilities have various degrees of operation due to damage, security concerns and fuel shortage as a result most are operating beyond capacity thus the need for additional bed capacity and human resources (18). Structures/Space, Systems: Hospitals in the Gaza Strip have been issued orders to evacuate - Evacuation orders are currently applicable to 21 hospitals (20 hospitals in Gaza City and North Gaza and 1 hospital in Rafah), affecting over 2000 patients. There is no capacity for hospitals in the south to receive such vast numbers of patients. Such movement would pose an immediate threat to the lives of patients (28). Sustems: Non-entry of health workers for humanitarian response, including management of casualties (32-34).

Stuff entering Gaza account for about 9% of all logistical traffic, with an average of 46 trucks per day (Figure 2).

Table 1. Continued

No	Recommended actions	Staff, Stuff, Structures/Space, Systems
3	Identify methods of expanding hospital inpatient capacity (taking physical space, staff, supplies and processes into consideration).	Stuff, Structures/Space, Systems: … Field hospitals will be established but these cannot replace the existing capacity of the health system which needs to be reinforced through deployment of additional medical capacity to existing hospitals. …(18) . Structures/Space, Systems:… Complement the existing capacity with the deployment of selective Emergency Medical Teams allocated to key hospitals and establish three field hospitals. … (18). Stuff: …Large numbers of patients are being treated on the ground given there are not enough hospital beds… (22). Stuff, Structures/Space, Systems: The number of patients awaiting treatment is at 150% of capacity, given the closure of over 60% of primary care facilities in Gaza. Large numbers of patients are being treated on the ground given there are not enough hospital beds (22). Staff, Stuff, Systems: The Ministry of Health has requested the deployment of international medical teams, particularly those with expertise in trauma and surgical care, to enhance the hospitals' capacities and relieve the health workers who have been tirelessly. Although 14 teams worldwide are on standby, they cannot be deployed due to the ongoing siege (22). Structures/Space, Systems: As of 23 October, 5 of Gaza's main hospitals have erected tents within their compounds to accommodate patients due to a lack of available space. Shifa hospital, the largest in the Gaza Strip, is currently treating some 5000 patients, significantly over its capacity of 700 patients, and hosting about 45 000 internally displaced persons (IDPs). The Al Quds Hospital, also in Gaza city, is accommodating more than 400 patients and about 12 000 IDPs (22). Staff: The region is characterized by stretched staff capacity due to complex humanitarian crises, and emigration of trained staff (22). Structures/Space, Systems: Hospitals are overwhelmed with an average of 97% bed occupancy in all Ministry of Health hospitals; Al Shifa Hospital reported 110% bed capacity followed by Al Aqsa Martyrs and Abu Yousef Al Najjar (100%.) Hospitals are adding beds in installed tents, outpatient departments, corridors and in any available empty space to accommodate the influx of the rising volume of the injured. Overcrowding patients in hospitals increases the risks of encountering nosocomial infections for patients (29).
4	Designate care areas for patient overflow (e.g. auditorium, lobby).	Structures/Space: Field hospitals and emergency medical teams can complement and support existing hospitals and health workers in Gaza, but they cannot replace them (2). Structures/Space: 20% (7/35) of hospitals not functioning; 103% of hospital beds currently occupied in the 8 major hospitals. Hospitals are adding beds in installed tents, outpatient departments, corridors, and any available space (32). Structures/Space: 34% (12/35) of hospitals not functioning; 119% of hospital beds currently occupied in 7 major hospitals. At Shifa hospital alone, the bed occupancy rate has reached 165%. Fuel depletion immediately risks the lives of injured patients, those requiring surgery, patients in intensive care, and those on neonatal incubators (30).
5	Increase hospital capacity by outsourcing the care of non-critical patients to appropriate alternative treatment sites (e.g. outpatient departments adapted for inpatient use, home care for low-severity illness, and chronic-care facilities for long-term patients).	Stuff, Systems: In a separate statement, the ministry asked Egypt to open the Rafah border crossing to ensure the entry of aid and the exit of the wounded (35). Stuff, Systems: With no proper treatment and care, the 2,000 cancer patients in the Gaza Strip live in catastrophic health conditions (36).

4. Discussion

This study aims to analyse the impact of the Israeli aggression and siege on Gaza Strip on the health system and surge capacity of Gaza hospitals. In summary, the results of this study show that there is a dramatic breakdown or decrease in the surge capacity of Gaza in terms of stuff, staff, space and systems. With the full siege on 7 October, the health system is deteriorating day by day. In particular, the study found that: (1) humanitarian supplies and personnel were prevented from entering and leaving Gaza; (2) limited medical evacuation from Gaza, acute fuel shortages and shortages of medicines and medical supplies affected health facilities and ambulances; (3) northern Gaza was evacuated at gunpoint; (4) lack of Water, sanitation and hygiene (WASH) facilities in health facilities and shelters led to infectious diseases and outbreaks; and (5) lack of routine surveillance systems affected public health problems and surge capacity (1).

