Typology of residential long-term care units in Germany: An explorative hierarchical clustering on principal components analysis

Johannes Michael Bergmann (johannes-michael.bergmann@dzne.de)
Deutsches Zentrum fur Neurodegenerative Erkrankungen Standort Witten https://orcid.org/0000-0002-9942-4633

Armin Michael Ströbel
Deutsches Zentrum fur Neurodegenerative Erkrankungen Standort Witten

Bernhard Holle
Deutsches Zentrum fur Neurodegenerative Erkrankungen Standort Witten

Rebecca Palm
Deutsches Zentrum fur Neurodegenerative Erkrankungen Standort Witten

Research article

Keywords: Nursing, Multiple Correspondence Analysis, Explorative, Typology, Care structures, Residential long-term care, Hierarchical Clustering

Posted Date: December 2nd, 2019

DOI: https://doi.org/10.21203/rs.2.17870/v1

Version of Record: A version of this preprint was published on July 11th, 2020. See the published version at https://doi.org/10.1186/s12913-020-05401-4.

Typology of residential long-term care units in Germany: An explorative hierarchical clustering on principal components analysis

Johannes Michael Bergmann[1,2], Armin Michael Ströbel[1,2], Bernhard Holle[1,2], Rebecca Palm[1,2]

[1]German Centre for Neurodegenerative Diseases, Witten, North Rhine-Westphalia, Germany

[2] University Witten/Herdecke, Faculty of Health, Department for Nursing Science, Witten, North Rhine-Westphalia, Germany

Corresponding Author:

Johannes Michael Bergmann[1,2]

Stockumer Str. 12, Witten, North Rhine-Westphalia, 58453, Germany

Email address: johannes-michael.bergmann@dzne.de

Abstract

Background

Organizational health care research focuses on describing structures and processes in organizations and investigating their impact on the quality of health care. In the setting of residential long-term care, this effort includes the examination and description of structural differences among the organizations (e.g., nursing homes). The objective of the analysis is to develop an empirical typology of living units in nursing homes that differ in their structural characteristics.

Methods

Data from the DemenzMonitor Study were used. The DemenzMonitor is an observational study carried out in a convenience sample of 103 living units in 51 nursing homes spread over 11 German federal states. Characteristics of living units were measured by 19 variables related to staffing, work organization, building characteristics and meal preparation. Multiple correspondence analysis (MCA) and agglomerative hierarchical cluster analysis (AHC) are suitable to create a typology of living units. Both methods are multivariate and explorative. We present a comparison with a previous typology (created by a nonexplorative and nonmultivariate process) of the living units derived from the same data set.

Results

The MCA revealed differences among the living units, which are defined in particular by the size of the living unit (number of beds), the additional qualifications of the head nurse, the living concept and the presence of additional financing through a separate benefit agreement. Three clusters could be identified; these clusters occur significantly with a certain combination of characteristics. In terms of content, the three clusters can be defined as "house community", "dementia special care units” and "usual care".

Conclusion

The typology of living units allows to identify more suitable outcomes and to develop more tailor-made interventions. Furthermore, the development of a typology is useful to gain a deeper understanding of the differences in the care structures of residential long-term care organizations. The intended theory development on the subject of different types of living units and the subsequent definition of these units will enable the long-term evaluation of their influence in further health care research.

Keywords

Nursing, Multiple Correspondence Analysis, Explorative, Typology, Care structures, Residential long-term care, Hierarchical Clustering

Introduction

In Germany, nursing homes are an important part of health care organizations. At present, more than 11,000 institutions are providing service for more than 800,000 people [1]. Nursing homes vary enormously with regard to their structural characteristics.

Nursing homes may be affiliated with owners who have different business objectives (for-profit vs. nonprofit); they can be organized as chains with superordinate policies and regulations; they can provide more than 300 beds or fewer than 10, and they may be organized in separable units with different teams and philosophies of care. Additionally, their service mission is multilayered: they deliver professional nursing care, provide opportunities for social interaction and participation for their residents, and ensure that medical care by general physicians and specialists is being delivered and prescribed therapy is received. Likewise, nursing homes are expected to provide an environment that maintains their residents' preserved skills and that supports people with dementia in acting and making decisions autonomously for as long as possible. Nursing homes are also expected to provide an environment in which residents feel at home – not institutionalized – and can thus maintain their quality of life on the highest possible level [2].

German nursing home residents all share the attribute of being approved as care-dependent by the Long Term Care Insurance entity, which enables them to receive benefits. Because people wish to stay at home as long as possible, they do not move to a nursing home until their need for care exceeds what can be provided at home. As a result, nursing home residents are predominantly severely care-dependent; more than 70% are affected by the consequences of a dementia [3, 4].

In recent years, as problems with outcome quality have become public, the quality of care in nursing homes has attracted more political and scientific attention. In particular, it was reported that the needs of people with dementia were not being sufficiently addressed [5]. As a result,

nursing homes implemented various approaches to dementia care that necessitated some changes in organizational structure. One major change was to use designated care units to separate residents with dementia from residents without cognitive impairments, under the assumption that care for residents with dementia could be better provided in a special environment. The implementation of “Dementia Special Care Units” (DSCUs) was a worldwide development that had its origin in the United States. In Germany, it is estimated that 30%-50% of nursing homes have implemented at least one DSCU [5, 6].

The question of whether DSCUs provide better outcomes has been the subject of large research projects throughout the world. Leading researchers from the United States concluded after 20 years of research that *“(D)SCUs have been effective in changing certain processes of care that are associated with positive behaviors among dementia residents, the impact of such changes […] on cognitive or functional performance appear negligible. In fact, (D)SCUs […] may have the most demonstrable benefits for cognitively intact residents, their families and nursing home staff“* [7]. The authors of a Cochrane Review concluded*, “There is limited evidence to support the assumption that the care of people with dementia in special care units is superior to care in traditional care units. It is probably more important to implement best practice than to provide a specialized care environment.“* [8].

One reason why evaluation studies of DSCUs failed to produce explicit results may be that the interpretation of existing quasi-experimental studies is complicated because they are prone to many sources of nonrandom error [9]. One described challenge for the interpretation of the study results is the lack of definitional clarity for DSCUs [10]. Whereas in the U.S., DSCU typologies have been developed in response to this lack of clarity [11, 12], such typologies are still missing in Germany.

We conducted a study in German nursing homes that aimed to identify resident- and facility-related factors that are associated with the nursing home residents’ health care outcomes (DemenzMonitor study) [13]. One goal was to answer the question of whether we can find

differences in the quality of care and in residents' outcomes between living units that are dementia-specific and traditional care units. We also wanted to know if we would find differences between living units that are small and large because it is proposed that small living units are beneficial for people with dementia (ibid). Furthermore, we assumed that the extra funding some of the units received to finance more staff was also an important definition criterion. Therefore, in the absence of a typology for DSCUs and traditional care units, we defined the following types of living units [14]:

1. Large segregated living units without extra funding (LSLU I)
2. Large segregated living units with extra funding (LSLU II)
3. Large integrated living units without extra funding (LILU)
4. Small segregated living units without extra funding (SSLU)
5. Small integrated living units without extra funding (SILU)

We expected that large segregated living units with extra funding would have better staff resources, accommodate residents with more severe symptoms of dementia, provide a milieu that is more dementia-friendly and perform better with respect to national guidelines in the care of people with dementia and challenging behavior. Hence, we also expected to find differences among the living units with respect to the residents' care outcomes. In fact, the results of our subsequent analysis confirmed these assumptions only partly. Finally, we could not show that residents of dementia-specific (segregated) living units or small living units had better care outcomes compared to residents from other living units [15]. One reason why we did not find the expected results may be the a priori definition of the living unit types.

