



Research Article

The impact of indoor common spaces layout design on providing social distancing in residential complexes post COVID-19

Salahaddin Yasin BAPER¹, Siham Musheer KAREEM^{1,*}

¹Department of Architecture, College of Engineering, Salahaddin University-Erbil, Erbil, 44001, Iraq

ARTICLE INFO

Article history

Received: 14 June 2021

Accepted: 01 August 2021

Keywords:

Residential Building Design;
Indoor Common Space; Design
Methodology; Psychological;
Communication; Social
Distancing; Software Design

ABSTRACT

Understanding disease prevention and control is developing due to global pandemics such as severe new coronavirus illness (COVID-19). In addition, the transmission of viruses in residential structures, particularly multi-story apartment complexes, is growing.

This study examined the factors which characterise the reach in common interior spaces of social distance post-COVID-19. Secondly, the relationship between types of apartments and which are best after- COVID-19 can be observed. A questionnaire and data gathering for five apartment buildings selected in Erbil were used to the design technique. SPSS and space syntax (software design) and the correlation, regression, and descriptive statistics were then used to examine the data. This research investigates the essential link of social distancing factors in the living areas with independent variables, including physical, psychological, communication, and environmental aspects, in apartment spaces. This research also looks at social distancing factors in apartment spaces.

In addition, multiple regression analyses revealed an equation that represents the best prediction of social distance in multi-story living areas with various independent factors of indoor communities. The study shows a favorable association between the components in common interior spaces and social distancing between units with many floors based on a hypothesis test. It also analyses five typical plan typologies of a building with several levels, based on the study and questionnaire evaluations of the inhabitants' space syntax. As a consequence, the advantages and defects of each building type were evaluated. The mixed-method employed in this research has contributed significantly to the acceptability and readability of the design of multi-story apartments as a control tool. Furthermore, the analyses led to a clear preference for the single-loaded (gallery) corridor layout for social distancing.

Cite this article as: Baper SY, Kareem SM. The impact of indoor common spaces layout design on providing social distancing in residential complexes post COVID-19. Sigma J Eng Nat Sci 2023;41(4):699–715.

*Corresponding author.

*E-mail address: siham.kareem@su.edu.krd, arch.siham82@gmail.com

This paper was recommended for publication in revised form by Sania Qureshi



INTRODUCTION

Social distancing, two new words in the world, are no longer unknown to social anthropologists. Over 50 years ago, Edward T. Hall proposed the phrase proxemics, which found that social conduct is determined by the link and gap between human corpses. In his book *The Hidden Dimension*, he defined four distance measurements [1]. 1. Intimate (less than 1.5 feet, shared by friends and families), 2. person, common among friends and families, (1.5 to 4 feet), 3. social (4 to 12 feet, shared amongst friends), and 4. community (12 to 25 feet and more, shared among the general public). The total physical distance between bodies determines these four measurements, and each distance provides a distinct physical observation among people. One of the presently actively suggested pollution control measures is social distancing. Social distancing minimizes the humanity rate and slows the disease spread by setting 2 m as the standard distance to decrease the connection between diseased and uninfected people [3]. Though, in indoor spaces, such as department stores, cafes, corridors, and other stores, limited spaces, it isn't easy to maintain social distancing because the population density is relatively higher than in outdoor spaces. In addition, the epidemic of COVID-19 requires fear and isolation from the worldwide population. Despite these difficult circumstances, however, there remain conditions of compassion and community. "Social distancing" has even kept our relationship in certain circumstances. The link between people and activities is one such relationship.

A design method may now be characterized as a formal example of a design activity that acts as a mental instrument that helps designers to achieve an objective about the given circumstances and resources [3]. It means that techniques operate as information carriers, which allocate how their users receive, clarify, and adjust their behavior to implement specified designs. Therefore, a new design strategy to achieve social distance must be used to decrease covid-19 in this circumstance.

COVID-19 underlined the uncertain character of public and community land in cities and municipal planning. On the one hand, the propagation of the virus seems to be a classical illustration of Hardin's common disaster [4]. On the other hand, the pandemic spread was mainly caused by a community gathering in hallways, lobbies, entrances, courtyards, and other interior public areas, and, above important, daily consumption of ambient air. s However, during lockdowns, people seek out precisely the common and indoor public places.

In [5], the design of the software is a complicated process of thinking, which plays a key role in decision making. Still, their grasp of how decisions are taken is restricted, particularly concerning design challenges and the development of design solutions. Therefore, this study has picked space syntax software for analysis to develop

planning, design context, problem-solution co-evolution, and apply reasoning strategies that impact software design efficiency.

Nevertheless, many common areas have emerged due to this epidemic, and various public discussions are currently taking place. New characteristics for these areas can be found in studied and future urban planning. Nevertheless, new and valued qualities, crucial and vital to city life, can be taken on and observed by new ways sometimes believed and named 'amenities,' common and public areas. The purpose of this study was to analyze, based on a case study in Erbil, the influence of open-air spaces on social prevention in residential complexes after COVID 19. A deliberate land use plan and significant technological advancements in design recently supported multi-story apartment dwelling buildings. Several multi-story flats exceeding 12 floors have already been erected in the urban region and are constantly spreading because of the substantial overgrowth of these projects. The flats are classified as high-density, closeness, and sky-city and differ from other forms of housing, leading to a distinct architectural environment. Then, emphasis is placed on the vital features for the research of the apartment complex. s

This study attempts to employ an expert investigation to identify residential typology architecture's purpose and weighting variables. In the future, the results of this pilot study will aid in developing multi-story residential apartment complexes. To evaluate interpretation and comparison, five cases of multi-story residential apartments were chosen in Erbil City.

Term's Definitions

Indoor common spaces

According to the control effect [6] and social distancing in the common space of residents returning home [7]. Examples include the elevator lobby [8], stair corner [9], or some small extension platforms [10]. The indoor public spaces that are commonly found in multi-story residential buildings are divided into five categories in this research:

1. Ground-level open public spaces
2. Entrance halls
3. Stairs
4. Corridors
5. Elevators

Multi-story Apartment Building

It is a housing unit in a multi-story building in a group housing project. Multi-story buildings have more than four floors depending on the layout plan. It is principal to a series of social problems containing the deterioration in the mental health of the residents [11], a compact sense of belonging [12] lacking supporting facilities ([13], and a lack of monitoring that leads to an improved crime rate [14; 15; 16].

Typology Design

Typology comes from the word ‘type,’ defined by the Cambridge International Dictionary of English as a specific group of things or people with similar separation types. It forms a minor division of a more extensive set’ [17]. In this sense, ‘type’ is connected to classification based on comparing characters or features. McHenry [18, as cited in 19], defines it as an arrangement of groups, the associates of which are recognised by assuming stated characteristics that are commonly special and together specific groupings set up to assistance demonstration or review by creating a limited connection among occurrences. A type may indicate one or several kinds of features and contain only those significant types for the difficult question.’ This description distinguishes typology from classification by highlighting the former’s character as a system of the grouping of kinds to support the demonstration, or study, by establishing a limited connection between phenomena [20].

Social Distancing

It means ensuring space between people. For example, to prevent the spread of epidemiologic diseases like COVID-19 and decrease the risk of pollution, people should stay at a minimum of six feet (1.8 meters) from others [21]. According to another definition, social distancing defines the general class of behaviours that decrease connections between people in a community in which people may catch but have not yet been recognised (and, as a result, are not isolated) [22].

RELATED STUDIES

First, [23] tried to find a way to make the inside public spaces of multi-story apartment buildings more conducive to social contact among residents. In China’s multi-story apartment buildings, the study’s statement of the issue, a sense of culture, is difficult to determine. Furthermore, most occupants in multi-story apartment buildings have few opportunities to socialise with their neighbours. Therefore, the study also discusses how different forms of inside public space in a multi-story apartment building can be used as both circulation and a connection between apartments. Inside public spaces in multi-story apartment buildings are divided into five categories in this study: ground-level open public spaces, entrance halls, stairs, corridors, and lifts.

[24] aimed to demonstrate that typical indoor spaces are organised to have a divided social system. Different groups use the area in different ways, resulting in different conceptualisations. According to the authors, space has many fixed purposes and is built for particular purposes in many buildings.

Communication, wayfinding, organisational structures, physical function, accessibility, and social interaction were examined as indicators of indoor shared spaces.

