Indonesian Journal of Global Health Research
Volume 8 Number 6, December 2026
e-ISSN 2715-1972; p-ISSN 2714-9749
http://jurnal.globalhealthsciencegroup.com/index.php/IJGHR

EVALUATION OF THE EVACUATION ROUTE MAP ON THE 1ST FLOOR OF THE REGIONAL GENERAL HOSPITAL INTEGRATED SERVICE BUILDING AGAINST ISO 23601:2020

Kartika Wijayanti[1]*, Noorhadi Rahardjo[2], Bambang Hari Priyambodo[3], Diki Bima Prasetio[1]
[1]Master of Applied Occupational Health and Safety, School of Applied Sciences, Universitas Gadjah Mada, Gedung Teaching Industry Learning Center (TILC), Blimbingsari, Caturtunggal, Depok, Sleman, Daerah Istimewa Yogyakarta, 55281, Indonesia
[2]Master of Environmental Science Program, Graduate School, Universitas Gadjah Mada, Gedung Sekolah Pascasarjana Lantai 1, Jl. Teknika Utara, Pogung, Sinduadi, Mlati, Sleman, Yogyakarta 55284, Indonesia
[3]Department of Mechanical Engineering, School of Applied Sciences, Universitas Gadjah Mada, Jl Yacaranda Sekip Unit IV, Yogyakarta 55281 dan Jl Grafika No. 2A, Yogyakarta 55281, Indonesia
*kartikawijayanti1988@mail.ugm.ac.id

ABSTRACT
Evacuation route maps are essential visual safety media during emergency situations. However, compliance evaluations against the ISO 23601:2020 standard in regional general hospitals remain lacking. To evaluate the compliance level of the evacuation route map on the 1st floor of The Hospital based on ISO 23601:2020, identify the impact of visual safety gaps, and redesign the map. This study used a descriptive quantitative design to evaluate 6 map units using a checklist of 12 ISO 23601:2020 indicators and Guttman Scale data analysis. The evaluation showed that only 5 out of 12 indicators (41.67%) met the criteria (poor category), while 7 out of 12 indicators (58.33%) failed to meet them. Major gaps included the absence of "you are here" information, incomplete safety symbols, non-standard color usage, missing legends and emergency instructions, and outdated maps. A redesign was developed incorporating initial position markers, complete safety symbols, ISO standard safety color schemes, legend information, emergency instructions, mapping of 2 outdoor assembly point locations, and strategic placement recommendations. This redesign is expected to enhance safety communication effectiveness and serve as a reference for improving emergency response preparedness in other regional general hospitals.

Keywords: emergency; evacuation maps; evacuation routes; hospitals; iso 23601:2020 response

How to cite (in APA style)
Wijayanti, K., Rahardjo, N., Priyambodo, B. H., & Prasetio, D. B. (2026). Evaluation of the Evacuation Route Map on the 1st Floor of the Regional General Hospital Integrated Service Building Against ISO 23601:2020. *Indonesian Journal of Global Health Research*, *8*(6), 475–484. https://doi.org/10.37287/ijghr.v8i6.2698.

INTRODUCTION

Hospitals are public service facilities with a high level of mobility that are inhabited by users with diverse characteristics, ranging from health workers, patients, and ordinary visitors who are not familiar with the spatial layout of the building. As one of the major public service sectors in Sleman Regency, healthcare facilities serve a large and diverse population. Statistical data on population and healthcare facilities in Sleman Regency indicate the substantial demand for public health services in the region1. Regional public hospitals have a large and diverse number of visitors and patient waiters, which can hinder evacuation routes if not mapped properly. Integrated service buildings are one of the largest buildings in the hospital environment that integrate various health services centrally.

Evacuation maps have an important role to help ordinary users in understanding safety routes effectively. In emergency situations such as fires or natural disasters, the availability of visual safety communication media is an important instrument to direct all users to safe gathering points quickly, precisely, and in an orderly manner. Two-dimensional evacuation maps must be accurate, easy to understand, and correctly placed to help users exit quickly and safely2. Evacuation maps should also display gathering points by displaying signage and real orientation on location to accelerate

user understanding2,3. The existence of visual safety communication media in the form of evacuation maps must be able to provide information on the certainty of the user's position (orientation), guide intuitive evacuation route decision-making (wayfinding), and accelerate user response to safe gathering points without triggering bottlenecks or build-up on exit routes (Evacuation Efficiency).

