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Earthquake Preparedness in The Dental Office

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ABSTRACT

An earthquake is an unpredictable and potentially devastating natural event typically caused by the movement of tectonic plates along fault lines, volcanic activity, or even human-induced events such as nuclear tests. This devastating event has been observed to possess the capability to trigger various secondary hazards, including ground shaking, soil liquefaction, landslides, fissures, avalanches, fires, floods, and tsunamis. Accordingly, in the context of a dental office, earthquakes pose significant risks to the structure of the building, dental equipment, as well as patient records, and can lead to electric shocks, malfunctioning of X-ray machines, exposure to radiating ionization, and fires, all of which can further result in severe injuries, disability, or death. To mitigate the effects of the outlined threats, earthquake preparedness within dental offices is crucial. This includes not only preparation before an earthquake but also the implementation of effective mitigation and evacuation strategies. Earthquake preparedness among dentists and dental staff is essential for safeguarding individuals present in the office, both patients and workers. Therefore, this form of preparedness should comprise risk reduction, evacuation plans, data restoration protocols, recovery efforts, and reconstruction strategies. It is also important to state that providing dentists and dental staff with targeted disaster response training can further enhance individual ability to respond effectively to natural disasters. Written safety and emergency procedures should be reviewed annually, as well as regular drills and practices are promoted to ensure readiness in the event of an earthquake.

Keywords: Earthquake, Preparedness, Mitigation, Reduction of Risk.

ABSTRAK

Gempa bumi adalah guncangan bumi yang mengancam dan tidak terduga, yang disebabkan oleh pergerakan antar lempeng tektonik di sepanjang garis patahan kerak bumi, aktivitas gunung berapi, atau uji coba nuklir. Gempa bumi dapat mengakibatkan guncangan tanah, *liquefaction* tanah, tanah longsor, retakan, longsoran salju, kebakaran, banjir, dan tsunami. Konstruksi bangunan klinik gigi, peralatan kedokteran gigi, catatan medis pasien, sengatan listrik, kerusakan mesin sinar X, radiasi ionisasi dan kebakaran dapat membahayakan dan mengakibatkan kecacatan serta kematian. Persiapan sebelum gempa, mitigasi dan evakuasi merupakan aspek penting dari kesiapsiagaan gempa di klinik gigi. Kesiapsiagaan gempa bumi di kalangan dokter gigi dan tenaga kesehatan gigi merupakan suatu kewajiban untuk mendukung upaya perlindungan diri dan pasien termasuk mitigasi, reduksi risiko, evakuasi, pemulihan data, pemulihan, dan rekonstruksi. Dokter gigi dan tenaga kesehatan gigi dapat diberi kesempatan mengikuti tambahan pelatihan dengan target agar memiliki respon yang lebih efektif terhadap bencana alam. Prosedur keselamatan dan darurat tertulis harus ditinjau setiap tahun dan praktik rutin dianjurkan untuk sering dilakukan.

Kata kunci: Gempa Bumi, Kesiapsiagaan, Mitigasi dan Reduksi Resiko

1. Introduction

An earthquake is a sudden and rapid shaking of the ground caused by the breaking and shifting of rock beneath the surface of the Earth. This event can lead to building collapses and disruption of gas, electricity, and phone services, as well as trigger secondary hazards such as landslides, avalanches, flash floods, fires, and tsunamis [1, 2]. Typically, during earthquakes, buildings with foundations on unconsolidated landfills, former waterways, or other unstable soils are particularly vulnerable. This natural disaster can occur at any time of the year, and when populated areas are affected, several casualties, injuries, and significant property damage are sustained. Based on observations, the majority of earthquake-related injuries are due to collapsing walls, flying glass, and falling objects caused by ground shaking, or people attempting to move during the shaking. However, much of the damage from earthquakes is both predictable and preventable [1, 3]. Between 2000 and 2020, Indonesia experienced 4,245 small, 38,092 light, 4,163 moderate, 52 large, and four catastrophic earthquakes [4]. According to a previous study, the total number of health facilities damaged by the natural event in Indonesia between 2010 and 2022 amounted to 2,348 units [5].

Dentists and dental staff must be prepared for earthquakes to protect both themselves and the patients present in the medical environment during such emergencies [6]. As stated in a previous study, earthquake preparedness is especially critical in hospitals, as these institutions are the primary locations to which the injured are referred [7]. Hospitals must maintain healthcare services during disasters, which requires thorough preparation [8]. This is particularly important because the absence of adequate prevention and preparedness can lead to severe tragedies, as hospitals are not only essential for disaster relief but also among the first institutions impacted by such events [9].

