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Existing apartment buildings as a spatial reserve for assisted living

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Abstract

Purpose – Ageing populations induce needs to adapt existing housing. With ageing, the number of frail old people, who require assistance in daily life, is also increased. Converting existing housing into assisted living enables them to remain in their community while receiving necessary support and care. The purpose is to investigate whether post-war mass housing is spatially appropriate for adaptation into group homes for older people.

Design/methodology/approach – The research material is attained from Finland. Spatial requirements for group homes are drawn from 130 units built or renovated during 2000–2015. Spatial characteristics of mass housing are mapped from 105 apartment buildings built in the 1970s. The latter are matched with the former by comparing the connectivity of layouts, sizes of units and the numbers and sizes of individual spaces.

Findings – Group homes typically utilize a linear layout, which can easily be created in apartment buildings. Individual spaces of a group home fit apartment buildings effortlessly. Whole group home units mostly prove to be spatially feasible but result in looser dimensioning than is typical in existing units. The mass housing stock can be considered a spatial reserve for adaptation into group homes.

Originality/value – This is the first study to employ a large-scale, multi-case spatial mapping approach to analyse the adaptability properties of mass housing into assisted living. The findings pertain primarily to the Finnish context, but a methodology is presented which can be applied to other countries and also to other spatial functions.

Keywords Repurposing, Adaptability, Adaptive reuse, Mass housing, Population ageing

Paper type Research paper

1. Introduction

Existing buildings are increasingly seen as spatial reserves for users' changed and novel needs, making adaptation an alternative to new construction (Kohler and Hassler, 2002; Kovacic *et al.*, 2015). A key megatrend sparking these adaptation needs, especially in housing, is population ageing, which is a substantial global phenomenon (Kabisch and Grossmann, 2013; Eurostat, 2019). Finland, the target of this study, is among the countries where population ageing is most prominent. Currently over 22% of the Finnish population is over 65 years of age. By 2040, the projected figure will exceed 27%, putting Finland's population among the oldest in Europe (Eurostat, 2019) and correspondingly in the world (Serrano-Jiménez *et al.*, 2019).

The existing building stock in Finland, as in many other countries, is often considered inadequate in terms of supporting older people living independently, which highlights the need for home modifications (e.g. Jalava *et al.*, 2017; Pettersson *et al.*, 2017; Serrano-Jiménez *et al.*, 2019; Slaug *et al.*, 2020). What is more, with population ageing, the number of frail old people, that is, people requiring assistance in their daily activities, is also increased (Strandell

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and Wolff, 2019, p. 50). Oftentimes "regular" home modifications will not suffice to meet their needs, and more intensive forms of assisted living, such as group homes, become necessary. In this form of housing, not only does the physical environment accommodate the needs of older people, but professional care is also available. (Reed *et al.*, 2007). Compared to institutional care, assisted living is argued to be both preferred by the residents and more cost-efficient (Afshar *et al.*, 2017; Kovacic *et al.*, 2015).

In Finland, again like in many other countries, post-war mass housing is the main target requiring adaptations to support ageing in place (e.g. Pettersson *et al.*, 2017; Slaug *et al.*, 2020; Verma, 2019). Comprising circa 40% of all Finnish apartments (Official Statistics of Finland, 2019a), it is not only a quantitatively significant part of the housing stock but also substantially inhabited by ageing residents (Stjernberg, 2019). Kaasalainen and Huuhka (2016) have already presented mass-customizable home modification models for making apartments in this type of housing more age-friendly. So, the current study focusses on adaptability for assisted living. The main objective is to assess the spatial suitability of 1970s apartment buildings for conversion into group homes for older people through the following research questions:

(1) What are the typical spatial requirements of assisted living group homes?

(2) What are the typical spatial structures and dimensions of spaces in 1970s apartment buildings?

(3) How adaptable are existing apartment buildings for use as assisted living group homes?

Similar to many countries worldwide (Kabisch and Grossmann, 2013), population ageing in Finland is most pronounced in the areas simultaneously undergoing the greatest decline in total population (Stjernberg, 2019). Under these circumstances, adaptation of the existing stock may very well be the only viable option to improve the physical living conditions of older people, because new construction is economically infeasible. It is also increasingly argued that adaptation should be prioritized over demolition and new construction for environmental and social reasons even where new construction is economically viable (e.g. Huuhka, 2016). When it comes to assisted living, solutions based on adaptation can support ageing in place, which is a widely adopted policy goal (Serrano-Jiménez *et al.*, 2019; Slaug *et al.*, 2020). Ageing in place can help maintain one's place-bound identity and social networks, which are features that are positively connected to an individual's community satisfaction and well-being (Afshar *et al.*, 2017; Fitz *et al.*, 2016; Kovacic *et al.*, 2015).

In the context of post-war mass housing, the economic conditions of adaptations, regardless of the location, are tightened by the fact that the housing being older denotes that it typically suffers from physical deterioration. The technical repair needs have also been considered an opportunity to include ageing in place supporting adaptations into renovation projects that would take place regardless (Jalava *et al.*, 2017; Verma, 2019 Pettersson *et al.*, 2017). Still, it has been asserted that novel and cost-effective methods and concepts must be developed to support making existing neighbourhoods age-friendly (Behr *et al.*, 2011; Serrano-Jiménez *et al.*, 2019).

So, the current study introduces an analysis methodology applicable to many contexts, even if the research results pertain to the Finnish conditions. The novelty of the developed method lies in particular in a mass mapping approach, which is based on large data sets. Unlike the usual case-study-based research, which by definition delves into the particularities of a singular instance, the current approach originates from the domain of building stock research (see Kohler and Hassler, 2002). It aims at providing generalizable findings about the adaptability of a large mass of buildings for a given purpose, so its future applications can also encompass building stocks and novel functions other than the 1970s mass housing and the assisted living investigated in the current paper.

2. Materials and methods

Previous research has presented a range of methods for evaluating a building's general adaptability, based on, for example, its structural system (e.g. Rockow *et al.*, 2019). To evaluate the adaptability for a certain function, however, more specific consideration of spaces and their connections is required. Therefore, this study presents a large-scale multi-case study in which the spatial requirements of group homes are compared systematically to the spaces available in existing apartment buildings. For this, two separate samples of building plans were used: a sample of existing group homes and a sample of existing apartment buildings.

