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ORIGINAL RESEARCH

Assessment of Social Distance between Customers in Urban Hypermarket during COVID-19 Pandemic by Simulation Approach

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Abstract: **Introduction:** Social distance is important for reducing the spread of the new COVID-19 pandemic, especially in public places. In addition, urban stores are one of the crowded places where observing social distance is considered necessary. Therefore, the present study aimed to evaluate the social distance between customers in urban stores during the outbreak of the COVID-19 pandemic using a simulation method. **Materials and methods:** Research data were collected from the closed-circuit television footage of a store from a hypermarket in Iran, and then customers' social distance was analyzed through their movement behaviors by two modes of 1 and 2-meter distance using software similar to the Pathfinder simulator. Further parts of the urban store required corrections considering the first scenario and the two-meter distance between people compared to the second scenario and the one-meter distance between them. **Results:** Based on simulation results, dense areas were identified in different sections of the hypermarket, namely, places where the shelves distance was 1 meter to 2 meters. More precisely, this research provided a method for evaluating different parts of the store in terms of population density regarding maintaining social distance. **Conclusion:** Several suggestions were presented to stores for maintaining social distance based on research findings.

Keywords: Social Distance; Covid-19; World Health Organization; Disease Control and Prevention

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1. Introduction

COVID-19 pandemic as an infectious disease emerged in early December 2019 in Wuhan, Hubei, China (12). The World Health Organization (WHO) and the Centers for Disease Control consider social distancing as an effective method for reducing the incidence of COVID-19 (11). In the absence of vaccines, countries are using various forms of social distancing as a policy to slow the spread of the virus worldwide. Social distancing appears in various forms and its main purpose is to keep people apart in order to decrease their contact rates (7). Shops and hypermarkets are crowded places that have not been closed since the outbreak of COVID-19 because of selling essential products, and observing social distance are one of the great importance in these places. In addition, different stores and hypermarkets have activated online shopping during this period. Further, some measures have been taken for in-person purchases, including disinfecting store shelves and carts, arranging products by employees in accordance with hygienic actions, using masks by sellers, observing social distance through labels indicating the distance in the cash register section of the store, and the like.

Accordingly, most stores pay attention to social distance between customers and sellers and observe social distance in the cash register section of the store. However, they have failed to observe the social distance between customers in different parts of the store. Thus, taking appropriate measures to observe social distance is extremely essential for stores since it is unclear when COVID-19 is eradicated and there is no vaccine or definitive medicine for this disease.

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Using a simulation method based on human movements, the present study analyzed different parts of a hypermarket in Iran by considering the social distance between the customers.

1.1. Literature Review and Research Background

1.1.1. Social distancing and COVID-19

COVID-19 is a pandemic disease that has spread highly rapidly in Iran and several countries and has caused the transmission of acute infectious pneumonia. The epidemic has posed the risk of death from viral infections and unbearable stress on people in different parts of the world (16). Thus, social distancing is considered a key measure regarding reducing the prevalence of COVID-19, aiming at decreasing the likelihood of contact between infected and healthy individuals (17). It is believed that social distancing can reduce disease spread since transmission through respiratory droplets requires people to approach a certain distance (14). According to Mohler et al. (10), social distance includes guidelines for maintaining distance in public places, placing restrictions on gatherings and business activities, and staying at home. Based on the report by the Centers for Disease Control and Prevention (13), the social distance for reducing COVID-19 is 6 feet (approximately 2 meters). Furthermore, the WHO (2) has declared that the minimum distance between people is 3 feet (approximately 1 meter). Although hygiene observance and social distance decrease the number of cases per week, they increase the epidemic period. Moreover, such actions reduce the severity of cases by decreasing viral inoculation. It is noteworthy that social distance and health measures act as the first and second factors in reducing the number of contacts per person and the risk of disease transmission, respectively (4).

1.1.2. Simulation of customers' movement and distance in the store

The movement behavior varies from store to store although certain patterns exist that remain quite constant (5). Additionally, crowding affects consumer behavior and reduces the desire for buying (8). Similarly, customers avoid entering narrow corridors (5) since they feel that their personal space is shared with other shoppers in this situation. For example, they may push others while crossing or pass them uncomfortably at a close distance. In cultural contexts such as the United States or the United Kingdom, people maintain a relatively large social distance although they are significantly closer to each other in other contexts such as the Arab or Latin American countries. Accordingly, storefronts are narrower in these countries. In the United States, retail stores should have wide enough corridors for customers to easily walk past each other before entering (5). Based on the Butt-Brush effect, sales decrease in areas where buyers cannot pass without pushing other buyers (14). In this regard, simulation models provide potential tools by which planners can predict the movement patterns of large numbers of people and design urban spaces (15).