Preparedness refers to activities designed to establish mechanisms for rapid responses that are aimed at minimizing the risks and impacts of disasters [10]. It is widely recognized as the most critical phase in the disaster response cycle [11]. Accordingly, the World Health Organization (WHO) has emphasized the importance of three key components of disaster preparedness, namely structural, non-structural, and functional preparedness [12].

Considering the high frequency of earthquakes globally, particularly in Indonesia, it is essential to address earthquake preparedness within the healthcare system to ensure its ability to provide critical care during emergencies. Effective emergency response in this regard comprises ten key components, including 1) triage (risk identification and assessment), 2) clear communication protocols, 3) command and control, 4) disaster planning, 5) education, testing, training, and exercises, 6) logistics, equipment, and supply management, 7) surge capacity, 8) safety and security, 9) monitoring and assessing hospital disaster preparedness and relevant indicators, and 10) post-disaster recovery and restoration [13]. Therefore, this study aimed to briefly describe the preparedness of dental hospitals and clinics against earthquakes. By integrating the ten key components of preparedness, the investigation also aims to assist hospital managers and authorities in enhancing earthquake preparedness within medical centers [14].

2. Literature Review

The primary hazards faced by dentists and dental workers during an earthquake range from falling structural components or furnishings to inadequately secured materials, burns from fires caused by gas leaks or electrical shorts, and exposure to chemicals from stored or processed substances. Many of these hazards, both during and after an earthquake, are predictable and can be mitigated through proper hazard identification, planning, and risk reduction strategies, hence the importance of preparedness [12, 15, 16]. In dental offices, preparedness before an earthquake includes efforts to mitigate risks, protect patient records, secure supplies and equipment, as well as plan for potential partial or total destruction of the premises [15].

In line with previous investigations, all public service buildings, particularly healthcare facilities, are expected to have high standards of structural safety and earthquake resistance [3, 17]. Risk mitigation in these settings should include ensuring the seismic safety of both structural and non-structural elements of the facilities [18]. Dental offices, including hospitals, consist of non-structural elements, which constitute a complex network of specialized equipment, furniture, ducting, wiring, and mechanical fittings that are particularly vulnerable during an earthquake. In healthcare facilities, non-structural elements can account for 80% to 90% of the total value, dissimilar to typical office buildings. Therefore, it becomes important to comprehend that even if the building structure remains intact, the facility may be rendered non-functional due to damage to equipment, pipelines, partitions, and stored materials. According to previous studies, the

structural safety of healthcare buildings is the responsibility of the Public Works Department and building designers, but the risk management of non-structural components falls under the jurisdiction of the staff and authorities of the healthcare facility [12, 19]**.** The American Dental Association's Council on Dental Practice has developed specific guidelines for earthquake preparedness in dental practices [6]. However, there is limited additional literature, as dental clinics and dental hospitals are often considered integral parts of the broader healthcare system, with earthquake preparedness typically governed by hospital guidelines [20].

The mitigation of non-structural risks as one of earthquake preparedness in dental office includes a four-step process. Step I focuses on raising awareness and understanding of earthquake safety requirements. Dentists and staff must be sensitized and educated on safety measures, as well as the structural and non-structural components of the facility. Structural elements such as columns, beams, slabs, and walls bear the weight of the building, while non-structural elements, including windows, doors, stairs, partitions, and various building contents comprising furniture, medical equipment, water tanks, medical gases, pipelines, and electrical systems, do not [19].

Step II includes the identification of earthquake hazards within the hospital. Tall and narrow furniture, such as cupboards, shelves, and storage cabinets, as well as hanging objects, pose significant risks during an earthquake. These items can fall on individuals, block doors, passages, and exits, as well as obstruct evacuation routes. Items placed on wheels or smooth surfaces can roll and crash, those on shelves may fall and cause severe damage, and pipes may break, thereby disrupting the water supply [19].

Step III focuses on hazard surveying and prioritization. This includes reducing non-structural hazards with the assistance of engineers and technicians by relocating furniture and securing non-structural building elements, furnishings, and equipment to walls, columns, or floors. It is also essential to ensure that building exits remain unobstructed, easily accessible, and clearly marked [19]. Accordingly, the facility owner, dentist, or a designated staff member should be responsible for maintaining fire detection and alarm systems, as well as ensuring that fire extinguishers are in proper working order [6].

