Designing the temporary dental clinic in the Covid-19 global pandemic

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Abstract. Covid-19 pandemic has directed hospitals to concentrate services for patients who are positive or still in undefined status. Some countries are even forced to build temporary structures or utilize multifunctional buildings such as sports/public halls. On the other hand, hospitals still have to keep performing other routine services and this becomes a challenge for them. When global attention nowadays focuses more on how hospitals serve the Covid-19 cases, this research proposes another side of healthcare service needed by people in the pandemic, which is the dental clinic. The spread of Covid-19 through droplets puts both dental patients and practitioners at risk target of Covid-19 transmission. Therefore, particular standards and protocols are mandatory to be deployed. A prototype design of the temporary dental clinic is the main output from this research. The main objective is to provide service for the community without being afraid of contracting the pandemic as the clinic will be isolated from the regular hospital buildings. To achieve this objective, this research employed three approaches for the methodology. It was started with the desk study to review references on recent technology of temporary building structures. Followed by the online questionnaire using the Google platform distributed to 206 registered dental practitioners in Aceh, in collaboration with the Indonesian Dental Association, Aceh Province, Indonesia. The questionnaire collected the data related to the needs, standards, procedures, and dental service protocols under the Covid-19 pandemic as the main reference for the design process. The last approach was gathering feedback from dentists and international architects who are experts in building science and technology. This was done through a series of pre-design reviews. This research has a high degree of urgency globally, including Saudi Arabia, which is also impacted by the Covid-19 pandemic. It is also in line with Saudi Vision 2030 to enhance the standard quality and sustainability of healthcare services. The prototype design proposed in this research does not only contribute to the Covid-19 pandemic in particular but also post-Covid scenarios or other possible global pandemics in the future.

Keywords: Dental Clinic, Covid-19, Prototype Design, Temporary Structure, Saudi Vision 2030, Healthcare Service
1. Introduction

Covid-19 pandemic has directed hospitals to concentrate services for patients who are positive or still in undefined status. Some countries are even forced to build temporary structures or utilize multifunctional buildings such as sports/public halls. On the other hand, hospitals still have to keep performing other routine services and this becomes a challenge for them. When global attention nowadays focuses more on the service of hospitals during the Covid-19 pandemic, this research proposes another side of healthcare service that is also needed by people in the pandemic period, which is the dental clinic.

Under the humanitarian architecture umbrella, an idea to design a temporary dental clinic is proposed. A prototype design of the temporary dental clinic is the main expected output of this research. The objective is to provide services for the community without being afraid of contracting the pandemic as the clinic will be isolated from the regular hospitals. There is an urgency to focus on this service as both dental patients and dental practitioners are at a higher risk since it is dealing with the mouth, which is the main source of Covid-19 transmission. This group also needs attention from healthcare sector management, practitioners, and the authorities.

The approach applied in this research emphasizes the concept that dental health is a service at a high risk of Covid-19 transmission and certain standards and protocols are mandatory to be deployed. This clinic will be different from regular dental clinics as it was designed specifically for pandemics standard procedures and protocols. This research has a high degree of urgency globally to enhance the standard and sustainability of healthcare service which does not only give benefit for Covid-19 pandemic in particular but also post-Covid scenarios or other possible global pandemics in the future.

2. Literature review

At the end of 2019, the world was shocked by the rampant outbreak which was named by the World Health Organization (WHO) as Covid-19. This epidemic quickly spreads around the world uncontrollably and hit about 1% of the worldwide population by 27 December 2020, which also gives significant effects on the socio-economic life of the global community [1]. The direct transmission from person to person particularly through respiratory droplets [2] is not only the main reason for the quick spread of the pandemic but also because it is transmitted through contaminated surfaces and by hands contacts [3]. Two years have passed, but this epidemic has not ended yet, even until this paper was written (at the end of 2021) this epidemic is continuing with the discovery of new, more virulent variants.

The most overwhelmed groups dealing with this pandemic are from the healthcare sector, medical practitioners, and their support systems. In particular, the dental health workers since the virus spreads through saliva and airborne aerosols [4], which are closely related to the dental health procedure and services. Although it is recommended to limit the dental service during the Covid-19 pandemic to only serious or emergency cases only [3], however, the demand of the public service for emergency dental cases during pandemics is still crucial [5]. There is an urgency to pay attention also to this group since both the dental practitioners and the patients have the same high risk of transmission. Therefore, it is not only hospitals that have to adapt to new procedures and protocols for Covid transmission, but also dental clinics.

Until recently, there are no specific standardized protocol guidelines were developed yet to prevent the transmission of Covid-19 in healthcare facilities [6] including for dental care services [7]. However, based on similar cases in the past such as Ebola and tuberculosis, the guideline for the design of healthcare services can be developed [6]. There are common principles that can be applied in designing dental care facilities. The main consideration is the function, besides accessibility and aesthetic aspects including the accessibility for patients and staff with special needs [8, 10]. Other aspects to be considered are circulation or activity flows, the system of ventilation, and controlling the aerosol generated from the dental treatments [1, 9, 10]. It is also important to design the zoning to ensure the flows of the activities that reduce the transmission risks [2, 6, 9, 10].

