

Responsiveness and Adaptability of Housing Spatial Design to New Emerging Functions: The Case of COVID-19 Pandemic



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ABSTRACT

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The paper aims to measure the ability of housing design in Palestine to respond to any emerging functions and needs and the ability to adapt to new and possible sudden lifestyle changes. Four different interior house types were analyzed, two refer to the traditional approach of the closed plan, and another two types refer to the modern approaches of the open plan in terms of adaptation to new needs. These needs are adaptability to work from home, flexibility to change, separate or merge functions, and the adaptability to respond to health issues like quarantine. The study adopts the method of architectural analysis and questionnaire to measure people's opinions about all types in terms of sudden functions. The study takes the COVID-19 pandemic conditions as a case study. The main finding of the study is establishing a relationship between style of housing spatial design and the ability for adapting sudden changes in lifestyle. It shows that the traditional designs adapt to most changing lifestyles successfully, the independent guest room was converted into an office or guaranteed room. Moreover, the modern open plan house design with a T shape of the day wing is the best choice for adapting to the post-COVID-19.

1. INTRODUCTION

The COVID-19 pandemic has dramatically changed the concept of home in many countries around the world in a sudden manner. The home is no longer restricted to the usual functions of eating, sleeping, and social activities. This change emerged because of the need to stay at home for a long time [1]. Here, the sudden need for new functions that the home should provide to respond to the pandemic has emerged such as health quarantine, working from home, and E-learning [2]. Worldwide, this has led to the importance of functional adaptation of existing residential buildings with these sudden functions [3], to come up with recommendations that increase the ability of housing units to adapt to the future's changing lifestyle. On the international level, different studies addressed the post COVID-19 pandemic in terms of home design features and the importance of these design features in case of satisfying the uses during long staying such as the case of COVID-19 pandemic [4]. Other studies addressed the flexibility and adaptability to fundamentals requirements of housing during emerging situation for certain building elements [5]. Those studies found that the houses and the users have changed, modified or transformed their houses and their way of living and working during the pandemic. And there were recommendations to take into consideration the housing flexibility and adaptability to emerging uses in the future housing design. These recommendations are not valid for all, as each country will have different housing spatial design because of the different cultural aspects, user's behaviors and housing size.

However, for the housing sector in Palestine, there is a lack of studies to evaluate the flexibility and the adaptability of the

housing design, the interior design, and the functional arrangement under critical conditions including emergencies, health crises, working from home, and e-learning. Before the pandemic, home design in Palestine was gradually changed to keep up with the new challenges, and the interior design of homes transformed from traditional closed plans to modern open plans. The modern design includes living space, an open kitchen, and dining in one merged space. While the traditional trend of interior design for homes was more based on the separation of functions into separate rooms such as the living room, guest room, and closed kitchen. Accordingly, this study discusses the ability of each of the two previous patterns to adapt to the Corona pandemic and the required changes to adapt to new jobs inside the home as a case study.

2. LITERATURE REVIEW

Studies for building responsiveness and adaptability for different building use like health care facilities show that convertibility, scalability, and adaptability should be taken into consideration in the design development and building management to respond to any emerging scenario [6]. Residential building studies addressed the importance of flexibility and adaptability to contemporary needs and the changing lifestyle. Adaptability should include building design, construction, interior design, and furniture design [7]. Other studies addressed the health and well-being challenges during the pandemic and its capacity to provide access to green elements, flexibility to function change, indoor comfort, and indoor air quality [8]. At the urban planning level, the previous studies emphasize the importance of taking into consideration

at the master plan level and urban development planning the issue of flexibility and adaptability to be able to respond to the emergency scenarios like what happened during the covid-pandemic [9]. At the interior design level, a study proposed a conceptual model and several suggestions to cope with emergencies and the change of functions [10]. Regarding the building systems like ventilation systems, a study found that the current ventilation systems are not compatible with the long use and the change in the functions like what happened during the pandemic, and the same study proposed innovative ventilation strategies to be able to adapt to the emerging situation and the long use of residential buildings [11].

These studies emphasize that the flexibility and adaptability of the buildings is contributing to sustainable development goals. Aziz et al. [12] consider flexibility and adaptability as sustainable measures for space and building architectural design. Since the chosen approach for spatial design of the house is a major factor in housing adaptability, the following section discusses the adaptability of two famous design approaches in Palestine: (traditional) closed plan, and (modern) open plan.