The sample of group homes contains architectural drawings for 130 individual group homes in 30 assisted living facilities. It contains both municipal and private service providers' facilities from the three largest cities of Finland. The sample comprises all facilities listed in the cities' online information channels at the time of sampling (October 2015) for which plans were available in the building supervision offices' archives. All of the group homes were either constructed or comprehensively renovated during or after 2000 and are thus indicative of current practices.

The sample of existing apartment buildings contains architectural drawings for 105 apartment buildings from the years 1970–1979. To fit a typical group home layout, sufficient floor area is required (for details, see section 3.1). Hence the study was restricted to buildings with at least two stairwells. To facilitate the study of multiple connected stairwell units, only buildings where the stairwells are in line, that is, the long façades are mainly straight, were included. This is not strictly a requirement for adaptability and was done merely to streamline the study process. Within these criteria, the cases were selected randomly from the archive of the Housing Finance and Development Centre of Finland (ARA), which contains building permit documents for all publicly funded housing projects in Finland. Only residential floors were examined, that is, ground floors with utility spaces were excluded. All residential floors in a building have identical plans, and thus each building is represented by a single floor. Determining the relevant properties of the studied buildings and use cases is a key part of the method developed. Therefore, more detailed descriptions of both samples are presented in the results section (chapter 3).

The study represents building stock research. The developed analysis method draws from network theory, statistical research and comparative research. The spatial properties of both building types were studied through a network of nodes formed by distinct spaces, similar to the analysis of spatial form in space syntax (UCL Space Syntax, 2020). For these spaces, properties including their dimensions, function and position in relation to the whole floor and to each other were recorded. This provided a picture of the spatial requirements and the spatial reserve and allowed comparisons of fit from the perspectives of overall layout, individual spaces and groups of spaces, utilizing a large number of cases. The research process is presented in Figure 1, both as a methodological framework and in relation to the specific research questions and structure of the current paper.

2.1 Generalizability

To evaluate the adaptation potential and thus the spatial reserve in the larger building stock, representativeness of the samples must be considered. In previous research (Huuhka *et al.*, 2015; Kaasalainen and Huuhka, 2016), samples of 276 and 320 buildings from the years 1968–1985, both of which included the 105 buildings in this study, were extensively compared to

Research phase	Research action(s)	Data source(s)	*In current paper*
Properties of spaces required and available for adaptation			***Research questions 1 and 2***
1. Determining connectivity layouts required and available.	Forming connectivity graph(s) of required layouts.	Existing buildings, known requirements.	*Formed manually based on existing buildings and literature.* ***Ch. 3.1***
	Forming connectivity graphs of available layouts.	Existing buildings.	*Formed manually based on existing buildings.*
2. Determining total area required and available.	Recording area(s) required.	Existing buildings, known requirements.	*Recorded manually based on existing buildings and literature.*
	Recording area(s) available.	Existing buildings.	*Recorded semi-automatically based on existing buildings.*
3. Determining suitable adaptation cases.	Comparing connectivity graphs and recorded areas.	Phases 1 and 2.	*Connectivity fit confirmed visually. Areas compared manually to exclude unsuitable cases.*
4. Determining properties of individual spaces required and available.	Recording relevant properties required by individual functions.	Existing buildings, known requirements.	*Dimensions recorded manually based on existing buildings, other requirements based on literature.* ***Ch. 3.2.1***
	Recording relevant properties of individual spaces available.	Existing buildings found suitable (phase 3).	*Dimensions, relative locations, and connectability recorded semi-automatically based on existing buildings.* ***Ch. 3.2.2***
Fit between spaces required and available for adaptation			***Research question 3***
5a. Determining adaptability for individual functions.	Comparing spaces required by individual functions to all spaces available.	Suitable existing buildings (phase 3), properties of individual spaces (phase 4).	*Fit compared semi-automatically based on dimensions and numbers of spaces.* ***Ch. 3.3.1***
5b. Determining adaptability for full repurposing.	Comparing spaces required by all functions to all spaces available.	Suitable existing buildings (phase 3), properties of individual spaces (phase 4).	*Fit compared semi-automatically based on dimensions, numbers, relative locations, and connectability of spaces.* ***Ch. 3.3.2***

Figure 1.
Methodological process of the research. Recording and/or comparison of properties can be either automated or manual

the corresponding Finnish housing stock and found highly representative. Furthermore, it was noted that in addition to the highest construction volume, the 1970s had the greatest degree of repetition in building designs. Similar research does not exist for group homes. However, as their sample is reasonably large and covers multiple cities and service providers, it is considered to provide a sufficient perspective into the current state. For both samples, the repetitiveness observed suggests applicability of the results outside the studied material.

3. Results: adaptability of apartment buildings to group homes

3.1 Layout and total area compatibility

Linear layouts like the one in Figure 2 (left) were observed to comprise the vast majority (77.7%) of existing group homes. In addition, 10.8% consist of a small loop from which linear wings extend, and 11.5% are nonlinear. Consequently, the repurposing part of this study focusses on the linear layout, where functions are arranged along a central corridor and