[25] attempted to explain the means of access into various levels of the building and access through individual units on floors, based on previous similar research regarding

typology in multi-story apartment buildings. The study focused on metrics such as mobility, circulation, and connectivity that are linked to indoor common spaces and typology. To characterise the strategy from the features of the designs, a reductive approach to data interpretation was used. It also identified the most common indoor standard room, a single central walkway with lobby and hallway access.

[26] attempted to determine the effect of spatial configuration parameters on the practical efficiency of apartment layouts. The research looked at the spatial organisation, architecture, social order, and privacy concerning indoor common spaces and typology. This study’s approach was statistical spatial analysis using space syntax tools. Among previous related studies about COVID-19 in multi-story apartment buildings, Galym Tokazhanov et al. (2020) tried to explain the following COVID-19 pandemic and evaluate the expected changes in sustainability requirements of residential buildings. The study focused on the indicators related to the multi-story apartment building and COVID-19, such as indoor finishing material, health and safety, comfort, innovative technology, green and natural environment, design, and social wellbeing. The methodology in this study was based on a review of the literature.

Also, [27] tried to explain the coronavirus pandemic and social distancing strategy for coronavirus prevention among the residents of buildings in Calabar, Nigeria. The study focused on the indicators related to the multi-story apartment building and COVID-19, such as good-quality materials, aesthetically pleasing environment, and social lifestyles. The methodology in this study was based on a survey and observation.

[28] tried to observe the factors prompting social distancing over space planning and organisation and the spatial organisation and space configuration suitability. The study focused on the indicators related to the multi-story apartment building and COVID-19, such as spatial organisation, wayfinding, accessibility, and circulation. The methodology in this study was based on space syntax software.

Statement of the Problem

It is evident from the surveyed literature that many indicators influence the layout of common indoor spaces throughout buildings and that many construction tools are available. However, the relationship between multi-story apartment residential building types and limiting the spread of COVID-19 has not been discussed in any study.

- The noticeable potential significance of COVID-19 is a worldwide aversion to huge crowds. Concerts, cultural occasions, sporting occasions, ceremonies, mass gatherings, daily activities, and political complaints involve many people, commonly in common indoor spaces, such as ground-level open public areas, entrance halls, staircases, corridors, and lifts. These indoor spaces (inside the building) for crowds and activities will be applied to reducing the spread of COVID-19. Therefore, COVID-19 is one of the most critical factors

in the apartment. This question comes to mind: Which of the following factors has the optimum design plan type for reducing COVID-19 spread?

- Through the quarantine, people were said to practice social distancing and to stay home every time possible. However, the World Health Organization (WHO)'s examination of the spread of COVID-19 in the world showed that 78% to 85% of transmission happens inside families. One concern connected to this is disinfection when inhabitants reappear from outdoor the home. Furthermore, the multi-story apartment residential building includes many different plan types that may provide an additional indoor common space in apartment buildings. Therefore, according to the situation observed above, the research problem can be expressed as a verification of the relationship between the architectural plan types of multi-story residential buildings and limiting the spread of COVID-19 in its common indoor spaces.

Research Aim and Objectives:

This study aims to estimate how to decrease the spread of COVID-19 by the plan type on the common indoor spaces in the multi-story apartment buildings in Erbil City. To reach this purpose, the following objectives are stated:

- To survey the strength and the direction of relationships between the indoor common spaces and indicators for controlling COVID-19 in residential buildings.
- To define the optimal design layout type for restricting COVID-19 in multi-story residential buildings.
- To recognise the optimal indicators within the indoor spaces of multi-story apartment residential buildings.
- To provide specific layout design guidelines for common indoor spaces in multi-story apartment residential buildings.

Research Questions

There are FIVE research questions based on the objectives stated above:

1. In the visibility-graph analysis (VGA), which type has the closest relationships between connectivity, integration, and visibility, as well as the highest assessment-mean value for each indicator?
2. Which factor has the best typology plan design for providing social distancing?
3. Which type of vertical circulation (staircase or lift) is the best field for securing social distancing?
4. What type of graph has the most incredible visibility correlations between the first and second moments?
5. What is the difference between measuring indoor common-space indicator by questionnaire and measuring with space syntax?

Hypothesis

To guide the research, the following research hypothesis was expressed and tested in the study:

Hypothesis(H1) There is an affirmative relationship between physical factors and the social distancing of common indoor spaces in an apartment building.

Hypothesis(H2) There is an affirmative relationship between psychological factors and the social distancing of common indoor spaces in an apartment building.

Hypothesis(H3) There is an affirmative relationship between communication factors and the social distancing of common indoor spaces in an apartment building.

Hypothesis(H4) There is an affirmative relationship between environmental factors and the social distancing of common indoor spaces in an apartment building.

MATERIALS AND METHODS

The analysis used mixed methodologies, integrating quantitative and qualitative approaches, to increase the accuracy of the research results. The theoretical framework is chosen using the qualitative approach. Meanwhile, the quantitative method is used for testing the research objectives, hypothesis, and research questions.

In general, the research methodology is managed through six stages listed below:

1. **In the first stage**, to describe a theoretical model, previous related studies were reviewed. As a result, the research model developed consists of four independent variables of indoor common space factors: physical, psychological, communicational, and environmental factors, and one dependent variable, which is social distancing.
2. **The second stage** included a pilot study conducted with residents of an apartment using a quantitative questionnaire survey to evaluate the theoretical model.
3. **In the third stage**, a qualitative case study selected using a phenomenological methodology that involves findings, field notes, and documentation
4. **In the fourth stage**, a quantitative survey method is conducted over a case study by adopting the quantitative questionnaire to answer the research questions and research hypotheses.
5. **In the fifth stage**, syntactic analysis of the spatial organisation of the research case study is used to support the result of the fourth stage.
6. **In the sixth stage**, SPSS software is used to evaluate the questionnaire results and find a correlation between space syntax and quantitative questionnaire results.

Theoretical Framework

Based on the investigation of the previous related studies, this study develops to express the theoretical research model, as presented in figure1. Therefore, the pilot study was accepted to test the academic research model.

Pilot study

A pilot study is showed to test the theoretical model of this study to form the social distancing of residential spaces from independent variables of common indoor areas, which includes;(physical factors, psychological factors, communication factors, environmental factors), and defining the social distancing concept as the dependent variable.

This pilot study aims to estimate indoor common spaces' impact on the social distancing of indoor residential areas. First, a quantitative questionnaire survey had been arranged by using simple and clear statements. Then, the questionnaire was distributed randomly on the 22nd of October 2020 to the inhabitant living in different apartment places in Erbil city. About 170 questionnaires out of 150 were returned, the data were analysed using the statistical package for the social sciences; SPSS software. In observation, correlation analysis (person product-moment correlation coefficient test) is used to discover the correlations between the factors and define the linear relationship's strength and direction.

Moreover, multiple regression analysis was conducted to express an equation that denotes the best prediction of the social distancing of residential spaces from several independent factors of common indoor spaces. The correlation coefficient showed a positive relationship between the three indoor common space factors included (physical factor, psychological factors, and communication factor) and the social distancing of the apartment inside spaces. Furthermore, multiple regressions showed that the apartment indoor common spaces factors clarified 63.7% of the difference toward the social distancing of the apartment inside spaces. Therefore, the study concluded that physical, psychological, and communication were the significant

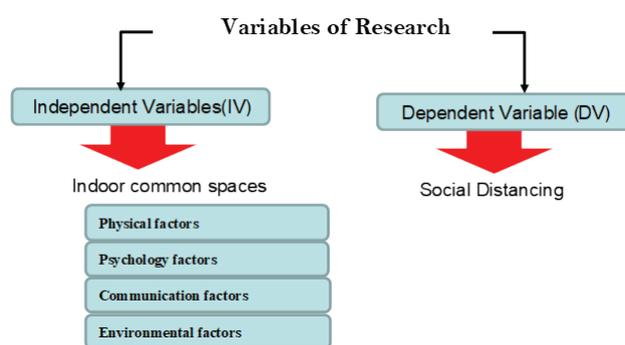


Figure 1. Theoretical Model of common indoor spaces (IV) vs social distancing (DV).

factors that directly impacted the social distancing of inside areas, as shown in Figure 1.

