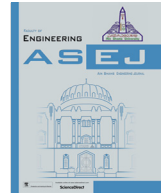




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The impact of COVID-19 on visitors' wayfinding within healthcare centers

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ABSTRACT

The novel COVID-19 pandemic has caused substantial calamities in developing countries such as Iran, which initially suffered from inadequate infrastructure essential for the pandemic control. Due to the ongoing development of this malady, healthcare centers are recognized as one of the most significant hotspots within public settings so they are directly pertinent to the physical and mental health of visitors. The main objective for conducting the present study is to investigate the impact of the COVID-19 pandemic on the visitors' wayfinding procedure within Qa'em hospital, located in Rasht, northern Iran. The adopted methodology in the present study is based on a comparison between the collected data regarding the wayfinding behavior of visitors before and after the outbreak of the COVID-19 pandemic using mixed methods, namely Space Syntax, gate counting, people following, and semi-structured interviews. The obtained empirical results displayed that visitors were significantly confused and hesitant throughout their wayfinding process after the outbreak of the pandemic. Indeed, spatial accessibility and legibility were not found to be adequate for facilitating the wayfinding of the visitors. Moreover, the requirements for the reconfiguration of furniture layout in the waiting areas, according to the underlying notions of social distancing, became conspicuous as the pragmatic implications for the post-pandemic healthcare centers.

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1. Introduction

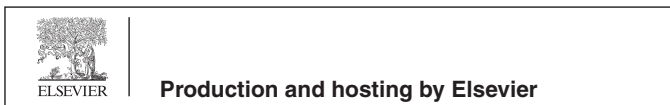
COVID-19 (the Coronavirus disease 2019) impacts the population's physical health, and has implications for their social and emotional functioning [1]. The ongoing virus is frighteningly caus-

ing enormous disruptions all over the world [2,3]. Due to the fear of infection, the epidemic has transformed our built environment [4] and subsequently, it has significantly affected the presence of people in their public life [5]. Consequently, once the COVID-19 pandemic gets under control, the built environment will never be the same. Although the current worldwide epidemic has been posing a challenge at all levels of the built environment, it will certainly take time to mitigate the potential risks, or stop the virus from spreading, by making an antiviral-enabled paradigm [6]. The COVID-19 pandemic has wreaked havoc on a variety of factors such as societal and cultural [7], socio-economic [8–11], socio-psychological [12–14], socio-environmental [15–17], human mobility behavior [18–21], and emotional stress or disorders [22–24]. Previous research confirms that during all phases of the design process, thorough attention should be paid to the physical, social, and psychological requirements of individuals in order to

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avoid future disabling conditions caused by overwhelming COVID-like situations [25].

Close proximity to other individuals, without wearing face masks and especially during social activities such as talking, singing, shouting, or while sneezing and coughing, initially emerged as a potentially serious factor for escalating disease transmission [26,27]. However, the concept that wearing face masks can certainly aid the society to minimize the risk of transmission of any respiratory virus still remains controversial [28]. Several studies have confirmed that morphological characteristics of the built environment can be modified to mitigate the risk of COVID-19 transmission [29,30]. Chief among them are crowding indoor spaces far more than outdoor ones [31,32]. Crowded indoor places such as prisons, churches, dormitories, buses, work places and healthcare centers were implicated in outbreaks [32–34]. Due to the fear of becoming exposed to COVID-19, such crowded environments cause panic and distress among individuals [35,36].

This is particularly applicable in hospital settings, where the COVID-19 disease can impose stress on a variety of facets such as wayfinding, accessibility and comfort, and consequently influence users' mental health during emergency situations [25]. As a result, crowd management in these environments has the potential to shape users' perceptions and avoid major problems [37,38]. In the meantime, wayfinding is the process of reaching a predetermined destination, which involves adopting special behavioral patterns in order to navigate between the two points of origin and destination [39,40]. Since the procedure of wayfinding is directly related to enhancing the efficiency of space, and its psychological effects on human life [41–43], the significance of investigating the impact of this novel pandemic on the wayfinding procedure of people becomes more profound than ever before.

Despite the fact that more than two years have passed since the advent of the novel coronavirus in Iran, this country still faces wide-ranging challenges in managing and controlling the pandemic. Considering the prohibition on the import of western vaccines due to political issues, the process of vaccination in this country was substantially procrastinated compared to other neighboring countries. At the time of conducting the present research, only about 37% of the country's population was fully vaccinated, and there is still a significant gap in achieving the 80% confidence level. According to evidence, the novel COVID-19 pandemic will continue in developing countries such as Iran, which has inadequate infrastructure for pandemic control. At the moment of conducting this study, Iran is on the margin of arriving at the sixth peak of the COVID-19 pandemic, and it seems that once again, the breakout will cause several calamities by targeting the unvaccinated population.

In this regard, observance of hygienic protocols, in particular within public spaces, is still deemed to have the highest priority in order to impede the outbreak of the pandemic in Iran. Hence, the process of the psychological impact of such protocols, such as the use of face masks on people's behavioral patterns, constitutes challenges to the general public [44,45]. It seems that such constraints and their consequent psychological effects have a significant impact on two the factors of *pedestrian's mobility* and their *ability of wayfinding* within public places, such as healthcare centers, that characterize an intricate spatial configuration structure. On the other hand, due to the ongoing trend of this malady, hospitals and healthcare centers are recognized as the most significant hotspots within public settings. This fact is directly pertinent to the physical and mental health of visitors.

Previous literature has acknowledged that the process of visitors' wayfinding within hospitals has NOT been conducted in a straightforward approach, which may intensify the public's level

of anxiety and stress [46,47]. Accordingly, due to the emergence of an intervention variable (COVID-19), it is considered indispensable to investigate the impact of this pandemic on the process of visitors' wayfinding. The primary aim followed by conducting the present study is to investigate the impact of the COVID-19 pandemic on visitors' wayfinding process within the studied healthcare center in Rasht, northern Iran. Thus, the following questions are proposed in order to acquire the appropriate responses: 1- What is the impact of COVID-19 on the mobility of visitors within the studied healthcare center? 2- What is the influence of COVID-19 on visitors' wayfinding procedures within the studied healthcare center during pandemic periods?

1.1. Literature review

So far, a number of studies have previously been conducted on factors affecting hospital resilience in confronting COVID-19 in Iran. Moreover, some sorts of management strategies to control the crisis of COVID-19 in terms of the optimum usage of all forces and hospital equipment were reported [48,49]. However, there are very limited sources available regarding the architectural attributes of healthcare centers, or even indoor spaces, to investigate the impact of pandemics on users' (particularly visitors) perception. Most of the studies which have been driven on the healthcare environment have concentrated on the correspondence between COVID-19 and patients or staff [50–52]. Meanwhile, the impact of COVID-19 on the visitors' movement behavior within healthcare centers has NOT yet been sufficiently addressed.