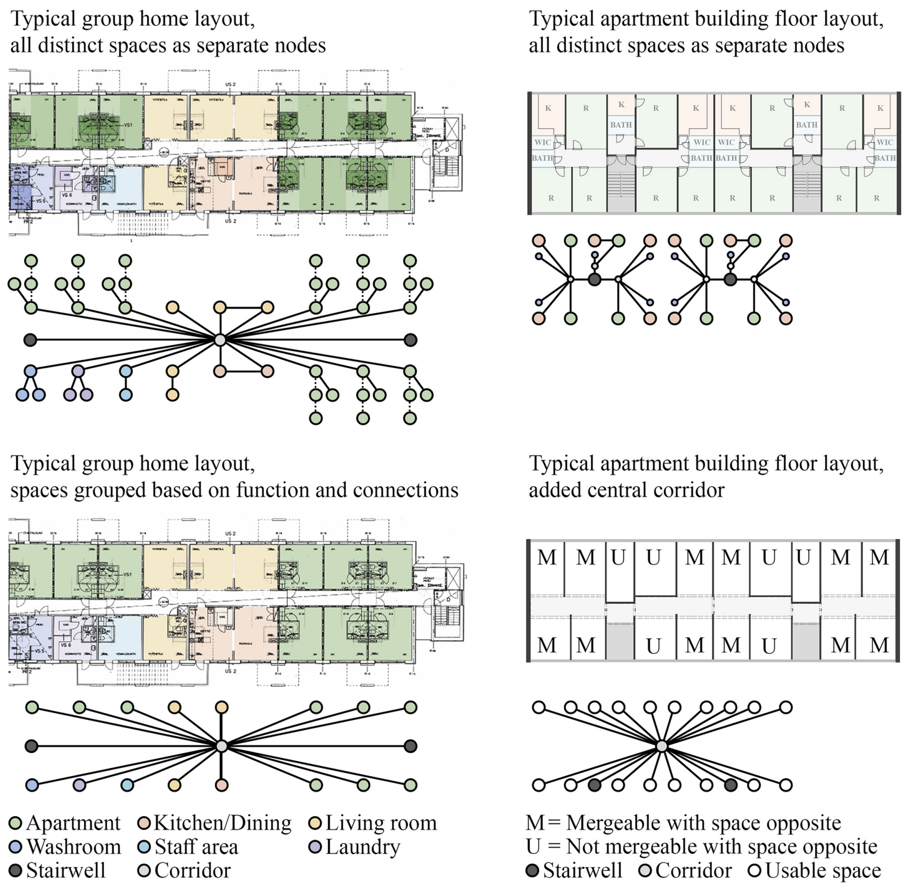

Figure 2.
Spatial structures of typical group homes and apartment buildings. Group home main functions with a single corridor access point are consolidated into space groups

accessed from it. Each main function (for details, see section 3.2.1) typically has only a single access point to the corridor. No recurring patterns for the location of the main functions were found in the sample.

For the existing apartment buildings, the examination of spaces includes the addition of a central corridor, necessary for the conversion into a linear layout group home (Figure 2, right). These buildings proved highly propitious for this addition: the corridor aligning with original stair landings – and consequently the apartments' entrance halls and bathrooms or walk-in closets – maximizes the usability of the existing spaces and minimizes the effect of load-bearing cross-walls.

In this study, it is expected that for accessibility reasons (elevator retrofits), the stairwells will need to be renewed regardless, which allows arranging an access through them. The stair landing could, however, also be bypassed by routing the corridor through the adjacent spaces, even though this slightly complicates the layout and reduces the area available for other uses. The minimum acceptable width for the corridor, excluding, for example, doorways in cross-walls, is 1800 mm for two wheelchairs to pass (Kilpelä, 2019). If this requirement exceeds the original hall width, space is taken primarily from the side with no shear walls parallel to the corridor.

As the existing apartment buildings are considered here as targets for comprehensive adaptation and renovation, their spatial structure is evaluated based only on the location of load-bearing walls, to which limited changes are possible, such as creating doorways. All of the buildings in the sample, like most buildings from the period (Huuhka *et al.*, 2015; Kaasalainen and Huuhka, 2016), have a cross-wall frame, that is, load-bearing cross-building walls. Consequently, most spaces along the long façades have a load-bearing wall between them – always between apartments, and in 77.1% of the sample buildings also within apartments. Taking into consideration the structural system and the addition of a central corridor, for the purposes of this study, the spatial structure of an existing floor can thus be expressed by describing the dimensions of existing spaces along the long façades and whether spaces opposite to each other can be merged across the corridor, that is, whether there is a longitudinal shear wall separating them. The load-bearing walls do not always extend straight across the building frame (see the end of building apartments in Figure 2). In such cases, mergeability is evaluated between the spaces that share the most width between them. Due to the central corridor layout, the location of spaces along the façades has no effect on connections between functions. This is evident in Figure 2 (bottom), where all spaces in both building types connect directly to the corridor.

Comparing the two research samples, two group home sizes (8 and 13 residents) were found sufficient to cover the common amounts of floor area available in apartment buildings. In Figure 3, the black bars show the distribution of floor areas in apartment buildings, while the shaded areas indicate interquartile ranges (IQR, middle 50%) of floor areas for the two group home sizes. IQRs were used to avoid evaluating adaptability using extreme examples. All floor areas consider non-corridor areas only. For existing group homes, these were measured directly from plans. For apartment buildings, the adapted layouts with corridors retrofitted were considered.

Of the apartment building sample, a total of 95.2% (100 buildings) were found size-wise suitable for 8- or 13-resident group homes. Corresponding to the IQRs for these group home sizes, 360.0 m^2 of apartment building floor area was chosen as the dividing line between the group home sizes used for the adaptation study. This resulted in 43 8-resident cases and 57 13-resident cases for the spatial adaptability evaluation. These also correspond closely to Finnish

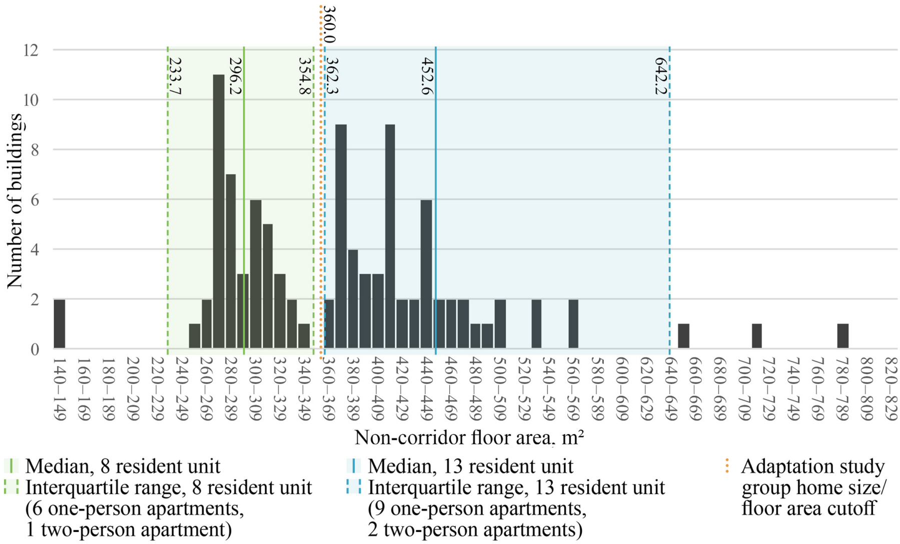

Figure 3.
Non-corridor floor areas on apartment building floors (black bars) and interquartile ranges for 8- and 13-resident group homes (shaded areas)

design guidance and general North European practice, where sizes typically range between 7 and 15 residents. (ARA, 2015; Rakennustietosäätiö, 2013; Regnier and Denton, 2009). The mean and median for the research sample are 14 residents. Thus, in terms of overall size and layouts, the existing apartment buildings were found to suit current group home designs.