In our study protocol of the DemenzMonitor study, we additionally formulated the aim of investigating groups other than dementia-special/ traditional/ large/ small living units that are based on other criteria. The previous results indicate that the types defined a priori are

associated with a variety of other structural criteria [14], implying that there are more complex relationships that can be considered for the development of living unit types.

Because there are more than 30 relevant criteria for living units, we decided to pursue our objective by conducting a multivariate analysis. For this reason, the aim of the present study is to develop an empirical typology of living units based on all these criteria in order to systematically map differences among them. Instead of using a priori defined criteria to define different types, we will use an explorative clustering technique that identifies the criteria that are most relevant. The difference from the previous analysis is that with this approach, the numbers and types of clusters are calculated by a “data-driven” analysis. We aim to compare the results of the typology with our previous published results on the structural characteristics of the living unit types to conclude whether the applied methods are meaningful with respect to the typology development of the living units.

The present article will provide answers to the following research questions:

1. How many clusters of care units with similar characteristics can be identified?
2. Which characteristics are most important when identifying clusters (because they contribute the most to the cluster structure)?
3. To what extent do the identified clusters differ from those previously published?

Materials & Methods

Design and sample

For the study, cross-sectional data from a convenience sample of 103 living units in 51 nursing homes were used. The data are from the 2013 measurement period of the DemenzMonitor study [13]. This is the same data source on which the previous definition of types was performed, which allows a direct comparison of the results. Participating nursing homes were

defined according to the German statutory long-term care insurance law, under which people in need of care are reimbursed by the statutory long-term care insurance.

Beyond that, there were no inclusion or exclusion criteria for the participation of nursing homes; diversity was intended. The nursing homes that declared their interest in participating were included. All nursing homes participated voluntarily.

Data collection

The data were collected by the nursing home staff using a standardized questionnaire. Therefore, specific questionnaires were developed and tested. The details of the questionnaire development are described in depth elsewhere [13, 14].

In separate questionnaires, the data were collected at the level of the nursing home, the living units and the residents. The living unit questionnaire was completed by the head nurse; the nursing home questionnaire was completed by the nursing home manager; and the resident questionnaire was completed by a registered nurse familiar with the resident. More details on data collection can also be obtained from previous reports [6, 14].

Definition and measures

For the present study, we evaluated the same items on the structural characteristics of the living units that were used in the previously published results [14]. These are variables for structural characteristics, such as the organization of meal services, size of the living unit, interior design, architectural characteristics, staffing, etc. The data level of the variables is exclusively categorical. An overview of the variables and their distributions is provided in the results section (see Table 2). In addition to the structural characteristics, resident variables were included to determine age, sex, presence of dementia diagnosis and severity of dementia [16]. This variable

was used exclusively to further describe the identified clusters and did not contribute to their calculation.

Statistical analysis

Multiple correspondence analysis (MCA) and agglomerative hierarchical cluster analysis (AHC) were used to develop the typology of living units. First, an MCA was used whose principal components represent synthetic quantitative variables that summarize all categorical variables [17]. This is a dimension-reducing procedure that selects a few characteristic combinations from the many possible characteristics so that as much information as possible is retained from the data. Second, an AHC is performed with the dimensionally reduced data; this method is suitable for identifying groups of living units that are mapped in the geometric structures of the MCA [18]. The statistics that are applied in this study are not restricted to a certain sample size, so it can also be used to describe structures in data with small sample sizes, see [19] for an example with n=12. The statistical software R was used to conduct the statistical analyses [20]. MCA and AHC analyses were performed with the R package “FactoMineR” using the MCA and HCPC functions [21]. The plots of the results were generated using the R Package “factoextra” [22]. The R-code and the raw data are available in the supplemental information.

To make the procedure transparent and the graphical results comprehensible, the following sections contain a brief description of the methods used. This includes methodical analysis steps that provide a basis for decision-making regarding the presentation of results. We decided how much information is retained by the MCA and how many clusters are formed by the AHC. These intermediate steps are necessary for the explorative approach and are therefore described in the methods section.

Correspondence Analysis

Correspondence analysis (CA) is a descriptive data analysis technique that simplifies the presentation of complex data by reducing dimensions. CA enables the graphical representation of both the row and column characteristics of a contingency table in the same low-dimensional spatial area. Thus, CA belongs to the family of methods (factor analysis and principal component analysis (PCA) that reveal patterning in complex datasets. MCA is a specific application of CA that can be understood as a generalization of CA to cases in which there are more than two variables [23]. MCA is performed by applying the CA algorithm to an indicator matrix (also called a complete disjunctive table) [24]. Therefore, we apply the MCA to a table with living units in the rows and structural characteristics in the columns. The deviation of these row or column profiles from their respective average profile, the so-called centroid G, is used as a measure of the variance in the data. This measure of variance is called inertia in the context of MCA, which is calculated using the weighted Chi^2-distances between the profiles (living units or structural characteristics) and their respective average profiles.

Finally, there is a crucial relationship that brings the principal coordinates of the rows and those of the columns together on the axis λ_s of the same rank s [23]. This relationship is defined by the so-called transition formulas, which suggest, for each axis, that the sign of the coordinates of living-units points determines the sign of coordinates of the structural characteristics category points relative to an axis (and vice versa) [18]. This property is essential to the superimposed representation of living units and structural characteristics used in this publication. Hence, there is an algorithm for determining the coordinates of the row and column profiles in relation to the principal axes using the singular value decomposition (SVD) [25]. In a nutshell, MCA calculates the SVD of the complete disjunctive table, yielding a set of eigenvalues λ_s and corresponding eigenvectors (here called axes). The eigenvalues are also called inertia in the context of MCA. The researcher has to choose how many of the axes and eigenvalues he or she wants to omit to reduce the dimensions of the data cloud. Here, the inertia provides guidance. This means that the best low-dimensional solution is calculated that is capable of distinguishing geometric

patterns in the data by mapping each structural characteristic and living unit as a point in a nuclear space [26]. To determine the number of axes (dimensions) to be analyzed, various information about the percentage of explained inertia and the interpretability of each axis is taken into account. Table 1 illustrates the proportion of explained inertia for each axis in decreasing order and thus provides the information needed to make decisions about the number of axes to be analyzed. For high-dimensional data sets, the modified inertia rates should also be considered because the inertia rates of the first dimension are usually low. The modified inertia rates highlight the significance of the first principal axis [27]. The second axis brings the cumulated modified inertia rate to 90.90%. Therefore, only the first two axes will be interpreted in the results.

Axes	Inertia %	Cumulative inertia %	Modified inertia %	Modified cumulative inertia %
1	17.44	17.44	60.76	60.76
2	**13.76**	**31.21**	**30.13**	**90.90**
3	8.15	39.36	3.90	94.80
4	7.38	46.73	2.22	97.01
5	7.36	54.09	2.19	99.20
6	6.36	60.45	0.73	99.93
7	5.35	65.80	0.05	99.97
8	5.26	71.06	0.03	100.00
9	4.85	75.92	0.00	100.00
10	4.13	80.05	0.00	100.00
11	**3.66**	**83.71**	**0.00**	**100.00**
12	3.00	86.71	0.00	100.00
13	2.32	89.03	0.00	100.00
14	2.12	91.15	0.00	100.00
15	1.98	93.13	0.00	100.00
16	1.82	94.95	0.00	100.00
17	1.61	96.56	0.00	100.00
18	1.53	98.09	0.00	100.00
19	1.10	99.19	0.00	100.00

Axes	Inertia %	Cumulative inertia %	Modified inertia %	Modified cumulative inertia %
20	0.81	100.00	0.00	100.00

Table 1: Inertia of axes, inertia rates, and modified rates.