In the event of an emergency, an adequate number of exit doors should be sensibly located to facilitate quick evacuation. These doors must remain unobstructed and clearly marked. Doors that do not lead out of the dental office or building should be appropriately labeled, such as "Restroom," "Private Office," or "Closet," to avoid confusion. In this step, written escape procedures and clearly marked routes are mandatory components of emergency plans [6].

The availability of clearly marked-out roads is particularly important because obstructions such as file cabinets or boxes of supplies stacked high can significantly hinder egress from a dental suite, potentially causing tragic delays during an evacuation, especially if the office is plunged into darkness due to a power failure or if dense smoke from a fire develops. Supplies should be stored properly to avoid blocking doors, stairs, or hallways. Maintaining clear pathways is not only aesthetically pleasing to patients but could also be life-saving when a quick exit route is necessary or an alternate route must be used during an emergency as the impacts of earthquake in dental office consist of damage of structural integrity and its equipment, environmental pollution from medical waste, potential injuries, and mortality [6].

Step IV includes the reduction of non-structural hazards. All non-structural hazards should be systematically identified and prioritized as high, medium, or low priority, with actions taken immediately or as needed. This process comprises a thorough survey and categorization of all hazards in each area of the hospital, followed by appropriate mitigation measures. Hospitals or health facilities should establish a dedicated committee to carry out this task and continuously monitor progress. Systems such as automatic sprinklers, fire detection and alarm systems, as well as fire doors, must be maintained in proper working order and replaced according to manufacturer recommendations [6, 19].

The protection of patient records, computer data, and disaster recovery must also be carefully considered. Disasters such as floods, fires, or impacts (e.g., from falling trees or flying debris) that damage or destroy computer workstations or servers could lead to permanent data loss without reliable backups. Dentists using information and application systems to manage respective practices should perform daily backups of system data to safeguard and recover damaged records. This applies to all patient treatment information, whether stored electronically or in paper format, which should be stored offsite in a secure location that is safe from fires, floods, and other hazards [6]**.**

For dentists renting space, it is essential to have a lease agreement that adequately addresses "acts of God," such as fires, floods, or earthquakes. A properly drafted agreement will specify the responsibilities of both the dentist and the landlord concerning recovery and restoration. This ensures that the severity of the damage is mitigated, thereby reducing the potential impact on the ability of the dentist to continue business operations in the leased space [6].

3. Discussions

Preparedness for dentists, dental workers, and patients to respond to an earthquake is essential. Dentists and dental teams must be able to perform earthquake drills and mitigate risks within the dental office, including those associated with non-structural components. Preparedness in this context, comprises several key steps that must be followed before and during an earthquake [15, 21]. Accordingly, dental professionals must address knowledge gaps and time constraints in order to effectively mitigate and anticipate hazards and risks associated with earthquakes. In order to effectively address this gap, it is essential to enlist the help of professional hazard mitigation personnel, as these individuals can assist with conducting risk assessments and providing recommendations related to geographic location, potential risks, and relevant insurance considerations. For example, the implementation of earthquake-resistant building designs and structures is critical in districts with higher earthquake risks. In addition to facility preparedness, dental professionals must also plan comprehensively for the risks posed by environmental health consequences, such as water pipe leakage, mercury contamination, radiation, electrical hazards, sanitary damage, and the outbreaks of infectious disease. In addition, emergency preparedness kits should be readily available and equipped with essential supplies, including flashlights, fully charged batteries, a battery-powered radio, basic medical supplies, and non-perishable food and water to last several days. It is also important for employees to exchange contact and location information with family members before, during, and after a disaster event [17].

Some key actions that should be carried out during earthquakes include immediate hazard identification, removing hazards, and establishing safe zones. A safe zone could be under a sturdy table or desk, against an interior wall, away from windows, bookshelves, or tall unstable furniture. This is particularly important because the closer a person is to a safe place, the lower the risk of injury, and statistical data have shown that individuals who attempt to move more than 10 feet during an earthquake are more probable to be injured.