This model of people's movement behavior is applied to simulate the movement of objects and people by using flow, average speed, and density. It should be mentioned that the simulation of human movements and behaviors, especially in different situations, is related to estimating the selected path and optimizing the flow of motion for various purposes. In addition, factors such as space layout designs and path structures are considered important for determining the movement of people in the simulation model. Further, monitoring people's movement during the visit determines which places are more or less visible. Furthermore, managers can segment the market and offer more diverse and focused options according to the needs of specific groups if they are aware of these preferences (1).

In their study (6) focused on grocery shopping preferences during the COVID-19 pandemic by considering three associated scenarios including the increase, decrease, or persistence of new cases in the past two weeks. Based on their results, the epidemic trend made a significant difference in grocery purchasing preferences. They further found that consumers are less likely to buy in-store groceries as the disease spreads rapidly. However, they reported that when the disease decreases, the purchasing method is relatively less important (6).

In another study, Li et al. (9) examined the shopping behavior of Chinese consumers during the COVID-19 outbreak. Data from an online survey suggested that the epidemic of the disease has led to changes in customer behavior, and the farm market has lost most of its customers although small independent retailers have experienced the highest level of customer retention flexibility (9).

2. Methodology

In the present study, the simulation method was used to evaluate the social distance in the store. To this end, data were collected through the closed-circuit television camera of a hypermarket in Iran and then analyzed using the Pathfinder simulator software, which is a human movement simulator. In this regard, each person enters the simulation environment based on a set of parameters and individual characteristics and independently makes their decisions. Different scenarios can be examined by using multiple simulations and changing individuals' characteristics. This advantage, together with the advanced motion system and three-dimensional (3D) modeling has made the simulations of this software more realistic compared to other similar software. Moreover, the features of this software include running accurate walking simulations with the possibility of changing

Figure 1: Hypermarket plan.

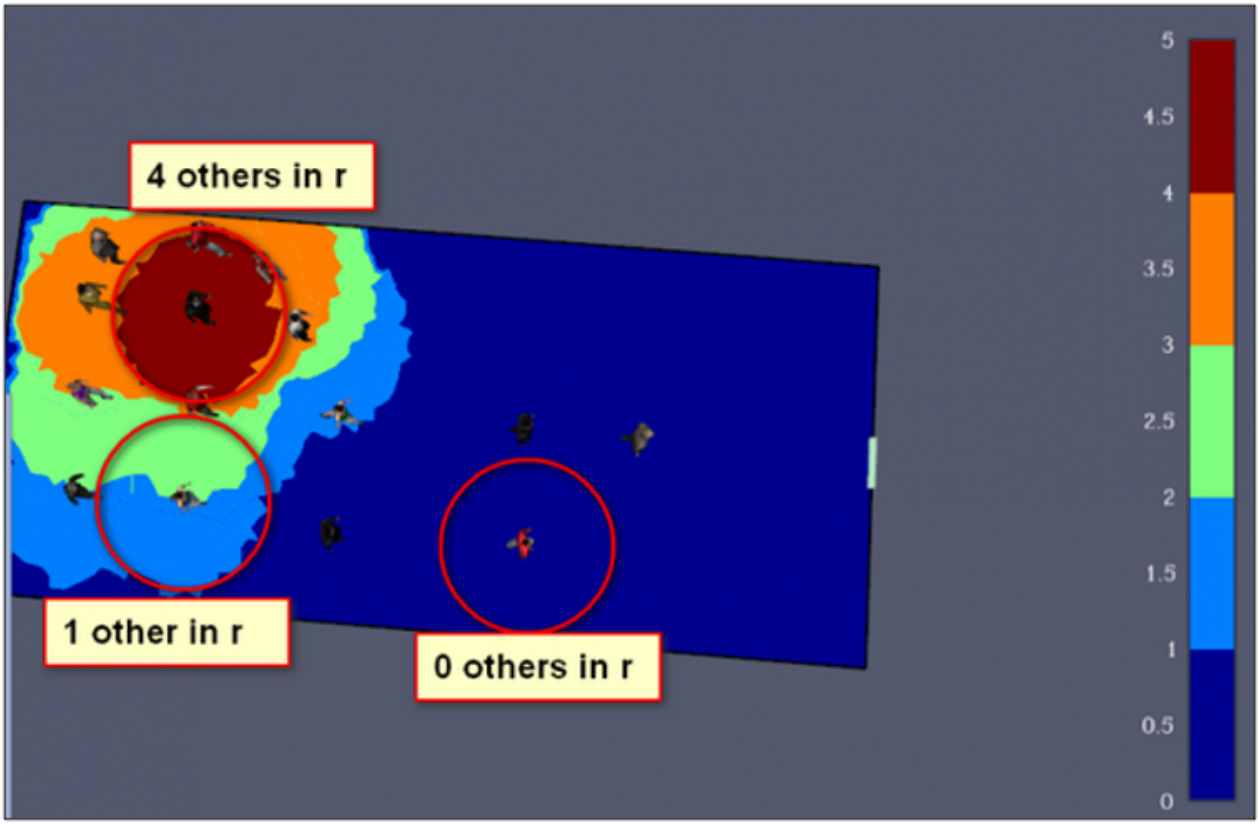

Figure 2: The concept of social linkage in Pathfinder software.