In Indonesia, disaster management is regulated under Law of the Republic of Indonesia Number 24 of 2007, which emphasizes systematic, integrated, coordinated, and comprehensive disaster management, including preparedness and emergency response4. SNI 03-1746-2000 and Regulation of the Minister of Health Number 52 of 2018 stipulate that health service facilities must have evacuation routes, safety signs, gathering points, and light fire extinguishers5,6. The international standard ISO 23601:2020 regulates the design of evacuation route maps so that they are easy to understand by all building users. This international standard provides guidelines for the design and use of safety elements as well as the orientation principle of evacuation maps to the observer position, which shows the importance of visibility, understanding, and ease of recognizing evacuation routes in an emergency7. The application of the standard is expected to accelerate users' understanding of evacuation information in emergency conditions.

This study focuses on the evaluation of the evacuation route map on the 1st floor of the XYZ Hospital Integrated Service Building using the ISO 23601:2020 framework. The selection of the research focus at XYZ Hospital is based on the characteristics of the DIY area that has vulnerability to disaster risk as well as the dynamics of the density of health service facilities and local residents which have implications for the need for efficient safety facilities8–11. GPT RSUD XYZ is a 5-storey building, on the 1st floor which is used for outpatient polyclinics and various other service support activities such as radiology and pharmacy, so that there is a population of visitors and patient waiting who are unfamiliar with the layout of the building12. In the initial indication, the position of the map placement that is not strategic, the map that has not been updated since 2016, and the map that has not contained the mandatory elements of ISO 23601:2020 on 6 map units on the 1st floor, will have an impact on the risk of evacuation delays, so that the evaluation study at this location is the main point.

During emergency situations in hospitals, evacuation maps and signage play an important role in establishing spatial orientation for users. Previous studies on signage in healthcare facilities have shown that clarity and strategic placement of signage directly increase decision-making speed towards the exit and reduce user confusion in normal and emergency conditions13–15. Research on hospital signage shows that design that pays attention to the availability of information and ease of reading text has been proven to reduce confusion during evacuation3,13,15. There is a relationship between signage and evacuation plans that can affect the effectiveness of evacuation16–19. However, there are limitations in previous studies that have not clearly distinguished between the role of signage and standardized evacuation maps. Especially in hospitals, there have been no studies that evaluate the level of suitability of evacuation maps using the ISO 23601:2020 standard that supports the effectiveness of safety communication. The main objectives of this study are: (1) Measuring the suitability between the evacuation route map of XYZ Hospital with the requirements of ISO 23601:2020, (2) Identifying the lack of safety symbols on the evacuation route, (3) Developing a repair design design to improve the perfection of the evacuation route map in accordance with the ISO 23601:2020 standard. The results of this study are expected to be a reference for regional general hospitals that face similar challenges in improving preparedness through the implementation of the ISO 23601:2020 standard.

METHOD

This study uses a descriptive quantitative design to measure the level of suitability of the evacuation path map on the 1st floor of GPT RSUD XYZ. This design is used to describe the actual condition

of the evacuation path map through direct observation and compare it with the criteria in ISO 23601:2020. The research flow can be seen in Figure 1 of the following flow chart.