3.2 Properties of existing spaces

3.2.1 Types and dimensions of spaces in group homes. Table 1 (left) presents the space types found in the studied group homes. Nearly all group homes proved to contain the same selection of general space types. In the vast majority of cases, the kitchen is home-like and used for making, for example, breakfast, while the main meals are delivered from elsewhere. The category of "other" spaces mostly contains small technical spaces and, very rarely, other small non-essential functions. The areas for most space types vary based on the number of group home residents.

In the adaptability study, the median values given in Table 1 are considered desirable while the IQR lower bound is considered the minimum. Including the most tightly dimensioned first quartile would likely include poorly functioning spaces, as even the IQR lower bound often falls below current recommendations. IQR upper bounds are presented for reference but were not used to exclude suitable spaces. In some cases, this creates somewhat loose dimensioning, which is discussed in section 3.3.2. In addition to sufficient area, different functions have different needs for windows and minimum space width. Table 1 also presents the requirements used for these in the adaptability study, drawn from Finnish building regulations and officially recognized design guidance (Kilpelä, 2019; Rakennustietosäätiö, 2013; Ympäristöministeriö, 2017a).

3.2.2 Dimensions of spaces in apartment buildings. As described in section 3.1, existing spaces on apartment building floors are formed by the façades, load-bearing cross-walls and the retrofitted central corridor. The widths of these spaces were observed to vary around three measurements: 3,000, 3,600 and 4,400 mm, with 3,600 mm being overwhelmingly the most common. The distribution of depths is much less focussed, mainly ranging from 2,800 to 6,100 mm. For combinations of width and depth, the most common space sizes are approximately 3,600 $\times$ 3,200 mm (or reversed) and 3,600 $\times$ 5,100 mm. Accordingly, the space sizes peak around 12 and 19–20 m^2. Thus, most spaces fulfil the dimensional requirements of the various group home functions: 98.6% are at least 2000 mm wide and deep, exceeding the minimum set for utility spaces (see Table 1). 74.6% are at least 3,000 mm wide and deep, making them large enough for all functions given sufficient area.

3.3 Spatial adaptability assessment

Retrofitting the central corridor enables the apartment buildings to have the desired connectivity layout for a group home (see section 3.1). In addition, an uncompromised adaptation requires that (1) suitable spaces for each individual function exist, and (2) there is a sufficient number of these spaces. If suitable spaces do not exist, adaptation can be very difficult or costly, requiring substantial changes to the load-bearing structure. If there is merely an insufficient – but reasonable – number of spaces, a smaller group home can still be created. Thus, this section looks first into the availability of suitable spaces for the various functions of a group home (section 3.3.1). Then, it is examined whether these functions can be placed alongside one another without running out of suitable spaces (Section 3.3.2).

3.3.1 Single function adaptability. The findings indicate that a major challenge in repurposing apartment buildings into assisted living is fitting reasonably sized apartments within the boundaries of the existing structural layout. Only rooms at least 3,000 mm wide can be used as the main residential rooms of an accessible apartment (Rakennustietosäätiö, 2013). Figure 4 shows that a one-person apartment can be formed either by fitting both the main room and the bathroom into a single existing space (A) or by placing them into adjacent

Table 1.
Space types and non-corridor floor areas for 8- and 13-resident group homes. Areas are based on group homes of similar size (±1 resident), except for apartments which include all apartments in the sample ($N = 1{,}421$ for one-person, $N = 168$ for two-person)

Space type	Specific functions included	% of group homes space type exists in	Area (m^2), 8-resident group home				Area (m^2), 13-resident group home					
			IQR lower bound (min)	Median (mdn)	*IQR upper bound*	Sampled group homes	IQR lower bound (min)	Median (mdn)	*IQR upper bound*	Sampled group homes	Min. Width (mm)	Must have window
One-person apartment	Apartment for a single resident, with bathroom	100.00%	20.6	23.6	*25.1*	130	20.6	23.6	*25.1*	130	3,000	Yes
Two-person apartment	Apartment for two residents, with bathroom	62.20%	26.5	29.8	*35.8*	130	26.5	29.8	*35.8*	130	3,000	Yes
Shared living room	Lounges, multi-purpose rooms	100.00%	22	40	*55.5*	11	40	60.5	*117.9*	54	3,000	Yes
Shared dining and kitchen	Dining and kitchen areas	100.00%	16	19.5	*34.5*	11	27.5	39.5	*55*	54	3,000	Yes
Shared washroom	Washroom, toilet, sauna	77.70%	19	19.5	*22.3*	6	19	24.5	*24.5*	41	2000	No
Laundry	Laundry, drying room, utility room	95.40%	7	13	*13.5*	9	12	13	*20.5*	53	2000	No
Staff area	Office, staff changing room, staff toilet	100.00%	11.9	22	*27*	11	13.8	25.5	*54.9*	54	2000	No *
Storage	General and medicine storage, cleaning, rinsing room, waste	100.00%	5.1	6	*10.8*	11	9	12.5	*66.1*	54	–	No
Other	Technical spaces, shared computer area	71.50%	3	4.5	*4.8*	7	3	4.8	*5.5*	35	–	No

(*continued*)

Table 1.

