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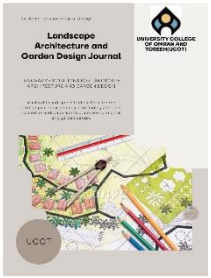

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Developing a Conceptual Model of Environmental Factors Affecting the Formation of Safe Room in Home

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Detailed abstract

Introduction

Security is one of the most fundamental human needs and an essential requirement for survival, stability, and quality of life. In recent decades, the increased frequency of natural disasters and human-made threats has made residential safety a major concern in architectural and urban studies. Events such as earthquakes, floods, storms, explosions, armed conflict, industrial accidents, and toxic releases have shown that ordinary housing often lacks sufficient protective capacity during emergencies. In response to these conditions, the concept of the safe room has gained importance as a practical architectural strategy for reducing vulnerability and improving household resilience.

A safe room is a specially protected space designed to provide temporary shelter during hazardous situations. Unlike ordinary rooms, it must preserve occupant safety, maintain a minimum level of functionality, and support emergency survival needs for a limited period. In residential architecture, safe rooms are particularly significant because the home is not only a daily living environment but also the first line of protection against external threats. A house that cannot protect its occupants in crisis cannot fully fulfill its social and human function.

Although many studies have addressed shelters, passive defense, and emergency accommodation, fewer have focused on the environmental and architectural factors that shape the formation of a safe room in residential buildings. Important questions remain regarding location, accessibility, spatial dimensions, ventilation, structural resistance, emergency equipment, and interior organization. This research addresses that gap by identifying the key environmental factors influencing safe room formation and organizing them into a conceptual model for residential application.

The aim of the study is to determine the main architectural, spatial, functional, and environmental indicators that affect safe room design and to integrate them into a practical framework that can support architects, planners, and policymakers in improving residential safety.

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Materials and Methods

This study used a qualitative approach and a descriptive-analytical method. The research was based on a library review and documentary analysis of scientific articles, books, technical reports, standards, and guidelines related to housing safety, passive defense, safe room design, and shelter planning.

The research process included several stages. First, the concepts of security, threat, housing, shelter, and safe room were examined to establish the theoretical framework. Second, previous studies and technical guidelines were reviewed to extract recurring design criteria and environmental requirements. Third, the extracted indicators were classified into thematic categories such as location, accessibility, dimensions, structural system, materials, ventilation, sanitation, communications, lighting, emergency supplies, permeability, and interior arrangement. Fourth, logical reasoning and comparative analysis were used to synthesize these categories into a conceptual model of safe room formation in residential buildings.

Because the study is conceptual rather than empirical, it does not rely on field measurement or occupant surveys. Instead, it integrates existing knowledge from architecture, crisis management, and shelter standards to develop a framework that can be adapted to different residential conditions and hazard scenarios.

Findings

The findings show that safe room formation depends on the interaction of multiple environmental and architectural factors, not on structural strength alone. Among these, location is the most important. The safe room should preferably be placed in the central part of the building, away from exterior walls and direct exposure to blast waves, debris, and external hazards. Interior rooms, corridors, storage spaces, basements, and enclosed spaces without windows may be appropriate if they meet safety criteria.

Accessibility is another essential factor. The room must be quickly and safely reachable by all residents, including children, older adults, and persons with limited mobility. The route should be short, direct, and free from obstacles. In emergency conditions, even a small delay can reduce protective effectiveness. Therefore, the design of access routes is as important as the design of the room itself.

Dimensions and capacity also play a major role. The room must provide enough space for the expected number of occupants while still remaining functional during temporary confinement. If the space is too small, crowding, stress, and discomfort may undermine its effectiveness. Thus, safe room capacity should be planned according to the number of users, the expected duration of occupancy, and the need for limited movement within the room.