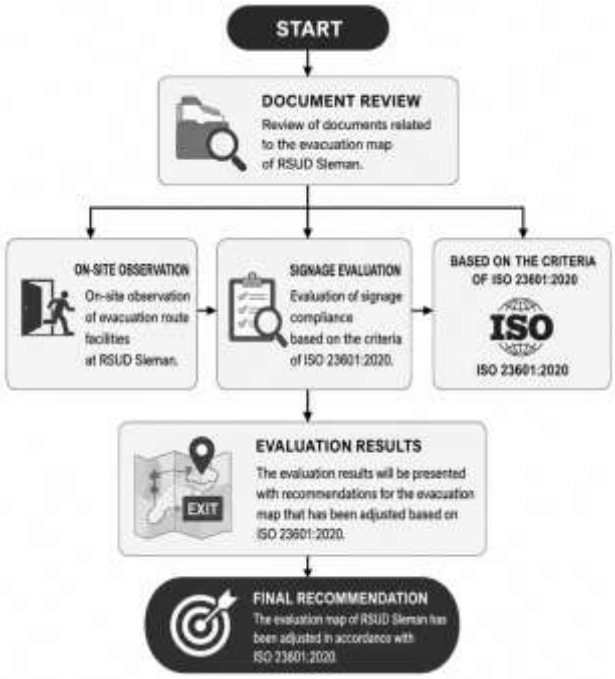

Figure 1. Research flow diagram

The location of the study is the 1st floor of GPT RSUD XYZ. The object of the research includes 6 units of evacuation route maps installed in the area. The selection of the location is based on the characteristics of the building which has 5 floors, as well as on the 1st floor which is an outpatient poly area and supports other health services in the form of radiology and pharmaceutical units, where there are various user groups with varying levels of understanding of the spatial layout of the building.

The research instrument is in the form of an evaluation checklist sheet containing 12 main indicators based on ISO 23601:2020 described in Table 1. The data obtained was analyzed in a comparative descriptive manner by comparing existing conditions to standard criteria. The results of the analysis were then categorized into appropriate and non-conforming.

Table 1.
Checklist of evaluation indicators based on ISO 23601:2020

No	ISO 23601 Criteria	Indicator
1	Orientation	Orientation according to the reader's point of view
2	User position	There is a "You are here" symbol
3	Safety symbols	There are safety symbols (emergency exit, evacuation route direction, assembly point, fire extinguisher and hydrant)
4	Color scheme	Safety color according to ISO
5	Background color	White background
6	Visualization of evacuation route routes	There are arrows
7	Floor number information	Information available
8	Legend information	Legends are available and easy to understand
9	Emergency instructions information	There is information on emergency directions including emergency contacts
10	Placement of evacuation maps	Placement in strategic locations
11	Map size	Size suitable, minimum A3
12	Map update	Maps are regularly updated/reviewed

RESULT

Based on the results of observations of 6 map units, as shown in Figure 2, it shows that most of the evacuation route maps at XYZ Hospital have not met the ISO 23601:2020 standard optimally. The available maps only provide basic information about the direction of the evacuation route, but do not contain a number of important elements needed to accelerate user understanding in the event of an emergency.



Figure 2. Existing evacuation route plan

Based on Figure 2 above, a gap with the ISO 23601:2020 standard is found, namely:

1. Not including a "You're here" marker: This makes it difficult for the user to determine the starting location and direction of movement to the nearest exit.
2. Does not include the location of fire extinguishers, hydrants and assembly points: Information on the location of safety equipment and assembly points is an important component because it is directly related to emergency response measures.
3. There is no legend information and emergency instructions yet
4. Inconsistency in the color of the evacuation route: On the map, red is used which is not in accordance with the provisions of the standard safety color.
5. There have been no improvements or changes to the evacuation map since 2016.

Conformity of the evacuation route map of RSUD XYZ with ISO 23601:2020 requirements

The level of conformity of evacuation maps to the 12 main indicators of ISO 23601:2020 can be described in Table 2 below.

Table 2.
The level of suitability of the evacuation route map at XYZ Hospital based on ISO 23601:2020

No	ISO 23601 Criteria	Indicator	Findings	Status
1	Orientation	Orientation according to the reader's point of view	Conform to the user's vision	Conform
2	User position	There is a "You are here" symbol	No "You're here" marker	Inappropriate
3	Safety symbols	There are symbols (emergency exit, evacuation route direction, assembly point, fire	Partially fulfilled, there is a symbol of the direction of the evacuation path	Inappropriate

