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Research paper

Prediction of depressive symptoms at high age (80+) by psychological, biological and functional factors

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ABSTRACT

Background: Late-life depression (LLD) is highly prevalent, especially in people aged 80 years and older. We aimed to investigate predictors and their influence on depressive symptoms in LLD.

Methods: We analysed data from the NRW80+ study, a population-based cross-sectional study of individuals aged 80 years and older. Data from $n = 926$ cognitively unimpaired participants were included. We reduced 95 variables to 21 predictors of depressive symptoms by using a two-step cluster analysis (TSCA), which were assigned to one of four factors (function, values and lifestyle, autonomy and contentment, biological-somatic) according to a principal component analysis. A second TSCA with complete data sets ($n = 879$) was used to define clusters of participants. Using weighted mean composite scores (CS) for each factor group, binary logistic regression analyses were performed to predict depressive symptoms for each cluster and the total population.

Results: The second TSCA yielded two clusters (cluster 1 ($n = 688$), cluster 2 ($n = 191$)). The proportion of participants with depressive symptoms was significantly higher in cluster 2 compared to cluster 1 (39 % vs. 15 %; OR = 3.6; 95 % CI 2.5–5.1; $p < .001$). Participants in cluster 2 were significantly older (mean age 88 vs. 85 years; $p < .001$), with a higher proportion of women (56 % vs. 46 %; OR = 1.5; 95 % CI 1.1–2.0; $p = .016$), had a higher BMI ($p = .017$), lower financial resources (OR = 2.3; 95 % CI 1.6–3.5; $p < .001$), lower educational level (OR = 1.8; 95 % CI 1.2–2.5; $p = .002$), higher proportion of single, separated or widowed participants (OR = 1.9; 95 % CI 1.3–2.6; $p < .001$) and a smaller mean social network ($p = .044$) compared to cluster 1. Binary logistic regression analyses showed that the weighted mean CS including the autonomy and contentment predictors explained the largest proportion of variance (22.8 %) for depressive symptoms in the total population (Nagelkerke's $R^2 = 0.228$, $p < .001$) and in both clusters (cluster 1: Nagelkerke's $R^2 = 0.171$, $p < .001$; cluster 2: Nagelkerke's $R^2 = 0.213$, $p < .001$), respectively.

Limitations: The main limitations are the restriction to cognitively unimpaired individuals and the use of a self-rated questionnaire to assess depressive symptoms.

Conclusions: Psychological factors such as autonomy and contentment are critical for the occurrence of depressive symptoms at higher age, independent of the functional and somatic status and may serve as specific targets for psychotherapy.

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1. Introduction

Late-life depression (LLD) is defined as a depressive episode in people over the age of 60. In addition to the core symptomatic features of depression, LLD is often accompanied by somatic and cognitive symptoms (Morin et al., 2020). The prevalence of LLD has been estimated to be 8 to 16 % with a particular increase in the age group above 80, making it increasingly relevant in the light of the demographic changes in many societies. (Büchtemann et al., 2012; Whyte and Rovner, 2006).