Hierarchical Clustering on Principal Components

Following the MCA, an AHC will be performed, clustering the living units on the basis of the calculated principal coordinates of the MCA [23]. The agglomerative procedures start the calculation process at the "finest partition", which means that each living unit initially represents a cluster. The calculation process merges two clusters and is continued step by step until all living units are united into a single cluster. This creates a hierarchical relationship between the clusters of the living units, which can be visually represented by a fixed order of the cluster solutions in the dendrogram (see Fig. 1). The Ward process [28] applied here is of particular importance among the agglomerative processes. In the Ward method, the living units that increase the variance criterion the least are merged. The variance criterion, also called the error square sum, represents the distance squares between the observation values of a group and the group mean [29]. The purpose is to merge the living units (groups of living units) that increase the inertia in a group as little as possible. The total inertia consists of the "within-cluster inertia", which describes the deviations of the living units (points) from their cluster center, and the "between-clusters inertia", which describes the deviations between the individual cluster centers and the overall center of all living units. An analysis of the inertia decomposition is valuable to describe the quality of the cluster solution. The aim is to identify an appropriate cluster solution that minimizes the variability of the "within-cluster" or maximizes the "between clusters" variability:

$$\frac{between - clusters\ inertia}{total\ inertia}$$

formula 1

The ratio in formula 1 indicates how high the explained proportion of variability of a certain cluster partition is in the total variability. The explained proportion of variability can be presented in a comparable way to the Scree plot by depicting the gain of the between-clusters inertia for the increasing number of clusters in decreasing order. The numbers of clusters with the highest percentage decrease in the gain of the between-clusters inertia are marked by a bend (elbow criterion) in the curve of the inertia gain in Figure 1. For this reason, three clusters were chosen. The proportion of "between-clusters inertia" that can be measured using formula 1 is 25.41% for a three-cluster solution.

To understand how this value is derived, the following information is helpful: It is always true that the "between clusters inertia" of partitioning into two clusters is less than the first eigenvalue (17.44%) of the MCA. Similarly, the map induced by two principle axes expresses more inertia (31.21%) than partitioning into three clusters [23].

Figure 1: Dendrogram for the hierarchical representation of the living unit clusters.

For the combined application of MCA and AHC, two principles of conduct have been taken into account that are recommended in the method literature[23]:

1. The extracted dimensions of the MCA, which represent very insignificant proportions of explained inertia, can be interpreted as statistical "noise". It is therefore recommended for the subsequent performance of the AHC that only those axes are included in the analyses that explain a high proportion of total inertia (approx. 80% to 90% in total).

2. The axes retained in the MCA should be interpretable. As a rule, this makes the results of the AHC easier to interpret.

In our analysis we choose 11 components that summarize 83.71% of the total inertia. Subsequent to the hierarchical cluster analysis, a test value can be applied to check the extent to which the categories correspond with the identified clusters. The v-test is a test to compare the proportion of the category in a cluster compared to the proportion of the category in the global dataset. The test is based on the hypergeometric distribution [30].

Description of the residents

The resident variables of the 1806 residents on age, sex, dementia diagnosis and severity of dementia were not considered for the calculation of the MCA and AHC models. These data were used only for the final description of the identified clusters. Finally, these residents' data are compared between the clusters by using the R package “atable” [31].

Results

The data of the 103 living units applied to calculate the MCA and AHC include $Q = 19$ variables with a total of $K = 39$ categories. The variables and frequency distributions of their categories are displayed in Table 2.

Table 2: Variables, categories and their absolute and relative frequencies.

Results MCA

The calculation of the total inertia of the data amounts to $K/Q - 1 = 1.053$ and is distributed over a total of $K - Q = 20$ eigenvalues. The average eigenvalue is $\bar{\lambda} = 1/Q = 0.052$ and explains 4.93% of the total inertia.

The first axis $\lambda_1$explains 17.44% of the total inertia, and the second axis λ_2 explains 13.76% of the total inertia. Thus, the MCA map (Fig. 2) represents 31.21% of the total inertia. For the interpretation of the principal axes, the categories that contribute significantly to the explanation of the principal axis are informative. These include all categories whose contribution exceeds the average contribution of 2.56%.

Figure 2: MCA map for the superimposed representation of living units (blue points) and structural characteristics (red triangles).

The first principal axis applies to the following categories: “living unit has a size ≤ 15 beds” (Size 0), “living unit is additionally financed” (Finance 1), “living unit has only single rooms” (SRoom 1), “nurses do not work exclusively in one unit” (AssignN 0), “lunch is cooked in the kitchen of the unit” (Selfcook 1), “a registered nurse is not always present” (PresenceRN 0), “all meals are served homestyle on the table” (Mealserv 1), “segregated living concept” (Segregative 1), “do not exclusively have single rooms” (SRoom 0), “living unit has a size > 15” (Size 1), “residents-per-service staff member ratio is less than or equal to the median” (SSMRatio 1), “residents-per-service staff member ratio is greater than the median” (SSMRatio 0), and “integrative living concept” (Segregative 0). The categories are sorted according to their contributions, so that the first category Size 0 explains the main contribution to the first axis. A substantial contribution to the second principal axis is made by the following categories: “no special qualification in psychogeriatric care” (Jobqual 0), “segregated living concept” (Segregative 1), “built specially for people with dementia” (Build 1), “is additionally financed” (Finance 1), and “living unit has a size ≤ 15” (Size 0). These categories each explain between seven and ten percent of the second principal axis.

The cosine angle, which can be measured between two categories at the centroid, represents the tetrachoric point correlation. This property is useful for describing the explored data structure

in Figure 2. The categories that are close to each other, such as “living unit is additionally financed” (Finance 1), “special qualification in psychogeriatric care” (Jobqual 1), “living unit is protected by exit controls” (Guarded 1), etc. are correlated positively with each other and describe the corresponding living units in this area.

Binary categories always correlate negatively and are located at 180 degree angles opposite to each other. Most of the living units that are distinguished by the binary categories are scattered in the left and right upper areas of Figure 2. These living units differ significantly from the living units displayed on the second principle axis below the centroid.

Results of the AHC

Figure 3 displays the convex hulls of the three cluster solutions in the correspondence space of the MCA map. The two clusters in the upper left (living units = circles) and upper right area (living units = squares) differ in the first dimension. These clusters are related to the categories that make a significant contribution to the first principal axis.

The largest cluster (living units = triangles) is close to the centroid and differs in the second principle axis. This cluster represents the average living unit type and is associated with the categories that contribute significantly to the second principal axis.

Figure 3: MCA map with clusters (black = dementia special care units, green = usual care, red = house community).

By applying the v-test, it was determined by which categories the respective clusters are characterized. The test results show that each of the three clusters in Figure 3 occurs with a specific combination of categories. Table 3 illustrates these combinations, which leads us to the content-related definition of our three cluster types. We designate the three clusters as "home community", "dementia special care units" and "usual care".