Surge capacity represents a consensus of understanding of how to protect and support the need for medical personnel during an emergency or disaster (47). This also means forecasting the demand for personnel needed in the face of a hazard rather than at a normal time. The WHO's surge capacity guidelines refer to this under various articles specific to emergencies and disasters. However, it is observed that the guidelines are insufficient in assessing the surge capacity of the Gaza health system during the siege of Gaza. For example, health personnel were attacked, injured and killed, exhausted and working beyond their capacities (1, 26-30, 32-34, 37). Therefore, it is an important point of discussion question that the WHO surge capacity guideline is

Table 1. Continued

No	Recommended actions	Staff, Stuff, Structures/Space, Systems
6	Verify the availability of vehicles and resources required for patient transportation.	Staff, Stuff, Structures/Space, Systems: ... the explosion ... at the Al Ahli Anglican Episcopal Hospital … However, evacuation for many had simply not been possible due to insecurity the critical condition of many of the patients, and indeed, the lack of ambulances, staff and capacity in the rest of the health system, ... When that hospital was hit, it was fully operational. And indeed, it had reached its maximum capacity (11). Stuff, Structures/Space, Systems: Hospitals in Gaza City and North Gaza continue facing evacuation orders, which are impossible to carry out. Moving patients puts their lives at immediate risk, while there is insufficient capacity in the south to accommodate a further influx of patients (25). Stuff, Systems: The massive damage to infrastructure and insecurity is making it difficult for ambulances to reach those in need and for the injured and sick to get to health facilities. Because of limited ambulance capacities, private vehicles have had to assist the evacuation of injured persons, without the protection of medical emblems. Fuel reserves for ambulances are additionally depleting (29, 32). Stuff: Limited fuel supplies affecting ambulance functioning and access to the sick and injured (32). Stuff, systems: Destruction severely affecting infrastructure in the Gaza Strip and obstructing ambulance access to the injured. According to the Ministry of Health, 2700 people, including 1500 children reported to be missing and may be trapped under the rubble, obstacles to providing first aid response (1, 32, 34). Stuff, systems: The destruction in the Gaza Strip is severely affecting the infrastructure and hindering access to ambulances for the injured. It has been reported that 1,870 people, including 1,020 children, are missing and may be trapped under the rubble, with first aid responses being obstructed. The use of private vehicles for the injured is compromising their safety (30). Stuff: Acute shortage of fuel and electricity is seriously affecting the most critical functions at all hospitals and the ability of ambulances to respond. Fuel depletion risks the lives of patients in intensive care, those requiring surgery or neonatal incubators and over 1000 patients dependent on dialysis (33, 34). Stuff: Ambulance functioning has been affected with 28 ambulances out of service due to damage or fuel shortage (30). Stuff, Systems: Telecommunications in Gaza (including mobile phone lines and internet) were shut down from evening of 27 to 29 October, affecting ability of injured persons to call ambulances and Civil Defence teams (30).
7	Establish a contingency plan for inter-facility patient transfer should traditional methods of transportation become unavailable.	Structures/Space, Systems: ...And the destruction of that hospital yesterday heaped further pressure on this crumbling, this failing, this sad health care system. Not only were the victims rushed to Shifa Hospital, one of the many other hospitals in Gaza on the verge of collapse, ... (11). Systems: … Referral pathways must be re-established; medical evacuations must be initiated and specialty medical referral outside the Gaza Strip be resumed (18). Systems: Both hospitals have established a mechanism for mutual referrals (24). Systems: The Gaza Emergency Operation Centre, supported by WHO, has sustained heavy damages. 42 attacks on health care in the West Bank affecting 42 ambulances and including 28 attacks involving obstruction to delivery of health care; 20 involving physical violence towards health teams; 11 involving detention of health staff and ambulances; and seven involving militarised search of health assets (23). Systems: A humanitarian corridor for unimpeded, life-saving patient referrals and movement of humanitarian personnel and essential health supplies has not yet been established (26). Systems: A humanitarian corridor must be urgently set up to facilitate the unimpeded movement of lifesaving humanitarian and health supplies, personnel, and patient referrals (27, 37). Structures/Space, Systems: Hospitals in northern Gaza have been issued orders to evacuate. The order is applicable to 20 hospitals currently functioning in Gaza City and North Gaza governorates, affecting over 2000 patients. There is no capacity for hospitals in the south to receive such vast numbers of patients. Such movement would pose an immediate threat to the lives of patients. A further hospital in Rafah has also received evacuation orders (29). Structures/Space, Systems: 13 hospitals in Gaza City and North Gaza are currently functioning and facing evacuation orders. Evacuation orders are impossible to carry out and risk the lives of over 2000 inpatients, particularly the most vulnerable requiring life support. Bed capacity in the south (1/3 of that in the north) cannot accommodate and there is insufficient ambulance capacity. o Most dialysis capacity (80%) located in in the area ordered for evacuation (30, 32, 34). Systems: Exit and evacuation of patients and casualties: No evacuations to date due to closure of borders. 95 patients per day are unable to access the specialized health care they would usually receive outside the Gaza Strip (30).

inadequate and there is a need for a guideline that can assess staff capacity under siege and armed conflict.