A model of four independent variables (physical, psychological, communication, and environmental factors) assesses common indoor spaces and a dependent factor to show social distancing in residential areas in this study. Table 1 describes the theoretical design model, including four independent and dependent variables for developing the questionnaire. First, the factor measurements are based on a review of the available literature, as shown in Figure 1. Then, the specifics of factor measurements are discussed.

Table 1. Sub factors summary of IV Variables

N	Main Factors	Sub factors
1	Physical factors	1.1. Width area. 1.2. Arrangements of furniture (flexibility) 1.3. Physical activity 1.4. Number of floors 1.5. Space efficiency (Adequacy of ceiling height, opening amount of residential unit, flexibility of space)
2	Psychology factors	2.1. Sense of community. 2.2. Sense of stability (solidity) 2.3. Visibility (visual connection) 2.4. Connection with nature environment 2.5. Safety 2.6. Durability of building materials 2.8. Partition design 2.9. Density
3	Communication factors	3.1. Accessibility 3.2. Circulation 3.3. Way finding 3.4. Connect in space 3.5. Floor marking 3.6. Availability of communication technology
4	Environmental factors	4.1. Ventilation 4.2. Effect of material (wall, floor, roof...) 4.3. Greenery space

Case studies classification

Having drawn all the selected cases, the next step is categorising them according to the plan types. For example, multi-story residential apartments were chosen and then classified based on five categories of plan types [29][37].

1. **Point:** includes the plans that have one central vertical circulation, near which all the entrances to the apartments are located
2. **single-loaded corridor (gallery):** involves plans connected to a long corridor with one or more central vertical circulation, on one side of which all the apartments are located.
3. **The double-loaded corridor contains plans with one or more essential vertical circulation connected with a long passage where all apartments are positioned on both sides.**
4. **Large-scale developments (segment):** contains the plans with one or more essential vertical circulation. The parallel outlines are repeated two or more times. Still, those parts are connected to create the building's final design.
5. **Mixed:** one or more of the types above were in the same building (corridor with a segment and so on).

Five case studies of multi-story apartment residential buildings (apartments) in Erbil City were selected as a study (Table 2) for review and comparison, with one case representing each of the styles listed above[37].

RESULTS AND DISCUSSION

The results are distributed into three parts.

1. The results acquired through a quantitative questionnaire survey.
2. The results obtained through the spatial analysis of the typical floor plan of each case study.

3. The results from the correlation between the quantitative questionnaire results and quantitative, syntactic spatial analysis.

Results Obtained From Questionnaire Survey Analysis

The statistical findings will be divided into three categories as follows.

The below is a descriptive analysis of the IV and DV factors

The descriptive study will investigate whether there is a connection between respondents' behaviours and their observations of indoor common-space variables. As a result, the statistical evaluations below were carried out, with the maximum mean of the variables exceeding 3.70 and a standard deviation of 1.09 for responsiveness to communication factors require variables (SD).

The minimum range of the mean for environmental factors was 3.16 and 1.11 standard deviations. As a result, psychological and physical characteristics are close to zero, with 3.60 and 3.47 SD and 1.00 and 0.93 SD, respectively. Table 3 shows that social distancing was 3.56, with a standard deviation of 0.90.

Correlation statistics between IV factors and the DV factor

Correlating analysis is used to assess the relationships between indoor common-space factors (physical, psychological, communication, and environmental) and social distancing to explain and test the hypothesis of a meaningful correlation between dependent and independent variables. In addition to defining the strength of the linear relationship between variables, correlation analysis (the Pearson product-moment correlation coefficient test) was used to discover the correlations between the variables. Each independent variable has a dependent variable associated

Table 2. Case studies

Plan Typology of apartment	POINT	GALLERY(single-loaded corridor)	Double loaded corridor	Large scale developments (Segment):	Mixed:
Case study	Kamarany city	Gulan tower	Lebanon Village	Mamostayan city	Empire world

Table 3. Result (Mean, Standard deviation, and %Agree) of factors

Factors	Mean	Std. Deviation	Agree to %
Physical factors	3.47	1.00	0.70
Psychological factors	3.60	0.93	0.72
Communication factors	3.70	1.09	0.74
Environmental factors	3.16	1.11	0.63
Social distancing	3.56	0.90	0.71

Table 4. Summary of Correlation Analyses between Dependent and Independent factors

Hypothesis	r	P	Result
1. There is a POSITIVE (affirmative) relationship between physical factors and the social distancing of common indoor spaces in an apartment building.	0.75	p < 0.00	Significant
2. There is a POSITIVE (affirmative) relationship between psychological factors and the social distancing of common indoor spaces in an apartment building.	0.612	p < 0.00	Significant
3. There is a POSITIVE (affirmative) relationship between communication factors and the social distancing of common indoor spaces in an apartment building.	0.625	p < 0.00	Significant
4. There is a POSITIVE (affirmative) relationship between environmental factors and the social distancing of common indoor spaces in an apartment building.	0.152	P>0.06	Insignificant

with it. Coefficients of correlation will vary between -1.00 to +1.00. A perfect negative correlation is represented by a value of -1.00, whereas a perfect positive correlation is represented by +1.00. A value of 0.00 indicates that there is no correlation [30].

From 0.05 to 0.01, the correlation procedure was applied to a two-tailed statistical significance test. The data in Table 4 is a summary of the findings of this study's correlation analysis. This study aims to determine a meaningful relationship between the independent variables (common indoor spaces) and the dependent variable (social distancing), resulting in the hypothesis.

Table 4 shows the correlation analyses; more than half of indoor common-space factors (physical, psychological, and communication) positively (significantly) correlate to social distancing; however, environmental factors have a weak (insignificant) relationship with the study's primary dependent variable.

Multiple regression analysis between IV factors and the DV factor

Multiple regressions are used to assess the association between independent variables (indoor common-space factors) and a dependent variable in this study (social distancing). Thus, the best estimate in the social distancing of apartment buildings from independent variables in common indoor spaces would be represented by an equation.

The recommended model was determined by the joined result of the independent variables, namely (1) physical factors, (2) psychological factors, (3) communication factors, (4) environmental factors, and (5) social distancing. As a result, the model is expressed as follows:

$$\text{Social Distancing} = \beta + \beta_1 + \beta_2 + \beta_3 + \beta_4$$

Where social distancing = the social distancing dimensions

β = constant of beta value

β_1 = Beta value of physical factors

β_2 = Beta value of psychological factors

β_3 = Beta value of communication factors

β_4 = Beta value of environmental factors

The multi-regression of the model is brief in Table 6, whereas the R2 for this model is 0.661, demonstrating that

the indoor common-space factors explain 66.1% of the variation of social distancing.

Overall, the physical ($\beta=0.443$, $p=0.000$), psychological ($\beta=0.346$, $p=0.000$), and communication factors ($\beta=0.270$, $p=0.030$) have significant, positive relationships with social distancing. The result expresses that the physical factor is most significant because each change in these factors is correlated with a 0.472-change in social distancing. Environmental factors ($\beta=0.006$, $p=0.901$) have a non-significant relationship with social distancing.

Table 5. Summary of Multiple Regressions Analysis of IV variables

Model	β	t	P value
Constant	0.637	2.944	0.004
Physical factors	0.586	10.627	0.000**
Psychological factors	0.354	6.605	0.000**
Communication factors	0.270	2.500	0.030*
Environmental factors	0.008	0.164	0.901

R2=0.661

a. Dependent Variable: F5(Social distancing)

b. (Constant), F1, F2, F3, F4

*Significant at the level 0.01 (Sig \leq 0.05), n=50

**High significance at the level 0.01 (Sig \leq 0.01), n=50

The beta values denote the exclusive effect of each factor in the equation, resulting in the model's final equation, which is as follows

$$\text{Social Distancing} = 0.637 + 0.586 \text{ physical factors} + 0.354 \text{ psychological factor} + 0.270 \text{ communication factor} + 0.008 \text{ environmental factor.}$$

Results Obtained From Space Syntax Analysis

Whether or not they have replied to research questions would be determined by the findings and data presented in the previous parts. As previously mentioned, space-syntax analysis was used to measure the typical floor plans of five chosen apartments in Erbil using depth-map software to search details and results. In addition, the questionnaire

produced additional information and outcomes for people who live in apartments. Connectivity, integration, and visibility were the key variables and indices used in both analyses. The below summarises the findings from both studies to see how they helped provide compelling answers to the study questions.