In term of the construction aspect, a temporary structure such as containers, tents, modules, inflatable, panels systems, is recommended [11], due to its flexibility, low maintenance, large capacity, and suitable for short to midterm use [10]. Not only the exterior structure, but the interior
design should be also well-considered. Often this aspect was ignored by the designer or architects which leads to the less efficient buildings [12]. This is the challenge as well as the opportunity at the same time for architects, interior designers, builders, and constructors to design pandemic-responsive dental clinics that follow the standard quality.

It is also critical for the worldwide authorities to maintain the healthcare system in an emergency such as the pandemics [12] due to the increasing number of transmittable diseases in the future [13]. There should be an assurance for the public to have safer facilities and sustainable healthcare services provided for them [13]. This is part of the action to achieve Sustainable Development Goals 3: “Ensure healthy lives and promote well-being for all at all ages” [14].

This pandemic is still not over yet. The world is still dealing with it and the future impacts and risks for the new pandemics are still high according to the UN report [14]. Not only achieving Goal 3, but providing disaster-responsive healthcare facilities is also part of the effort to achieve Goal 11 of Sustainable Development Goals, to ‘Make cities and human settlements inclusive, safe, resilient, and sustainable” [15]. All these efforts are also in line with Saudi Vision 2030 commitment to improve the healthcare standard facilities as well as enhancing the quality of service including in the prevention effort to reduce the spread of infectious diseases [16].

3. Methods
A prototype design of the temporary dental clinic is the main output from this research. The main objective is to provide services for the community without being afraid of contracting the pandemic as the clinic will be isolated from the regular hospital buildings. The data needed for this research are data on dental clinic programming, data on standard protocols and procedures for Covid-19 healthcare services particularly for dental services, and data on recent technology for temporary building structures. To achieve the objective, this research employed three approaches for the methodology. It was started with the desk study to review references on recent technology of temporary building structures. Then followed by the online questionnaire using the Google platform distributed to 206 registered dental practitioners in Aceh, in collaboration with the Indonesian Dental Association, Aceh Province, Indonesia who has experience managing the dental-care services during an emergency when Aceh was hit by the massive Indian-Ocean Tsunami of 2004. The questionnaire collected data related to dental clinic programming, required facilities, standards, procedures, and dental service protocols under the Covid-19 pandemic. This data was used as the main reference for the architectural design process. It helped the researchers to design a prototype design of a temporary dental clinic that is suitable for emergency purposes by using portable technology that is quickly built with easy deployment, and simple storage systems. The last approach was gathering feedback from dentists and international architects who are experts in building science and technology. This was done through a series of pre-design reviews.

4. Findings and design proposal

4.1. Findings
The research collected 206 responses to assess the condition and facilities needed for the pandemic situation. Responses with YES answers above 51% are considered as design strengths. Meanwhile, the responses with NO answers above 51% are considered as design weaknesses or aspects that need to be considered in designing the dental clinic for the pandemic situation. This research found that providing separated zones according to the case actions (such as those that produce aerosols and not produce aerosol) is the most important aspect of the programming of the clinic (76.2% NO answer). While the other facilities needed are the exhaust fan, glass or plastic divider for the registration area, air-tight self-closing for the examination room, walls painted with oil paint, epoxy, acrylic base or antibacterial paints. There is also a need for a special dressing room for the dentists and nurses. In general, this research found that the programming needed for the emergency dental clinic for a pandemic is categorized into four. First is the room facility that includes the emergency room, screening/examination/consultation room, service room for each section and ward. Second, the supporting room facilities: administration room, medical record room, pharmacy, radiology, dental
materials storage, sterilization room, and simple laboratory. Third, additional Facilities: doctors’ room, nurses’ room, personal protective equipment dressing room, and a patient’s waiting room. Fourth: compressor tool and waste disposal facilities.

4.2. Design proposal
Geo-Dent Care is the name given for the dental clinic proposed by this research (figure 1). It is a module of care unit that can be assembled and dissembled using the least skilled manpower. The rapid assembly of the unit is suitable for emergency cases particularly during pandemics like Covid-19. The module was designed in a way that certain openings have more control over the flow of users. Multiple units are also possible to be built altogether to create complete dental clinic facilities that can accommodate massive users. The unit is easy for repairing, replacing broken panels or components since it was designed in parts. Coming as a package, it can be distributed and shipped locally and internationally. The unit is made from polycarbonate panels with ribs creating the outside envelope of the unit. The triangulated ribs create resistance and strength to the structure (figure 2).