Studies on the risk factors and aetiology of LLD have led to the hypothesis that LLD results from a multidirectional interaction of biological, psychological and social factors (Aziz and Steffens, 2013). Most of the recent studies have focused on the role of biological factors including the vascular depression hypothesis (Alexopoulos et al., 1997), the role of inflammation (Alexopoulos and Morimoto, 2011), the dysregulation of the hypothalamic–pituitary–adrenal axis (HPA), the reduction of nerve growth factors (Geerlings and Gerritsen, 2017) and the association of LLD with neurodegenerative diseases such as Alzheimer's disease (Byers and Yaffe, 2011). Other factors that have been reported to impact the risk of LLD include the overall physical morbidity, chronic disorders and functional impairments as well as socioeconomic factors (Fernandez-Rodrigues et al., 2022). Psychological and social variables as risk factors for LLD have been less well studied, although they are as important as physical factors in understanding the aetiology of LLD. Studies have shown that having a weak social, emotional and supportive network, living in isolation and losing a partner can facilitate the onset of depressive symptoms (Devita et al., 2022). Furthermore, a study in institutionalized older people has shown, that psychological variables such as environmental mastery (a sense of self-efficacy and competence in managing one's environment), purpose in life, and autonomy, are more important in understanding depression than traditional medical risk factors, such as medical illness and disability in this patient group. These three psychological variables discriminated strongly between patients with and without depression at higher age (Davison et al., 2012). Moreover, evidence suggests that psychological factors such as a high sense of autonomy are negatively correlated with depression symptoms (Tang et al., 2020). On the other hand, high levels of self-esteem and sense of control are protective factors against the development of LLD (Devita et al., 2022). Nevertheless, most research on LLD is derived from clinical or epidemiological studies with a strong medical background. In contrast, there is a lack of data from large cohorts of individuals over the age of 80 focusing on the role of psychological and social predictors of LLD.

Here, we present the data from a study developed in a gerontological and social science setting, focusing on determinants of quality of life in people aged 80 years and older. The uniqueness of this study lies in the extended assessment of psychological aspects and of living conditions. In this dataset, we include a wide range of demographic, sociological, psychological, somatic and functional factors and indicators in a combined analyses to obtain predictors of depressive symptoms. Due to the large number of variables, we used a hypothesis-free, data-driven approach to avoid biased pre-selection of the data.

2. Methods

2.1. Study design

The *NRW80+* study is an interdisciplinary project combining gerontology, social psychology, and ethics which aims to assess living conditions and predictors of quality of life in individuals at high age (≥80 years). The potential target population included all individuals who had reached 80 years of age by 31 July 2017 and whose registered primary residence was in the state of North Rhine-Westphalia (NRW) in Germany (17.93 million). Participants were randomly selected from population registries. A sample of 94 communities was drawn from the entirety of all communities in NRW. The registration offices of the selected communities provided a random sample of inhabitants, amounting to 48,137 addresses. The group of study participants to be contacted consisted of 8040 individuals based on a priori power analysis and an expected response rate of 20–25 % (Brix et al., 2018; Wagner et al., 2018). Enrolment and assessments were conducted between 2017 and 2019 (Hansen et al., 2021). A detailed description of the study design has been reported previously (Hansen et al., 2021).

2.2. Participants

A total of 1863 participants agreed to a computer-assisted in-person interview with an experienced and trained interviewer from the market research institute Kantar (formerly TNS Infratest, Munich, Germany). The sample was representative of the population in terms of age (80–84, 85–89 and 90+), gender, household size, marital status and community size. Of the 1863 interviews, 15 were incomplete and 167 were proxy interviews (48 % children, 24 % spouses, 23 % other close persons e.g., children-in-law, 5 % professional caregivers). 57 % of the 167 participants with proxy interviews had moderate to severe cognitive deficits (Brix et al., 2018). The proxy interviews were not included in the selection of variables. In addition, the selected statistical methods chosen ensured that the incomplete data sets mentioned above were not included in the analyses.

For the present analysis, we included a subsample of 926 cognitively unimpaired participants with a DemTect score ≥ 13 points. The DemTect is a validated German comprehensive cognitive test for the detection of mild cognitive impairment (MCI) and early dementia (Kalbe et al., 2004). All participants provided written informed consent prior to study enrolment. The study was approved by the Ethics Committee of the University of Cologne (No. 17–169).

2.3. Assessments

Detailed information on the participants was collected using demographic, sociological, medical and psychological questionnaires and scales. A total of 688 variables consisting of single items and total questionnaires scores were obtained. The variables cover health, lifestyle/technology use, political and social networks, values, personality, experiences, life events and interpersonal conflicts. The instruments used to assess each predictor and a detailed description are listed in Supplementary Table 1.