Assessment of indicators

Integration, connectivity, and visibility were the three space syntax indices used in this study. The following are the definitions of these indices.

Integration

This is the space significance guide. The index of spatial accessibility is another name for it [31]. If the rate of space is high, it is placed in the centre of the grouping. If the system's mean value is high, the system is closely associated and interconnected, and therefore the system's accessibility is high [32]. Integration is a definite characteristic that specifies the points (spaces) in a system are combined or separated; the degrees mean the moves in the strategy are the most integrated. Red, orange, yellow, and green represent the most integrated (accessible spaces), while blue and dark blue represent the least integrated (inaccessible spaces) (less accessible spaces). The significance of spatial integration, also known as visual integration, is essential for predicting movement and connection [33]. It is the standard depth of the space compared to other areas within the system, and it serves as an international standard. Another measure that aids in understanding the integration is spatial depth.

Connectivity

The term “connectivity” refers to the number of links that connect one space to another. A space with no connectivity is a self-contained space. An area with a variety of connectivity is connected to a lot of the other regions. If the mean accessibility of all places in a building is high, there are more relationships among spaces, passages, roads, loops, and more moving routes [31].

Visibility

Visibility/ readability or intelligibility is the connection between connectivity and integration value. When associated spaces are also integrated spaces, there is a clear and visible spatial relationship. In this case, the device processes that make up the system are visible or readable [31]. Visibility is the association coefficient between integration and connectivity. If spaces with high integration and high

connectivity are equivalent, visibility is high; otherwise, visibility is low. This catalogue is linked to the order of parts-to-whole relations and signifies the reliability of centrality and preference by the same symbol.

It is relevant for understanding some of the methods and ideas pertinent to the calculation and measurement process used in interpreting and evaluating the effects of the measures of space syntax analysis mentioned above.

About the indicators of space syntax analysis, it is suitable to explain some of the tools and concepts related to the calculation and measurement method used to analyse and discuss the results. These concepts and tools can be mentioned as:

1. **Isovist space** is “the total area that can be viewed from a point.”
2. **Visual mean Depth** between two spaces is definite as “the least number of syntactic steps in a graph that are required to touch one from the other”

A spatial attribute for key research parameters was also determined to measure indicators space syntax attribute of three parameters. The physical factor is measured through connectivity and visual integration, and the visibility attributes; the integration attribute calculates the psychological factor. Finally, communication is measured by the mean depth and visual integration attribute. To measure the indicators for flexibility is connectivity, density is integration, and accessibility is a visual mean depth, as shown in Table 6.

Responses to research questions

The first research question

In the visibility-graph analysis (VGA), which type has the closest relationships between connectivity, integration, and visibility, as well as the highest assessment-mean value for each indicator?

Based on assessments and responses from apartment residents, the single-loaded corridor (gallery) type had the highest mean connectivity value of 4.25. In contrast, the point type had the lowest mean value of 2.62.

According to the connectivity values obtained from the space syntax study, the single-loaded corridor (gallery) had the highest value, while mixed-loaded corridors had the lowest (see Figure 3). The single-loaded corridor (gallery) had the maximum integration value, with 117, according to the integration mean values dependent on space syntax analysis, and the lowest in the large-scale development (segment), with 5.38 (see Figure 4). The double-loaded

Table 6. Summary of research factors indicators and space syntax attribute

Indoor common spaces factors	Indicators	Space syntax attribute
Physical factors	Flexibility	Connectivity
Psychological factors	Density	Visual integration
Communicational factors	Accessibility	Visual mean depth

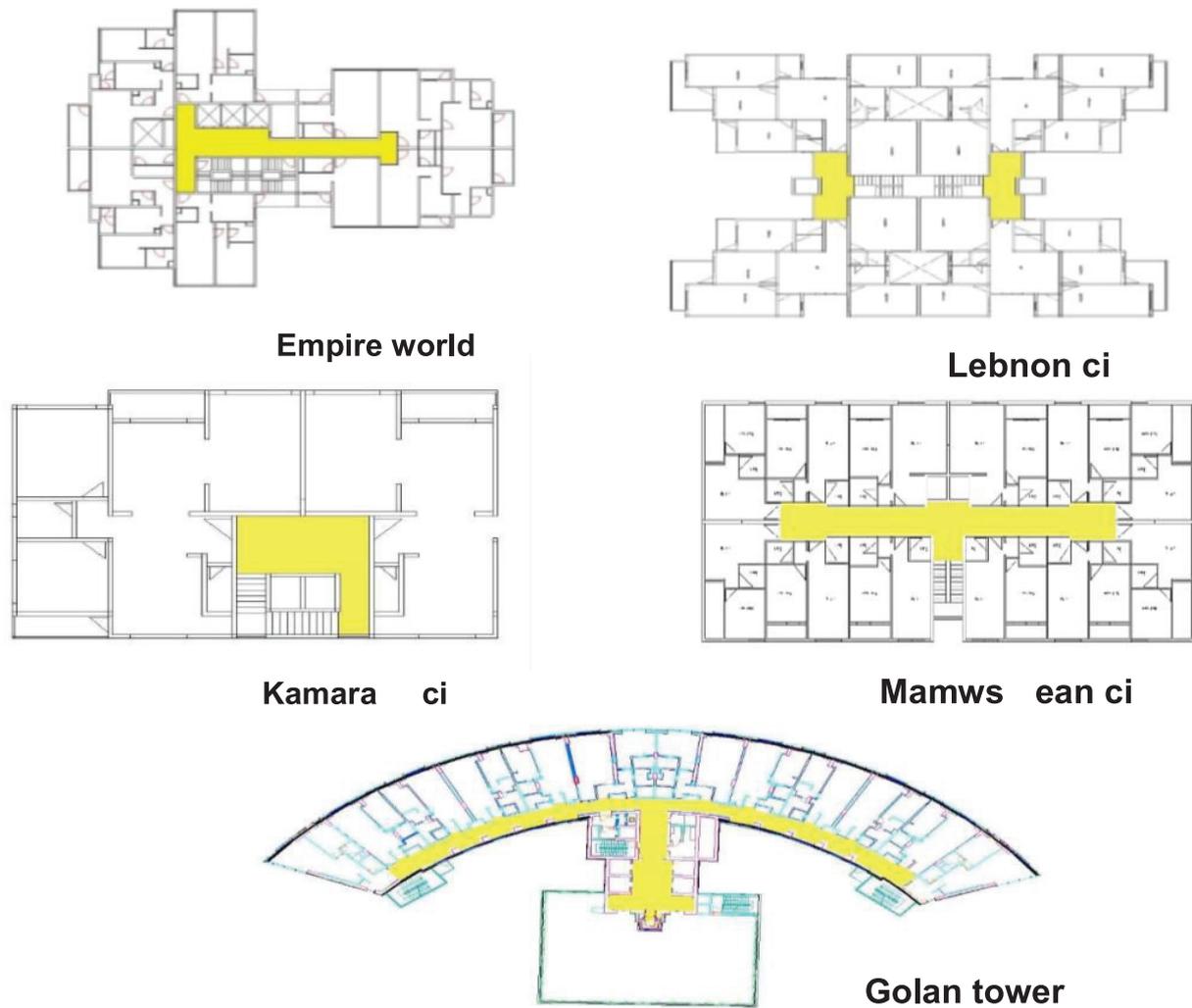


Figure 2. A typical floor plan of the chosen cases, showing the corridors and vertical circulation (stair cases and elevator).

corridor and mixed have the same mean value for the connectivity factor (2.5). The highest integration value was 117 in the single-loaded corridor (gallery), and the lowest was 5.38 in the large-scale development (segment) according to space syntax analysis (see Figure 5&6). The findings showed up in both analyses for the connectivity factor. That of the five types, the single-loaded corridor (gallery) had the highest values. The connectivity attribute in this study is used to measure the flexibility parameters of physical factors in indoor apartment spaces.

Accordingly, the highest value of connectivity represented the more flexible spaces than the spaces with a lower degree of connectivity. Consequently, and the numerical comparison results showed that the connectivity results value among the cases study. At the same time, the single-loaded corridor type of layout design has a more flexible design than the other types. Additionally, a large-scale development type layout design can be

considered the second flexible design among the cases 204 value. The visual integration attribute measures the density in psychological parameters in the apartment corridor area. The highest degree of integration is considered the higher degree of density, while the lowest integration value is supposed the segregated space with a lower degree of density.