speed, visualizing 3D places and people, setting different characteristics and parameters for people, having the ability to customize the volume and density of the population, and providing 3D and accurate simulation evaluation results.

To analyze the data, the hypermarket plan was designed in AutoCAD software and then entered the Pathfinder emulator software environment, and finally, each customer entered the software with their movement behaviors. Figure 1 displays the hypermarket plan.

Figure 3: The status of social linkage in the first scenario.

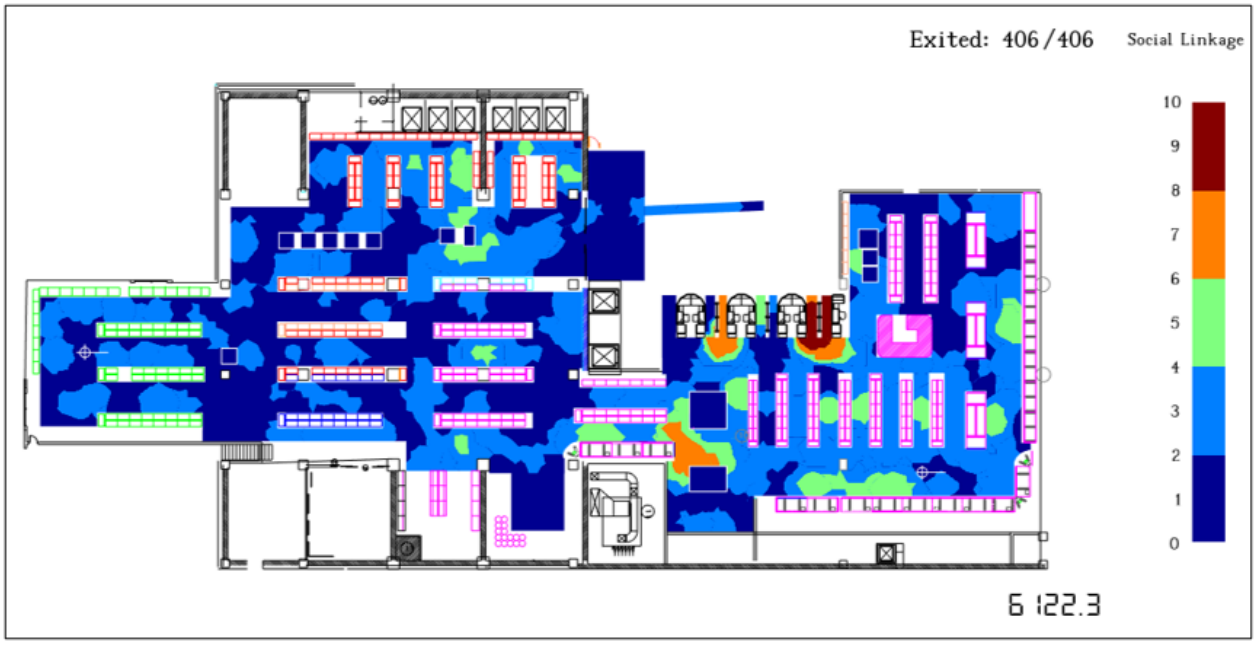

Figure 4: The status of social linkage in the second scenario.

2.1. Data Analysis

After designing the plan in AutoCAD software, the plan and customers were simulated with their specific behaviors in the Pathfinder software environment. Additionally, the concept of social linkage was described for data analysis.

2.2. Social linkage

It considers a certain radius (R) as the center of an individual and evaluates the social bond based on the number of other

factors in that radius. Figure 2 depicts the concept of social linkage in Pathfinder software.