The "Drop, Cover, and Hold On" technique should be practiced regularly, ideally every six months. This technique includes dropping under a solid desk or table and holding on to one leg during earthquakes. It requires that individuals keep respective heads down, while also protecting respective eyes. Practicing these actions will help dental professionals adopt the measure as an automatic response, thereby reinforcing safe behavior. In many instances, hesitation occurs when individuals try to recall the appropriate actions during an earthquake but regular practice helps reduce this hesitation and improves response times.

Aftershocks are smaller earthquakes that follow the main shock and can cause further damage to weakened buildings. These smaller earthquakes can occur in the hours, days, weeks, or even months after the initial quake. It is also important to be aware that some initial tremors may be foreshocks, signifying the probability of the occurrence of a larger earthquake. During these natural events, it is essential that remain in respective safe places until all shaking has ceased, even if aftershocks continue. Subsequently, each individual is expected to assess respective conditions and address any injuries before assisting others, such as co-workers or victims. It is also advised that individuals move cautiously, keeping an eye out for hazards caused by fallen or broken objects [15].

When the emergency evacuation alarm sounds, all employees, visitors, and patients should exit quickly and carefully, following the emergency evacuation plan of the building. It is very important to state that elevators should not be used during emergencies as the technology may be damaged or malfunction. Those unfamiliar with escape routes may need guidance, especially disabled persons, children, the elderly, and individuals using wheelchairs or crutches. Furthermore, no individual should return to the area to retrieve personal belongings or attempt to fight a large fire [6, 21].

During earthquakes, a common phenomenon that occurs within a building is electric shock. Typically, electric shocks occur when a current of electricity passes through the body, causing sudden and painful reactions, including nerve stimulation and muscle contraction. This can lead to cardiac arrest, erratic heartbeats, paralysis of breathing, as well as burns to the skin and internal tissues [22, 23]. If an individual witnesses or

suspects an electric shock, it is important that the person avoids becoming a second victim by exercising extreme caution, especially in situations where the contact point or surrounding area is wet, as water conducts electricity. An individual in this scenario should ensure that the power source is deactivated by switching off the supply and also administer first aid only when under safe conditions [24, 25].

Immediately all staff, visitors, and patients have successfully evacuated, and everyone should be gathered at a predetermined location. Subsequently, firefighters should be informed on the scene about the presence and location of any compressed gas cylinders or large quantities of hazardous chemicals inside the facility. Such materials could intensify the fire or pose explosive risks, endangering both firefighters and building occupants [6,19]. It is also important to activate the Emergency Response Organization as needed and assist these organizations in the scene [6, 21].

After ensuring safety, the resulting damage, including structural integrity, potential injuries, and mortality should be assessed. Accordingly, equipment and materials should be evaluated, essential services provided, and infrastructure recovery activities initiated. Refrain from re-sterilizing flood-damaged, pre-packaged sterile products such as surgical gauze, paper points, gloves, or bandages, as these items are generally not guaranteed to be sterile once wet or exposed [6]**.**

Safety is an ongoing necessity for protecting people and the environment, both presently and in the future. Buildings of dental office must have an earthquake-resistant design with building structure quality that meets the technical requirements for earthquake-resistant buildings and is supported by adequate technical calculations involving parties who have capabilities in the field of building construction. Risks associated with ionizing radiation, particularly in the event of an X-ray machine malfunction or operational errors, such as a failure to terminate exposure, must be rigorously assessed and controlled [26]**.** Ensuring radiation safety is crucial while still allowing nuclear energy to contribute to equitable and sustainable development. Therefore, it is essential that governments, regulatory bodies, and operators worldwide ensure nuclear materials and radiation sources are utilized in a safe, ethical, and beneficial manner [25]. In the event of a nuclear or radiation emergency, potential exposure situations must be identified. Based on observations, these emergencies may arise due to (a) The energy from a nuclear chain reaction or the decay of its products or (b) Radiation exposure [25].

4. Conclusion

In conclusion, dentists and dental staff can enhance their effectiveness as responders to earthquakes and other natural disasters through additional targeted training. To further enhance the effectiveness of the employees, healthcare institutions are expected to review written safety and emergency procedures at least annually and practice the outlined protocols regularly. Subsequently, policymakers should identify and establish best practices, competencies, and Standard Operating Procedures (SOPs) for including dental health professionals in earthquake response and preparedness across all dental institutions. The undergraduate dental curriculum should also include specific competencies related to disaster management and mitigation, both at local and national levels, ensuring that dental professionals are well-equipped to handle these emergencies.

5. Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this study.

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