No	ISO 23601 Criteria	Indicator	Findings	Status
		extinguisher and hydrant)		
4	Color scheme	Safety color according to ISO	Colors do not follow safety standards	Inappropriate
5	Background color	White background	White background	Conform
6	Visualization of evacuation routes	There are arrows	There is a directional line indicating the route to the emergency exit	Conform
7	Floor number information	Information available	There is information on the floor number	Conform
8	Legend information	Legends are available and easy to understand	No legends available	Inappropriate
9	Emergency instructions information	There is information on emergency directions including emergency contacts	No emergency instructions information available	Inappropriate
10	Placement of evacuation maps	Placement in strategic locations	Partially discovered	Inappropriate
11	Map size	Size suitable, minimum A3	A3 map size	Conform
12	Map update	Maps are regularly updated/reviewed	The map hasn't been updated since 2016	Inappropriate

Data analysis to determine the percentage of conformity on each map indicator is calculated using the following Guttman Scale approach:

$$P = \frac{f}{N} X\ 100\%$$

Description:

P = percentage of map suitability

f = total score obtained from the answer "Appropriate" (score 1)

N = total assessment indicators on the instrument

Based on the results of the assessment in Table 2, 5 of the total 12 assessment indicators were obtained in accordance with the results, so that the calculation was:

$$P = \frac{5}{12} X\ 100\% = 41{,}67\%$$

The percentage results obtained were then interpreted according to the assessment categories adopted from the relevant reference, as presented in Table 3[20].

Table 3.

Percentage score interpretation category[20]

Percentage score	Categories of interpretation
0 – 55%	Less
56 – 75%	Enough
76 – 100%	Good

The impact of the gap between the existing conditions of the evacuation path map and the ISO 23601:2020 standard is presented in the following Table 4.

Table 4.

The impact of the evacuation path map gap on the ISO 23601:2020 Standard

No	ISO 23601 Criteria	Consequences of the gap
1	User position	In an emergency, the building user must be able to quickly recognize his or her location before determining the evacuation direction. Visitors or patients who are unfamiliar with the hospital layout will take longer to understand the map if there is no initial position marker.
2	Safety symbols	The location of the fire extinguisher is needed as supporting information for officers or users who are trained in dealing with early stage fires. The gathering point serves as a safe final location for data collection and coordination after users leave the building.
3	Color scheme	The use of red for evacuation routes may cause confusion of perception in the event of an emergency. Users may mistakenly distinguish between the self-rescue route (which should be green) and the location of the fire extinguishing equipment (in red), potentially hindering the evacuation process.

No	ISO 23601 Criteria	Consequences of the gap
4	Legend information	The absence of legends causes the safety symbols on the map to not be clearly depicted by the building user. This can lead to misinterpretation of the function of the symbols or the route direction displayed.
5	Emergency instructions information	The absence of emergency action instructions and emergency contacts leaves users without guidance on the first critical steps to take in the event of an emergency, as well as making it difficult for users to immediately contact the internal emergency response team.
6	Placement of evacuation maps	Placing maps outside of strategic locations (such as not being near entrances, stairs, elevators, or main corridors) makes it difficult to find maps when needed. This can potentially cause users to miss important navigation information before taking self-rescue action.
7	Map update	Maps that have not been updated since 2016 show weaknesses in the safety information maintenance mechanism. Spatial changes that are not followed by map updates can create navigation blind spots and potentially lead users to paths that are no longer suitable.

Based on the results of the evaluation, the redesign of the map needs to contain the "You are here" symbol, the location of the fire extinguisher, the gathering point, legends, safety colors, and orientation according to the reader's position. These improvements need to be accompanied by a periodic update policy so that the map is always in accordance with the actual condition of the building.

Identify the safety symbols of the evacuation path map

Safety symbols on the evacuation route that are clear and easy to understand are indispensable in planning design because it greatly affects the ease of users in finding an exit route to a safe gathering point. The existing map in GPT RSUD XYZ does not yet have symbols in the form of emergency exits, evacuation route directions, gathering points, fire extinguishers and hydrants. Safety symbols in the form of arrows that indicate red directions are not in accordance with safety rules. Symbol recommendations can be shown in Table 5 below.

Table 5.
Safety symbols

Elemen	Recommended Symbols
Light fire extinguisher (fire extinguisher)	
Hydrant	
Fire alarm	
Emergency stair exits	
Gathering Points	
Evacuation routes	

Source: ISO 7010

The redesign of the evacuation path map design was prepared based on the findings on the non-conformity status and ISO 23601:2020 principles. This recommendation is focused on adding safety symbol elements, completeness of legend information and the location of the user's position, suitability of color schemes, and periodic data updates, as seen in Table 6 below.