Dementia special care units (N=21)	Usual care (N=59)	House community (N=23)	Not significant
Finance 1 (100%, 76%, 16%)	Size 1 (73%, 98%, 77%)	Size 0 (92%, 96%, 23%)	Separate 1
Jobqual 1 (65%, 81%, 25%)	Jobqual 0 (73%, 95%, 75%)	SRoom 1 (68%, 91%, 30%)	Guarded 0
Segregative 1 (50%, 95%, 39%)	Finance 0 (68%, 100%, 84%)	Selfcook 1 (57%, 70%, 27%)	Furniture 0
Build 1 (43%, 95%, 46%)	Build 0 (80%, 76%, 54%)	AssignN 0 (100%, 30%, 7%)	Furniture 1
RNRatio 1 (34%, 86%, 51%)	Segregative 0 (76%, 81%, 61%)	PresenceRN 0 (80%, 35%, 10%)	Outdoor 1
Guarded 1 (53%, 43%, 17%)	RNRatio 0 (80%, 68%, 49%)	Mealserv 1 (57%, 52%, 20%)	Outdoor 2
SRoom 0 (28%, 95%, 70%)	SRoom 0 (69%, 85%, 70%)	SSMRatio 1 (36%, 83%, 51%)	AssignSSM 0
SSMRatio 0 (32%, 76%, 49%)	AssignN 1 (61%, 100%, 93%)	Finance 0 (26%, 100%, 84%)	AssignSSM 1
Size 1 (25%, 95%, 77%)	Selfcook 0 (65%, 83%, 73%)	Outdoor 0 (57%, 17%, 7%)	CNARatio 1
Selfcook 0 (25%, 90%, 73%)	Separate 0 (75%, 41%, 31%)		CNARatio 0
	Mealserv 0 (63%, 88%, 80%)		NARatio 1
	PresenceRN 1 (61%, 97%, 90%)		NARatio 0

Table 3: Clusters and their characteristic categories.

The percentages in brackets of Table 3 contain the following information:

1. The first percentage value specifies how many living units with the corresponding characteristic are displayed in the cluster. For example, all living units with the characteristic Finance 1 are included in the cluster "Dementia special care units".
2. The second percentage value specifies how many living units in the cluster have the corresponding characteristic. For example, 76% of the living units in the cluster “Dementia special care units” possess the characteristic Finance 1.
3. The third percentage value specifies the total of living units with the corresponding characteristic.

The categories describing the clusters are sorted in decreasing order according to their significance, so that the first categories have the lowest p-values. All listed categories used to describe the three clusters satisfy the $p < 0.05$ requirement. With the exception of the last

column, "Not significant", where all categories are displayed that do not provide significant information for the clusters.

Furthermore, three cases of attributions in the categories can be differentiated for the interpretation of the clusters in Table 3. The first case of attribution concerns categories that are only informative for a particular cluster. We describe this case as a “unique characteristic”. This applies, for example, to the “living unit is protected by exit controls” (Guarded 1) category in the "dementia special care units" cluster.

The second case concerns dichotomous categories relating to different clusters. We define this case as "strong difference". This is valid for the categories “living unit was not specially built for people with dementia” (Build 0) and “living unit was built specially for people with dementia” (Build 1) because Build 1 relates to the cluster "dementia special care unit" and Build 0 to the cluster "usual care".

The third case will be applicable when a category is related to two or more clusters. We define this case as "intersection". This applies to the category “do not exclusively have single rooms” (SRoom 0), which is indicative of both the cluster "dementia special care unit" and the cluster "usual care". However, it should be noted that the second case also applies to the category “living units do not exclusively have single rooms” (SRoom 0) because “living units have only single rooms” (SRoom 1) is informative for the cluster "house community”.

Categories describing the second case are particularly suitable for describing differences between two clusters.

Table 3 shows that these category combinations allow clear distinctions to be made from the cluster "usual care". The five top categories of the cluster "dementia special care unit" and cluster "house community" can be distinguished by the dichotomous categories of the cluster "usual care".

In contrast, the differences between the clusters "dementia special care units" and "house community" are distinguished more by their unique characteristics. This distinction is

404 exemplified by the fact that categories such as “special qualification in psychogeriatric care”
405 (Jobqual 1), “segregated living concept” (Segregative 1) and “living unit is protected by exit
406 controls” (Guarded 1) are informative for the cluster “dementia special care units”, but, including
407 their dichotomous category, have no significance for the cluster “house community”.
408

409 **Results for Residents**

410 The examination of the resident data in Table 4 shows that no differences with regard to the
411 variables "gender", "age" and "diagnosis of dementia" were found, despite the large number of
412 cases.

Cluster	Dementia special care units	Usual Care	House community	p
Observations	324	1235	247	
Age				
Mean (SD)	81 (9)	83 (8.9)	84 (8.7)	0.0011
valid (missing)	324 (0)	1235 (0)	247 (0)	
Sex				
female	75% (243)	77% (953)	73% (180)	0.3
male	25% (81)	23% (282)	27% (67)	
missing	0% (0)	0% (0)	0% (0)	
Diagnosis of dementia				
no	2.2% (7)	33% (407)	23% (56)	<0.001
yes	98% (317)	67% (822)	76% (188)	
missing	0% (0)	0.49% (6)	1.2% (3)	
DSS				
No dementia (0-2)	1.5% (5)	25% (306)	21% (51)	<0.001
Mild-moderate dementia (3-7)	13% (42)	31% (388)	30% (73)	
Severe dementia (8-14)	85% (277)	44% (538)	50% (123)	

Cluster	Dementia special care units	Usual Care	House community	p
missing	0% (0)	0.24% (3)	0% (0)	

Table 4: Resident characteristics of the three clusters of dementia special care units, usual care and house community.

However, there are clear differences in the diagnosis and severity of dementia. The relative frequencies of dementia diagnosis and severe dementia are significantly higher in the “dementia special care units” cluster.

Discussion

The aim of this study was to empirically develop a typology of living units based on their structural characteristics. Using an explorative clustering technique on data from 103 living units in 51 nursing homes, we identified three different clusters (types). We designated the types as “house community”, “dementia special care units” and “usual care”. The three categories that have the greatest influence on the formation of these types are named below.

The categories that showed the strongest influence on the first type, “dementia special care units,” were “additionally financed” (Finance 1), “special qualification in psychogeriatric care” (Jobqual 1) and “segregated living concept” (Segregative 1).

The categories that contributed most to the second type, “usual care,” were “large size” (Size 1), “no special qualification in psychogeriatric care” (Jobqual 0) and “not additionally financed” (Finance 0). The categories that showed the strongest influence on the third type, “house community,” were “small size” (Size 0), “living unit with only single rooms” (Sroom 1) and “cooked lunch in the kitchen of the living unit” (Selfcook 1). Prior to this study, we used a

435 deductive approach to define living unit types and used the variables size, living concept, and
436 finance (Palm et al. 2014).
437 If we compare the types identified with the multivariate inductive method to these a priori
438 defined types, we can see that some categories that were used for definition also have a strong
439 impact on the types developed in the MCA model, whereas others have not.
440 Two types were defined using the categories “large size” (Size 1), “segregative living concept”
441 (Segregative 1) and the variable “additional financing regulated by a special agreement”
442 (Finance 0 and Finance 1). Hence, they differed with respect to the additional financing variable,
443 which was present in one type but not in the other. In the MCA model, the categories “no
444 additional financing regulated by a special agreement” (Finance 0) and “large size” (Size 1)
445 correlate with each other, but there is no correlation between the categories “segregative living
446 concept” (Segregative 1) and “large size” (Size 1). However, the category “segregative living
447 concept” (Segregative 1) correlates strongly with the category “additional financing regulated by
448 a special agreement” (Finance 1) but not with “large size” (Size 1).
449 The categories “small size” (Size 0) and “segregated living concept” (Segregative 1) that were
450 also used to define the type “small segregated living units without extra funding” (SSLU) a priori
451 showed no correlation in the MCA model.
452 If we look at the variables that were significant in determining the empirically developed types, it
453 becomes apparent that other variables play roles that were not considered in the a priori
454 definition. This observation applies to “building specific for residents with dementia”, “special
455 qualification of the head nurse in psychogeriatric care”, “availability of single rooms”, “resident-
456 per-service staff member ratio (is less or equal than the mean)”, “possibilities to cook lunch in
457 the living unit”, etc.
458 The different types of development techniques had an impact on the affiliation of the 103 living
459 units to the types. To illustrate this, Table 5 presents a cross-table that contrasts the affiliations
460 of the living units with the different types.