In order to reduce morbidity and mortality and improve human welfare, the health system diversifies its resources into a wide range of items, such as beds, ventilators or medicines, which are referred to as 'stuff' or 'equipment' (47). Each of these is known to affect surge capacity in different ways. For example, the need for additional ventilators and beds increases during a pandemic (48). Similarly, supply chain problems affect the import of some medicines (49). These examples can be seen in normal times as well as in emergencies and disasters, when there are limited or no restrictions between countries (50). The impact of armed conflict on healthcare systems, particularly in regions under

Table 1. Continued

No	Recommended actions	Staff, Stuff, Structures/Space, Systems
8	Identify potential gaps in the provision of medical care, with emphasis on critical and emergent surgical care. Address these gaps in coordination with the authorities and neighbouring and network hospitals.	Stuff, Systems: Since it imposed its blockade on Gaza in 2007, Israel has banned the import of radiotherapy machines, among other equipment, because it believes that they could be used for military purposes. As a result, many Gazans have to ask for permission to leave the territory to go to Palestinian hospitals in East Jerusalem. The most important is the Makassed, financed with Palestinian and Arab funds, where the PNA pays for the treatment of patients from Gaza and the West Bank, as was the case with Nabil (38). Stuff, Systems: WHO-supported mass casualty response plans and protocols have been activated in the main hospitals. However, restrictions on movement are obstructing the delivery of medical supplies into Gaza as stocks begin to deplete, creating an acute shortage (27).
9	In coordination with the local authorities, identify additional sites that may be converted to patient care units (e.g. convalescent homes, hotels, schools, community centres, gyms).	Stuff, Systems: Functioning of health care facilities and ambulances is critically affected by acute shortages of fuel with lack of mains electricity, as well as depletion of medications and medical supplies (24). Structures/Space: Amid the escalating healthcare challenges in the Gaza Strip, the European Hospital has reached its limit. The swelling number of patients necessitated the conversion of a nearby school into a field hospital, a decision emblematic of the dire circumstances Gaza faces. This situation underscores the urgency of addressing the healthcare crisis in Gaza, emphasizing the necessity for international support and medical resources. The European Hospital's decision to use a school as a makeshift medical facility echoes the challenging times. The school-turned-hospital serves as a stark representation of the healthcare crisis Gaza Strip faces. It underscores the magnitude of the problem as authorities resort to drastic measures to provide medical care amid the overflow of patients (39).
10	Prioritize/cancel nonessential services (e.g. elective surgery) when necessary.	Stuff, Structures/Space: Two hospitals -- Al-Aqsa Hospital in central Gaza and Nasser Hospital in southern Gaza -- are overwhelmed and are being forced to prioritize those with life-threatening conditions, according to Doctors Without Borders, or Médecins Sans Frontières (MSF), which has staff working at both medical centers (40). "We are trained to deal with mass casualties, but not like this," Ghneim, 28, said. "We have no anaesthesia to treat patients with severe pain, patients with shrapnel in their head or abdomen, people whose arms or legs have been amputated." (41) Staff, Stuff, Structures/Space: In the crowded corridors of the European hospital in Khan Younis, exhausted doctors decide who among the huge influx of patients arriving from the north of Gaza should live or die. Paul Ley, an orthopaedic surgeon at the European hospital, said displaced people were sleeping in lifts, a small team was working round the clock in four operating theatres to amputate limbs infected after days without treatment, and there was an acute shortage of painkillers. Triage decisions had to be made instantly which, in one case, meant leaving a 12-year-old child to die with only palliative care in order to preserve dwindling resources (42).
11	Adapt hospital admission and discharge criteria and prioritize clinical interventions according to available treatment capacity and demand.	Stuff, Structures/Space: C-sections are being performed without basic medical supplies or anaesthesia and without any postnatal care. "If fortunate enough to reach a health centre or hospital, they are admitted only when fully dilated and are dismissed within a few hours after giving birth due to overcrowded facilities and extremely limited resources," Ms Awadallah told The National. "A number of C-sections are being performed without basic medical supplies or anaesthesia and without any postnatal care." A Gaza mother experienced this first hand when she was asked to leave the hospital within hours of giving birth last week. Stuff, Structures/Space: … The hospital's 200-bed section for surgery patients now has 900 packed into the building, with some placed in operating theatres because of the lack of space. "We cannot offer pain killers or even proper antibiotics to all patients," Dr Abusada said. "Anaesthesia is sometimes not available and sometimes we discharge patients without antibiotics." … (43)
12	Designate an area for use as a temporary morgue. Ensure the adequate supply of body bags.	Structures/Space: GAZA, Oct 15 (Reuters) - Health officials in the Hamas-run Gaza Strip have resorted to storing the bodies of Palestinians killed by Israeli air strikes in ice cream freezer trucks because moving them to hospitals is too risky and cemeteries are short of space (44).
13	Formulate a contingency plan for post mortem care with the appropriate partners (e.g. morticians, medical examiners and pathologists).	Systems: The Palestinian Health Ministry in Gaza said a mass grave inside the Al-Shifa Hospital will be dug on Saturday to bury 100 bodies lying in the hospital (45). Systems: The bodies of dozens of unidentified people were buried on Wednesday in a mass grave at a cemetery in Khan Yunis, in the southern Gaza Strip. … A week after the war began, Philippe Lazzarini, the head of the UN agency for Palestinian refugees (UNRWA), said there was a shortage of body bags (46).