2.1 The closed versus open plans

The ability to change use is a kind of adaptability that can be applied in the spatial design of both types: closed and open plans but in different ways [13]. Hence, in a closed-plan house, an individual room can be used as a bedroom, sitting room, or dining room. This is an important type because the future need of homeowners can be associated with other factors rather than the increase in family members, but more often with a change in the use of space [14]. Additionally, homeowners can move to another home and other homeowners with different needs and habits will replace them in the same home, making this adaptability and flexibility a vital kind of adaptive housing [15]. For example, a guest room in the original design of the house may not be used in the future according to the change in families' relationships with other families or neighbors [16]. Therefore, by being able to change the use of the guest room, another adequate activity can be recommended for this room, such as a study room, or working area to ensure efficient use of spaces in the future [17].

The multiple-use capability of the closed plan within the spatial arrangement can be viewed as incorporating two or more uses in the same room or place [18]. For example, the same room can be used for dining and studying at different times during the day. This closed plan type relies on maximum space utilization efficiency to reduce the number of rooms required for multiple functions and thus the required area of the residential unit. The multiple uses of central spaces are another example in the closed plan, courtyards, and central corridors, which provide important space for both movement and social activities [19, 20]. The possibility of multiple uses of space can reduce the necessary partitions to separate rooms, which reduces the use of building materials. Furthermore, the closed plan -in some cases- may not have the flexibility of the interior design to accommodate more than one use in the same room [21], because of the differences in functions needed in terms of space proportions, furniture, and openings sizes.

On the other hand, open plans can also facilitate multiple uses and changes of use for the spatial design, but are different compared to the closed plan; one large space can accommodate multiple uses such as living room, dining room, and kitchen in a unified open space at the same time but

without providing acoustical and visual privacy between spaces [22]. This idea makes the open plan restricted to some activities like social and entertainment with less capacity to provide a relevant atmosphere for functions that need concentration such as studying, e-learning, and using computers for work [23]. Accordingly, an open plan facilitates integrative capacity which is a kind of creating spaces that facilitate the changing of spaces and sometimes the entire surrounding into a different environment over time [24]. This means that at least two spaces are designed to be combined into a single space currently and in the future. This kind can help use spaces efficiently in a limited area. A temporary partition can be used to divide the space and be reversible. The ability of one space to integrate with another may require some attention in design openings, furniture layout, and the relationship of spaces to other parts of the house [25].

An open plan has also the potential to reduce the area of the house, and give a sense of large spaces at the same time. However, it can cause a decrease in room numbers in the original plan. Hence, the open plan can reduce the required space of the home for a small householder in the present by reducing the area of the residential units [26]. However, the space area will increase by integrating it with other spaces or dependencies based on the future needs of the householders. The open plan also facilitates the ability of space to be divided, because it consists of designing a single large flexible space that can be divided into at least two spaces if needed in the future [27]. This partition can be permanent like the use of fixed walls, or temporary using flexible walls. In this sense, many adaptable house designs suggest sliding walls for a temporary division of the space, which will obtain a high level of flexibility to divide and combine the interior spaces of the house as needed [28].

2.2 Flexibility and adaptability of interior design

Various adaptation types can be used to adapt to the changes in our homes, such as the ability of the spaces to integrate, subdivide, grow, change uses, and multiple uses [29]. These kinds can provide many economic, socio-cultural, and environmental benefits to the users. However, design for adaptability may suggest some limitations in implementation methods, which may sometimes lead to expensive treatments [30]. Because of this, the overdesign for adaptation may be an exaggerating option, if the expected need of householders to adapt were not taken into account [31].

Another kind of adaptability is the ability to grow which can be found in both closed and open plans. Being able to grow for space means being able to expand beyond the current spatial design of the residential unit. This kind may require additional outdoor space for ground floor growth, in addition to upper terraces for vertical growth. These exterior spaces can be designed in the original plan for this future extension [32]. Hence, the growing process is the incremental construction of the spaces to increase the usability of the house as needed [33]. This kind introduces an extension to a given space; to accommodate the growing number of householders.

As a result, functional adaptability takes many forms and kinds within the housing unit to accommodate the new functions and activities of the family over time. Two kinds of which are supported by the closed plan, the first is the ability to change use in the same spaces and the ability for multi-use in the same space. The other two kinds are supported by the open plan: the first is the ability to merge more than one use in

the same space, and the ability to divide the space into two or more zones. Moreover, the ability to grow, or extend the area of the space is supported by two types: closed and open plans. Such kinds are found in different percentages in both open plan and closed plan as possible approaches for designing housing units with flexibility and adaptability. This study tries to explore the efficiency of these kinds of adaptabilities in adapting to the corona pandemic in Nablus city in the two types of housing design closed and open plans. This assessment will be used to improve the future flexibility and adaptability of housing design to respond to future changes, especially in case of emergencies.