	Dementia special care units	Usual care	House community
LSLUI	3	11	1
LSLUII	16	0	0
LILU	1	47	0
SSLU	1	0	8
SILU	0	1	14

Table 5: Cross table for comparison between the a priori defined types and the types identified by the explorative clustering technique.

One can see that all of the living units that were formerly affiliated with the type “large segregated living units with additional financing regulated by an agreement” (LSLU II) are now affiliated with the type “dementia special care units”.

However, three living units that were formerly affiliated with the type “large segregated living units without extra funding” (LSLU I) are also affiliated with the type “dementia special care units”. It is surprising that one living unit that was formerly affiliated with the type “large integrated living units without extra funding” (LILU) is now also affiliated with “dementia special care units”. This may be explained by the fact that this living unit does not have the characteristic “segregative living concept” (Segregative 1) but is defined by the type-specific characteristics “built specially for people with dementia” (Build 1), “special qualification in psychogeriatric care” (Jobqual 1), residents-per-registered nurse ratio is less than or equal to the median (RNRatio 1), “do not exclusively have single rooms” (SRoom 0), “residents-per-service staff member ratio is greater than the median” (SSMRatio 0), “lunch is not cooked in the kitchen of the living unit” (Selfcook 0) and “large size” (Size 1).

When looking at the type “usual care”, it is clear that the majority (47 of 59) were formerly affiliated with the type “large integrated living units without extra funding” (LILU). However, 11

living units from the type “large segregated living units without extra funding” (LSLU I) are now affiliated with the “usual care” type. The type “house community” is more or less consistently compounded by living units that were formerly affiliated with the small living units (integrated and segregated without extra funding).

Again, what is surprising is that one living unit that was formerly affiliated with the type “large segregated living units without extra funding” (LSLU I) is now affiliated with the type “house community”. This can be explained by the categories “lunch is cooked in the kitchen of the living unit” (Selfcook 1), “all meals are served home style on the table” (Mealserv 1), “residents-per-service staff member ratio is less than or equal to the median” (SSMRatio 1) and “living unit is not additionally financed” (Finance 0), which were evident in this living unit.

In the present study, we also showed which variables and categories do not contribute to the cluster model “constant assignment of service staff” (AssignSSM 0 and AssignSSM 1), “certified nursing assistant ratio” (CNARatio 0 and CNARatio 1), “residents-per-nursing assistant ratio” (NARatio 0 and NARatio 1), “furnishing of public rooms” (Furniture 0 and Furniture 1), “living unit is located in a separate building” (Separate 1), “living unit is not protected by an exit control” (Guarded 0).

Some of these variables (“furnishing of public rooms” and “constant assignment of service staff”) also did not show significant differences between the formerly defined five living unit types.

In contrast to the previous results, “intersections”, “unique characteristics” and “strong” differences” between the clusters can be identified for the current cluster solution.

This is evident in the classification of the categories that are described for the results of Table 3. These attribution possibilities result from the multivariate static model, enabling the relationships between the clusters to be described in detail.

Furthermore, the cluster association in the current results is not determined by the fact that the living units have all the cluster-specific characteristics in Table 3. Rather, the probability that a living unit belongs to a particular cluster increases with the presence of each additional cluster-specific characteristic. Thus, in terms of the data, it is probable (92% chance) that a living unit with the characteristic “small size” (Size 0) belongs to the cluster "house community".
The probability increases to 95% if the characteristic “lunch is cooked in the kitchen of the living unit” (Selfcook 1) is specified in addition to the characteristic “small size” (Size 0). When a living unit has the first three characteristics of the cluster "house community", the affiliation is 100%. With this application, the typology can also be applied to living unit characteristic combinations that are not contained in our data.

Finally, a comparison of the “dementia special care units” cluster in Table 3 with more recent research shows that empirical studies that investigate the influence of a Dementia Special Care Unit on residents’ outcomes often do not use multiple indicators to define them but rely on single indicators such as the availability of specially trained staff [32], SCU placement variable of the MDS 2.0 [33] or the US OSCAR reporting system [34, 35]. Other studies combine several indicators based on an a priori set definition [36]. The latter used the indicators specially trained staff, 100% of the residents of the unit have a dementia and the unit is closed. However, in our sample of living units, these combinations of indicators are applicable only to living units with additional funding regulated by an agreement, not to all living units that exclusively house residents with dementia.

Conclusions

The analysis of the living units shows that systematic differences based on the interrelationships of numerous characteristics can be identified. These results lead to a complex type formation,

as seen from the fact that the types are described by the interaction of nine or more characteristics. This supports the assumption that definitions that are solely based on size or living concept ignore the diversity within these groups [14].

A main result of the comparison is that the five a priori types would not be formed in the multivariate model because there are major groups of characteristics that correspond more to each other than to other characteristics and thus lead to a more stable cluster solution. If the intersections of the five cluster solutions and the three cluster solutions are considered, it becomes apparent that the variable "additional financing regulated by a special agreement" and "size of the living unit" are particularly suitable for distinguishing between them. The variable "living concept" has a significantly lower impact on the differentiation of clusters. This can be seen, on the one hand, in the ranking of the categories and, on the other hand, in the result that the variable is insignificant for the cluster "house community".

Regarding a classification of living units based on the present study, the following practical recommendation can be made: It can be assumed that a living unit belongs to a cluster if it has three or more of the characteristics shown in Table 3. If we look at the first three characteristics of the clusters, we see the following allocation probability:

1. If a living unit is assigned the characteristics “additional financing regulated by a special agreement” (Finance 1), “special qualification in psychogeriatric care” (Jobqual 1) and “segregative living concept” (Segregative 1), then it is 100% in cluster 1.
1. If a living unit has the characteristics “living unit has a size > 15” (Size 1), “no special qualification in psychogeriatric care” (Jobqual 0) and “not additionally financed” (Finance 0), then it is 96.49% in cluster 2.
2. If a living unit with the characteristics “living unit has a size ≤ 15 beds” (Size 0), “living unit has only single rooms” (SRoom 1) and “cooked lunch in the kitchen of the living unit” (Selfcook 1), then it is 100% in cluster 3.

If the characteristics in the ranking of the table are higher, the classification of the corresponding living unit is more reliable.

From a methodological perspective, it should be noted that the formation of a typology of living units based on complex characteristic correlations can be more appropriately described using a multivariate statistical method. A methodological approach such as the one applied in the present study is suitable to map the multiple interrelationships in the care landscape [26, 37]. An advantage of this explorative analysis is that it delivers a cluster solution that fits the data. In the previously published results, eight possible types were defined a priori, of which only five types could be realized in the data [14].

There are methodological limitations of the DemenzMonitor study and the present study that limit the external validity of the results. The participating institutions are spread over 11 federal states. It should be noted here that the distribution of institutions among the federal states in the data set does not correspond to the actual distribution of inpatient geriatric care institutions in Germany. Therefore, the results cannot be considered representative of German care institutions in general. A further methodological limitation relates to the dichotomization of variables. For the staffing variables, the ratio was split using the median. Such a definition is difficult to justify and is normative. This causes information to be lost. An alternative would be to use methods that can map both categorical and metric variables in a model. Pagès recommends more advanced methods, such as Factorial Analysis of Mixed Data [24].