siege or embargo, is multifaceted and severe. A study focused on north-west Syria between October 2014 and June 2017 revealed a strong negative association between bombardments and routine health services like outpatient consultations and antenatal care. However, conflict incidents were positively associated with emergency maternity services such as deliveries and C-sections, possibly due to the psychological trauma and fear of unpredictable war conditions during labor. This situation led to an overstretched coverage of health facilities, with patients traveling long distances for healthcare, indicating a failure of the health humanitarian response to meet minimum standards (51).

Similarly, the besieged Gaza Strip is unable to meet its supply needs because it does not have access to the Egyptian Rafah crossing, Gaza's only border point. As a result, ambulances are unable to reach the wounded under the rubble due to a lack of fuel, hospitals are unable to provide treatment due to a lack of supplies and medicines, and public health problems are reported due to a lack of a functioning monitoring system (1, 2630, 32-34, 37). It's for this reason that WHO's current surge capacity section will be re-

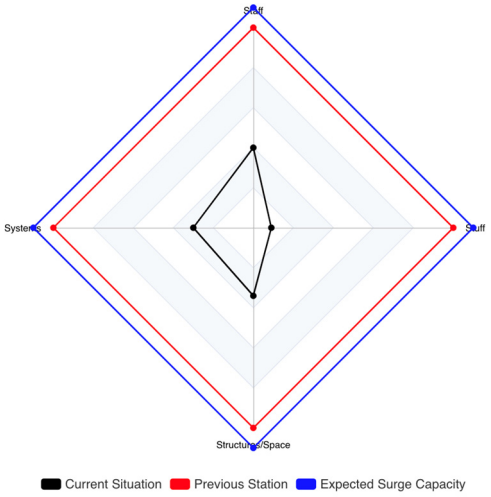

Figure 2. Radar view of the current situation of Staff, Stuff, Structures/Space, Systems compared to before the siege.

evaluated specifically for siege and armed conflict in the context of stuff.

The most important expansion of capacity in hospital plans for an emergency or disaster is the expansion of hospital structures/areas. This means various methods such as configurable hospital rooms, modular equipment, air filtration, radiation or blast protection, creation of reserve wards, use of out-of-service areas (47), tent or field hospitals. However, what has been stated so far refers to the expectations of a functioning hospital under normal conditions. By 7 October, Gaza's health system, which served a population of over 2 million, was already on the brink of collapse, with only 35 hospitals operating at full capacity, 3,412 beds and a maximum ratio of 1.55 hospital beds per 1,000 people. The conflict exacerbated this already critical situation, leading to hospital closures, disruption of services to the population, physical damage to hospital infrastructure and transport systems, and the evacuation of many medical facilities (52). Despite this, it is known that in hospital wards and gardens that were not bombed during the siege of Gaza, attempts were made to expand the treatment area by spreading mattresses on the floor. There are also examples of tents and field hospitals(1, 2630, 32-34, 37). Until the collapse of the health system in Gaza, many efforts were made to improve the system. However, these efforts have come up against the Israeli embargo. There is therefore a need to revise the WHO surge capacity guide in terms of surviving health facilities and how to protect the health system left behind, and to provide guidance on how to protect health systems from future sieges.

Staff, stuff and structures/space are important components for a functioning health system. Systems is the most important component for controlling, commanding, communicating and coordinating these in surge capacity (47). This enables the inter-hospital referral system or the implementation of hospital disaster plans during an emergency or disaster. A hospital disaster plan implemented with systems is expected to work in conjunction with the entire health cluster and ensure the organisation of medical needs. Particularly in the besieged Gaza, it is known that the Emergency Operation Centre was damaged by bombardment. Attacks on Ambulance, physical violence to prevent the provision of health services, the detention of health personnel and ambulances, and the treatment of health teams as if they were a military element all undermine the functioning of emergency plans (21, 23, 53-56). A systematic review of literature on violence against healthcare in conflict highlighted that such attacks, including those on health workers, facilities, patients, and transports, represent serious violations of human rights and international humanitarian law. The review emphasized the need for enhanced documentation of these attacks to understand their true scope and develop stronger protection, advocacy, and accountability mechanisms (57). However, in addition to documentation, for a health system to function well, the material, human and physical components must be intact. Because of problems in these three components, the effectiveness and efficiency of the systems component cannot be properly assessed. For these reasons, the WHO section on surge capacity needs to be updated or studied as a new area specific to siege and armed conflict in the health system. In particular, the concept of surge capacity can be considered more applicable to emergencies and disasters. For this reason, we see the concept of surge capacity under siege and armed conflict as a new area of discussion that needs to be explored in the literature.