In contrast, the lowest visual integration result is represented to the kind of large-scale development with 5.38. The results showed that the higher degree of visual integration means shallow space, described as more space than the segregated space. Generally, the gathering space in the apartment is occurring in shared spaces that include; corridor, staircase, and elevator. Consequently, the single-loaded corridor layout design plan showed a higher physiological factor than the other types. as shown in Table (7 and 8).

Table 7. Attribute summaries of all spatial layouts (cases study) based on visibility map analysis

Types	Single loaded corridor(gallery) (Gulan tower)			Double loaded corridor (Lebanon village)			Large scale development (segment) (Mamostyan city)			Point (Kamarany city)			Mixed (Empire world)		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Connectivity	112	584	661	18	131.4	308	88	204	224	87	183.6	223	11	31.18	42
Integration	8.46	117	596	7.59	83.3	203.7	2.49	5.38	12.7	8.63	37.87	173	4.07	21.86	130
Mean depth	1.00	1.09	1.62	1.03	1.14	1.90	1.52	2.33	3.66	1	1.176	1.60	1.023	1.27	1.74

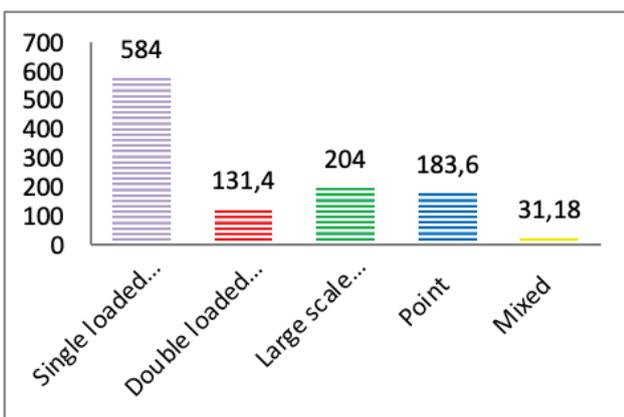


Figure 3. Connectivity values /Space Syntax.

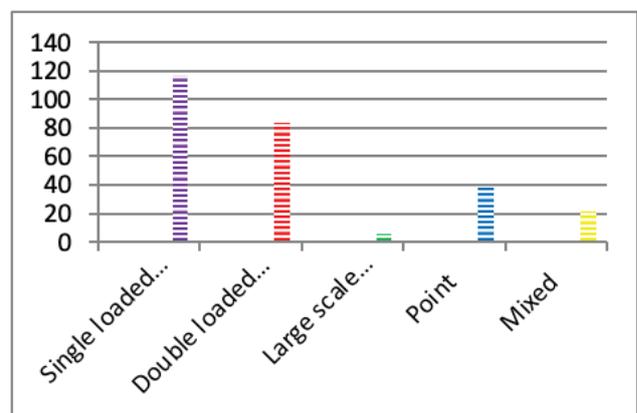


Figure 5. integration values /Space Syntax.

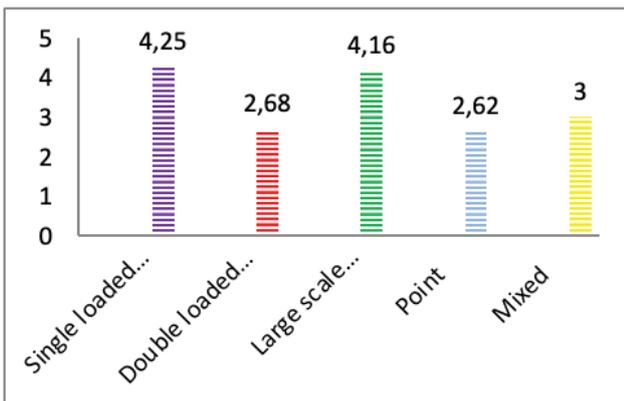


Figure 4. Connectivity values /Questionnaire.

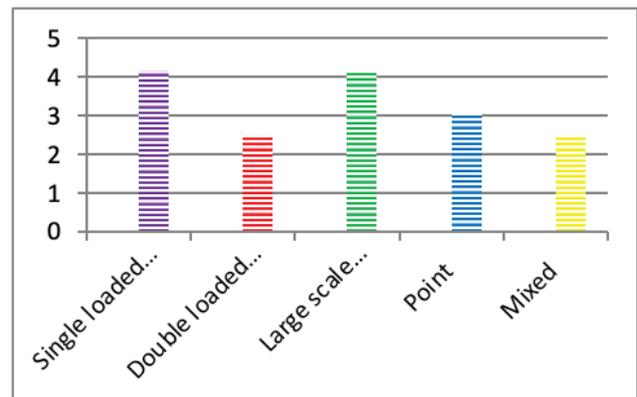


Figure 6. integration values /Questionnaire.

The second research question

Which factor has the best typology plan design for providing social distancing?

According to the assessments and responses collected from the questionnaire survey concerning apartment layout, the single-loaded corridor (gallery) type plan had the best-achieved type plan design for providing social distancing (168). In contrast, the worst type of plan design was found in point with (48), As shown in Figure 7.

The third research question

Which type of vertical circulation (staircase or lift) has the best field of view for social distancing?

According to isovist map analysis, the mixed type had the highest visibility mean value for the vertical circulation values, with 21.03. The single-loaded corridor type had the lowest mean value, with 8.68. The survey results indicate the exact value estimates for the central vertical circulation (field of view), with high mean values of 4.23

Table 8. Mean value from the questionnaire

Question	Single loaded corridor(gallery) (Gulan tower)	Double loaded corridor (Lebanon village)	Large scale development (segment) (Mamostyan city)	Point (Kamarany city)	Mixed (Empire world)
Indicators					
Connectivity					
• The availability of Space flexibility of common indoor spaces (in terms of structural design) will positively affect social distancing.	4.16	3.12	4.10	3.10	3.0
• The modification of furniture (flexibility) from corridor spaces has a positive impact on providing social distancing.	4.34	2.25	4.22	2.15	3.15
Overall connectivity agreement (satisfaction) values(mean)	4.25	2.68	4.16	2.62	3.0
Integration					
• The community's sense of responsibility in the indoor spaces positively affects providing social distancing.	4.24	2.34	3.80	3.22	2.20
• Density (number of people) in the corridor and elevator negatively affects providing social distancing.	4.15	3.2	4.40	2.83	2.78
• Using signs (wayfinding diagrams) to identify horizontal and vertical circulation systems paths leads to increased social distancing.	4.10	2.0	4.32	3.21	2.47
Overall connectivity agreement (satisfaction) values(mean)					
Visibility					
• Field of view for vertical paths (ELEVATORS AND STAIRCASE)	4.16	2.51	4.17	3.08	2.5
• Field of view for (visual connection) to building's entrance and lobby.	2.20	3.12	4.23	3.85	4.30
Overall connectivity agreement (satisfaction) values(mean)					
Mean depth					
• Increasing corridor widths will lead to providing social distancing.	3.86	2.55	3.80	3.88	4.10
• The open-access (accessibility) to the entrance, elevator, staircases, and corridors positively affects social distancing.	3.03	2.83	4.0	3.86	4.20
• The variety of circulations within inner spaces will increase social distancing.	2.34	3.20	4.21	3.80	3.64
• The variety of circulations within inner spaces will increase social distancing.	2.13	2.86	3.56	3.76	2.80
Overall connectivity agreement (satisfaction) values(mean)	2.43	2.66	4.0	3.92	2.89
	2.30	2.90	3.90	3.82	3.11

1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree

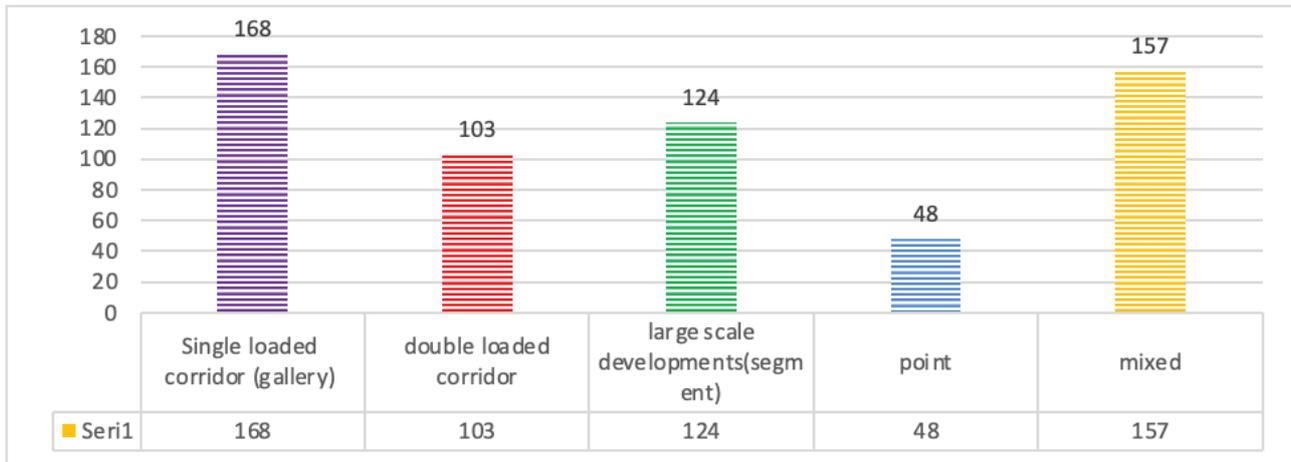


Figure 7. Comparisons among typology design plan.