It should also be noted that no research has been carried out related to architectural spaces during the COVID-19 pandemic that would compare individuals' movement behavior before and after the pandemic. All the results obtained from previous research are about providing some architectural design solutions and strategies in order to enhance social distancing [6,53–55], providing the state of equilibrium between social distancing and social interactions [56], infection control [57–60] and spatial perception [61–64]. While in this paper, the impact of the COVID-19 pandemic on visitors' wayfinding experiences has been scrutinized in order to compare the acquired data before the outbreak, and during the outbreak of COVID-19 within healthcare centers. To do so, attempts have been made to investigate whether the COVID-19 pandemic has altered human behaviors and wayfinding experiences within architectural spaces. Therefore, the present study has endeavored to bridge the identified scientific gap as its contribution to the scientific body of knowledge.

2. Material and methods

The adopted procedure in the present study is based on a comparison between the acquired data regarding the wayfinding behavior of visitors before and after the outbreak of COVID-19. Thus, the research method in this study characterizes a mixed approach encompassing both quantitative and qualitative procedures. In the following subsections, the method of implementing each adopted procedure is explained meticulously.

2.1. Spatial configuration analysis using space syntax

The analytical approach commenced with respect to the spatial configuration of the case study in order to identify the characteristics of the studied hospital based on the notion of Space Syntax. In this regard, in its initial stage, simulation analysis has been accomplished based on axial, convex and visibility graph analysis (VGA) by drawing the architectural plan of the hospital in AutoCAD

2010, and importing it into the Depthmap 10 software. In the axial analysis, there are some variables such as *integration*, *connectivity*, and *intelligibility* which have an influential role on the wayfinding behavior of visitors. In this term, a higher numerical value of *integration* within a space is an indicator of the frequent usage of that space by visitors [65]. While a higher quantitative value of *connectivity* is an indicator of better accessibility within the spatial configuration structure [66]. Consequently, the correlation between *connectivity* and *integration* results in spatial *intelligibility*. Multiple studies have validated that a higher degree of correlation indicates a higher level of spatial legibility [67–71]. Also, numerous studies have substantiated the crucial role of spatial legibility and accessibility on facilitating the wayfinding process within the built environment [41,72–76].

On the other hand, there are some variables in the VGA which have an influential role on wayfinding behaviors, such as *visual integration*, *visual clustering coefficient (VCC)* and *visual entropy*. According to Turner (2001) [77], VCC indicates the proportion of vertices which are connected within the proximity of the current vertex, compared to the number that could possibly be connected. In other words, a higher value of VCC illustrates *pause points* within the built environment [77,78]. Also, visual entropy can be used to address the degree of complexity in a spatial configuration system regardless of its geometric features. The value of visual entropy can be increased through of an augmentation of spatial variety. Thus, visual entropy can present an outlook toward how ordered the configurational system is [77].

2.2. Empirical observations

In the next step of the analytical approaches, empirical observations, namely the *gate count* and *people following* methods, have been adopted. The main objective of using the *gate count* method is based on the following reasons: Firstly, the consistency between the findings of the syntactical simulation and the reality; and secondly, the acquisition of visitors' mobility within the hospital. In the meantime, the main objective of using the *people following* method is to collect a set of empirical data to pursue the wayfinding behavior of visitors from an origin to a certain destination, and their possible transformations within time and space. In addition, it provides a suitable platform to measure the level of consistency with VGA outputs in the syntactical analysis. It is worth pointing out that since the focus of this study is on the visitor's wayfinding behaviors, the conducted empirical observations have been carried out in the ground floor of the hospital.

2.2.1. Gate count observation method

The *Gate Count* method refers to a procedure that normally measures the level of density of pedestrian movement flow within a built environment. It allows scholars to gather a great deal of data in respect to the level of mobility in the form of a quantitative analysis. The location of gates can usually be determined based on a wide variety of low-integrated, integrated, and high-integrated spots within the studied public space. The collected data should be obtained based on the provision of maximum visual field in order to count the people who cross the imaginary gate lines. In this research, eight gates have been determined based on the variety of functions, as well as the integration level in the ground floor of the hospital. Ultimately, the obtained quantitative data from the gate count method before and after the outbreak of the COVID-19 pandemic were compared using the Statistical Package for Social Science (SPSS) software. Hence, the *t-test* was used to compare the independent groups with parametric data in order to figure out whether there is a significant difference or not.

2.2.2. People following observation method

People Following is a qualitative observational method which provides an opportunity to obtain the movement behavioral patterns of individuals. Also, it has been considered as a potent procedure to assess the wayfinding behaviors of people within the built environment. This method is applicable within urban spaces, as well as in buildings; in that the origin to a destination movement behaviors of people should be followed to capture any sort of confusion, pause and hesitation during the wayfinding process. Intrinsically, this method can be considered as a dynamic observation technique, and the participants should be selected indiscriminately in order to rule out the chance of being biased. Accordingly, the movement pattern of each individual has been recorded and depicted on the printed plan of the hospital. Each individual's motion path has been recorded using a specific color in order to avoid indistinguishable movement patterns. Finally, the observed patterns obtained from tracing methods before and after the outbreak of the COVID-19 pandemic are compared inferentially. It is important to note that the sample size developed in this qualitative method consisted of 50 participants including 25 women and 25 men in an attempt to control the gender equity of the sample population.

2.3. Qualitative semi-structured interviews

Ultimately, a set of qualitative semi-structured interviews (SSIs) has been utilized as an instrument that aids describe the quantitative findings meticulously. Interviews can be considered as one of the most common procedures in social and behavioral sciences to validate and support the accuracy of research data. In this research, it was intended to utilize SSIs because of their flexible and open-ended nature. SSI is a verbal interchange during which the interviewer attempts to elicit the required information from the participants who are involved in the case study by asking a number of predetermined questions. Based on the evidence, the focus group in this method can be flexibly variable, ranging from 6 to 12 participants, and the process of interviewing can be continued until adequately saturated responses have been received [79,80]. Therefore, the sample size in this study reached theoretical saturation when it came to inquiring 11 participants. The interviews were conducted on individuals who had attended the studied healthcare center at least once after the outbreak of the pandemic. The study also considered different races (foreign: 3 and local: 8), genders (male: 5 and female: 6) and ages (teenager: 2, adult: 6 and senior: 3).

Face-to-face semi structured interviews are conducted to identify and describe the impact of COVID-19 on visitors' behaviors, feelings and wayfinding. The interviews, lasting approximately 15–30 min, took place in the lobby of *Qa'em Hospital* during visiting hours (3–5 pm), and were carried out during a 5-day period. Accordingly, after inquiring some personal information, the interviewees were presented with the main questions, which consisted of three categories including general, psychological, and wayfinding inquiries. The proceedings of the SSIs were audio recorded in order to focus more on interactions that were taking place during the interviews. Also, by transcribing the interviews' content, it has been attempted to extract required data as an influential approach to elicit identified codes within the analysis process using NVivo 12. It should be noted that ethical issues, including the participants' confidentiality and anonymity, have been carefully considered in this study. The interrelations of all the adopted procedures, as well as their role on the functional flow of the present study, have been depicted below (Fig. 1). It should be noted that as one of the most important healthcare centers in the north of Iran, *Qa'em Hospital* (Fig. 2) was determined as the case study to assess the possible transformations developed in this study.