Space type	Specific functions included	% of group homes space type exists in	Area (m^2), 8-resident group home IQR lower bound (min)	Median (mdn)	*IQR upper bound*	Sampled group homes	Area (m^2), 13-resident group home IQR lower bound (min)	Median (mdn)	*IQR upper bound*	Sampled group homes	Min. Width (mm)	Must have window
Total area for shared spaces			83.9	124.5	*168.2*		124.3	180.3	*344.4*			
Total area with apartments			*233.7*	*296.2*	*354.8*		*362.3*	*452.6*	*642.2*			

Note(s): * Offices not for long-term working spaces (B and C). Multiple adjacent one-person apartments can be placed using principles D and E. In principle D, the hall as shown is then replaced by the bathroom for one apartment. In principle E, the hall is made public space or split between the apartments. Two-person apartments can follow principles A–C directly, or a larger layout with separate main rooms can be formed using principles D–F.

Using the adaptation principles in Figure 4, Table 2 shows the number of buildings in the sample where suitable spaces were found to exist and the number of buildings that were observed to have enough such spaces for a targeted group home size corresponding to the floor's total area. All studied buildings could fit the target number of apartments when placed without the common functions. In most cases, consuming more than one existing space per apartment was required (i.e. principle A was not feasible). Even though a number of apartments typical to new construction were unattainable in most buildings (see section 3.3.2), this analysis shows that the individual spaces themselves do not preclude successful apartment design in the adaptation.

Unlike apartments, the common functions of a group home vary greatly in their need for privacy. Shared living room, dining and kitchen areas can be – and often are – open towards the corridor and each other. So, they can be formed by merging spaces across the central corridor. Other functions need closed spaces and therefore require one or more spaces on one side of the corridor or at the end of it. Staff and storage areas can be spread around the layout as individual spaces of suitable size. All apartment buildings in the sample could fit all group home functions using minimum dimensioning either as a single space, a combination of multiple spaces or both (Table 3). Most functions were found to fit rather well even using the larger, median dimensioning. Thus, as with apartments, it can be concluded that the availability of spaces for any individual function does not prevent successful adaptation.

The shared living room proved to be the hardest common function to fit, because it is a relatively large space. No existing single space was found to be large enough for a median-sized living room. A space for a minimum-sized living room existed in every sixth building – exclusively in the 8-resident cases. One large living room can, however, be replaced with multiple smaller ones. This is also common in the existing group homes: 63.3% have more than one living room. Moreover, multiple smaller living rooms may support a sense of hominess often lacking in these facilities (Reed *et al.*, 2007; Regnier and Denton, 2009).

In most cases, placing the dining and kitchen area required merging existing spaces, although many buildings were also observed to contain a suitable single space. Theoretically, kitchen and dining could also be placed in separate rooms. For this to be practical, though, the spaces would have to be adjacent to one another, connectable through a large retrofitted doorway.

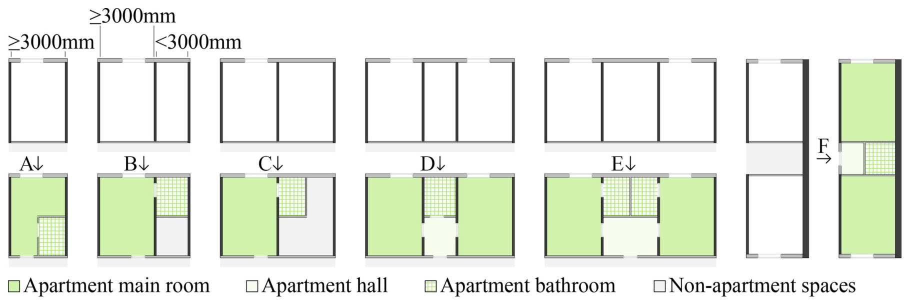

Figure 4.
Adaptation principles for forming apartments utilizing existing spaces

Adaptation principle used / Dimensioning used	Single room, bath included (A) Mdn	Single room, bath included (A) Min	Single room, separate bath (B or C) Mdn	Single room, separate bath (B or C) Min	Two rooms, shared bath (D) Mdn	Two rooms, two baths (E) Mdn	Two rooms, end of floor (F) Mdn
Single-person apartment							
Buildings with any suitable spaces	23	46	86	100			
Buildings with enough suitable spaces	1	16	63	92			
Two-person apartment (single main room)							
Buildings with any suitable spaces	8	15	20	42			
Buildings with enough suitable spaces	8	15	20	42			
Two-person apartment (two main rooms)							
Buildings with any suitable spaces					66	100	87
Buildings with enough suitable spaces					66	100	85

Table 2. Number of buildings with spaces suitable for apartment creation with median and minimum dimensioning ($N = 100$). With principles D–F (Figure 3), area is always above median

	Single space Mdn	Single space Min	Merged space Mdn	Merged space Min	Two separate single spaces Mdn	Two separate single spaces Min	Separate single and merged space Mdn	Separate single and merged space Min	Two separate merged spaces Mdn	Two separate merged spaces Min	Three separate single spaces Mdn	Three separate single spaces Min
Shared living room	0	17	3	48	33	76	54	99	91	99	91	100
Shared dining and kitchen	32	48	48	99								
Shared washroom	46	86	98	98								
Laundry	100	100	*	*								
Staff area	29	100	98	98	100	100	*	*	*	*	*	*
Storage	100	100	*	*	*	*	*	*	*	*	*	*
Other	100	100	*	*	*	*	*	*	*	*	*	*

Note(s): * Possible but unnecessary

Table 3. Number of buildings with suitable spaces for common areas with median and minimum dimensioning ($N = 100$)

The shared washroom was found to fit in a single existing space in most buildings using minimum dimensioning and in nearly half the buildings using median dimensioning. Utilizing merged spaces requires them to be located at the end of the building to avoid thoroughfare – this was possible at both ends of 82 buildings and at one end of 98 buildings. Also, compared to the living room, dining and kitchen areas, which require large uniform spaces, partition walls are less likely to pose a problem for washrooms, so even non-mergeable, adjacent spaces could often be useable.

Laundry, storage and other areas for both group home sizes are all small enough to fit in available single spaces. Especially the latter two are also propitious ways of utilizing areas left over by other functions, as even narrow spaces are fit for them and they can be distributed around the group home.