3. MATERIALS AND METHODS

To assess the flexibility and the adaptability of the housing architectural design to respond to the users' needs in the cases of emergency and emerging contemporary needs, the study used two methods. The first method is an onsite analysis of the commonly used architectural housing design in Palestine to select the most used housing design. This method includes surveying housing types in the case study neighborhood in Nablus city (Al Maajeen neighborhood shown in Figure 1) in terms of units' spatial design, to set an adequate classification of most common types of both traditional and modern approaches. Such classifications are used to make the comparative analysis of this study. The second method is a questionnaire survey to evaluate the users' satisfaction with the responsiveness of the architectural design. Therefore, the study uses a quantitative method, which is based on an architectural analysis based on the functional adaptation capacity of the housing units, and a qualitative method by surveying a questionnaire and interviewing the residents in 10 samples of each type.

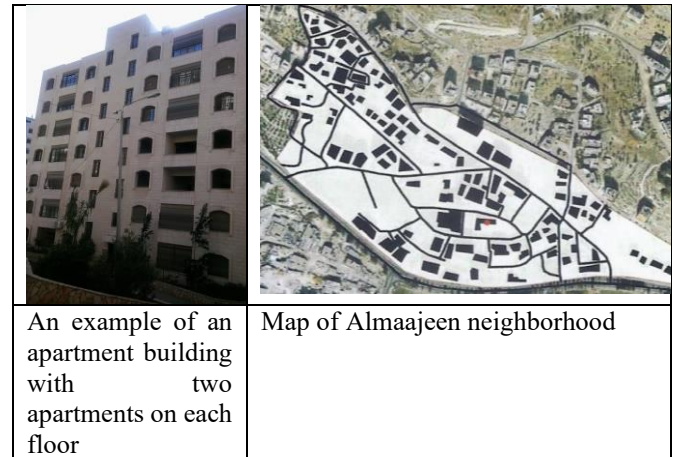
3.1 Selecting the spatial design typologies

A field survey was conducted for the Al-Maajeen neighborhood in the city of Nablus seen in Figure 1, to select the most used housing unit types in this area. This neighborhood is considered a representative of the modern and contemporary housing in Palestinian cities. The study uses a set of methodological tools that combine data collection for built plans, and surveys of engineering professionals and real estate developers. The information collected was then analyzed.

The survey identified two main types of housing unit layouts: the first is the classic housing unit layout, which includes, in addition to the sleeping suite and family activity suite, a special guest suite. This suite typically has a guest living room, dining room, bathroom, and separate entrance. The second type is a modern design, where the interior design of the residential unit is characterized by the presence of a day suite in the form of open space in addition to the sleeping suite and does not contain a private guest suite.

On the building level, the field study revealed that most of the residential buildings are multi-story apartment buildings. Each floor consists of one or more apartments. In addition to a staircase and sometimes an elevator. The staircase shall be the common area among the inhabitants. The type of residential building that contains one apartment and two apartments on each floor was chosen for the study. This type is characterized by the opening to the four sides just like single houses and

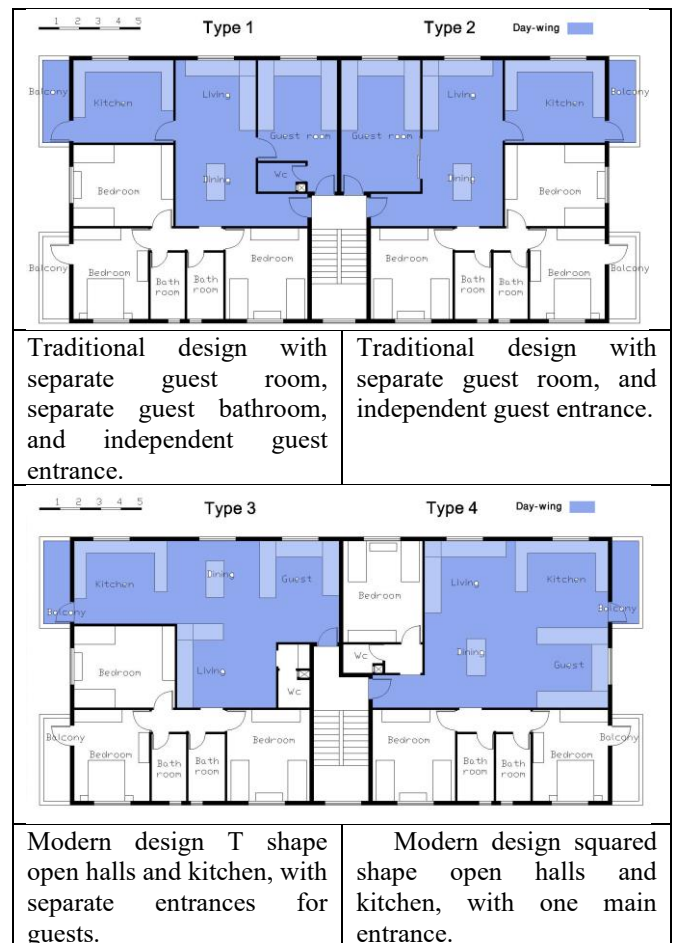
opening on three sides just like the attached house, which increases the ability of the housing unit to change in the interior design.