Table 9. Attribute summaries (Isovist map)

Types	Single loaded corridor(gallery) (Gulan tower)			Double loaded corridor (Lebanon village)			Large scale development (segment) (Mamostyan city)			Point (Kamarany city)			Mixed (Empire world)		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Attributes															
Vertical circulation and corridor	2.54	8.68	19.129	14.24	14.24	14.24	18.9	19.10	19.47	8.81	13.25	17.7	0.25	21.03	43.06
Lobby and main entrance	2.46	11.4	20.34	15.34	19.32	23.30	16.10	18.05	20	16.0	17.50	19	0.40	25.22	50.04

and 4.30 for mixed and significant scale development (segment), respectively, followed by the single-loaded corridor 2.20 as the lowest value. The mixed type had the highest mean value for the lobby and entrance field of view, at 25.22, followed by 11.4 for the single-loaded corridor; the mixed type was the best of the five cases, As shown in (Table. 9&10)

The forth research question

What type of graph has the most incredible visibility correlations between the first and second moments?

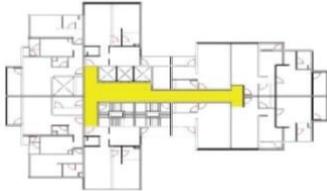
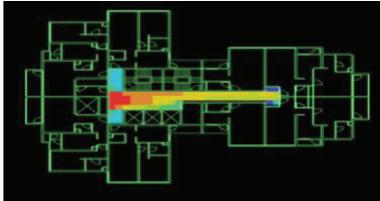
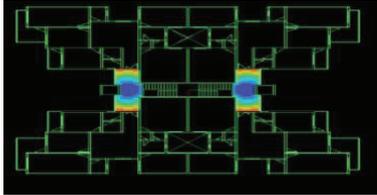
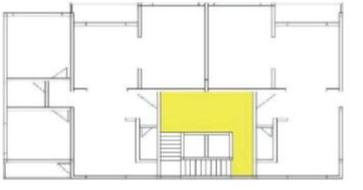
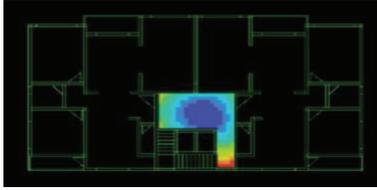
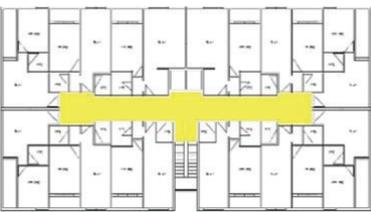
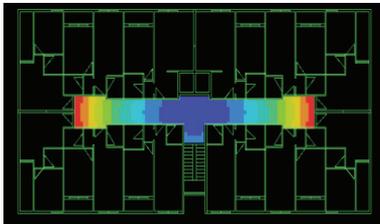
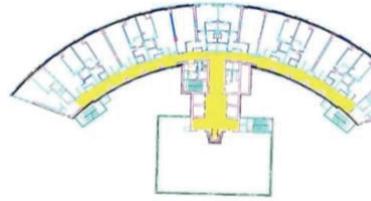
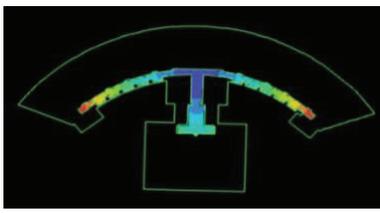
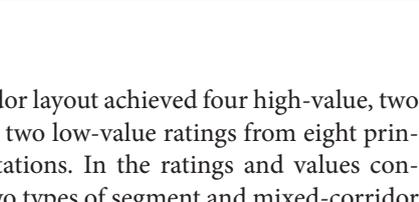
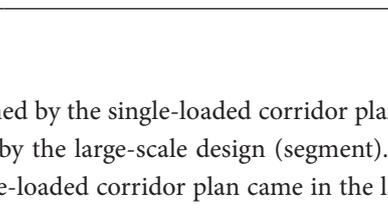
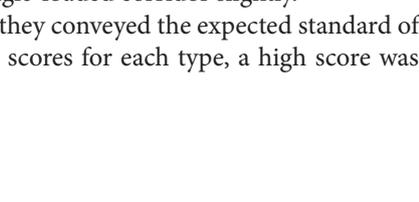
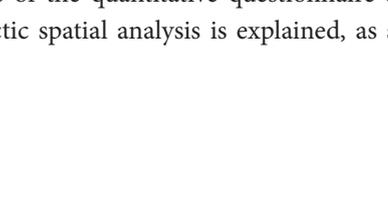
According to visibility map analysis, the single-loaded corridor (gallery) had the highest visibility correlation for the first-moment point, with R2 = 0.86. On the other hand, the segment type had the lowest, with R2 = 0.37, while the single-loaded corridor had the highest second-moment point, with R2 = 0.65, and the segment type had the lowest, with R2 = 0.14. It means that the single-loaded corridor has the best correlation in terms of the first and second moments, as shown in (Table 11).

The fifth research question

Does a measuring indoor common-space indicator by questionnaire differ from measuring with space syntax?

According to the findings of both analyses (space syntax and questionnaire), the single-loaded corridor plan has a more significant advantage. At the same time, this achieved the highest mean values for each of the parameters and variables accepted for calculation and comparison purposes. From the data, it can be concluded that these types of proposals are best measured for residential apartment buildings due to the high degree of connectivity of the axes of movement to and from the interior spaces and corridors and the architectural and spatial integration of areas., as well as the entrances’ and vertical circulation’s high visibility within the building’s architectural structure. In addition, compared to the four types of the design plan and main spaces, such as lobbies and entrances, this type has a large field of view and distribution. Table 10 displays the data obtained from the indicators and factors of connectivity, integration, and visibility from the study of the space-syntax and questionnaire surveys focused on evaluating questionnaires. A

Table 10. Isovist map analysis

Types	Typical floor plan	Visibility map
Mixed		
Large scale development	Empire world 	
	Mamwstyeay city 	
Double loaded-corridor		
Point	Kamarany city 	
	Lebnon city 	
Single loaded-corridor	Golan tower 	

single-loaded corridor layout achieved four high-value, two medium-value, and two low-value ratings from eight principles and interpretations. In the ratings and values conducted, the other two types of segment and mixed-corridor are equal. However, the type of the double-loaded corridor plan exceeds the single-loaded corridor slightly.

Additionally, as they conveyed the expected standard of accomplishment by scores for each type, a high score was

obtained by the single-loaded corridor plan and a medium score by the large-scale design (segment). In contrast, the double-loaded corridor plan came in the last place slightly lower than the point type. The relationship between the results of the quantitative questionnaire and quantitative syntactic spatial analysis is explained, as shown in (Table 12).