2.3. Two scenarios were considered for evaluating social distance in the study sample

2.3.1. Scenario 1. The social distance between people is 2 meters based on the recommendations of the Centers for Disease Control and Prevention

An effective radius of 2 meters was considered to examine the social linkage. Figure 3 is plan of Ghoghnoos Hypermarket that illustrates the social linkage in the store in the first scenario. As shown, the parts of the store with the most customers are identified where the intended distance is not observable. Areas that are orange, red, and green can be considered as high-risk points while light and bold blue points can be regarded as low-risk areas due to the entry of some people into families and groups and the lack of social distance between them. In this case, several sections are considered as high-risk areas, including the entrance section of the store, which is the location of the special sales products of the store, the sanitary ware section, the entrance section to the second hall of the store, and the cash register. In addition, other related areas included food products sold by the seller, the beverage section, and the space between food shelves, especially in the second hall near the cash register.

2.3.2. Scenario 2. The social distance between people is 1 meter based on the recommendations of the World Health Organization

An effective radius of 1 meter was considered to examine the social linkage. Figure 4 is plan of Ghoghnoos Hypermarket that illustrates the social linkage in the store in the second scenario. As shown, the parts of the store with the most customers are identified where the intended distance is not observable. In this case, several sections are considered as high-risk areas, including the special sales products section of the store, sanitary ware section, the entrance section to the second hall of the store, and the cash register. In addition, other related areas included food products sold by the seller, the beverage section, and the space between food shelves in the second hall.

According to research, to determine the number of people who can enter the store while maintaining social distance, it is recommended that food stores consider a space of 5 square meters per person in the store (3). This space is obtained through retail space minus floor space for fittings, shelves, displays, and the like.

Total area of the surveyed store = 1988 m^2

Total area of fittings, shelves and displays = 730 m^2

Store capacity with maintaining social distance=(Total area of the surveyed store-Total area of fittings.shelves and displays)/5

Store capacity with maintaining social distance=(1988-730)/5 ≈252 person

3. Results and Discussion

Social distancing, especially in public places is one of the government's measures regarding reducing the rate of COVID-19 during its outbreak. According to the results of the store research, social distance is required in places such as stores. In addition, observing social distance in stores is necessary for preventing declining store sales, in general, and reducing the prevalence of COVID-19 during this period, in particular. Based on the Butt-Brush effect, social distancing is of necessity in normal times as well. This research presented a method for determining the important parts of the store and modifying dense parts. In this study, social distancing between store customers was investigated by a simulation approach using two scenarios. The first scenario was a distance of 2 meters between people, and the entrance section of the store was identified based on simulation results. This section encompassed the location of the special sales products of the store, the section related to sanitary ware, the entrance section to the second hall of the store, cash register, products, and the food sold by the seller, the beverage section, and the space between food shelves, especially in the second hall near the cash register of high-risk areas. In the second scenario, the distance between people was considered to be 1 meter, and high-risk areas were the special sales product section, the sanitary ware section, and the entrance section to the second hall of the department store, as well as the cash register and food products sold by the seller. The beverage section and the space between food shelves in the second hall were determined as well.

In general, the areas of the store were considered of high risk if the distance between the shelves was 1 meter to 2 meters. It was also possible to calculate the number according to the size of the store and the capacity of the store while maintaining the social distance and to control the number of customers entering or leaving so that there was no overcrowding according to conditions.

4. Conclusion

Based on the research findings, the following suggestions can be presented for stores.

- Using various methods including simulating customers' movement behaviors, examining store departments in terms of population density and the distance between the customers at different times, and modifying locations that need correction;

- Calculating the number of people who can enter the store while maintaining social distance relying on the size of the store and controlling the entry and exit of the customers so that they do not enter more than capacity of that store;

- Determining the distance between people, during the outbreak of COVID-19, in proportion to space in front of each part of the labels on the ground in different parts of the store where there is a separate seller and the cash register part of the store where the customer has to wait, as well as using obstacles and population control cones to create a suitable distance in sections where there is a queue;
- Improving parts of the store where the effective width between the two shelves is small and the movement of people next to each other, especially with people who enter the store with the store shopping cart;
- Locating special sales sections in different parts of the store and somehow farther away from the entrance of the store in order to prevent the collision of the customers who enter the store and those who stop to shop next to the special sales shelves;
- Demonstrating the full capacity of the store, while considering the social distance, using signs or obstacles in the entrance and the crowded sections of the store;
- Determining busy hours and crowded places of the store and thus the hours for the elderly and other at-risk groups;
- Making the corridors one-way as much as possible to minimize interference and facilitate physical distance for the customers;
- Using employees for guiding customers and monitoring the observance of social distance, especially in the areas where there is the highest concentration of customers.

5. Appendix

5.1. Acknowledgment

5.1.1. Ethical approval

Ethical approval was waived by the local Ethics Committee of University A in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

5.1.2. Consent to participate

Informed consent was obtained from all individual participants included in the study.

C5.1.3. Consent to publish

Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

5.2. Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

5.3. Funding support

None.

5.4. Author's contributions

All the authors had the same contribution.

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