All buildings proved to allow minimum-sized staff areas without merging spaces, and nearly a third even fit median-sized ones. As with the washroom, merged spaces at the ends of the building can be utilized, allowing median dimensioning in the same 98 buildings. Additionally, splitting staff areas into multiple separate spaces is also possible, enabling median dimensioning in all 100 buildings.

3.3.2 Full floor group home adaptability. When studied separately, each of the 100 buildings could accommodate the required number of apartments and each common function. However, as most of these functions compete for the same spaces, the final step is to examine how often and how well all of them can be placed together, still fulfilling all individual spatial requirements. This determines the degree of compromise in the adaptations compared to new construction.

When evaluating the adaptability of an apartment building into a full group home, common functions were placed first, since they essentially define a group home. When needed, compromises were made in the number of apartments, which only affects the efficiency of the design. Figure 5 presents this procedure, alongside an example of an existing building layout before and after adaptation. All functions were placed using minimum dimensioning, since the individual placement studies (section 3.3.1) already demonstrated that very few buildings could accommodate median dimensioning.

Most existing apartment buildings were found to not accommodate the target number of apartments, although there were also many that did. Of the 43 cases targeting 8 residents, 25 fit all one-person apartments and 37 fit all but one. For 57 cases targeting 13 residents, the corresponding figures were 16 and 27, while 44 fit all but two one-person apartments. Of all 100 cases, only ten could fit all two-person apartments – six 8-resident and four 13-resident cases. In many, though, increasing the resident number by adding more one-person apartments was possible. On average, cases aiming for eight residents could fit six, and cases aiming for 13 residents could fit eight.

Comparing facilities of equal resident count, the group home designs created in this study by adaptation used on average 128.5% of the floor area used by existing facilities. On the existing apartment building floors, placing all possible group home functions used on average 84.8% of the available non-corridor floor area. If the leftover area would be used for more shared or utility spaces (as it is not suitable for further apartments), the area used by the adaptations would reach on average 151.8% that of the existing facilities. Some of the leftover spaces result from the current method, which excludes combinations of spaces requiring larger structural changes. In practice, some side-by-side spaces might be combined into, for example, a living room by replacing one load-bearing wall with a compensating beam and columns, thus potentially allowing a rearranged layout with more apartments. As 91.4% of the leftover spaces were adjacent to a stairwell – directly or through each other – using them for non-group home functions would also appear largely feasible. In either case, most adaptations created herein proved rather loosely dimensioned compared to the existing facilities.

Comparing non-corridor floor areas per resident, the amount of 31.6–66.8 m^2 (median 45.4 m^2) in the adapted cases is mostly within the variation found in the existing facilities, 19.5–52.2 m^2 (median 36.0 m^2). Naturally, the issue of leftover spaces applies here too, potentially increasing the area per resident used to 37.1–99.8 m^2 (median 53.8 m^2). For reference, Finnish design guidance recommends at least 45 m^2 per resident, including corridors but excluding some storage and technical spaces (Rakennustietosäätiö, 2013), which based on the studied group homes equals approximately 37 m^2 non-corridor floor area.

The main obstacle for spatial adaptation proved to be the share of existing spaces narrower than 3,000 mm (25.4%), unsuitable for use as apartment main rooms or as shared living, kitchen or dining areas. This made fitting a high number of apartments without significant changes to load-bearing walls challenging and thus creating groups homes as