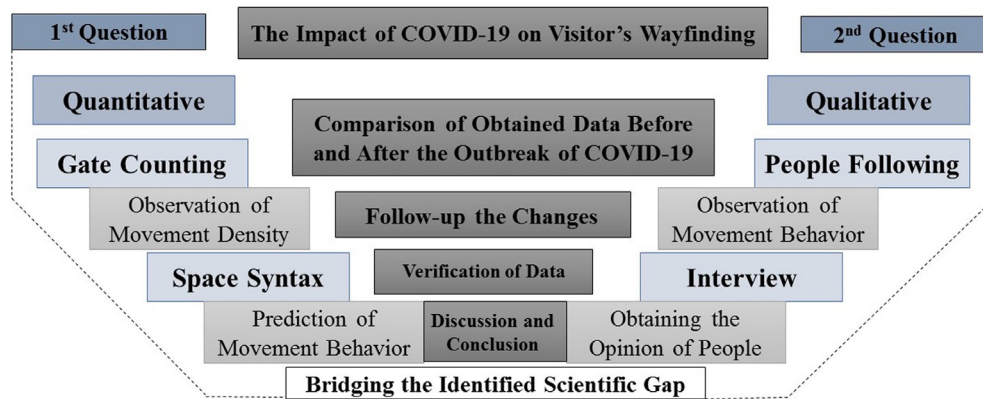


Fig. 1. The functional flow of the present research.

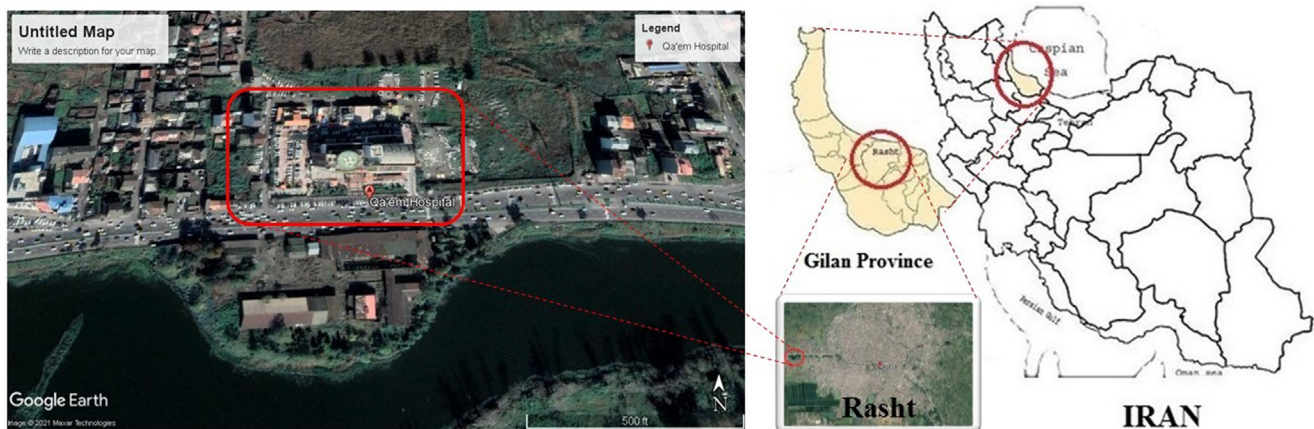


Fig. 2. Location of the case study on the map (Study Area, Rasht, Gilan Province, Iran).

3. Research findings

This section represents the required data in relation to the gate count and people following, coupled with the VGA and axial map analysis of the identified healthcare center in Rasht, northern Iran. In respect to the syntactical analysis, a warmer color demonstrates a higher quantitative value, while a colder color indicates a lower numerical value in the syntactical analysis. Ultimately, the simulated analysis models have been generally compared with the reality obtained from direct observations and the qualitative SSI.

3.1. Spatial configuration analysis using space syntax

In this subsection, the obtained data in relation to the spatial configuration analysis using the Space Syntax method has been presented. The general analysis obtained from the syntactical analysis of the present study consists of three major steps, namely axial, convex and VGA. The three major analyses of the axial map including *integration*, *connectivity*, and *intelligibility*, which featured an influential role on the process of wayfinding within the built environment, have been concentrated on in this study. The findings of the simulation analysis indicated that the lobby space, with the quantitative value of 8.50, featured the highest value of integration. Also, this space, with the numerical value of 108, is considered to be the most connected space in the spatial configuration analysis. It is worth bearing in mind that based on the prognostication of the simulator software, due to the linear organization of the case study, a perpendicular axis toward the main entrance of hos-

pital creates the most crowded gatherings. Also, the level of correlation between integration and connectivity indicated that the value of R^2 is equivalent to 0.88, which delineates the high level of intelligibility (Fig. 3). This fact reveals the high level of spatial legibility according to the spatial configuration analysis, which provides a suitable platform for the wayfinding of visitors.

The findings obtained from the VGA analysis suggested that the lobby space, which is located in front of the main entrance, featured as the most visually connected space with the numerical value of 955. This is despite the fact that the most visually integrated space, with the quantitative value of 7.20, is located in the emergency ward. Next, the lobby, with the numerical value of 6.93, and the reception space, with the integration value of 6.80, are considered as the most visually integrated spaces, respectively. The results obtained from agent-based analyses have also indicated that the lobby space, with the numerical value of 489, featured the most potential space. Also, spaces such as the vicinity of the reception desk and the emergency ward, with the quantitative values of 478 and 453, are considered as the next priorities, respectively. The obtained simulation analysis from the visual entropy illustrated an acceptable range of regularity within the lobby space. Meanwhile, according to the spatial configuration analysis, some spaces such as the threshold of the entrance and the threshold of the vertical circulations, with numerical values of 2.21 and 2.19, are considered to be the most intricate spaces, respectively. Ultimately, the findings obtained from the VCC indicated that the entrance space, with the quantitative value of 0.84, and the reception desk, with the quantitative value of 0.75, are considered to be the highest potential spaces for visitors to

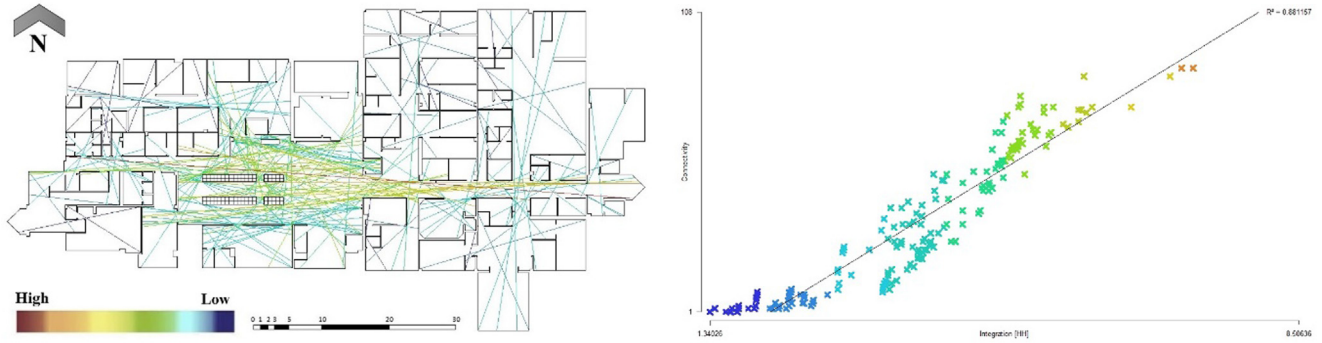


Fig. 3. Axial map analysis and the intelligibility value of the hospital.

pause (Fig. 4). It should be noted that the main concentration of the analysis is based on the spaces visitors normally encounter on their way to their target destination.