An example of an apartment building with two apartments on each floor

Map of Almaajeen neighborhood

Figure 1. The selected neighborhood (on the right) and the housing type (on the left)



Traditional design with separate guest room, separate guest bathroom, and independent guest entrance.

Traditional design with separate guest room, and independent guest entrance.

Modern design T shape open halls and kitchen, with separate entrances for guests.

Modern design squared shape open halls and kitchen, with one main entrance.

Figure 2. The selected architectural spatial design types, where types 1 and 2 represent the closed plan and 3 and 4 represent the open plan

On the interior spatial design level, four different types were chosen to design the apartment for the same building, but on different floors, as shown in Figure 2. Type1 represents the traditional spatial design in Nablus city, Type1 traditional plan1 Traditional design with separate guest room, separate guest bathroom, and independent guest entranceType2

traditional plan2 Traditional design with separate guest room, and independent guest entranceType3 modern plan2 Modern design, T shape open halls and kitchen with independent guest entranceType4 modern plan2 Modern design squared shape open halls and kitchen.

3.2 The questionnaire survey

The survey was designed to measure users' satisfaction with their home's interior design, as well as their satisfaction with the environment that surrounds them. The survey aims to measure the responsiveness and flexibility of architectural design to respond to emergency and contemporary needs during the COVID-19 pandemic.

After analyzing the characteristics of the different residential units, the study selected 40 different units in the selected neighborhood to carry out the survey. 10 units for each special design type are explained in Figure 2 above. Inclusion and different criteria were adopted in the selection of the sample units. Thus, the selected units vary in location: near the center or on the neighborhood's border. The sample also differs in family characteristics in terms of number, ownership, and income as shown in Figure 3. The number of respondents is 40 and respondent characteristics as shown in Figure 3. The questionnaire was carried out by reviewing the householders.

The questionnaire was divided into three main categories: Ability of the current design to adapt new functions with 10 questions about the area, space organization, user comfort, and child security; Alterations to adapt sudden function with 11 questions about the type of alteration and reasons for alteration; and the flexibility for the emerging functions with 5 questions about social interaction, entertainment, working from home, studying from home, and quarantine.

Recipients were asked to fill in the answering sheet using an adequate number to set their satisfaction from 1 to 5, where 1 is the lowest degree of satisfaction and 5 is the highest one. Then, the results were calculated in a percentage format for all categories as follows:

Percentage of satisfaction=

$$= \frac{\text{Percentage of satisfaction} \times \text{Summation of scores for each question}}{\text{number Of recipients} * 5} * 100\%$$

Figure 3 shows that relatively large families in terms of

number are dominant in the surveyed sample; the highest range of person's number in the households is five or more. However extended families do not exist in the sample, which leads to a belief that most families have three or more children in the sample; thus 100% of the sample are nuclear families. Moreover, most of the families 80% are in the form of both parents and children in the same house, and they are originally from the city as the father's birthplace is Nablus. The figure shows also the main characteristics of the recipients, in first hand, there is a high percentage of youth in the sample 20-30 38%, and 31-40 40%. On the other hand, most of the recipients are female 80%, because they stayed more at home than males, which increases the opportunity to fill out the questionnaire for females.