The geodesic dome was used for the structure with triangulated ribs that give more resistance and structural integrity. Dome is made from 4 different types of reparative panels for easy packing and assembly. The quantity of the panels ranges from 5-6. The panels are made from polycarbonate surfaces with aluminum ribs for structural integrity. Those panels create the outer envelope of this system. Using a joint system, the inner skin made out of flexible materials (leather or tensile structure) was attached to the outer envelope. It provides an interior environment that is easy for maintaining and a fast repair process. This is also to ensure hygiene and reduce the chances of contamination. The lighting will depend on both artificial and natural light through ventilation. If the weather helps, the ventilation can be open in the dome. The part that has an opening in the inner tensile skin of the structure will mesh so it will prevent insects from coming in, while at the same time letting the air and light flow and come in. The polycarbonate panels used are semi-transparent, this allows natural light to enter the unit. Since it is semi-transparent (not 100% clear) and they have some sort of diffuser, and create terminal a gap, which will benefit the unit (figure 3).
The circle nature of the structure provides an interior layout with a circular motion from the center where the examination chair was positioned. This allows easy movement around the space and creates smooth flows of the users inside the unit. There are 3 openings made to the units, two of them are designated to the patient for entry and exit the unit. The other opening is for the dentist's entry and exit. The nurse can use any of them. These openings are located at different sides of the module to ensure less interaction and to avoid jam points. The suspended lighting will be used for the artificial light for the unit. Another artificial light (attached or detached) is needed for the examination chair (figure 4).
Figure 5. Dental unit interior details (cabinet and utilities)

The interior cabinet was specifically designed to fit the unit shape or type of the module. The cabinet uses different joints that do not require a lot of fastening, and also it has openings for supplies of utilities including water, electricity, and sewer. The water supply is hidden and attached to the cabinet. There are openings in the tensile structure that can be sealed to have pipes for these supplies (figure 5).
The unit is divided into three different functions: dentist stations, nurse stations, and the examination care unit. The dentist station can accommodate only two dentists. Each dentist has two care units to work with. While waiting for the first patient to get ready, the dentist can check the other patient, or until the first room gets cleaned and sanitized. The nurse station will be in the middle of the zone. At least one nurse station is needed for each care unit and more than two nurses in the station. Nurses do not have a path for them because they are moving around, while patients and dentists have clear paths that have to be part of the assembly in the site. This sequence was designed to allow the continuing workflow, therefore, can serve the largest amount of patients in a short amount of time (figure 6).

The idea of the master plan is to create the flow of the users. The zones based on the urgency level were created to minimize the interaction of users thus reducing the chance of contamination. Each
dentist needs two modular units to increase productivity and reduce operation time (figure 7). Based on the screening results of patients, there are 5 categories of treatment proposed for this master plan: 1. Emergency management of life-threatening conditions; 2. Urgent conditions that can be managed with minimally invasive procedures and without aerosol generation; 3. Urgent conditions that need to be managed with invasive and/or aerosol-generating procedures; 4. Non-urgent procedures; and 5. Elective procedures. To respond to these treatment conditions, the care units were arranged in a specific layout (figure 8). The variables would be the distance between the care units, the circulation flow, location on the site, the design of the care units.

5. Conclusion and further research

Under the umbrella of Humanitarian Architecture, this research was designed as an integrated healthcare facility during the Covid-19 pandemic. It is divided into stages started with designing a temporary dental clinic first as there is urgency for this service. Geo-dent unit is the first outcome produced from this continuous research. The design proposal has been reviewed by the architect/building science experts as well as the dentists. Some detailed technical issues should be considered for the improvement of the design for the next steps of the design such as defining the deployment and storage system, assembly procedure, airflow circulation including (air conditioning and exhaust fan placement). In addition, the application of a negative pressure ventilation system and the air-tight (self-closing door) has to be well designed too, so that air exchange inside and outside the building is adequate. The most important thing is to design the airflow inside the unit to ensure the in and out air flowing as well so the aerosol and non-aerosol-based actions are controllable. Moreover, to accommodate the ergonomic needs of different users, the design of the furniture also needs to be flexible. Lastly, the foundation/base of the unit and ventilation/opening needs to be waterproof-designed to protect the unit from the water coming during rainy seasons, so the unit can be used worldwide in various climate conditions. The next stage of the research will be focused on the improvements of the design based on the feedback from the design review process. The design will also be expanded for the supporting facilities including administration room, medical record room, pharmacy, radiology, dental materials storage, sterilization room, simple laboratory, personal protective equipment dressing room, a patient's waiting room, compressor tool, and waste disposal facilities. The outcomes will be planned as a final prototype with the practical manual for users. Furthermore, the research will be continued and integrated later for other facilities including maternity clinic, children clinic, and elderly clinic to serve vulnerable groups (elderly, pregnant women, and children) as integrated healthcare facilities in the post-Covid-19 scenario or other possible global pandemics in the future. Not only to enhance the quality standard of medical care in KSA as committed in their Vision 2030 but also to ensure the sustainability of the public healthcare service worldwide which is part of the World Sustainable Development Goals.

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