The conclusions relevant to future organizational nursing and care research can be summarized as follows: Because the study is designed as an explorative study, no power analysis was performed to identify and validate specific clusters. Therefore, it would be desirable for future studies to test the three-cluster solution on a more representative sample with the use of

583 confirmatory techniques. Furthermore, it is still necessary to answer the question of whether we
584 can determine differences in the quality of care and residents' outcomes between dementia-
585 specific and traditional care units. To this end, it remains important to represent the existing
586 differences among the living units, which result from the complex diversity of specialized
587 institutions, as accurately as possible in a typology.
588

589 **Abbreviations**

590 AHC: Agglomerative Hierarchical Cluster Analysis; CA: Correspondence Analysis; DSCUs:
591 Dementia Special Care Units; LILU: Large integrated living units without extra funding; LSLU I:
592 Large segregated living units without extra funding; LSLU II: Large segregated living units with
593 extra funding; MDS: Minimum Data Set; MCA: Multiple Correspondence Analysis; OSCAR:
594 Online Survey, Certification, and Reporting; SCU: Special Care Unit; SILU: Small integrated
595 living units without extra funding; SSLU: Small segregated living units without extra funding;
596 SVD: Singular value decomposition
597

598 **Acknowledgements**

599 The authors are grateful to all study participants. The authors would like to acknowledge their
600 colleagues Anne Bleckmann and Tobias Stacke for their careful reading of the paper.
601

602 **Authors' contributions**

603 JB and RP contributed towards the design of the study. AS and JB conducted the analysis of
604 data. JB, RP, AS drafted the manuscript. BH and RP contributed to the conception and revised
605 the article critically for intellectual content. All authors provided input into the discussion and
606 approved the final manuscript.
607

Funding

The German Centre for Neurodegenerative Diseases funded the study.

Availability of data and materials

All data (with the exception of person-related data in Table 4) analyzed during this study are included in this published article and its supplementary information files.

Ethics approval and consent to participate

The ethics commission of the German Society for Nursing Science has approved the research [14].

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]German Centre for Neurodegenerative Diseases, Witten, North Rhine-Westphalia, Germany

[2] University Witten/Herdecke, Faculty of Health, Department for Nursing Science, Witten, North Rhine-Westphalia, Germany

References

1. Statistisches Bundesamt: **Pflegestatistik 2015. Pflege im Rahmen der Pflegeversicherung. Ländervergleich - Pflegeheime.** Wiesbaden: Statistisches Bundesamt; 2017.
2. Ausserhofer D, Deschodt M, De Geest S, van Achterberg T, Meyer G, Verbeek H, Sjetne IS, Malinowska-Lipien I, Griffiths P, Schluter W *et al*: **"There's No Place Like Home": A Scoping Review on the Impact of Homelike Residential Care Models on Resident-, Family-, and Staff-Related Outcomes**. *J Am Med Dir Assoc* 2016, **17**(8):685-693.
3. Hoffmann F, Kaduszkiewicz H, Glaeske G, van den Bussche H, Koller D: **Prevalence of dementia in nursing home and community-dwelling older adults in Germany**. *Aging clinical and experimental research* 2014, **26**(5):555-559.
4. Schäufele M, Köhler L, Hendlmeier I, Hoell A, Weyerer S: **Prävalenz von Demenzen und ärztliche Versorgung in deutschen Pflegeheimen: eine bundesweite repräsentative Studie**. *Psychiatrische Praxis* 2013, **40**(04):200-206.
5. Schäufele M, Köhler L, Lode S, Weyerer S: **Menschen mit Demenz in stationären Altenpflegeeinrichtungen: aktuelle Versorgungssituation**. In: *Pflegebedarf und Versorgungssituation bei älteren Menschen in Heimen Demenz, Angehörige und Freiweillige, Beispiele für "Good Practice".* edn. Edited by Schneekloth U, Wahl HW. Stuttgart: Kohlhammer Verlag; 2009: 159-219.
6. Palm R, Holle B: **Forschungsbericht der Studie DemenzMonitor. Umsetzung demenzspezifischer Wohn- und Betreuungskonzepte in Einrichtungen der stationären Altenhilfe**. In. Edited by Deutsches Zentrum Zentrum für Neurodegenerative Erkrankungen (DZNE) e.V. SW. Witten; 2016.
7. Holmes D, Teresi JA, Ory M (eds.): **Special Care Units**. Paris, New York: Serdi Publisher, Springer Publishing Company; 2000.
8. Lai CK, Yeung JH, Mok V, Chi I: **Special care units for dementia individuals with behavioural problems**. *Cochrane Database Syst Rev* 2009(4):CD006470.
9. Sloane PD, Lindeman DA, Phillips C, Moritz DJ, Koch G: **Evaluating Alzheimer's special care units: reviewing the evidence and identifying potential sources of study bias**. *Gerontologist* 1995, **35**(1):103-111.
10. Grant LA, Kane RA, Stark AJ: **Beyond labels: nursing home care for Alzheimer's disease in and out of special care units**. *J Am Geriatr Soc* 1995, **43**(5):569-576.
11. Degenholtz HB, Kane RA, Miller MJ: **Developing a typology of nursing home environments**. *Journal of Housing For the Elderly* 2006, **20**(1/2):5-27.
12. Grant L: **Beyond the dichotomy: an empirical typology of Alzheimer's Care in Nursing Homes**. *Research on Aging* 1998, **20**(5):569-592.
13. Palm R, Köhler K, Schwab CG, Bartholomeyczik S, Holle B: **Longitudinal evaluation of dementia care in German nursing homes: the "DemenzMonitor" study protocol**. *BMC Geriatr* 2013, **13**:123.
14. Palm R, Bartholomeyczik S, Roes M, Holle B: **Structural characteristics of specialised living units for people with dementia: a cross-sectional study in German nursing homes**. *International Journal of Mental Health Systems* 2014, **8**(1):39.
15. Palm R, Trutschel D, Sorg CGG, Dichter MN, Haastert B, Holle B: **Quality of Life in People With Severe Dementia and Its Association With the Environment in Nursing Homes: An Observational Study**. *Gerontologist* 2018.
16. Köhler L, Weyerer S, Schäufele M: **Proxy screening tools improve the recognition of dementia in old-age homes: results of a validation study**. *Age and ageing* 2007, **36**(5):549-554.