Structural integrity and material quality are fundamental to physical protection. The safe room should be able to resist seismic loads, impact forces, debris penetration, and other emergency-related stresses. Reinforced concrete, strengthened masonry, steel framing, and properly designed connections contribute to higher resistance. Materials should be durable and impact-resistant, and brittle or hazardous materials should be avoided. In retrofit situations, the room should function as a “room within a room,” meaning that it remains structurally independent from surrounding spaces.

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Ventilation and environmental control are also critical. A safe room must limit the infiltration of smoke, dust, toxic gases, and contaminated air while maintaining acceptable indoor air quality. This requires controllable or independent ventilation, proper sealing around openings, and, when necessary, filtering measures. The balance between protection and air quality is one of the most important performance conditions of a safe room.

The study also highlights the importance of sanitary facilities, water storage, and emergency supplies. Even short-term sheltering becomes difficult without basic hygiene and hydration. Emergency equipment such as a first-aid kit, flashlight, fire extinguisher, emergency radio, backup batteries, and signaling devices improves the room's usability and increases occupant confidence during crises.

Communication and lighting systems are likewise necessary. Communication tools allow occupants to receive official instructions and remain connected with emergency services, while backup lighting supports visibility, reduces panic, and improves safety during power outages. These systems contribute not only to functionality but also to psychological comfort.

Another significant factor is permeability and enclosure quality. Safe rooms should have limited openings, controlled air exchange, and strong separation from exterior conditions. Rooms with few windows and tightly sealed doors provide higher protection. The quality of enclosure affects resistance against environmental hazards as well as the level of security and privacy inside the room.

Finally, interior organization and furnishing influence practical safety. Loose objects, unstable furniture, and fragile items can become hazards in emergencies. For this reason, the room should be arranged in a simple, secure, and uncluttered manner, with all necessary elements firmly fixed.

Based on these findings, the study proposes a conceptual model that links spatial, structural, environmental, and functional variables into an integrated framework for safe room design in residential houses.

Discussion and Conclusion

The findings show that safe room design is a multidimensional architectural problem. It cannot be reduced to wall reinforcement or emergency equipment alone. Instead, it requires the simultaneous consideration of location, access, structure, ventilation, emergency preparedness, and spatial organization.

One major conclusion is that the safest room is not necessarily the strongest one, but the one that combines structural resistance with accessibility, functionality, and environmental control. A highly resistant room that is difficult to reach or lacks ventilation, water, or emergency equipment may fail in practice. Therefore, safe room design should be approached holistically.

The study also indicates that residential safe rooms should, whenever possible, be integrated into everyday housing layouts rather than treated as isolated additions. Multi-purpose spaces that can be used normally but converted quickly during emergencies are often the most realistic and efficient solution. This is especially important in dense residential settings where space is limited and new construction may not always be possible.

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The proposed conceptual model demonstrates that the formation of a safe room depends on the combined effect of environmental factors. Location, accessibility, dimensions, structure, materials, ventilation, communication, lighting, sanitary provisions, emergency supplies, enclosure quality, and interior arrangement all contribute to performance. If these factors are considered together, the result is a safer and more resilient residential environment.

In the Iranian context, the study suggests that safe room criteria should be more clearly integrated into residential design practice. Designers are encouraged to allocate centrally located spaces with limited openings, secure construction, controllable ventilation, emergency equipment, and unobstructed access. Such spaces should also be planned for use by all family members, including those with physical limitations.

In conclusion, the formation of a safe room in a residential house is shaped by multiple environmental and architectural factors. The conceptual model developed in this study provides a useful framework for designing safer homes and strengthening household preparedness against both natural and human-made threats. It can serve as a basis for future empirical research, design guidelines, and policy development in residential safety, passive defense, and crisis management.

Declarations

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Conflict of Interest: The authors declare that they have no conflict of interest.

Authors' Contributions: Both authors contributed to the conceptualization, literature review, analysis, interpretation, and writing of the manuscript.

Data Availability: Data and materials used in this study are available from the corresponding author upon reasonable request.

Ethical Approval: This study was based on library research and documentary analysis and did not involve human participants or animals.

Keywords: Safe room; security, threat, housing, home, safe room