To better understand surge capacity under siege and armed conflict, the concepts of daily surge and extraordinary surge need to be explained. These two concepts are similar in terms of dealing with a large increase in demand for medical or public health resources and straining the capacity of the system. However, disaster surge, used for catastrophic events, is larger and more complex than daily surge, which remains at a simpler level. Here, surge is a measure of responsiveness as a result of the mismatch between population, demand (surge) and resource availability (capacity) (58). There is a stratified continuum in which both daily surge and disaster surge occur. Daily surge response capability only routinely uses available capacity (resources). At the other end of the continuum, the daily capacity threshold is exceeded when a disaster plan is activated or additional resources beyond those available for normal operations are required (59).

According to Barbisch et al. (2006), local medical response, which continues at a certain level of routine during a sudden-impact event, peaks when a sudden-impact event occurs and exhausts capacity within 8-48 hours. At this stage, inventory (supplies) delivery may be interrupted, personnel (staff) are depleted, physical facilities (structure) run out of space and the planning timeline for mutual aid partners and national support to arrive is 72 hours later. In addition, delays or interruptions in external assistance for any reason will further extend the timeline (60). This results in reduced local medical response capacity and increased surge capacity. This is more likely to occur in major disasters where there is loss of personnel, supplies, facilities and systems. However, with planned co-operation, relief efforts and national support within the extended timeline, the need

for disaster surge will be reduced to zero. This situation will not be valid for every type of disaster. For example, it is known that due to the long years of siege in Gaza, a limited amount of medical aid reaches the region. The medical facilities of the region provide services at a level lower than the medical capacity of a normal country under today's conditions. Figure 1 shows the surge capacity of Gaza under siege and armed conflict. Figure 2 also shows the actual 4S situation in Gaza under siege, although it gives the 4S capacity of the hospitals in normal times and the 4S expectation in disasters. It is known that before the full siege, the need for medical intervention was maintained with the support of the UN and various aid agencies. However, with the full siege by Israel and the declaration of war on 7 October, it can be seen that the use of previously sent medical supplies has peaked and the medical intervention capacity has decreased as the entrances and exits to Gaza have been closed and the need for surge capacity under siege and armed conflict has increased. Therefore, what is happening in Gaza is different from a normal war and there is a need to extend the 4S capacity concept specifically to this context in order to protect hospitals that can survive the bombardment under siege.

4.1. Limitations

The topics of this study should be addressed in the context of the following issues. The data of the study is based on reports and news from international official organisations and some news websites. Therefore, the conclusions about the items in the WHO's surge capacity section were not obtained by interviewing hospital staff in Gaza. In addition, the items were used to make an assessment of the health system as a whole, rather than specific to a single hospital.

5. Conclusion

The findings of this study highlight the following key points:

1. Severe Impact on Health Services: The long-standing siege, compounded by frequent military incursions, has severely undermined the operational capabilities of Gaza's healthcare facilities. The shortage of medical and trauma supplies, vital medications, water, fuel, and electricity has critically hampered health services, adversely affecting both diagnostic and treatment capabilities.

2. Overwhelmed Healthcare Infrastructure: The escalation of hostilities has resulted in substantial casualties, leading to an overwhelming burden on the already strained healthcare system. The high occupancy rates in hospitals, coupled with a significant portion of health facilities being non-operational, illustrate the dire situation.

3. Ripple Effect in the West Bank: The crisis in Gaza has had a profound impact on the West Bank, exacerbating vulnerabilities and healthcare demands among Palestinian refugees. This indicates the interconnectedness of the health systems and the need for a coordinated approach in addressing the challenges. The only way to enhance the resilience of a completely divided and fragmented national healthcare system and other areas appears to be the establishment of geographical and administrative integrity between Gaza and the West Bank. This unity will make a very positive contribution to the healthcare system resilience and its surge capacity of both regions

4. Necessity for Context-specific Framework: The study emphasized the inadequacy of existing surge capacity guidelines in addressing the specific challenges faced by the Gaza healthcare system. There is a pressing need for a tailored framework that takes into account the unique constraints of Gaza, including limited access to resources, recurrent conflicts, and the socio-political landscape.

5. Model for Other Conflict Zones: The tailored strategies and recommendations proposed in this study have the potential to enhance the resilience of Gaza's healthcare system. Moreover, these strategies can serve as a model for other regions facing similar challenges, offering insights into managing healthcare systems under extreme and complex crisis conditions.

In conclusion, the study provides a comprehensive analysis of the surge capacity preparedness in Gaza's healthcare system under siege and armed conflict, offering valuable insights and actionable strategies for enhancing healthcare resilience in conflict zones. It calls for a concerted effort from local and international stakeholders to develop and implement a context-specific framework that can effectively address the unique challenges faced by healthcare systems in conflict-ridden regions like Gaza.

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Authors' contributions

CC data collection and analysis, CC and CC manuscript writing, and all authors read and acted on the final draft.