17. Blasius J, Greenacre M: **Visualization and verbalization of data**. Boca Raton: CRC Press Taylor & Francis Group; 2014.
18. Le Roux B, Rouanet H: **Multiple correspondence analysis**, vol. 163: Sage; 2010.
19. Blasius J: **Korrespondenzanalyse**. München: Oldenbourg Wissenschaftsverlag GmbH; 2001.
20. **R: A Language and Environment for Statistical Computing** [https://www.R-project.org/]
21. Lê S, Josse J, Husson F: **FactoMineR: an R package for multivariate analysis**. *Journal of statistical software* 2008, **25**(1):1-18.
22. Kassambara A, Mundt F: **Package 'factoextra'**. *Extract and visualize the results of multivariate data analyses* 2017, **76**.
23. Husson F, Lê S, Pagès J: **Exploratory multivariate analysis by example using R**: Chapman and Hall/CRC; 2017.
24. Pagès J: **Multiple factor analysis by example using R**. Boca Raton CRC Press Taylor & Francis Group; 2014.
25. Greenacre MJ: **Biplots in practice**. Bilbao: Fundacion BBVA; 2010.
26. Costa PS, Santos NC, Cunha P, Cotter J, Sousa N: **The use of multiple correspondence analysis to explore associations between categories of qualitative variables in healthy ageing**. *Journal of aging research* 2013, **2013**.
27. Benzećri J-P: **Correspondence analysis handbook**. Boca Raton CRC Press Taylor & Francis Group; 1992.
28. Ward Jr JH: **Hierarchical grouping to optimize an objective function**. *Journal of the American statistical association* 1963, **58**(301):236-244.
29. Backhaus K, Erichson B, Plinke W, Weiber R: **Multivariate analysemethoden. Eine anwendungsorientierte Einführung**, 14., überarbeitete und aktualisierte Auflage edn. Berlin, Heidelberg Springer Gabler; 2016.
30. Lebart L, Morineau A, Piron M: **Statistique exploratoire multidimensionnelle**, vol. 3: Dunod Paris; 1995.
31. Ströbel A: **atable: Create Tables for Clinical Trial Reports**. *The R Journal* 2019, **11**(1).
32. Luo H, Fang X, Liao Y, Elliott A, Zhang X: **Associations of special care units and outcomes of residents with dementia: 2004 National Nursing Home Survey**. *The Gerontologist* 2010, **50**(4):509-518.
33. Zimmerman S, Anderson WL, Brode S, Jonas D, Lux L, Beeber AS, Watson LC, Viswanathan M, Lohr KN, Sloane PD: **Systematic review: Effective characteristics of nursing homes and other residential long-term care settings for people with dementia**. *Journal of the American Geriatrics Society* 2013, **61**(8):1399-1409.
34. Cadigan RO, Grabowski DC, Givens JL, Mitchell SL: **The quality of advanced dementia care in the nursing home: The role of special care units**. *Medical Care* 2012, **50**(10):856-862.
35. Castle NG: **Special care units and their influence on nursing home occupancy characteristics**. *Health Care Management Review* 2008, **33**(1):79-91.
36. Arens OB, Fierz K, Zúñiga F: **Elder abuse in nursing homes: Do special care units make a difference? A secondary data analysis of the Swiss Nursing Homes Human Resources Project**. *Gerontology* 2017, **63**(2):169-179.
37. Yang X, Good N, Khanna S, Boyle J: **Exploratory multivariate analysis of hospital admissions data in conjunction with workforce data**. *Conference proceedings : Annual International Conference of the IEEE Engineering in Medicine and Biology Society IEEE Engineering in Medicine and Biology Society Annual Conference* 2017, **2017**:2626-2629.

Variable	Categories	Shortname	Frequency (N=103)
Size of the living unit	Number of beds in living unit ≤ 15	Size 0	23% (24)
	Number of beds in living unit > 15	Size 1	77% (79)
Availability of single rooms	Living units do not exclusively have single rooms.	SRoom 0	70% (72)
	Living units have only single rooms.	SRoom 1	30% (31)
Building specific for residents with dementia	The living unit was not specially built for people with dementia.	Build 0	54% (56)
	The living unit was built specially for people with dementia.	Build 1	46% (47)
Architectural segregation from other units	The living unit is not located in a separate building or floor and is not separated by a closed door.	Separate 0	31% (32)
	The living unit is located in a separate building, floor or is separated by a closed door.	Separate 1	69% (71)
Exit control	The living unit is not protected by an exit control.	Guarded 0	83% (86)
	The living unit is protected by exit controls.	Guarded 1	17% (17)
Furnishing of public rooms	Furnishings are solely functional (Functional furniture is provided by the institution and designed for a special use.)	Furniture 0	13% (13)
	Furnishings are functional and individual (Individual furniture is purchased from private individuals.)	Furniture 1	87% (90)
Opportunities to cook lunch in the living unit	Lunch is not cooked in the kitchen of the living unit.	Selfcook 0	73% (75)
	Lunch is cooked in the kitchen of the living unit.	Selfcook 1	27% (28)
Meal serving system	All meals (breakfast, lunch and dinner) are not served homestyle on the table (tray system, dish system, buffet system or mixed system).	Mealserv 0	80% (82)
	All meals (breakfast, lunch and dinner) are served homestyle on the table.	Mealserv 1	20% (21)
Constant assignment of nurses	Nurses do not work exclusively in one designated living unit.	AssignN 0	6.8% (7)
	Nurses work exclusively in one designated living unit.	AssignN 1	93% (96)
Constant assignment of service staff	Service workers do not work exclusively in one designated living unit.	AssignSSM 0	25% (26)
	Service workers work exclusively in one designated living unit.	AssignSSM 1	75% (77)

Continuous presence of a registered nurse	A registered nurse is not always present during the day shift in the living unit.	PresenceRN 0	9.7% (10)
	A registered nurse is always present during day shift in the living unit.	PresenceRN 1	90% (93)
Special qualification of head nurse in psychogeriatric care	The head nurse of the living unit has no special qualification in psychogeriatric care.	Jobqual 0	75% (77)
	The head nurse of the living unit has a special qualification in psychogeriatric care.	Jobqual 1	25% (26)
Additional financing regulated by a special agreement	Living unit is not additionally financed.	Finance 0	84% (87)
	Living unit is additionally financed.	Finance 1	16% (16)
Living concept	Integration (residents with and without dementia live together in one living unit).	Segregative 0	39% (40)
	Segregation (residents with dementia live together in one living unit).	Segregative 1	61% (63)
Residents-per-registered nurse ratio (defined as nurses with a minimum education of three years).	The RNRatio is greater than the median (cut-off: median = 18).	RNRatio 0	51% (53)
	The RNRatio is less than or equal to the median (cut-off: median = 18).	RNRatio 1	49% (50)
Certified nursing assistant ratio (defined as nurses with a minimum education of one year)	There are no Certified nursing assistants working on the living unit.	CNARatio 0	30% (31)
	There are Certified nursing assistants working on the living unit.	CNARatio 1	70% (72)
Residents-per- nursing assistant ratio (defined as nurses without any education)	The NARatio is greater than the median (cut-off: median = 16).	NARatio 0	50% (52)
	The NARatio is less than or equal to the median (cut-off: median = 16).	NARatio 1	50% (51)
Residents-per-service staff member ratio	The SSMRatio is greater than the median (cut-off: median = 28).	SSMRatio 0	51% (53)
	The SSMRatio is less than or equal to the median (cut-off: median = 28).	SSMRatio 1	49% (50)
Accessible outdoor area	There is no accessible outdoor area.	Outdoor 0	6.8% (7)
	The residents can go out alone.	Outdoor 1	80% (82)
	The residents can only go out in the presence of a caregiver.	Outdoor 2	14% (14)

Table 2: Variables, categories and their absolute and relative frequencies.