Table 6.
Recommendations for improving evacuation maps

No	ISO 23601 Criteria	Recommendations
1	User position	Create a "You're here" marker
2	Safety symbols	Add a safety symbol
3	Color scheme	Color follows safety standards
4	Legend information	Create legend information
5	Emergency instructions information	Create emergency prompt information
6	Placement of evacuation maps	Evacuation maps are placed in strategic locations (main hallway, elevator, patient waiting room area)
7	Map update	Maps are updated and perform data updates

In the planning of evacuation maps, the color combinations that are often used are red and green. Green represents the elements of evacuation routes, safe routes and gathering points, and red for firefighting-related elements. In color theory itself, red and green are direct complementary (two colors that face directly on the color wheel) resulting in a high level of visual contrast (Hakim, 2012). Recommendations for safety color schemes are presented in Table 7 below.

Table 7.
Safety color recommendations for evacuation map design

Elemen	Color	Example colors
Evacuation routes	Green	00A650
Map background	White	FFFFFF
Location of the fire extinguisher	Red	D32F2F
Informational symbols	Blue	1976D2
Gathering point	Green	

Source: Encycolorpedia

The determination and mapping of gathering points in the outside area of the building is adjusted to the spatial layout of RSUD XYZ shown in Figure 3 below.

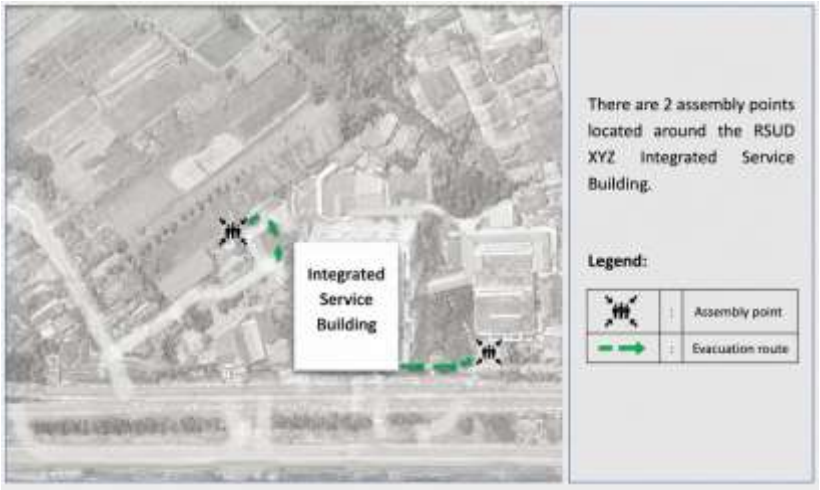

Figure 3. Satellite image of XYZ Hospital (Source: Google Earth)

The design principles developed include the use of a white background, a green evacuation route, consistent safety symbols, the orientation of the map according to the reader's position, the presence

of legends, the presence of a gathering point, the presence of the "You are here" symbol, a minimum A3 map print size, and adequate visual readability in the installation area, as presented in the following Figure 4.



Figure 4. Design of the evacuation route map on the 1st floor of Hospital

DISCUSSION

Based on the calculation results that show a figure of 41.67%, the suitability level of the evacuation path map in GPT XYZ is in the Less category and has several limitations in meeting the ISO 23601:2020 standard. These limitations have the potential to hinder the evacuation process, especially during emergency conditions that require quick decision-making. The non-compliant aspects include: the absence of user position markers, non-standard safety symbols and color schemes, missing legend information and emergency instructions, non-strategic map placement, and maps that have not been updated since 2016. These findings align with studies identifying legibility barriers in public facility evacuation maps-particularly in healthcare settings-which emphasize that the lack of "You Are Here" markers and non-standard safety symbols are consistently linked to low map legibility and potential disruptions to evacuation flow during emergencies (Hantari & Ikaputra, 2020; Sari & Bomo, 2023; Sarida et al., 2021).