3.2. Gate count analysis obtained from empirical observations

In this subsection, the data obtained from gate count analysis before and after the outbreak of COVID-19 have been presented. The observations were conducted at a specific time between 3 pm and 5 pm (visiting hours), during which the intended hospital spaces are usually overcrowded with patients' visitors. In this regard, eight gates were selected, ranging from low-integrated to high-integrated spots, based on a wide variety of integration values (Fig. 5). For this purpose, a 10-minute interval has been considered to assess the range of visitors passing from each gate. The findings obtained from the gate count method before the outbreak of COVID-19 have indicated that gates 4 and 2, followed by gate 1, featuring the total density of 70, 69 and 65, are considered to be the most crowded gates, respectively. Whereas gates 8, 6 and 3, featuring the total density of 8, 10 and 11, are identified as the least crowded gates, respectively. On the other hand, the obtained data in respect to the total observed density after the outbreak of COVID-19 revealed that gates 1 and 2, followed by gate 5, featuring the total density of 50, 38 and 36, are identified as the most

crowded gates, respectively. While gates 7, 8 and 6, featuring the total density of 4, 9 and 18, are identified as the least crowded gates, respectively. In general, the total observed density before the outbreak of COVID-19 was equivalent to 267. After the outbreak of COVID-19, the total observed density was diminished to 213 (Table 1, Fig. 6).

In order to complete the analysis process in this subsection, the findings obtained from the gate count method were compared using the SPSS software and the independent sample *t*-test. One of the prerequisites of conducting this test is the normal distribution of data. Accordingly, in its initial step, the *Kolmogorov-Smirnov* test for the normality of data was accomplished. The results of this test to check the normality status of data indicated that the level of significance is equivalent to 0.156. Since this value is higher than 0.05, it can be declared that the obtained findings characterize normal distribution. The results obtained from the *Levene's* test indicated that the level of P-value is equivalent to 0.005, which means an inequality of variances. Moreover, the value of the 2-tailed significance is equal to 0.575, which indicates that the mean of the groups is statistically equal to one another (Table 2). Therefore, there is no significant difference between the obtained data. Accordingly, based on the statistical calculation obtained from the gate counting method, the observed mobility of people within the studied healthcare center before and after the outbreak of

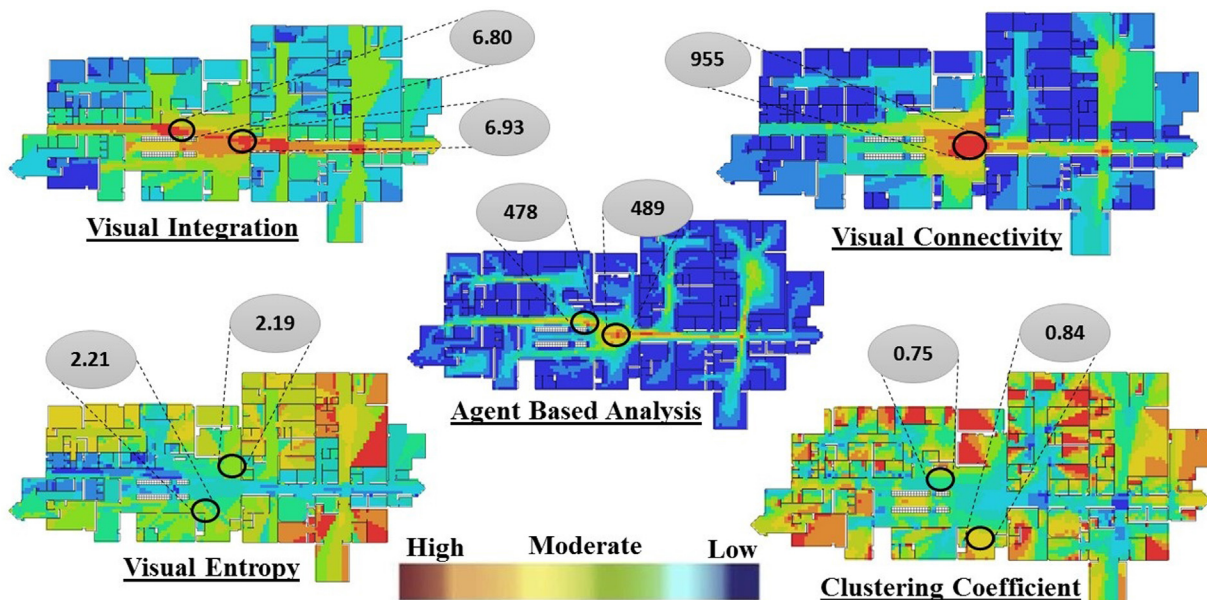


Fig. 4. Visibility graph analysis and the quantitative value of influential spaces in terms of the configurational analysis.

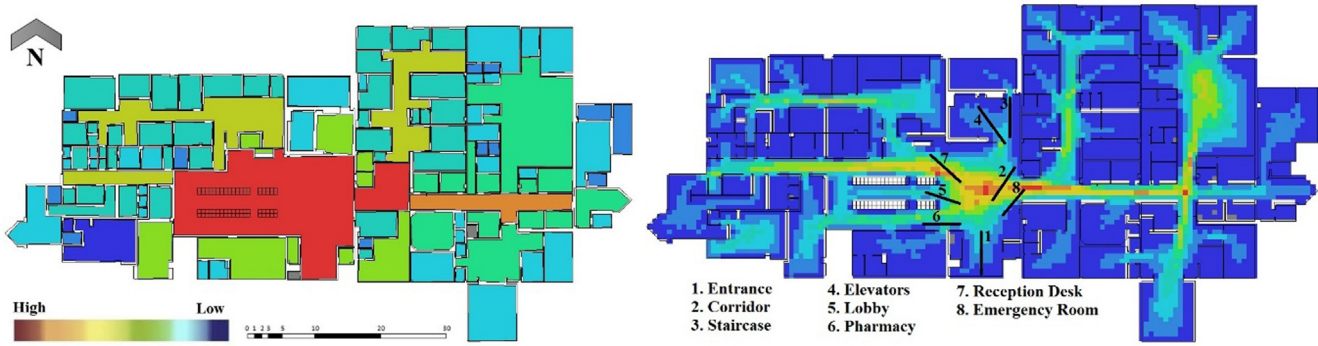


Fig. 5. Specified gates on the map to estimate the population density in the studied hospital, and the convex map analysis based on the spatial integration obtained by the Space Syntax method.