Figures

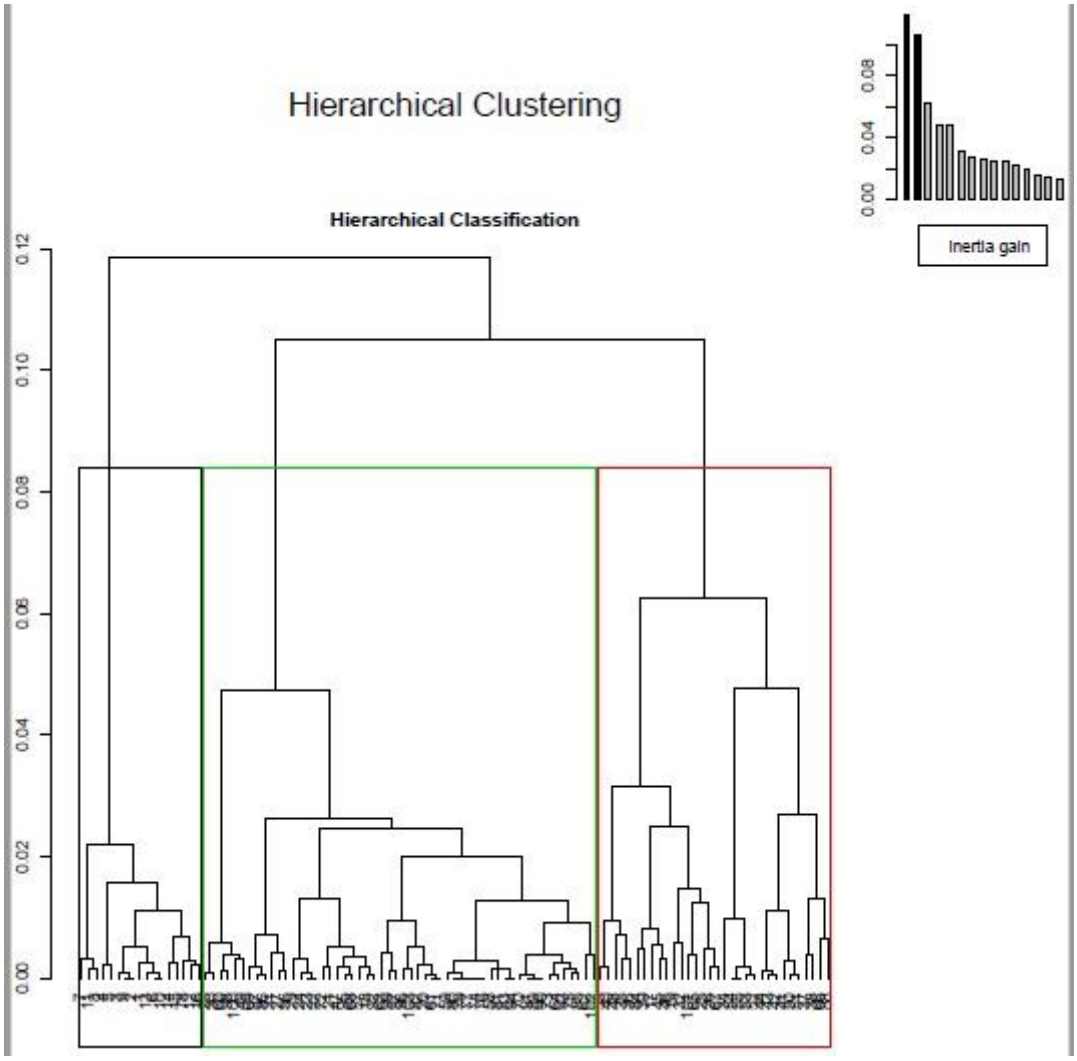

Figure 1

Dendrogram for the hierarchical representation of the living unit clusters.

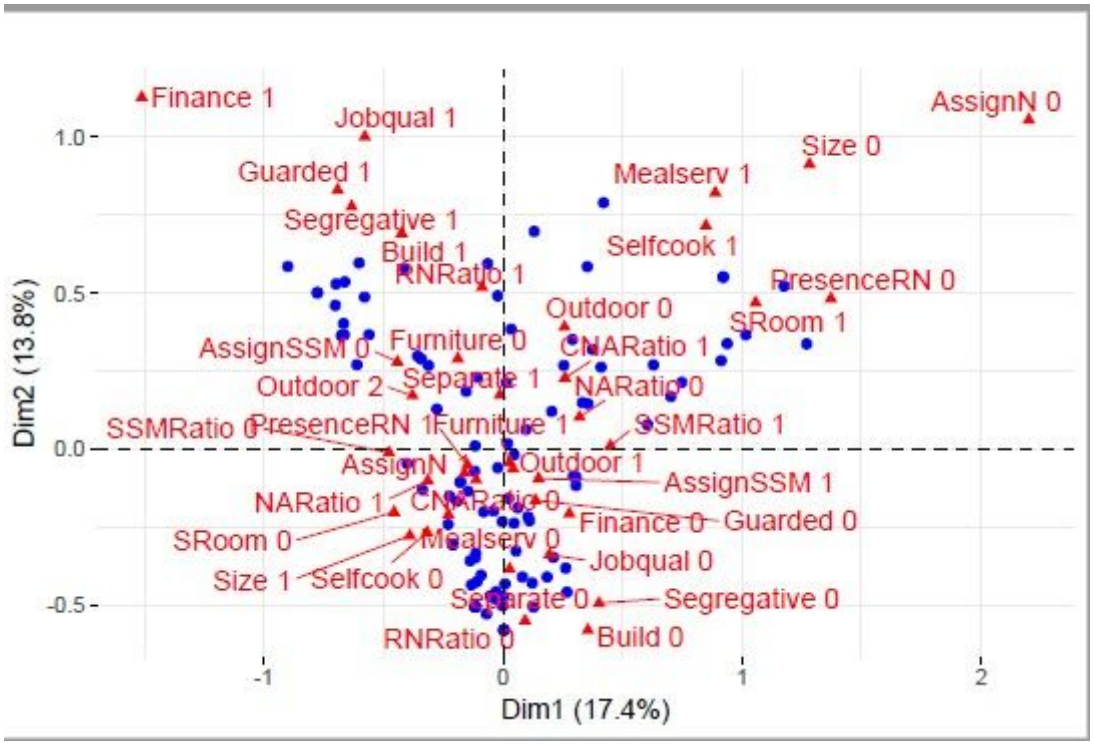

Figure 2

MCA map for the superimposed representation of living units (blue points) and structural characteristics (red triangles).

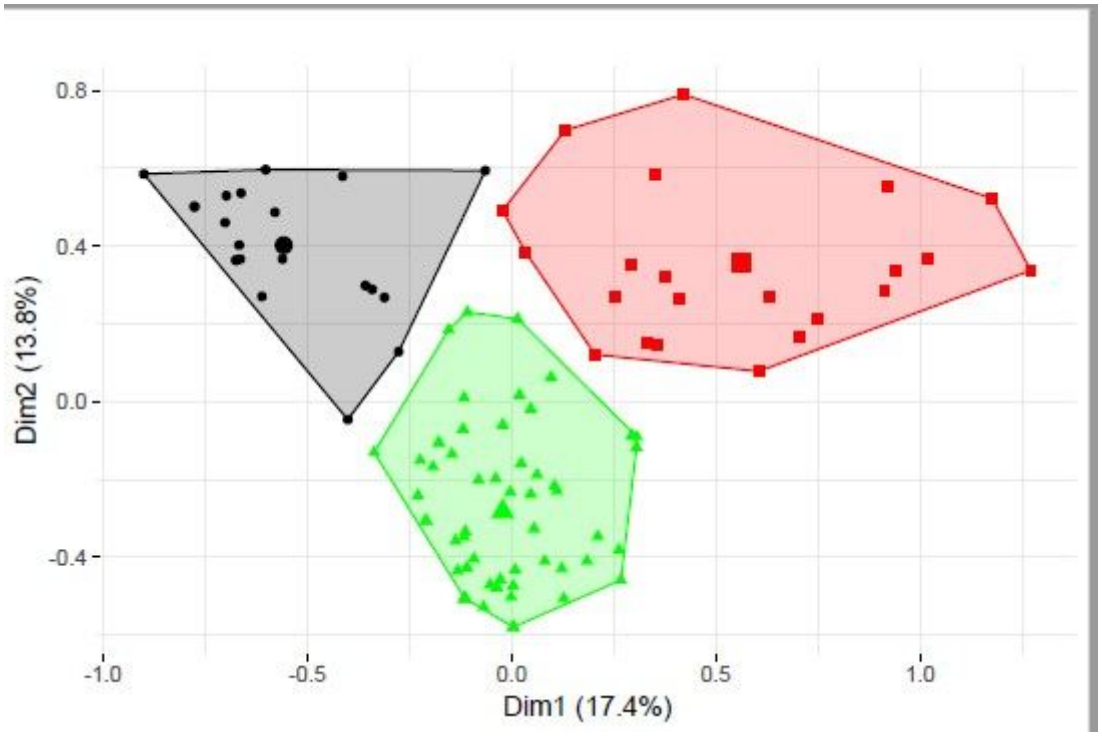

Figure 3

MCA map with clusters (black = dementia special care units, green = usual care, red = house community).