Table 11. visibility map analysis of the typical floors plans for all cases

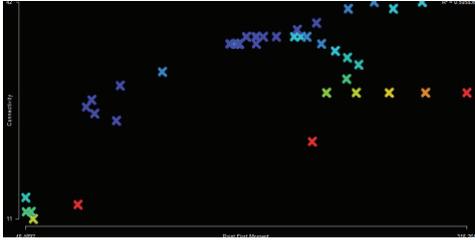
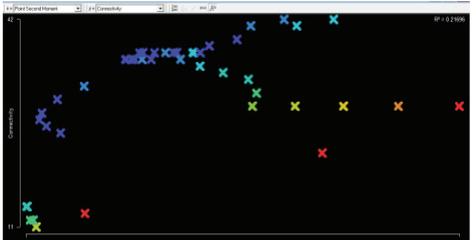
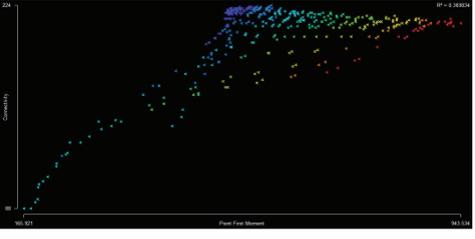
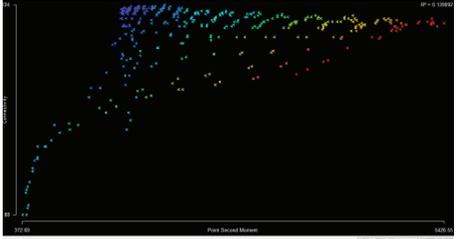
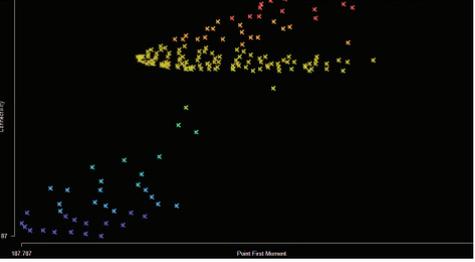
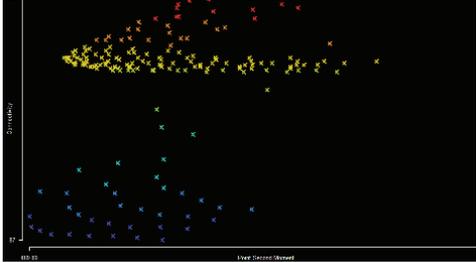
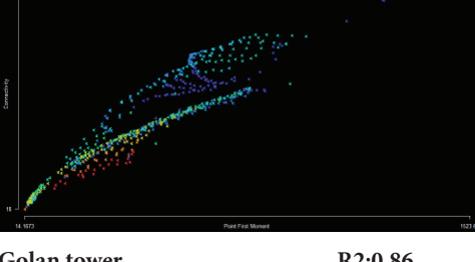
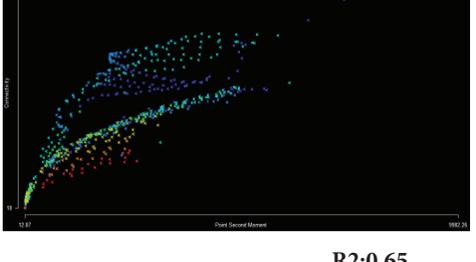
Types	Connectivity and point first-moment graph	Connectivity and point second -moment graph
Mixed	 <p>Empire world R2:0.50</p>	 <p>R2:0.21</p>
Large scale development	 <p>Mamwstyeen city R2:0.37</p>	 <p>R2:0.14</p>
Double loaded-corridor	 <p>Kamarany city R2:0.60</p>	 <p>R2:0.23</p>
Point	 <p>Lebnon city R2:0.60</p>	 <p>R2:0.31</p>
Single loaded-corridor	 <p>Golan tower R2:0.86</p>	 <p>R2:0.65</p>

Table 12. Overall values and data extracted from space syntax analysis and questionnaire survey

Types		Single loaded corridor (gallery) (Gulan tower)	Double loaded corridor (Lebanon village)	Large scale development (segment) (Mamostyan city)	Point (Kamarany city)	Mixed (Empire world)
Indicator/factors	Method of analysis	Average	Average	Average	Average	Average
Connectivity	Visibility map	584	131.4	204	183.6	31.18
	Questionnaire	4.25	2.68	4.16	2.62	3.0
Integration	Visibility map	117	83.3	5.38	37.87	21.86
	Questionnaire	4.16	2.51	4.17	3.08	2.5
Mean Depth	Visibility map	1.09	1.14	2.33	1.176	1.27
	Questionnaire	3.03	2.83	4.0	3.86	4.20

CONCLUSIONS

In our view, the lifestyle of individuals is the foremost factor that affects the search for new typological buildings and the development of a different urban residential climate. It is an individual- and family-conduct scheme. People's lives are continually changing below the impact of political, conceptual, economic, technical, physical, environmental, psychological, and other variables. Therefore, designers, urban planners, and other specialists who create a comfortable and suitable urban residential setting must carefully research the improvements and respond to changes in time [34].

This study realizes the positive relationship between indoor common-space and social distancing in residential spaces in Erbil's multi-story apartment buildings. A theoretical framework, including four factors (physical, psychological, communication, and environmental), has been created with the help of previous studies. The Pearson product-moment-coefficient-correlation results show a significant positive relationship between the acceptance of the physical factor and social distancing in indoor apartments, with a correlation coefficient of $r=0.75$ at $p<0.00$; similarly, psychological and communication factors show significant positive relationship factors have value-correlation coefficients of $r=0.612$ at $p=0.00$ and $r=0.625$ at $p<0.00$ in sequence, but environmental factors have a weak relationship with the study's main dependent factor (social distancing).

Otherwise, the multiple-regression results show that the indoor common-space factors clarified 66.1% of the variation toward the social distancing, and show that the physical ($\beta= 0.586$, $p=0.000$), psychological ($\beta= 0.354$, $p= 0.000$), and communication factors ($\beta= 0.270$, $p= 0.030$) have meaningful positive relationships through social distancing. In contrast, the environmental factor ($\beta= 0.008$, $p=0.901$) has a non-significant association.

The findings clearly show that physical and psychological influences significantly affect social distancing in residential indoor spaces. Communication and the environment are the following most essential considerations,

but only by a slight amount. These findings are focused on the multi-regression analysis statistical equation.

Typical floor plan design in management circulation systems (elevators and staircases), density, accessibility, wayfinding, width area, and flexibility inside a building is a complex and challenging process critical in architectural design. For this purpose, apartment buildings based on functional circulation systems and typologies play a crucial role in enabling residents to lead everyday lives while maintaining social distance.

The current thesis focused on Erbil's multi-story apartment complexes' spatial configuration, analysing five different multi-story apartment floor plans using space-syntax analysis and survey results. Findings from both analyses and evaluations (space syntax and questionnaire surveys) helped supply effective responses to the study's research questions. Due to the achievement of high values in most indicators assumed for calculation and comparison in the study, the single-loaded corridor-type (gallery) plan was preferred over others in the studies (double-loaded corridor, segment, point, and mixed plans). The following results were acquired based on the space-syntax analysis.

The single-loaded-corridor-type (gallery) plan is more integrated, readable, and visible than other types based on the visibility graph because of the high integration mean value. This increased integration value is due to the lower depth value recorded for this type compared to other types.

Integration is the value used to explain movement on the circulation line. Its high value causes the plan to be more noticeable, perceptible, and readable by considering the depth and evolution of the areas within the system. This type is also the most connected type-based visibility map in terms of connectivity.

For the selected locations, vertical circulations, main entrances, and lobbies, the mixed-type qualities and segment type have the best scores regarding the area of views provided (high visibility).

The main entrance's visibility in mixed and segment types improves the system's readability. By separating

the integration and reducing the system's interaction, the system's movement is reduced, making it less readable and interpreted. In specific ways, the more visible type is regarded positively.

The findings of the single-loaded corridor plan, especially those obtained from the visibility graph, are similar to the previous analysis from this viewpoint [35]. "Axial representation has a greater degree of space reduction than the visibility graph," according to [36]. The visibility-graph method provides a better example of architectural space because it represents the world more reliably. In addition, it reflects visual information provided to observers from any location that is accessible and free of restriction, making it more detailed than axial lines.

Based on spatial analyses relevant to human and building architectural architecture, researchers have discovered a connection between the different organisations of common indoor spaces and the potential ease of providing post-COVID-19 social distancing. To analyse the existing building's spatial organisation. A study method based on the space-syntax technique is widely used. It is possible to evaluate this approach when planning modern construction plans before designing and applying the building. As a result, it provides an opportunity to examine factors that must be considered in building projects in general and apartment buildings in particular.