Table 1

Comparing the quantitative data obtained from the gate observation, along with the axial and visual integration of each gate before and after the outbreak of COVID-19.

Number of gates	Axial integration of the hospital	Visual integration of the hospital	Total density at gate <u>before</u> COVID-19	Total density at gate <u>after</u> COVID-19
Gate 1: Entrance	5.12	5.16	65	50
Gate 2: Corridor	7.22	6.93	69	38
Gate 3: Staircase	4.88	4.55	11	23
Gate 4: Elevators	4.95	4.48	70	35
Gate 5: Lobby	6.93	6.25	13	36
Gate 6: Pharmacy	4.90	4.95	10	18
Gate 7: Reception	5.89	6.74	21	4
Gate 8: Emergency	6.47	6.70	8	9

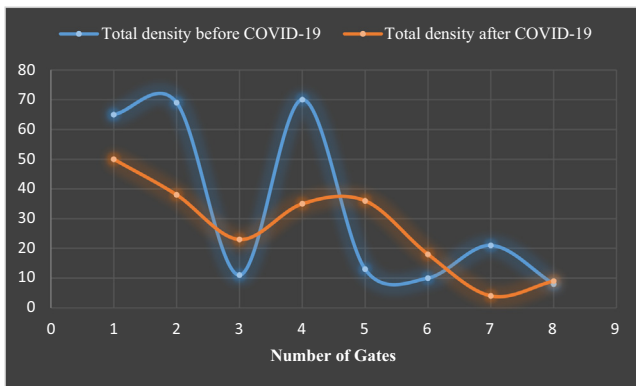


Fig. 6. Comparison of the total observed density at each predetermined gate before and after the outbreak of COVID-19.

COVID-19 demonstrates no significant difference. However, the observed alterations in the fluctuation trend of the graph (Fig. 6) indicates substantial changes in the usage level of some specific spaces that needed to be further scrutinized under the discussion section.

Table 2

Independent sample *t*-test on the gate count observation technique.

Levene's Test Sig.	T-Test for Equality of Means Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
				Lower	Upper
0.005	0.575	6.750	11.660	-18.966	32.466

3.3. People following analysis obtained from empirical observations

In this subsection, the movement patterns of people have been followed in order to grasp the visitors' wayfinding procedure within the studied healthcare center. The tracing process commenced from a predetermined origin (the entrance of the hospital) to a predetermined destination (vertical circulations: e.g. staircases and elevators). This method, which is intrinsically considered as a qualitative observation, was accomplished in order to follow-up the possible transformations in people's behaviors during their wayfinding procedure before and after the outbreak of the COVID-19 pandemic. It also provides an opportunity to make a general comparison between the consistency level of the VGA and empirical studies. The visual integration graph (Table 3A), as well as the visitors' scope of view from the origin point using the Isovist analysis are delineated (Table 3B).

To conduct the aforementioned empirical studies, 25 men and 25 women were traced in order to record their movement behavioral patterns and wayfinding procedures. The obtained results from *people following* observation before the outbreak of COVID-19 revealed that about 54% of visitors identified their destination successfully and reached their target with no hesitation. In the meantime, approximately 46% of the observed people became confused at the origin point and followed incorrect directions and after

Table 3
(A) Visual integration graph; (B) Isovist graph based on the visitors' viewpoint from the entrance.

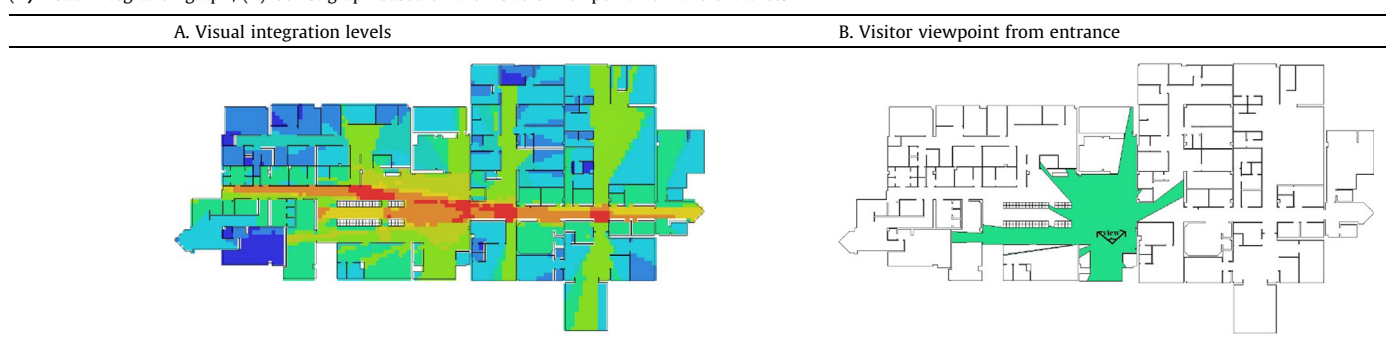
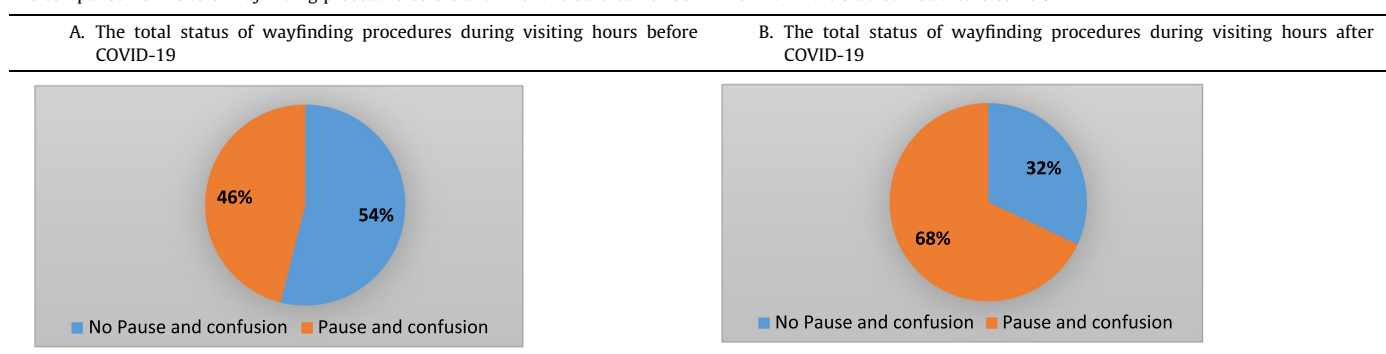


Table 4
The comparison of visitors' wayfinding procedure before and after the outbreak of COVID-19 within the studied healthcare center.



a while, they were able to figure out the correct directions toward their destination (Table 4A). However, the acquired findings from the empirical studies conducted after the outbreak of COVID-19 elucidated that merely 32% of visitors figured out their destination without any pause and confusion. Subsequently, around 68% of the observed visitors became confused during their navigation process, and were finally able to identify their intended destination after inquiring and taking advantage of guidance boards (Table 4B). Moreover, the movement patterns of visitors before and after the outbreak of COVID-19 were depicted. It should be noted that the patterns that included confusion during the wayfinding process have been delineated using a red color. While the patterns in which the visitors' identified their destination without any hesitation have been depicted by a color blue (Fig. 7).