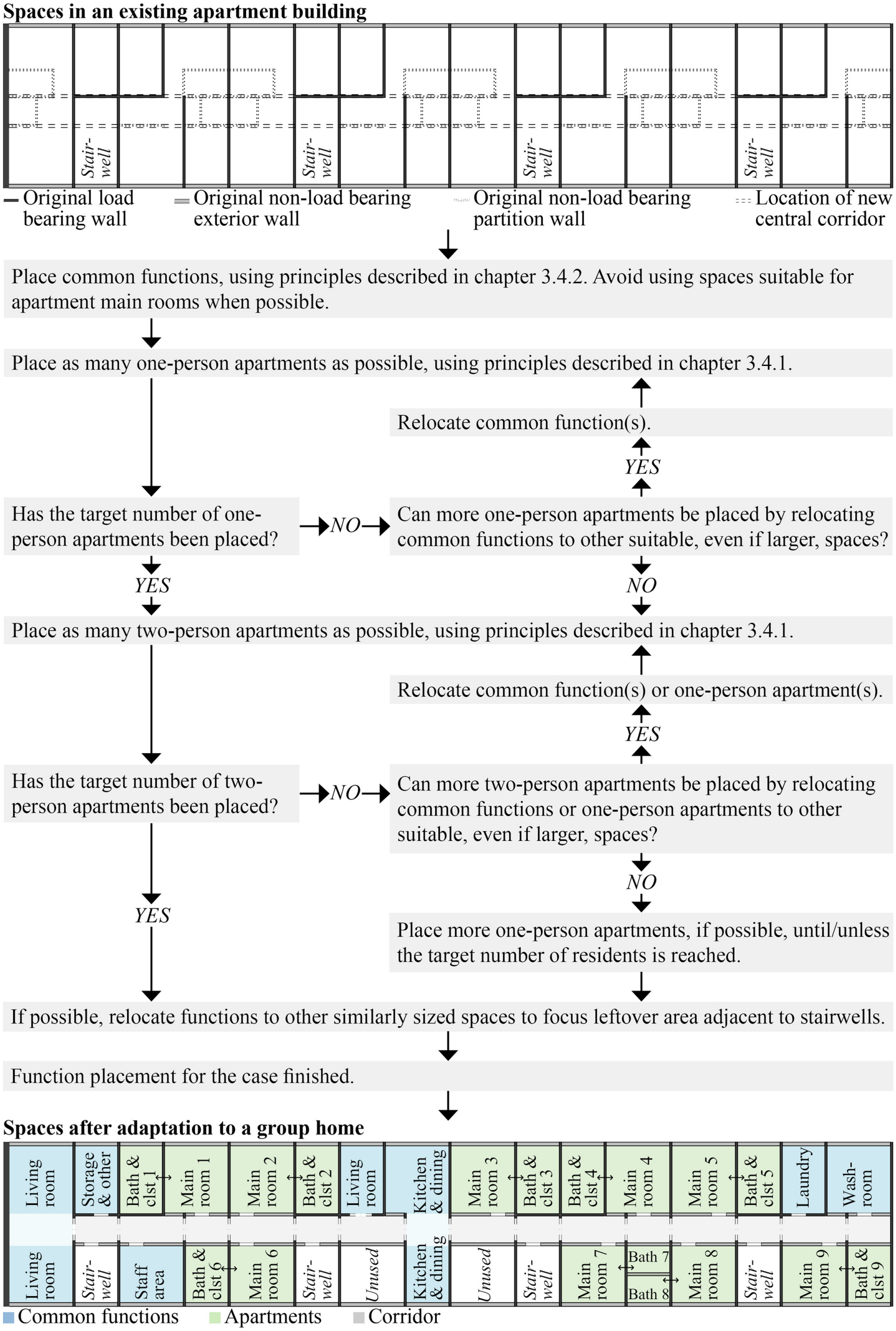

Figure 5.
Function placement in the full group home adaptability study

efficient as typical new construction mostly infeasible. Accepting a minimum width of 2,800 mm for these functions would reduce the share of unsuitable spaces to 13.2%, greatly increasing adaptation options.

Despite the challenges noted earlier, as a whole, the existing apartment buildings proved quite flexible for adaptation into group homes. Most existing rooms were found to be rather spacious compared to current construction, and their straightforward placement along the façades, as follows from the cross-wall frame, provides many options for placing functions. The central corridor design was mostly found to require very little changes to load-bearing structures – even doorways are often suitably placed. The connectivity of such a layout means that passage through rooms does not become an issue, which supports easy adaptability for different uses (cf. Herthogs *et al.*, 2019; Leupen, 2006). Overall, existing apartment buildings can be concluded to hold a large reserve of spaces suitable for assisted living with minor modifications, but most adaptation projects will have to accept more spacious dimensioning compared to current new construction.

4. Concluding discussion

This paper investigated the adaptability of Finnish post-war mass housing into assisted living group homes and in doing so, introduced a novel methodology for studying the adaptability of building stocks for specific new functions. The existing group homes were found to mostly utilize linear layouts with recurring selections of spaces. The layouts of existing apartment buildings were likewise observed to be repetitive. Taking into consideration the typical structural and spatial properties and the ways of allocating spaces for different uses, all apartment buildings were determined to contain suitable spaces for the various individual group home functions. Adaptation into full group homes also proved mostly feasible but resulted in less spatially efficient designs than is typical in current practice. Since adaptation can combat vacancies and replace new construction, it is certainly worth considering even from an efficiency perspective, as the extended building life cycles can enhance resource efficiency. The added spaciousness can also offer benefits from a quality of life perspective. In fact, the more loosely dimensioned adaptations can implement best practice recommendations for resident numbers and sizing of spaces better than the existing facilities.

The study shows that adapting the existing apartment building stock is a spatially viable alternative to new construction to provide assisted living, tightly integrated into the existing urban fabric, for the ageing population in Finland. In practice, the results can be used for estimating the adaptation potential of the existing housing stock as an alternative to new construction in a preliminary manner when new assisted living units are being planned, in combination with information about population, vacancies and housing needs in the area. However, repetitive post-war mass housing and the need for housing solutions that support ageing in place are by no means uniquely Finnish phenomena. Spatially and structurally similar prefabrication-heavy housing stocks exist across the globe (Alonso and Palmarola, 2019). They too may form substantial spatial reserves for adaptation. Such stocks are often situated in circumstances similar to the mass housing in Finland, that is, in areas with ageing populations and shrinkage, vacancies or otherwise tight economic conditions (e.g. Kabisch; Grossmann, 2013), where building adaptation could help address multiple pressing challenges at once. So, the presented approach, which provides a cost-efficient way to assess the conversion capacity, can help researchers map out these potentials in other countries, too.

To this end, the study's contribution consists not only of the findings pertaining to Finland but also of the developed methodology, which draws from network theory, statistical methods and comparative research. In this study, the methodology proved both effective and efficient in studying the adaptability of a large mass of buildings at once. In contrast to case studies – the conventional methods of architectural adaptability studies – the introduced stock approach combines a sufficiently detailed level of examination with wide generalizability of results. The success of the approach relies on identifying the representative features of both the stock to be adapted and the desired new function, which requires archival drawings to be available and sufficiently large data sets to be used. In this regard, identifying saturation, that is, the point where the findings become repetitive, is the key.

In the absence of methodologies like the one presented in this paper, case studies have been used in the past to proclaim general applicability, even if their findings are by definition not meant to be generalized. Thus, the current study provides one solution to bridge a yawning methodological gap. Recording the number and properties of spaces as simple network allows easy evaluation of adaptation potentials for various uses, also beyond the ones studied in the current paper. Due to the pressing societal need for older adults' housing solutions in Finland, the current research has focussed on assisted living. However, in future this method could also be utilized to assess the spatial reserves in other building stocks for other kinds of conversions. The methodology in itself is suitable for numerous applications, for example, from offices to housing or vice versa, as long as both the old and the new functions have a similar general spatial structure. This is to say that the method is fit for assessing adaptability from rooms to rooms or large halls to large halls, but not from rooms to halls or vice versa. Such conversions, which require plenty of added partitions or changes to existing load-bearing structures, may still be spatially and technically feasible, but the current method is not fit for evaluating that without further development.

The strengths of the approach presented in this paper lie in informing policy- and decision-makers about the hidden spatial adaptation potential of an entire stock. This way, the findings can help set policy goals in relation to prioritizing adaptation over replacement or vice versa. To determine the case-specific circumstances for the adaptation in any individual case, such as the technical or economic conditions, more detailed examination through case studies will still be needed. When it comes to the current study's findings, though, it seems clear enough from the spatial adaptability point of view that policymakers seeking to address the housing needs of ageing people should first and foremost consider the existing spatial reserve, in particular in declining municipalities, before introducing ideas of new construction.