Ethical statements

Ethical approval was not required as publicly available sources were used.

Conflict of Interests

The authors declare that they have no competing interests.

References

1. WHO. oPt Emergency situation update - Issue 15 [Internet]. 2023 Oct [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/oPt_Emergency_Situation_Update_-_NOV28.pdf?ua=1
2. WHO. WHO Director-General's remarks at the Emergency Meeting of the United Nations Security Council [Internet]. 2023 [cited 2023 Dec 8]. Available from: https://www.who.int/director-general/speeches/detail/who-director-general-s-remarks-at-the-emergency-meeting-of-the-united-nations-security-council---10-november-2023
3. Druce P, Bogatyreva E, Siem FF, Gates S, Kaade H, Sundby J, et al. Approaches to protect and maintain health care services in armed conflict – meeting SDGs 3 and 16. Confl Health [Internet]. 2019 Dec 29;13(1):2. Available from: https://conflictandhealth.biomedcentral.com/articles/10.1186/s13031-019-0186-0
4. OCHA. Hostilities in the Gaza Strip and Israel | Flash Update #66 [Internet]. 2023 Dec [cited 2023 Dec 12]. Available from: https://www.ochaopt.org/sites/default/files/Gaza_casualties_infographic_11_Dec_2023.pdf
5. Thomson B. Press Conference. 2023 Nov 10 [cited 2023 Dec 15];