3.4. The analysis of qualitative semi-structured interviews

The findings obtained from the SSIs were initially recorded using a smartphone and subsequently transcribed in order for them to be codified in a well-structured manner. Accordingly, a series of one-by-one interviews were conducted with the visitors who were the main target community developed in this study. The total number of participants were eleven individuals, of which five were male and six were female. The target community included the main companions of patients, and general visitors. A set of predetermined questions incorporating themes related to the impact of COVID-19 on visitors' behavior, feelings and wayfinding in the studied healthcare setting were proposed in order to directly inquire the visitors' opinions.

There were 14 pre-defined questions for the inquiring process, of which some were removed or added based on the type of the certain interviewee's responses. The questions are divided into two categories, namely behavioral and architectural features. The

behavioral category is related to topics such as visitors' emotions within the studied healthcare environment, the degree of their willingness to socialize and communicate with others, and the manner of following hygienic protocols during pandemic times. In the category of architectural features, there are questions on wayfinding, waiting space preferences (exterior or interior), type of access (elevator or stairs), furniture usage, and how to take advantage of new facilities in the visiting area (remote visiting).

The SSIs were later transcribed and analyzed to extract the behavior of visitors according to the spatial layout and circulation of the hospital configuration under the influence of the pandemic period using NVivo 12, which is a qualitative data analysis computer software. The data were analyzed in accordance with the three stages and principles of the grounded theory methodology, namely the Open, Axial, and Selective coding system [81]. The findings from these interviews were then used to corroborate the research findings in previous sections. The following results were obtained through analyzing the codes and the relationships between them.

The findings obtained from the semi-structured interviews revealed that visitors pay a considerable amount of attention to hygienic protocols in the studied healthcare center. The visitors considered themselves responsible for wearing face masks and using hand sanitizer to disinfect their hands as soon as they touched external objects. All of them hinted that they wore face masks, and nine of them corroborated using disinfectant products. A couple of participants declared that they changed their clothes immediately after returning home. Some interviewees mentioned using disposable gloves to protect their hands from the transmission of the virus, and some referred to frequent hand washing. A couple of the interviewees remarked about their superiority of preference in using a single-bed room during the pandemic period, and four participants mentioned observing physical distancing.

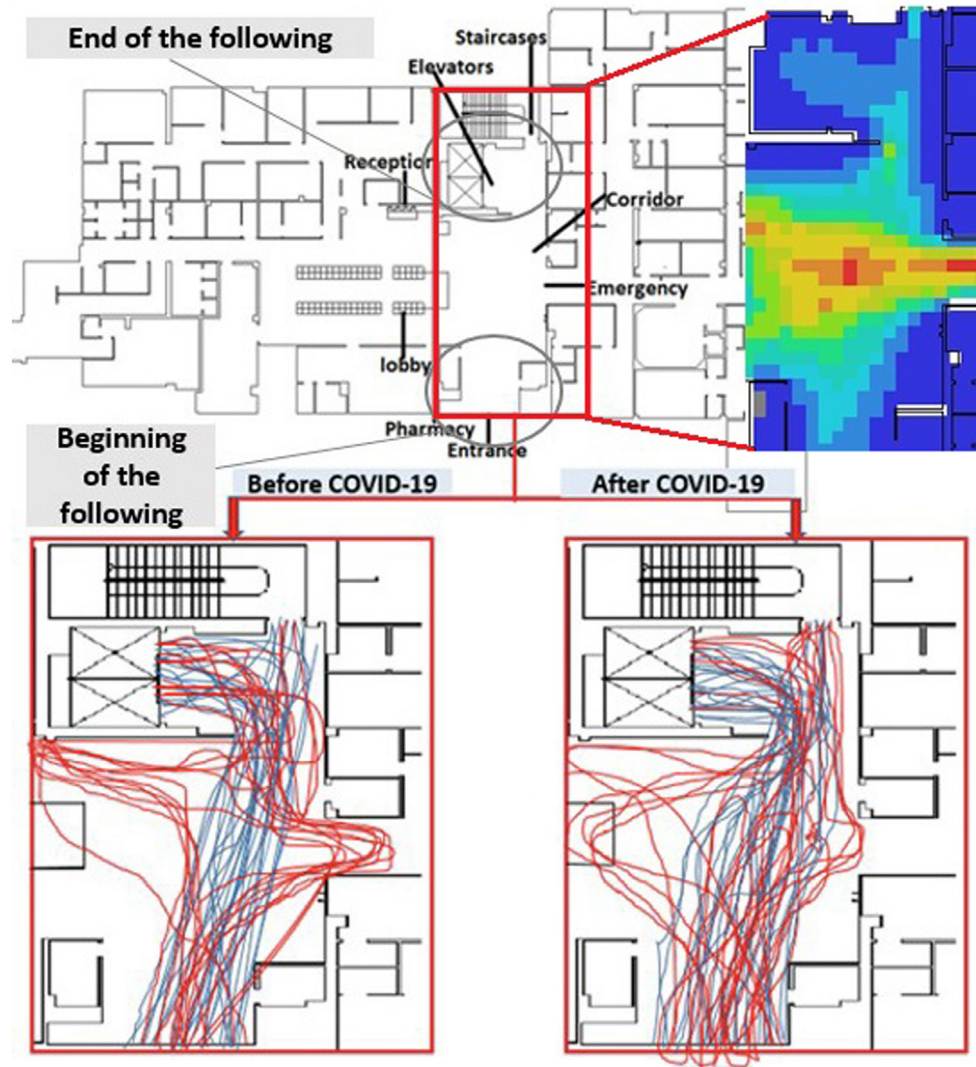


Fig. 7. Simulation of visitors' movement patterns which was observed through the people following method before and after the outbreak of COVID-19.

Interviewees asserted their feelings regarding their presence in the hospital and observing other people and patients. They mentioned feelings of concern, dread, distress and commiseration, and the majority of them felt scared, anxious and upset. For instance, a 30-year-old boy, whose father was hospitalized, said: "I witness that the patients lying in their beds next to my father's bed are dying, and it makes me feel uncomfortable and anxious". Some visitors pointed out their unwillingness to communicate with other people. They believed that interacting with others should be avoided because it increases the possibility of COVID-19 transmission. One of the participants argued her reluctance to even take a look at others in order to avoid talking to them. Another person stated that if she had to speak, she would answer very briefly, or spoke while observing a suitable range of physical distancing.