Several studies also highlight the importance of strategically placing informative signage to facilitate orientation during evacuations. However, field evaluations reveal that many evacuation maps lack explicit position markers in crucial areas such as emergency exits, risking confusion and delaying emergency response times. This reinforces the urgency of implementing evacuation maps incorporating "You Are Here" elements, standardized symbols, and strategic layouts to accelerate the evacuation process in large-scale facilities, particularly hospitals (Kaplan & Pyayt, 2022; Sari & Bomo, 2023). An effective evacuation map design should incorporate: (1) clear "You Are Here" markers, (2) consistent and accurate safety symbols, (3) integrated evacuation route maps featuring exit signs and assembly points, and (4) signage placement in critical locations with adequate color contrast-all supported by literature on wayfinding and modern signage (Ginting & Adriansyah, 2019; Hantari & Ikaputra, 2020; Puspitasari & Darmawan, 2013; Sari & Bomo, 2023). The primary contribution of this study lies in its in-depth analysis based on the 12 specific criteria of ISO 23601:2020 within a regional general hospital environment. Furthermore, this research not only maps conceptual gaps but also formulates redesign recommendations for ISO 23601:2020-compliant maps, equipped with user location markers and structured emergency instruction procedures.

CONCLUSION

The evaluation results indicate that the compliance level of the evacuation route maps on the 1st floor against the ISO 23601:2020 standard remains in the Poor category, fulfilling only 41.67% (5 out of 12 indicators). Major gaps identified include the absence of user position markers ("you are here"), incomplete safety symbols, non-standard color schemes, missing legends and emergency instructions, and maps that have not been updated since 2016. These deficiencies directly contribute to increased directional confusion among building occupants, risk delaying emergency response times, and hinder efficient decision-making during crisis situations.

To address these obstacles, a redesigned map based on ISO 23601:2020 was successfully developed, incorporating initial "you are here" position markers, directional evacuation routes to two outdoor assembly point locations, high-contrast safety color schemes (red and green), complete symbol legends, structured emergency action instructions, and strategic placement recommendations. This redesign is expected to enhance the effectiveness of visual safety communication at RSUD XYZ while serving as a practical reference for other regional general hospitals to sustainably strengthen emergency response preparedness.

REFERENCES

Al-Sharaa, A., Adam, M., Nordin, A. S. A., Mundher, R., & Alhasan, A. (2022). Assessment of wayfinding performance in complex healthcare facilities: A conceptual framework. Sustainability, 14(24), Article 16581. https://doi.org/10.3390/su142416581

Arikunto, S. (2013). Prosedur penelitian: Suatu pendekatan praktik. Rineka Cipta.

Badan Penanggulangan Bencana Daerah Daerah Istimewa Yogyakarta. (2026). Data kejadian bencana Kabupaten Sleman periode 2021–2026. BPBD DIY.

Badan Pusat Statistik Kabupaten Sleman. (2025). Kabupaten Sleman dalam angka 2025. BPS Kabupaten Sleman.

Badan Standardisasi Nasional. (2000). Tata cara perencanaan dan pemasangan sarana jalan keluar untuk penyelamatan terhadap bahaya kebakaran pada bangunan gedung (SNI 03-1746-2000).

Chan, W., & Armenakis, C. (2014). 3D building evacuation route modelling and visualization. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XL-2, 221–226. https://doi.org/10.5194/isprsarchives-xl-2-221-2014

Ginting, N., & Adriansyah, W. A. (2019). Penataan tata informasi di Bukit Lawang sebagai pengembangan wisata berkelanjutan. Talenta Conference Series: Energy and Engineering (EE), 2(1), 1–6. https://doi.org/10.32734/ee.v2i1.419

Hantari, A. N., & Ikaputra, I. (2020). Wayfinding dalam arsitektur. Sinektika: Jurnal Arsitektur, 17(2), 96–104. https://doi.org/10.23917/sinektika.v17i2.11561

Jialu, Z., Ujang, N., Manan, M. S. A., & Aziz, F. A. (2026). Wayfinding signage and walking perception in urban environments: A human factors and ergonomics framework based on a systematic review. Human Factors and Ergonomics in Manufacturing & Service Industries, 36(3), Article e70043. https://doi.org/10.1002/hfm.70043