Available from: https://www.youtube.com/watch?v=WceHxY1FwHk
6. UNRWA. UNRWA Updated oPt flash appeal [Internet]. 2023 Nov [cited 2023 Dec 1]. Available from: www.unrwa.org
7. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JPA, et al. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Healthcare Interventions: Explanation and Elaboration. BMJ. 2009 Dec 4;339(jul21 1):b2700–b2700.
8. World Health Organization (WHO). Hospital emergency response checklist An all-hazards tool for hospital administrators and emergency managers [Internet]. 2011. Available from: https://www.researchgate.net/publication/265163242
9. OCHA. Statement by the Humanitarian Coordinator for the Occupied Palestinian Territory, Lynn Hastings, on the hostilities between Palestinian armed groups in the Gaza Strip and Israel [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/statement-humanitarian-coordinator-occupied-palestinian-territory-lynn-hastings-hostilities-between-palestinian
10. OCHA. It's been a dreadful week. Humanity must prevail [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/it-s-been-dreadful-week-humanity-must-prevail
11. OCHA. We need immediate, safe humanitarian access across all of Gaza, UN relief chief tells Security Council [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/we-need-immediate-safe-humanitarian-access-across-all-gaza-un-relief-chief-tells-security-council
12. OCHA. Statement by Martin Griffiths, Under-Secretary-General for Humanitarian Affairs and Emergency Relief Coordinator, on aid delivery into Gaza [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/statement-martin-griffiths-under-secretary-general-humanitarian-affairs-and-emergency-relief-coordinator-aid
13. OCHA. Humanitarian Coordinator's opening remarks to Geneva-based correspondents [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/humanitarian-coordinators-opening-remarks-geneva-based-correspondents
14. OCHA. Lisa Doughten's remarks to the Security Council on behalf of Emergency Relief Coordinator, Martin Griffiths [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/lisa-doughten-s-remarks-security-council-behalf-emergency-relief-coordinator-martin-griffiths
15. OCHA. UN relief chief_ The crisis in Israel and the Occupied Palestinian Territory is a global crisis [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/un-relief-chief-crisis-israel-and-occupied-palestinian-territory-global-crisis
16. OCHA. Humanitarian Coordinator's remarks to Member States on the humanitarian situation in the Occupied Palestinian Territory [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/humanitarian-coordinators-remarks-member-states-humanitarian-situation-occupied-palestinian-territory
17. OCHA. Statement by Principals of the Inter-Agency Standing Committee, on the situation in Israel and the Occupied Palestinian Territory [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/statement-principals-inter-agency-standing-committee-situation-israel-and-occupied-palestinian-territory
18. OCHA. Flash appeal: occupied Palestinian territory [Internet]. 2023. Available from: www.unocha.org
19. OCHA. Informal Plenary Meeting of the General Assembly on the Humanitarian Situation in the Gaza Strip [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/informal-plenary-meeting-general-assembly-humanitarian-situation-gaza-strip
20. OCHA. Hostilities in the Gaza strip and Israel - Reported impact - Day 20-48 [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/publications
21. WHO. WHO operational response plan: occupied Palestinian territory [Internet]. 2023 [cited 2023 Dec 1]. Available from: https://www.who.int/emergencies/situations/conflict-in-Israel-and-oPt
22. WHO. Hostilities in the occupied Palestinian territory (oPt): Public Health Situation Analysis (PHSA) [Internet]. 2023 [cited 2023 Dec 1]. Available from: https://reliefweb.int/report/occupied-palestinian-territory/public-health-situation-analysis-phsa-hostilities-occupied-palestinian-territory-opt-05-november-2023
23. WHO. Hostilities in the occupied Palestinian territory (oPt): Public Health Situation Analysis (PHSA) [Internet]. 2023 [cited 2023 Dec 1]. Available from: https://reliefweb.int/report/occupied-palestinian-territory/public-health-situation-analysis-phsa-hostilities-occupied-palestinian-territory-opt-14-october-2023
24. OCHO. Hostilities in the Gaza strip and Israel: falsh update 55. 2023.
25. WHO. oPt Emergency situation report. 2023 Nov.
26. WHO. oPt Emergency situation report - Issue 1 [Internet]. [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/oPt-emegency-situation-report-issue-1.pdf?ua=1
27. WHO. oPt Emergency situation report - Issue 2 [Internet]. 2023 Nov [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/oPt-emegency-situation-report-issue_2.pdf?ua=1
28. WHO. oPt Emergency situation report - Issue 4 [Internet]. 2023 Oct [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/oPt-emegency-situation-report-issue_4.pdf?ua=1
29. WHO. oPt Emergency situation report - Issue 5 [Internet]. 2023 Oct [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/oPt-emegency-situation-report-issue_5.pdf?ua=1
30. WHO. oPt Emergency situation report - Issue 9 [Internet]. 2023 Oct [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/WHO_oPt_Sitrep_9.pdf?ua=1
31. OCHA. Statement by Martin Griffiths, Under-Secretary-General for Humanitarian Affairs and Emergency Relief Coordinator, about the situation in Israel and the Occupied Palestinian Territory [Internet]. 2023 [cited 2023 Nov 28]. Available from: https://www.ochaopt.org/content/statement-martin-griffiths-10-october-2023
32. WHO. oPt Emergency situation report - Issue 6 [Internet]. 2023 Oct [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/WHO_oPt_Sitrep_6s.pdf?ua=1
33. WHO. oPt Emergency situation report - Issue 7 [Internet]. 2023 Oct [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/WHO_oPt_Sitrep_7.pdf?ua=1
34. WHO. oPt Emergency situation report - Issue 8 [Internet]. 2023 [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/WHO_oPt_Sitrep_8.pdf?ua=1
35. Tekin E. Gaza Health Ministry warns 1,100 kidney failure patients at risk as hospitals lack fuel. Anadolu Ajansı [Internet]. 2023 Oct 23 [cited 2023 Dec 8]; Available from: https://www.aa.com.tr/en/health/gaza-health-ministry-warns-1-100-kidney-failure-patients-at-risk-as-hospitals-lack-fuel/3029763
36. Out of medicines, care- Gaza's cancer patients face death amid Israel war.
37. WHO. oPt Emergency situation report - Issue 3 [Internet]. 2023 Oct [cited 2023 Dec 10]. Available from: https://www.emro.who.int/images/stories/palestine/oPt-emegency-situation-report-issue_3.pdf?ua=1
38. EL PAIS. Israel arrests and expels Gazan patients seeking treatment in the West Bank. 2023 [cited 2023 Dec 8]; Available from: https://english.elpais.com/international/2023-11-27/israel-arrests-and-expels-gazan-patients-seeking-treatment-in-the-west-bank.html?outputType=amp
39. BNN. Gaza's Healthcare Crisis: European Hospital Turned School Into Makeshift Facility. 2023 Nov 19; Available from: https://bnn.network/breaking-news/health/gazas-healthcare-crisis-european-hospital-turned-school-into-makeshift-facility/
40. Kekatos M. Hospitals in southern Gaza are at "breaking point," international organizations say. abcNEWS [Internet]. 2023 [cited 2023 Dec 8]; Available from: https://abcnews.go.com/amp/International/hospitals-southern-gaza-breaking-point-international-organizations/story?id=105382793
41. Elassar A. 'Please stop this.' Gaza's hospitals are failing under the weight of war. US medical groups are scrambling to help. CNN [Internet]. 2023 [cited 2023 Dec 8]; Available from: https://edition.cnn.com/2023/11/11/middleeast/gaza-al-shifa-hospital-israel-attack?cid=ios_app
42. Burke J. 'We are overwhelmed'- southern Gaza's exhausted doctors