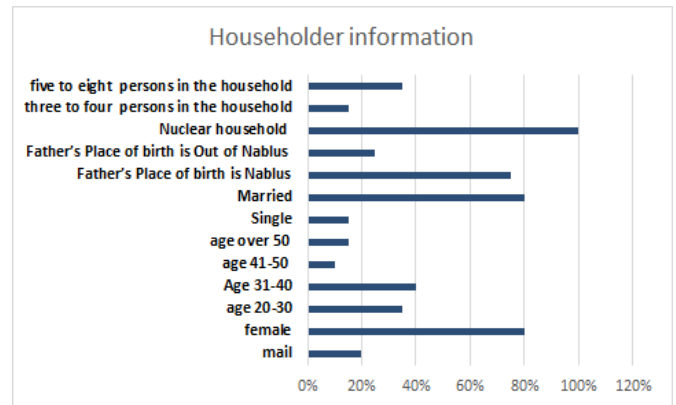


Figure 3. Householders' characteristics of the selected sample

4. RESULTS AND DISCUSSION

Results of this study are discussed under two main items: The first is the ability of the housing units in their current situation, of the two mentioned types (open and closed plan) to adapt to the changes in the lifestyle of families residing in them during the pandemic. The second is the changes that the residents made or intended to make inside their homes to get a better adaptation to the changes taking place in their daily lives. The results will also be used in both items to discuss the required changes to the future design to increase the ability and flexibility of housing units to adapt to life requirements after the pandemic.

Table 1. The ability of the house to adapt to new functions

Number	Questions about the users' satisfaction	Traditional design	Traditional design 2	Modern design	Modern design 4
		1 Type1	Type2	3 Type3	Type4
1	The available space	78%	78%	83%	87%
2	Interior space organization	78%	76%	83%	84%
3	Location of the kitchen, and bathrooms	76%	78%	84%	80%
4	Children's sleeping area	78%	78%	78%	77%
5	Degree of calm to perform other functions (ex. work or study)	80%	81%	76%	74%
6	Acoustical privacy to perform other functions (ex. work or study)	79%	80%	71%	71%
7	Visual privacy to perform other functions (ex. work or study)	77%	78%	70%	68%
8	Comfortable during summer and winter	79%	79%	73%	74%
9	Ventilation and artificial lighting	82%	82%	75%	77%
10	A secure place for children	83%	81%	73%	71%
Total		79.0%	79.1%	76.6%	76.3%

4.1 The ability of the current design to adapt to new emerging functions

Table 1 shows 10 questions used to measure people's satisfaction with the different parts of their homes during the Corona pandemic. Reliable measures were used to compare the traditional and contemporary plans, which are, satisfaction with spaces, thermal comfort, satisfaction with ventilation, calmness, and safety factors. These are very necessary elements to be available in all residential units, regardless of their design, especially during the long period of stay inside the house, where the need for healthy homes is doubled to reduce infections.

In the first question, people were asked how satisfied they are with their available space during the Corona pandemic. Although the area of the sample selected from the two types, the open plan, and the closed plan is approximately equal, the level of satisfaction among residents of modern open plan design is an average of 85% which is relatively more than that of residents of traditional houses (closed plan) 78%. The reason is that the open halls give a feeling of spaciousness and a suitable place for communication between family members in different parts such as living, dining, and kitchen. The ability of the open plan is greater than the closed plan in terms of adapting to the communication needs for longer periods between members of the same family during the pandemic period. Many families exploited the adaptation by spending a lot of time preparing food and playing with their children.

The second question is about the users' opinion on the organization of the various functions inside the home. The recipient's satisfaction with the interior organization for the open plan was an average of 84% compared to an average of 77% in the closed plan. Since the pandemic period was an opportunity to spend more time changing some details related to the arrangement of furniture and adapting it to the various recreational activities of the family. The study found that the residents of the open plan have been able smoothly and comfortably to adapt the open space to daily life changes. For example, enlarge the dining table space to play tennis, or add some seats to the living space to watch TV for a larger number of family members. In that period the open kitchen had a great role in collecting family members and increasing social contact between them, recipients have average satisfaction in the open plan 82% about the kitchen and bathroom location compared to the closed plan 77% as shown in question 3.

From this standpoint, it appears that the first three questions in the table have made progress in the percentage of users' satisfaction with open-plan homes because they are related to the formation of halls and kitchens and their ability to motivate spending recreational and social times among members of the same family at the time of the pandemic. However, the differences are less and the satisfaction rate is almost equal concerning bedrooms of children in question 4. There are no significant differences between the two styles because in each of them the rooms of children and adults are characterized by the same independence, 78%, and 77%. It is noted that many families have used bedrooms for other purposes during the pandemic, such as work and e-learning. However, this often causes disturbance to some family members, because these bedrooms are often shared by two or more people.

For questions 5 to 10, the table is witnessing a shift in the percentage of users' satisfaction is higher for the closed types over the open plan types. Question No. 5 shows that 85% of the recipients in the traditional closed plan are satisfied with

how quiet the home is, compared to 75% in the open plan. The observed reason is the ability of the independent rooms to provide quiet space for users, especially during the official meetings of the working father or mother, which turned to the online working system for many families. Likewise, more than 80% of the samples had one or more children who needed a quiet room to attend the electronic lectures. In this case, the guest room was reused in the traditional style (closed plan) as a multi-purpose room for study and work, away from the disturbance of other family members. This transformation was encouraged by the absence of visitors during the pandemic, so the room was redundant for the family and isolated from the inconveniences coming from the living and the kitchen. This room provides privacy for work and study, and can easily be converted into a multi-purpose room. The sixth question shows a greater satisfaction with acoustic privacy in the traditional closed plan, 79% compared to 71% in the open scheme.