References

Afshar, P.F., Foroughan, M., Vedadhir, A.A. and Tabatabaei, M.G. (2017), "The effects of place attachment on social well-being in older adults", *Educational Gerontology*, Vol. 43 No. 1, pp. 45-51.

Alonso, P.I. (2019), "Prolegomenon to a global history of large-concrete panel systems", Alonso, P.I. and Palmarola, H. (Eds.), *Flying Panels: How Concrete Panels Changed the World*, DOM, Berlin, pp. 32-59.

ARA (2015), *Suunnitteluopas: Keskeisiä Tavoitteita Valtion Tukemien Asuntojen Suunnittelulle*, Asumisen Rahoitus- Ja Kehittämiskeskus, Lahti.

Behr, R., Sciegaj, M., Walters, R., Bertoty, J. and Dungan, R. (2011), "Addressing the housing challenges of an aging population: initiatives by blueroof technologies in McKeesport, Pennsylvania", *Journal of Architectural Engineering*, Vol. 17 No. 4, pp. 162-169.

Eurostat (2019), "Population on 1st January by age, sex and type of projection", available at: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_18np&lang=en (accessed 13 March 2020).

Fitz, B.M., Lyon, L. and Driskell, R. (2016), "Why people like where they live: individual- and community-level contributors to community satisfaction", *Social Indicators Research*, Vol. 126, pp. 1209-1224.

Herthogs, P., Debacker, W., Tunçer, B., De Weerdt, Y. and De Temmerman, N. (2019), "Quantifying the generality and adaptability of building layouts using weighted graphs: the SAGA method", *Buildings*, Vol. 9 No. 4, p. 92.

Huuhka, S. (2016), *Building "Post-Growth": Quantifying and Characterizing Resources in the Building Stock*, Tampere University of Technology, Tampere.

Huuhka, S., Kaasalainen, T., Hakanen, J.H. and Lahdensivu, J. (2015), "Reusing concrete panels from buildings for building: potential in Finnish 1970s mass housing", *Resources, Conservation and Recycling*, Vol. 101, pp. 105-121.

Jalava, J., Lahtinen, H. and Tyvimaa, T. (2017), *Ikääntyneiden Asumisratkaisujen Tarve Ja Toteutus*, Ympäristöministeriö, Helsinki.

Kaasalainen, T. and Huuhka, S. (2016), "Homogenous homes of Finland: standard flats in non-standardized blocks", *Building Research and Information*, Vol. 44 No. 3, pp. 229-247.

Kabisch, S. and Grossmann, K. (2013), "Challenges for large housing estates in light of population decline and ageing: results of a long-term survey in East Germany", *Habitat International*, Vol. 39, pp. 232-239.

Kilpelä, N. (2019), *Esteetön Rakennus Ja Ympäristö*, Ympäristöministeriö, Helsinki.

Kohler, N. and Hassler, U. (2002), "The building stock as a research object", *Building Research and Information*, Vol. 30 No. 4, pp. 226-236.

Kovacic, I., Summer, M. and Achammer, C. (2015), "Strategies of building stock renovation for ageing society", *Journal of Cleaner Production*, Vol. 88, pp. 349-357.

Leupen, B. (2006), "Polyvalence, a concept for the sustainable dwelling", *Nordic Journal of Architectural Research*, Vol. 19 No. 3, pp. 23-31.

Official Statistics of Finland (2019a), "Dwellings by type of building, occupancy and year of construction, 2018", available at: http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__asu__asas/statfin_asas_pxt_116f.px/ (accessed 19 February 2020).

Pettersson, C., Slaug, B., Granbom, M., Kylberg, M. and Iwarsson, S. (2017), "Housing accessibility for senior citizens in Sweden: estimation of the effects of targeted elimination of environmental barriers", *Scandinavian Journal of Occupational Therapy*, Vol. 25 No. 6, pp. 407-418.

Rakennustietosäätiö (2013), *RT 93-11134 Vanhusten Palveluasuminen*, Rakennustieto, Helsinki.

Reed, R.L., Leigh, K.E. and Tremblay, K.R. (2007), "Designing assisted living facilities to foster a sense of home", *Housing and Society*, Vol. 34 No. 2, pp. 213-240.

Regnier, V. and Denton, A. (2009), "Ten new and emerging trends in residential group living environments", *NeuroRehabilitation*, Vol. 25 No. 3, pp. 169-188.

Rockow, Z.R., Ross, B. and Black, A. (2019), "Review of methods for evaluating adaptability of buildings", *International Journal of Building Pathology and Adaptation*, Vol. 37 No. 3, pp. 273-287.

Serrano-Jiménez, A. Lima, M.L., Molina-Huelva, M. and Barrios-Padura, Á. (2019), "Promoting urban regeneration and aging in place: APRAM – an interdisciplinary method to support decision-making in building renovation", *Sustainable Cities and Society*, Vol. 47, pp. 1-11, doi: 10.1016/j.scs.2019.101505.

Slaug, B., Granbom, M. and Iwarsson, S. (2020), "An aging population and an aging housing stock – housing accessibility problems in typical Swedish dwellings", *Journal of Aging and Environment*, pp. 1-19, doi: 10.1080/26892618.2020.1743515.

Stjernberg, M. (2019), *Concrete Suburbia: Suburban Housing Estates and Socio-Spatial Differentiation in Finland*, University of Helsinki, Helsinki.

Strandell, H. and Wolff, P. (2019), *Ageing Europe: Looking at the Lives of Older People in the EU*, Publications Office of the European Union, Luxembourg.

UCL Space Syntax (2020), "Spatial form analysis", available at: http://otp.spacesyntax.net/applying-space-syntax/building-methods/spatial-form-analysis/ (accessed 24 January 2020).

Verma, I. (2019), *Housing Design for All? The Challenges of Ageing in Urban Planning and Housing Design – The Case of Helsinki*, Aalto University, Helsinki.

Ympäristöministeriö (2017a), "Ympäristöministeriön asetus asuin-, majoitus- ja työtiloista", available at: https://www.finlex.fi/fi/laki/alkup/2017/20171008 (accessed 16 February 2020).

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