In relation to their wayfinding process, the majority of visitors pointed out their confusion throughout the process of finding their destination. Merely a couple of them found their way effortlessly, of which one of whom already had the experience of being in this particular hospital before. Four of the interviewees mentioned that they found their way to the patient's room by following the crowded route. Two of them asked the receptionist to help them

determine their desired routes. Even one of the participants claimed to have entered the emergency ward by mistake. Interviewees also noted their reluctance to use hospital furniture. However, most of them pointed out that they had no other choice, so they had to use those facilities. One of the visitors argued that he moved the position of his chair in order to constitute the equilibrium for observing physical distancing.

Regarding the chosen type of vertical access, most of the interviewees declared their interest to use stairs. Seven individuals expressed their preference for using stairs, as it was considered as a secluded and safer way to access their intended destination. Three of the participants also alluded that since their ultimate destination is located on the first floor, using the stairs is considered as a premier option. Three people stated that they used the elevator because of their physical problems (e.g. leg pain) or the stairs being out of sight. Meanwhile, one of them used both types of vertical accessibility.

Regarding their preference of waiting space, interviewees mentioned their presence in both the indoor and outdoor spaces within the hospital. Six people chose the indoor environment and five of them chose the outdoor environment. Those who chose the outdoor environment as their preferred waiting area considered it a

safer environment and went there to enjoy the fresh air. However, most of the participants remaining in the hospital defended their presence due to their short-time stay within the indoor environment. One of the interviewees stated that the reason for staying inside the hospital was the hot outdoor weather conditions. One visitor mentioned that she would prefer to stay in a semi-open space, which the studied healthcare center unfortunately lacks. Interviewees were also inquired about using the remote and virtual visiting systems available via online platforms. Nine of them found it a very interesting idea due to its efficiency in respect to controlling COVID-19 transmission, and merely two participants preferred to make visits in person. They justified their preference due to the reason that they were their patient's *main companion*, and the patient needed them to accompany them (Fig. 8).

4. Discussion

The primary objective followed by implementing the present study is to investigate the influence of the COVID-19 pandemic on visitors' wayfinding procedure within the studied healthcare center in Rasht, northern Iran. Accordingly, this section represents discussions in relation to the adopted findings developed in this study, interpretation of obtained data, along with interrelations among them. Moreover, by highlighting the novel contribution of acquired data in respect to the impact of COVID-19 on the mobility and wayfinding process of visitors within the studied healthcare center, the similarities and contradictions with the outcomes of other resembling studies shall be further discussed.

4.1. The interrelation between the simulation analysis and observations analysis

Overall, a general consistency is observable between the simulation analysis obtained from the *Space Syntax* method and the observation analysis obtained from the *gate count* method at the identified gates on the ground floor of Qa'em Hospital, Rasht. Nevertheless, some incompatibilities have been found between the integration value anticipated by the syntactical analysis and the mobility patterns of visitors within the empirical studies, which need to be taken into account. In particular, gate number 8, which is the emergency ward, featured the lowest density of visitors, regardless of its highest potential in terms of spatial connectivity and integrity. The reason behind that could be justified as the lack of any particular function for the visitors within this space. Conversely, gate number 4, which characterizes the lowest visual integration value, featured the highest crowded communities within the studied hospital. In fact, gate number 4, which is allocated to the elevators of the hospital, provides vertical circulation for the visitors and is densely occupied by visitors, despite its lower potential in terms of its integration value (Table 1).

According to the evidence obtained from International Health Facility Guidelines (2017) [82], vertical circulations are considered as one of the most important amenities which have an influential role in facilitating the wayfinding procedure. Since vertical circulations are some of the most frequently used spaces in health centers, their placement in positions which do NOT meet a proper visual and movement accessibility may lead to confusing the visitors. This fact manifests the reason why visitors felt confused at the



Fig. 8. The obtained data from interviews using the NVivo12 coding scheme system.

starting point of their journey in the process of wayfinding within the studied healthcare center. Since the elevators' space is quite hidden behind a partition wall, a considerable range of its visual connectivity is diminished. Therefore, regardless of its immediate access to the lobby, it lacks suitable visibility for the visitors and consequently, visitors were wandering around when it came to figuring out the route toward their intended destination (Table 3). The obtained results support the previous findings in respect to the positive effect of visual accessibility on facilitating wayfinding [83–87]. This fact also supports the obtained syntactical simulation of visual entropy, which indicates the high level of complexity within the threshold of vertical circulations.

The results obtained from the VCC illustrate that the entrance space, followed by reception desk are the spaces where visitors pause at during their process of wayfinding decision-making. This outcome is in line with the findings obtained from *people following* observations, in that the movement patterns of visitors are interrupted as they reach the entrance space of the studied healthcare center. Accordingly, the most frequent pauses occurred at the moment of reaching the threshold of the entrance space. Also, a general consistency is observed between the agent-based analysis obtained from the VGA and the movement patterns of visitors in the studied hospital (Fig. 7). On the other hand, the results obtained from the SSI substantiated that the majority of the participants became confused throughout their wayfinding process. Regardless of the high spatial legibility obtained from the syntactical analysis, the empirical studies proved that visitors are still confronted with obstacles during their navigation process. This may lead us to identify that the mere high level of spatial legibility is NOT adequate for facilitating wayfinding within healthcare centers. As a result, in case of confusion, visitors prefer to figure out their own destination instinctively by following crowded routes, asking receptionists, or following navigation boards.

4.2. The impact of COVID-19 on the mobility patterns of visitors

The results obtained from the *gate counting* method in two different intervals, namely before and after the outbreak of COVID-19 indicated the lower range of visitor's participation in the post-pandemic period within the studied healthcare center. This result conforms to the previous literature in terms of medical care visits during the lockdown [88]. However, the calculations derived from SPSS and the independent sample *t*-test revealed that this range of diminution is NOT considered significant (Table 2). Nevertheless, some remarkable changes in the visitors' mobility range have been observed at some specific uses of the hospital in question that needed to be taken into account. In general, the total observed density of visitors before the outbreak of COVID-19 was 54 individuals more than the acquired result after the outbreak of COVID-19 on the same day of the week and at the same time. Accordingly, the level of mobility at some of the functions such as the entrance, corridor, and emergency ward were proportional to the general reduction of visitor's density before and after the outbreak of COVID-19. One of the most substantial spaces that observed striking transformation in the level of mobility is the staircase. The obtained findings revealed that before the outbreak of the pandemic, the majority of visitors tended to use elevators for the sake of vertical circulations. However, the obtained results after the outbreak of the pandemic demonstrated that the range of visitor's density for using elevators was dropped to half. This outcome delineates the fact that people prefer to avoid being in close contact with others in the post-pandemic period. Hence, visitors demonstrated a particular propensity for using the staircases for their vertical circulations due to the safer intrinsic potential in order to avoid the possible transmission of the coronavirus.