As discussed previously, the need for social interaction and entertainment inside the home increased during the pandemic, and the need for privacy to perform work from home increased as well. The homes that contain a multi-purpose room were also distinguished by providing a high rate of privacy for work and study, as well as for quarantine, which explains the high index of satisfaction among recipients in the traditional closed plans 78% compared to only 69% among recipients in the open plans as shown in question 7.

Because the pandemic has forced the residents to spend unprecedentedly long periods in their homes, it was an appropriate opportunity to assess the environmental adaptation of homes in summer and winter. It is also noticed that the closed plan is better than the open plan in terms of adapting to different temperatures in summer and winter. The periods of home commitment were long and entered into several seasons. The answers to the eighth question show a higher satisfaction rate among the residents of the traditional closed plan, an average of 79% compared to an average of 74% among the residents of the modern open plan. The reason is due to the ease of cooling and heating the room if it is closed compared to the large and open spaces. This observation is confirmed by residents of houses with a modern plan, as they confirmed their increased presence in bedrooms during the pandemic, because of the ease of their adaptation and the cheapness of electricity costs compared to the air conditioning of open halls. The answers to the ninth question confirm the increase in the satisfaction of the residents of the traditional closed plan with ventilation and artificial lighting in the rooms by 82% compared to 76% in the open plans.

Another important thing that closed plans provide is to provide safety for young children - less than four years old -. The results of the tenth and last question show a greater satisfaction rate among the residents of the traditional scheme (82%) about the safety of their children, compared to 72% of the residents of the open scheme. The reason is that closed rooms help parents control children and keep them away from what harms them inside the house. In this context, the closed kitchen shows superiority in enabling the mother to close the door when the kitchen is not used to keep children away from sharp tools. On the other hand, the long periods that children needed to stay at home with the closure of nurseries and schools made it necessary to have a multi-purpose room - former for guests - to practice various recreational and educational activities in a safe environment that does not need much supervision by parents.

4.2 Required Alterations to adapt emerged functions

Table 2 shows the results of the questionnaire which are divided into two sections. The first section discusses the changes that residents have made or intend to make to the interior design of their homes to better adapt to the requirements of the emerging functions during the pandemic. The questions in the table include the changes to the openings (windows and doors), different functions and balconies, as well as other matters related to the furnishings and maintenance. The second section discusses the reason for these changes, and their relation to the items discussed in the previous table, such as obtaining a new function, better solar and ventilation, privacy, and quietness.

It is noticed that the presence of the independent rooms, especially the multi-purpose room, in the traditional closed plan reduced the need for fundamental changes to the house's interior design. Here, there is less need to make changes to the openings like windows and doors, compared to the open plan. The table shows that 30% of the residents of the open plan need to make modifications to the openings, either to create a new room or to change the function of one of the rooms. These changes are either by adding a space or dividing a large space into two parts. This type of change usually faces obstacles if changes are not allowed on the exterior facades of apartment buildings, which leads to reducing the possibility of such changes and consequently the difficulty of adapting to new functions in open-plan homes.

Regarding the need to make a change in the facilities, it was in the form of adding a bathroom or dividing the large bathroom into two bathrooms to fill the need for a larger number of bathrooms, especially in the case of quarantine and the need to isolate the bathrooms for the infected person from others. This need also increases in the open plan to 30% of cases because their homes often do not provide a private bathroom for guests, as in the traditional closed plan, which can be used as an additional bathroom for the family, so the need to change the bathrooms does not exceed 5% in the case of the traditional closed plan. The wide disparity between these results (25%) is properly due to the main character of the closed plan that composed of many permanent partitions compared to the open plan which led to much difficulties in the case of sudden changing of spatial design.

As for the need to make changes to the rooms' functions, it was 15% in the houses with a closed design, and the changes were to make the rooms large or small to suit the new uses. While the need to make changes to the rooms in the open plan increases to 30% of the selected sample. The reason is sometimes due to the need to create new rooms by dividing part of the open space and using it for study, work or quarantine. While many cases were unable to make changes to

the rooms, not because they were not needed, but rather because there was no suitable space for that change in their homes. Accordingly, it is expected that the percentage to increase much more than 30% if it is possible to make these changes in the open plan homes.