The survey results suggest that what was derived from the space syntax is very similar, if not identical, in many ways. Furthermore, the satisfaction levels obtained from the survey for all measurement indicators (integration, connectivity, and visibility) confirm the single-loaded corridor's advantage in the rest of the plans.

Finally, because of their thought and mathematical data, the results of both analyses (space-syntax analysis and resident responses) in this research offer a basis for creating multi-story apartment building designs, mainly post COVID-19. As a result, the new thesis effectively acts in a gap in the previous literature.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

- [1] Hall ET. *The Hidden Dimension*. Doubleday. Garden City, New York: Anchor Books; 1966.
- [2] Lewnard JA, Lo NC. The scientific and ethical basis for social-distancing interventions against COVID-19. *Lancet Infect Dis* 2020;20:631–633. [\[CrossRef\]](#)
- [3] Daalhuizen J, Cash P. Method content theory: Towards a new understanding of methods in design. *Des Stud* 2021;75:101018. [\[CrossRef\]](#)
- [4] Hardin G. The tragedy of the commons. *Science* 1968;162: 1243–1248. [\[CrossRef\]](#)
- [5] Christiaans H, Almendra RA. Accessing decision-making in software design. *Des Stud* 2010;31:641–662. [\[CrossRef\]](#)
- [6] Lin C, Jiang J, Shi H, Zhang Z, Liu J, Qin C, et al. Sequence architecture and depositional evolution of the northern continental slope of the South China Sea: responses to tectonic processes and changes in sea level. *Basin Res* 2018;30:568–595. [\[CrossRef\]](#)
- [7] Zhang P, Li F, Wiegman CH, Zhang M, Hong Y, Gong J, et al. Inhibitory effect of hydrogen sulfide on ozone-induced airway inflammation, oxidative stress, and bronchial hyperresponsiveness. *Am J Respir Cell Mol Biol* 2015;52:129–137. [\[CrossRef\]](#)
- [8] Butry DT, Chapman RE, Huang AL, Thomas DS. A life-cycle cost comparison of exit stairs and occupant evacuation elevators in tall buildings. *Fire Technol* 2012;48:155–172. [\[CrossRef\]](#)
- [9] Zhang M, Kim JC, Li Y, Shapiro BB, Porszasz J, Bross R, et al. Relation between anxiety, depression, and physical activity and performance in maintenance hemodialysis patients. *J Ren Nutr* 2014;24:252–260. [\[CrossRef\]](#)
- [10] Foth M, Sanders P. Social networks in inner-city apartment complexes and the implications for the residential architecture of public space. In: Co DI, Aurigi A, De Cindio F, van den Besselaar P (editors). *Digital Cities: The Augmented Public Space*. Italy: Universita' degli Studi di Milano; 2005. p. 33–43.
- [11] Evans GW, Wells NM, Moch A. Housing and mental health: a review of the evidence and a methodological and conceptual critique. *J Soc Issues* 2003;59:475–500. [\[CrossRef\]](#)
- [12] Wu WY, Ge XJ. Communal space design of high-rise apartments: a literature review. *J Des Built Environ* 2020;20:35–49. [\[CrossRef\]](#)
- [13] Deng W. Study on the interior public space for promoting neighbourhood communication of high-rise residential buildings (master thesis). Wuhan: Huazhong University of Science and Technology; 2012.

- [14] Costello L. From prisons to penthouses: the changing images of high-rise living in Melbourne. *Hous Stud* 2005;20:49–62. [\[CrossRef\]](#)
- [15] Gifford, R. The consequences of living in high-rise buildings. *Archit Sci Rev* 2007;50:2–17. [\[CrossRef\]](#)
- [16] Li M. Study on the inner public space of high-rise residence (master thesis). Xi'an: Xi'an University of Architecture and Technology; 2007.
- [17] Procter P. *Cambridge International Dictionary of English (Cambridge Illustrated History)*. New York: Cambridge University Press; 1995.
- [18] Freeman H. Mental health and multi-story apartment. In: Burrige R, Ormandy D (editors). *Unhealthy Housing, Research, Remedies and Reform*. London: Chapman and Hall; 1993. p. 68–190.
- [19] Agyefi-Mensah S. Functionality and adaptability of design solutions for public apartment buildings in Ghana: towards evidence-based design for sustainable lifespan building performance (doctoral thesis). Eindhoven: Department of the Built Environment, Technische Universiteit Eindhoven, The Netherlands; 2013.
- [20] Wojtowicz J, Fawcett W. *Architecture: Formal Approach*. New York: Academy Editions/St., Martin's Press; 1986.
- [21] Nazmy E. The effect of social distancing on the utilisation of open spaces case study. *MEJ* 2020;45:69–77. [\[CrossRef\]](#)
- [22] Wilder-Smith A, Freedman DO. Isolation, quarantine, social distancing and community containment: pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. *J Travel Med* 2020;27:taaa020. [\[CrossRef\]](#)
- [23] He X. Study of interior public spaces for the promotion of social interaction in multi-story apartment residential buildings (master thesis). Rochester: Rochester Institute of Technology; 2018.
- [24] Richter KF, Winter S, Santosa S. Hierarchical representations of indoor spaces. *Environ Plann B Plann Des* 2011;38:1052–1070. [\[CrossRef\]](#)
- [25] Agyefi-Mensah S, Post J, van Egmond EE, Badu E, Mohammadi M. A typological analysis of public apartment buildings in Ghana. *Archit Eng Des Manag* 2015;11:376–389. [\[CrossRef\]](#)
- [26] Koranteng C, Simons B, Awume J. Evolution of spatial configurations in Ghana's housing development: The case of private apartment buildings in Ghana. *Afr J Appl Res* 2019;5:12–23.
- [27] Obongha UE, Ukam LE. The impact of settlement pattern of some nigerian cities on the spread of Covid-19 pandemic. *Eur J Environ Earth Sci* 2020;1:1–6. [\[CrossRef\]](#)
- [28] Abdul Nasir NAB, Hassan AS, Khozaei F, Abdul Nasir MHB. Investigation of spatial configuration management on social distancing of the recreational clubhouse for COVID-19 in Penang, Malaysia. *Int J Build Pathol Adapt* 2020;39:782–810. [\[CrossRef\]](#)
- [29] Dogan T, Saratsis E, Reinhart C. The optimisation potential of floor-plan typologies in early design energy modelling. *Proceedings of BS2015: 14th Conference of International Building Performance Simulation Association*. International Building Performance Simulation Association (IBPSA), 2015. [\[CrossRef\]](#)
- [30] Muijs D. *Doing Quantitative Research in Education with SPSS*. 2nd ed. New York: Sage Publications; 2011. [\[CrossRef\]](#)
- [31] Hillier B, Vaughan L. The city as one thing, *Prog Plan* 2007;67:205–230.
- [32] Hillier B, Hanson J. *The Social Logic of Space*. Cambridge: Cambridge University Press; 1984. [\[CrossRef\]](#)
- [33] HD Arslan, BY C, akmak, Syntactic analysis, and evaluation on different primary school buildings in Turkey, in *Proceedings of the International Conference on Advances in Civil, Structural and Construction Engineering, CSCE, Rome, Italy, 2014*, pp. 9–13.
- [34] Generalov VP, Generalova EM. (2020, March). Influence of human lifestyle on creating the typological structure of the residential urban environment. In *IOP Conference Series: Materials Science and Engineering (Vol. 775, No. 1, p. 012045)*. Bristol, IOP Publishing, 2020. [\[CrossRef\]](#)
- [35] Natapov A, Kuliga S, Dalton RC, Hölscher C. Building circulation typology and space syntax predictive measures. In *Proceedings of the 10th International Space Syntax Symposium (pp. 13–17)*. London: Space Syntax Laboratory, The Bartlett School of Architecture, University College London. 2015.
- [36] Rashid M, Kampschroer K, Wineman J, Zimring G. Dpatial layout and face-to-face interaction in offices-a study of the mechanisms of spatial effects on face-to-face interaction, *Environ Plann B Plan* 2006;33:825–844. [\[CrossRef\]](#)
- [37] Majeed MN, Mustafa FA, Husein HA. Impact of building typology on daylight optimization using building information modeling: Apartments in Erbil city as a case study. *J Daylighting* 2019;6:187–201. [\[CrossRef\]](#)