forced to leave children to die. The Guardian [Internet]. 2023 [cited 2023 Dec 8]; Available from: https://amp.theguardian.com/world/2023/nov/24/we-are-overwhelmed-southern-gazas-exhausted-doctors-forced-to-leave-children-to-die
43. MENA. Gaza's pregnant women give birth in cars as hospitals overflow with bombing casualties. 2023 [cited 2023 Dec 8]; Available from: https://www.thenationalnews.com/mena/palestine-israel/2023/11/09/gazas-pregnant-women-give-birth-in-cars-as-hospitals-overflow-with-bombing-casualties/?outputType=amp
44. Ak-Mughrabi N. As Gaza death toll rises, bodies are stored in ice cream trucks. REUTERS [Internet]. 2023 Oct 15 [cited 2023 Dec 8]; Available from: https://www.reuters.com/world/middle-east/gaza-death-toll-rises-bodies-are-stored-ice-cream-trucks-2023-10-15/
45. Anadolu Ajansı. 100 bodies to be buried in mass grave inside Gaza's Al-Shifa Hospital. 2023 Nov 11 [cited 2023 Dec 8]; Available from: https://www.aa.com.tr/en/middle-east/100-bodies-to-be-buried-in-mass-grave-inside-gazas-al-shifa-hospital/3050418
46. FRANCE24. In Gaza, dozens of unidentified bodies buried in "mass grave" [Internet]. 2023 [cited 2023 Dec 8]. Available from: https://www.france24.com/en/live-news/20231122-in-gaza-dozens-of-unidentified-bodies-buried-in-mass-grave?utm_medium=social&utm_campaign=whatsapp&utm_source=user
47. Watson Sk, Rudge Jw, Coker R. Health Systems' "Surge Capacity": State of the Art and Priorities for Future Research. Milbank Q [Internet]. 2013 Mar 14;91(1):78–122. Available from: https://onlinelibrary.wiley.com/doi/10.1111/milq.12003
48. Fisher D, Hui Ds, Gao Z, Lee C, Oh M, Cao B, et al. Pandemic response lessons from influenza H1N1 2009 in Asia. Respirology [Internet]. 2011 Aug 25;16(6):876–82. Available from: https://onlinelibrary.wiley.com/doi/10.1111/j.1440-1843.2011.02003.x
49. Bartlett JG, Borio L. Healthcare epidemiology: the current status of planning for pandemic influenza and implications for health care planning in the United States. Clin Infect Dis [Internet]. 2008 Mar 15;46(6):919–25. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18279045
50. Çalışkan C, Özsezer G, Pay M, Demir G, Çelebi I, Koçak H. Web search behaviors and infodemic attitudes regarding COVID-19 in Turkey: A framework study for improving response and informing policy on the COVID-19 infodemic. Front Public Health [Internet]. 2022 Nov 8;10. Available from: https://www.frontiersin.org/articles/10.3389/fpubh.2022.948478/full
51. Ekzayez A, Alhaj Ahmad Y, Alhaleb H, Checchi F. The impact of armed conflict on utilisation of health services in north-west Syria: an observational study. Confl Health [Internet]. 2021 Dec 14;15(1):91. Available from: https://conflictandhealth.biomedcentral.com/articles/10.1186/s13031-021-00429-7
52. Mahmoud H, Abuzerr S. State of the health-care system in Gaza during the Israel–Hamas war. The Lancet [Internet]. 2023 Dec; Available from: https://linkinghub.elsevier.com/retrieve/pii/S014067362302634X
53. WHO. Gaza: UN expert condemns "unrelenting war" on health system amid airstrikes on hospitals and health workers [Internet]. 2023 Dec [cited 2023 Dec 12]. Available from: https://www.ohchr.org/en/press-releases/2023/12/gaza-un-expert-condemns-unrelenting-war-health-system-amid-airstrikes
54. MEMO Middle East Monitor. Israel army arrests 35 medical workers in Gaza. 2023 Dec 6 [cited 2023 Dec 12]; Available from: https://www.middleeastmonitor.com/20231206-israel-army-arrests-35-medical-workers-in-gaza/
55. TheGuardian. Injured Palestinians face potentially fatal delays in treatment, say aid agencies. 2023 Dec 12 [cited 2023 Dec 12]; Available from: https://www.theguardian.com/world/2023/dec/12/injured-palestinians-face-potentially-fatal-delays-in-treatment-say-aid-agencies
56. OCHA. Hostilities in the Gaza Strip and Israel | Flash Update #65 [Internet]. 2023 Dec [cited 2023 Dec 12]. Available from: https://reliefweb.int/report/occupied-palestinian-territory/hostilities-gaza-strip-and-israel-flash-update-65-enarhe
57. Haar RJ, Read R, Fast L, Blanchet K, Rinaldi S, Taithe B, et al. Violence against healthcare in conflict: a systematic review of the literature and agenda for future research. Confl Health [Internet]. 2021 Dec 7;15(1):37. Available from: https://conflictandhealth.biomedcentral.com/articles/10.1186/s13031-021-00372-7
58. Kelen GD, McCarthy ML. The Science of Surge. Academic Emergency Medicine [Internet]. 2006 Nov 28;13(11):1089–94. Available from: https://onlinelibrary.wiley.com/doi/10.1197/j.aem.2006.07.016
59. Asplin BR, Flottemesch TJ, Gordon BD. Developing Models for Patient Flow and Daily Surge Capacity Research. Academic Emergency Medicine [Internet]. 2006 Nov 28;13(11):1109–13. Available from: https://onlinelibrary.wiley.com/doi/10.1197/j.aem.2006.07.004
60. Barbisch DF, Koenig KL. Understanding Surge Capacity: Essential Elements. Academic Emergency Medicine [Internet]. 2006 Nov 28;13(11):1098–102. Available from: https://onlinelibrary.wiley.com/doi/10.1197/j.aem.2006.06.041