To overcome the previously discussed lack of space, some residents closed the balconies to increase the area of their homes and included them in the hall, or created small rooms in them for various activities. The table shows that 10% of the selected open-plan sample added balconies to the interior space and none of the families in the closed scheme needed to include balconies to increase the space in the closed-plan housing units.

The last item in the required changes in terms of making changes related to furniture and maintenance, table 2 shows a wide disparity between results. A high percentage (80%) in homes with a traditional closed plan design compared to modern open plan (0%) for two reasons, the first is the lack of a great need for fundamental changes such as changing rooms, bathrooms, and openings, so the largest percentage was for small changes. The other reason is the presence of independent rooms and multi-purposes that encouraged residents to acquire luxuries and accessories that help with multi-functionality, such as foldable and removable furniture, with a greater percentage than the residents of open-plan homes, which gives greater flexibility in the open halls to deal with traditional furniture and adapt it to suit many recreational and social activities as discussed before.

The second part of the table shows the reasons for these changes, whether they have already taken place or the residents intend to do. The first reason was to have better privacy. Where the result was higher in houses with an open design, higher by 10%, as expected for houses with a traditional closed design, only 5%, where the separate rooms provide better privacy. The second reason was to get a better space. This was the main driver of changes in modern homes, 50% compared to only 5% in traditional homes. This is due to the spaciousness of the open space and their occupation of most of the space, which increases the need for separate spaces for new activities such as study and remote work. On the other hand, there were other motives for making changes in modern open plan homes, such as obtaining better climatic conditions 10% versus 0%, quietness 10% versus 5%, or a better location of rooms 10% versus 5% in traditional closed plan homes. The largest percentage of change motivation in houses with traditional closed plan designs for other reasons (80%), including maintenance and obtaining better equipment and alternatives, due to the lack of need for the above-mentioned motivation of climatic conditions, privacy, and others as discussed previously in Table 1.

Table 2. Required Alterations to increase the ability of the house to adapt to new and emerging functions

	Required Alterations	Traditional design (type 1 and 2)	Modern design (type 3 and 4)
Type of alteration	Change opening (windows & doors)	0%	30%
	Conversion of utilities	5%	30%
	Conversion of rooms	15%	30%
	Closed balconies	0%	10%
	Others (maintenance, replace elements...)	80%	0%
Reason for alteration	Not enough privacy	5%	10%
	Achieving adequate area	5%	50%
	Climate circumstances	0%	10%
	Achieving better quietness	5%	10%
	Achieving better location	5%	10%
	Others (maintenance, replacing elements)	80%	0%

People were asked about their overall satisfaction with the adaptation of their homes to new jobs during the pandemic period. Table 3 shows the extent to which users in the selected sample are satisfied with the performance of the day wing of their homes - which includes living, dining, and the kitchen - in adapting to the new functions in the pandemic period, which is the need for greater times of social communication and entertainment, as well as the need to work and study from home. In addition to the need for quarantine for family members in case of infection. The table shows a greater percentage of satisfaction in general with the functions of social interaction and entertainment in modern open plan homes (the third and fourth types) compared to homes with traditional design (the first and second types). This is because the social and recreational functions were not completely new, but rather the need for them increased with the gathering of family members for a longer time during the pandemic. The open spaces in general showed a better ability to satisfy people in these aspects. On the contrary, the results in Table 3 showed that residents of houses with traditional closed plan design were more satisfied with the day wing area in terms of adapting to other new functions, like working from home and studying remotely. The first type of closed plan design showed the greatest ability to adapt to quarantine, as there is a separate bathroom for the guest room that was used for quarantine during the pandemic period.

The results show a necessity to develop a new design or a modification to the future interior design for single houses and residential apartments to respond to the future emerging functions. These emerging functions can be related to health conditions like pandemics, crises, and disasters resulting from wars or harsh climate events, fundamental changes in the work environment like moving towards working remotely, etc. The required changes in the architectural design should take into consideration (besides the basic function of the home) the social and entertainment requirements on one hand, and the need for adaptable space for other functions like work, study, quarantine, etc.

4.3 A comparison between the traditional and modern plans

The presented study aims to learn from the evaluation of adaptability and flexibility of architectural design of residential units in response to the COVID-19 pandemic. The result from the study can be adapted for similar conditions where housing should adapt to emerging functions and uses. The analysis of the field survey shows that the total ability to adapt to the new emerging functions of houses with modern (open plans) design (76%) in the third and fourth types, is less than the total ability to adapt in houses with traditional (closed plan) design (79%) as seen in table3. Although the population's level of satisfaction with the functional adaptation of the day wing is close to the open plan styles, 77% for the fourth type and 79% for the third type, compared to 80% for the first and second types. The reason for this convergence is that modern patterns were abler to respond to recreational and social functions, while traditional patterns were more capable of responding to newly created functions such as working and studying from home.