The other considerable difference was related to the higher tendency to use the lobby space in the post-pandemic period. In this regard, due to the lack of proper spacing between furniture to establish physical distancing, people have become less inclined to sit in the waiting area of the hospital. Therefore, the majority of them preferred to talk to their companions while on their feet, in an attempt to maintain their physical distancing from other visitors. In fact, visitors preferred to consider *personal spaces* for their interactions, rather than joining shared spaces with others. This issue is in line with previous findings regarding the waiting area typologies of healthcare centers in order to constrain the spread of COVID-19 [89]. On the other hand, the lobby space, due to its more spacious nature, and also being adjacent to the entrance space, provided better ventilation. This matter was an effective factor in reducing the transmission of the coronavirus based on the perspective of visitors. For these reasons, in the post-pandemic observations, the accumulation of people in the lobby increased dramatically. The other notable point is regarding the considerable diminution of visitors referring to the reception desk after the outbreak of COVID-19. According to the empirical studies, it is observed that visitors demonstrated a certain tendency to follow crowded routes in an attempt to find their way, instead of having to inquire from the receptionists or other such sources. On the contrary, previous studies tend to display support in referring to the concierge for the navigation process of visitors in hospitals [90], despite the fact that this range of inquiry from others has been diminished dramatically after the outbreak of COVID-19. Based on the evidence, the pandemic situation has forced visitors to restrict any sort of communication and interaction with other people and subsequently, visitors prefer to figure out their route toward an intended destination using their visual capabilities or instinctive procedures.

4.3. The impact of COVID-19 on the wayfinding procedures of visitors

The movement patterns of the people have been traced in order to comprehend the wayfinding procedures of visitors within the studied healthcare center. The obtained results indicated that visitors were thoroughly confused and hesitant throughout the process of finding their ways after the outbreak of the pandemic. In fact, under the influence of pandemic conditions, the navigation procedure from the point of origin (entrance) to the predefined destination of vertical circulation for the participants were fraught with multiple pauses and confusion. Unlike previous studies [91], the outcome of this research revealed that visitors tended to use some instinctive guidelines, such as following the crowded routes, figuring out their way using navigation boards, and inquiring from receptionists, in the process of identifying their destination in the post-pandemic period. Although the overall spatial legibility of the studied healthcare center was highly intelligible, some visitors still experienced confusion during their wayfinding process. These confusions have become particularly exacerbated after the outbreak of COVID-19, in which 68% of the participants were hesitant when it came to figuring out the route toward their ultimate destination. Aligned with previous findings [42,92], the reason behind this could be justified as the vague placement of two crucial elements, namely the *reception desk* and *vertical circulation*. The reception desk refers to the lower visual connectivity. While the vertical circulation refers to the opaque configuration of the elevators and staircase, which are partially hidden behind a partition wall. As it is evident in Table 3, these crucial spaces are limited in terms of both the visibility graph and the Isovist analysis.

The results obtained from the SSIs illustrated the visitors' concern, fear, anxiousness, and upset while being in the hospital after the outbreak of COVID-19 by revealing the responsibility of visitors in respect to observing hygienic protocols. This finding is in line

with previous studies [93]. The other notable point can be related to the substantial efficacy of COVID-19 on reducing tendencies for the establishment of social interactions among visitors. This issue may lead the visitors to acquire a sense of social isolation, which based on previous studies, negatively affects their mental well-being [94]. In relation to the impact of COVID-19 on the wayfinding procedure of visitors, the majority of participants in the interview corroborated their sense of confusion throughout the process of identifying their destinations. They also confirmed using their instinctive wayfinding procedures, such as following the crowded routes while navigating their way through the health center. The participants have also declared their lack of interest in using hospital furniture. This is due to their lack of compatibility with the pandemic conditions and protocols, and inadequate physical distancing, which manifests the reason for crowded gatherings in the lobby space after the outbreak of the pandemic.

Confirming the data obtained from the *people following* observation, the majority of the interviewees declared their interest in using the stairs instead of elevators after the outbreak of the pandemic. This is owing to the fact that using the stairs is deemed as a secluded and safer way to access their intended destination. It also impedes people from accumulating in the crowded elevator area. That is why the range of using the elevators has been substantially decreased after the outbreak of COVID-19 in an attempt to hamper the widespread virus among visitors. This means that the visitors' propensity for accumulation within the indoor public spaces at the studied healthcare center has strikingly decreased in comparison to pre-pandemic periods. Moreover, the necessity of considering a wide variety of spatial hierarchy, namely open, semi-open and enclosed spaces for the waiting area in healthcare centers has been emphasized by the visitors. In this regard, the built environment must act as a flexible platform to perform resiliently against probabilistic pandemic perils, so that in case of visitors' preference to enjoy fresh air, they would be able to avoid being enclosed within closed environments. This issue is in line with previously conducted studies in this field [95–97]. Ultimately, implementing online amenities for the sake of remote visiting systems of some relatives was found to be lucrative in order to dwindle the unnecessary accumulation of some visitors, and subsequently reducing the risk of COVID-19 transmission during pandemic periods.

5. Conclusion

The main contribution to the body of the existing scientific literature developed in the present study relies on two central notions: The primary one refers to the influence of COVID-19 on the mobility of visitors, and the latter refers to the impact of this pandemic on the wayfinding procedures of the visitors within the studied healthcare center. The results obtained from the empirical studies indicated that COVID-19 had a negative impact on the observed mobility within the studied healthcare center. However, the statistical calculations of the *t*-test substantiated that this mitigation of the observed mobility after the outbreak of the pandemic has NOT been found to be significant. On the other hand, the obtained empirical results displayed that visitors were significantly confused and hesitant throughout their wayfinding process after the outbreak of the pandemic due to the opaque configuration of the vertical circulations. The visitors also asserted to figure out their intended route using instinctive wayfinding procedures, such as following the crowded routes and using the navigation boards.

In conclusion, the present study revealed that staircases characterized an indispensable role in the visitors' wayfinding process during post-pandemic times at healthcare centers. Indeed, spatial accessibility and legibility were NOT found to be adequate for facilitating the wayfinding of the visitors. Furthermore, some factors

such as the transparency of vertical circulations and their iconic and central roles in the post-pandemic spatial configuration of healthcare centers should be taken into consideration. Evidently, visitors did NOT display a propensity for engaging themselves with crowded communities, and they prefer to avoid co-presences within accumulated areas as much as possible during post-pandemic periods. This trend has also led to the disability of social spaces, such as waiting areas, when it comes to adapting their furniture layout with pandemic circumstances.

Thus, paying particular attention to the transparency of vertical circulations, central role of reception desks, clarity of navigation boards, along with accessible and intelligible spatial configuration should be taken into account in order to facilitate visitors' wayfinding procedures in healthcare centers during post-pandemic times. Moreover, the requirements for the reconfiguration of furniture layout in waiting areas according to the underlying notions of physical distancing becomes conspicuous as the pragmatic implications for post-pandemic healthcare centers. The limitation that can be pointed out with regard to determining the present healthcare center as the case study can be complemented with further samples of studies in order to generalize the current subject matter as much as possible. In respect to further research suggestions, studies can scrutinize the in-depth configurational impact of post-pandemic healthcare centers on visitors' social, perceptual and behavioral implications using novel procedures such as *syntactical* and *virtual reality* simulations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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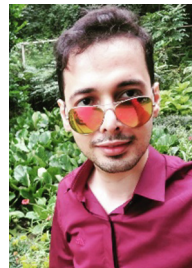
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