Jumadi, J., Carver, S., & Quincey, D. J. (2019). An agent-based evaluation of varying evacuation scenarios in Merapi: Simultaneous and staged. Geosciences, 9(7), Article 317. https://doi.org/10.3390/geosciences9070317

Kaplan, H., & Pyayt, A. (2022). Development of user feedback-based optimized encoding system for 3D-printed tactile maps. Disabilities, 2(3), 379–397. https://doi.org/10.3390/disabilities2030027

Kausar, D. R., Rosmalia, D., Imran, S., & Stevenson, N. (2018). Developing tourism industry and host community resilience through crisis and disaster management planning. International Journal of Academic Research in Business and Social Sciences, 8(16), Article 5119. https://doi.org/10.6007/ijarbss/v8-i16/5119

Ma, X., & Li, J. (2024). Design of emergency evacuation route for large buildings based on cloud computing and GIS big data. Journal of Intelligent & Fuzzy Systems, 46(4), 9975–9986. https://doi.org/10.3233/jifs-237834

Peraturan Menteri Kesehatan Republik Indonesia Nomor 52 Tahun 2018 tentang Keselamatan dan Kesehatan Kerja di Fasilitas Pelayanan Kesehatan. (2018).

Prakoso, S. G., Wijaya, A. A., & Putra, F. A. A. (2022). Indonesia's disaster resilience against volcanic eruption: Lessons from Yogyakarta. KnE Social Sciences, Article 10544. https://doi.org/10.18502/kss.v7i5.10544

Pratiwi, P. E., & Prastisho, W. (2025). Systematic literature review: Healthcare professionals preparedness factors in hospitals fire disasters in Indonesia. IOP Conference Series: Earth and Environmental Science, 1479(1), Article 012057. https://doi.org/10.1088/1755-1315/1479/1/012057

Puspitasari, D. G., & Darmawan, J. (2013). Signage dan penerapannya: Lingkungan Jalan Raya Tol Bintaro. Humaniora, 4(1), 475–484. https://doi.org/10.21512/humaniora.v4i1.3456

Rahmawati, F. (2025). Analysis of evacuation route and fire safety in main library university building. Arsitektura, 23(2), Article 109839. https://doi.org/10.20961/arst.v23i2.109839

S., L. M., N. R., N. G. E., N., N. T., A., H. R., P., B. A., & Tangdi, D. B. (2023). Preparedness for fire emergency in the nutrition laboratory at University X in Semarang: As a safety education for university students. Journal of Safety Education, 1(1), 22–28. https://doi.org/10.15294/jse.v1i1.70320

Sahoo, B., Pillai, J. S. K., Md, S., & Sahoo, M. C. (2024). Implementation of wayfinding signage in public hospitals and its evaluation towards quality improvement. Cureus, 16(7), Article e65435. https://doi.org/10.7759/cureus.65435

Sari, P., & Bomo, D. P. (2023). Evacuation system as a route guide on signage at Jakarta International Stadium. Proceeding International Pelita Bangsa, 1(1), 27–36. https://doi.org/10.37366/pipb.v1i01.2678

Sarida, L. F., Yunus, M., & Puspitasari, S. T. (2021). Analisa fasilitas safety building sebagai upaya pencegahan kebakaran di Gedung Fakultas Ilmu Keolahragaan Universitas Negeri Malang. Sport Science and Health, 3(10), 826–837. https://doi.org/10.17977/um062v3i102021p826-837

Undang-Undang Republik Indonesia Nomor 24 Tahun 2007 tentang Penanggulangan Bencana. (2007).

Wigati, S. S., Sopha, B. M., Asih, A. M. S., & Sutanta, H. (2023). Geographic Information System based suitable temporary shelter location for Mount Merapi eruption. Sustainability, 15(3), Article 2073. https://doi.org/10.3390/su15032073

Zheng, M.-C., & Chen, C.-I. (2023). Design and evaluation of radiation disaster prevention map based on evacuation behavior. Heliyon, 9(8), Article e18892. https://doi.org/10.1016/j.heliyon.2023.e18892