It is also noted that the ability to adapt to the modern open plan design was greater in the third pattern with T-shaped halls than the square hall in the fourth pattern. The reason is that the guest suite is somewhat isolated from the rest of the hall, as it facilitates the process of creating a new room using temporary partitions in case the family wishes to do so.

Table 4 shows that adaptability for the five sections discussed in the introduction is available in the third open plan style. This style combines the ability to bring about various changes from merging, dividing, and changing in function with only the need for simple modifications such as moving partitions that can be used to create a new room. In case there is a need for new functions to be quiet, such as work and study, these divisions will provide the needed conditions. Also, these partitions can be removed to increase the capacity of the space to accommodate the social and recreational activities of family members. Therefore, the third pattern is one of the patterns that are ablet to adapt to the changing lifestyle after the COVID-19 pandemic.

Table 3. A Comparison between day wing of the traditional and modern plans in terms of adaptability for the emerged functions in the corona pandemic

<i>Adaptability for the emerged functions</i>	Traditional design Type1	Traditional design Type2	Modern design Type3	Modern design Type4
Social Interaction	79%	79%	83%	84%
Entertainment	76%	78%	85%	85%
Working from home	79%	80%	75%	74%
Studying from home	82%	80%	76%	75%
Quarantine	83%	81%	76%	69%
Total	80%	80%	79%	77%

Table 4. A Comparison between the day wing of the traditional and modern plans in terms of kinds of adaptability

	Traditional design Type1	Traditional design Type2	Modern design Type3	Modern design Type4
The ability for merging more than one space			X	X
The ability for dividing the space into two or more zones			X	X
The ability to grow, or extend the area of the space	X	X	X	X
The ability for changing use in the same spaces	X	X	X	
The ability to multi-use in the same space	X	X	X	

5. CONCLUSION

As a result for the COVID-19 pandemic, more than one function was needed in the Palestinian houses: office for working, studying room, and quarantine room. It is not logical to insert these three rooms into the design. The new functions need separate rooms because they need a quiet atmosphere. However, the survey revealed different needs of families, not all families have the same need for working and learning from home. As a result, type 3 with the T shape of the day wing is the best choice for the future design of the post-covid19 lifestyle, because it can successfully provide the five stratifies of adaptability and contains the benefits of both open and closed plans.

Since this paper discusses the issue of housing units adapting to the COVID-19 pandemic, simple adaptation types that do not need major changes in the house should be taken into consideration. Thus, a multipurpose room seems to be the best choice for better adaptation of house spatial design for the new lifestyle. Although the pandemic has gone through several stages of stressing the commitment of homes, mitigating sometimes, and returning life to normal at other times. However, indications indicate the possibility of returning calls to stay at home at any time. In addition, this pandemic has greatly helped the growth of remote jobs and distance study. All of this makes it necessary to consider the new lifestyle when designing residential homes in the future.

The pandemic forced most families to spend long periods indoors, according to the instructions of the official authorities in all countries around the world. Although these measures were intended to separate people to reduce the chances of infection between them, it was also an important period for assessing the design of homes for many families. Those houses have become seen by the residents as places where they spend most of their time in. From this experience, it is necessary to know to what extent these designs responded to the unexpected long times that the residents spent in their homes while trying to adapt to that stage by carrying out recreational and social work and completing their work and homework inside their homes.

It assumes that the traditional design is more adaptable because of its dependence on separate rooms. So that one of these rooms can be converted to a different use more easily than an open plan. Therefore, it's recommended to concede the possibility of having a multipurpose room for the future lifestyle that simulates the traditional design of guest rooms, which is an independent room, with an independent bathroom, and a separate entrance to better adapt to the new changing lifestyle in the future.

The potential of flexible kinds for housing design offers the reduction of physical changes. These kinds are generally based on a minimal change in interior design, which can reduce the necessary costs to make that long-term change. Therefore, considering these changes in the original plan will reduce the need for future demolition and reconstruction.

Finally, it is recommended that architects and building engineers consider the future design's ability to adapt to emerging functions through flexibility for changes and providing spaces that can adapt to different functions. It is also recommended to do further research on adaptable housing design for affordable and sustainable housing in Palestine. Further studies can also deal with sudden changes in the housing environment on the urban scale, including streets, collective spaces and squares. It is hoped that these fields of

the search will assist in decreasing alteration costs of the housing environment and build much more comfortable and responsive housing.

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