2.3.1. Cognitive assessment

The cognitive status was assessed using the DemTect, which includes word list learning with immediate and delayed recall, number transcoding, semantic verbal fluency and digit span backwords. The maximum age-adjusted DemTect score is 18. Unimpaired cognition is defined as a score of 13–18, MCI as a score of 9–12, and dementia as a score of <9. The DemTect has shown a sensitivity of 97 % and a specificity of 93 % for a cut-off score of 13. (Kalbe et al., 2004; Kohn et al., 2007).

2.3.2. Assessment of depressive symptoms

The 4-item version of the Depression in Old Age Scale (DIA-S) was used to assess depressive symptoms. The DIA-S consists of the Items: "I am feeling down", "It is hard to motivate myself", "I can enjoy my life, even when things are sometimes more difficult" and "I tend to ruminate a lot". All four items were answered dichotomously with a "yes/no" response. A depressive state was defined by a score of ≥2 (Heidenblut and Zank, 2014, 2010).

2.4. Statistical analysis

2.4.1. Cluster analysis

We used a hypothesis-free, data-driven approach. The potentially relevant predictors were obtained by a two-step cluster analysis (TSCA)

without an a priori fixed number of variables, clusters or categories of variables. The TSCA is a hybrid approach that first uses a distance measure to separate groups and then a probabilistic approach to select the optimal subgroup model (Gelbard et al., 2007; Kent et al., 2014). The TSCA is particularly appropriate when the goal is to uncover the latent structure of the data or natural groupings within the data without necessarily making predictions about individual cases. By iteratively applying clustering algorithms and statistical criteria, the TSCA determines the optimal grouping of data points into clusters based on similarities between observations. In contrast, machine learning (ML) techniques are powerful tools for predictive modelling but are primarily concerned with making predictions based on patterns in the data. ML methods focus on training algorithms to generalise patterns in the data and are designed to optimise prediction accuracy. As such, they may not be directly suited to identifying underlying clusters within the data. In the TSCA a sequential approach is used to pre-cluster the cases based on the definition of dense regions in the analysed attribute-space first. In the second step (clustering), the pre-clusters are statistically merged in a stepwise manner by running hierarchical clustering models (Benassi et al., 2020). Such a technique presents several advantages compared to more traditional techniques, such as determining the number of clusters based on a statistical measure of fit (AIC or BIC) rather than on an arbitrary choice, the simultaneous use of categorical and continuous variables, the analysis of atypical values (i.e., outliers), and the ability to handle large datasets (Bacher et al., 2004; Gelbard et al., 2007; Kent et al., 2014; Mooi and Sarstedt, 2011) Comparative studies have found the TSCA to be one of the most reliable in terms of the number of subgroups detected, the probability of assigning individuals to subgroups, and the reproducibility of results on clinical and other types of data (Bacher et al., 2004; Gelbard et al., 2007; Kent et al., 2014). The TSCA was implemented in IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

In our analyses, we included 95 variables that were obtained from a minimum of $N = 900$ participants, in order to avoid a reduction of cases due to missing data. The included variables are listed in detail in Supplementary Table 1. The log-likelihood was used as the distance measure in the TSCA. The silhouette measure reflects the quality of cluster solutions. Silhouette measures of <0.2 are classified as poor, between 0.2 and 0.5 as fair, and silhouette measures >0.5 as a good solution quality (Sarstedt and Mooi, 2019; Tabachnick and Fidell, 2019). The relative importance of variables in the TSCA is shown in a plot in which the y-axis is the set of variables, and the x-axis is the importance value ranging from 0.00 (least important) to 1.00 (most important). The number of variables was reduced in our analysis by a first TSCA and by using an importance cut-off of >0.25.

2.4.2. Principal component analysis (PCA)

A second TSCA including complete data sets ($n = 879$) was applied to the 21 variables derived from the first TSCA (Supplementary Table 2) with the aim of identifying underlying clusters. The 21 variables were then subject to a principal component analysis (PCA) with Varimax (orthogonal) rotation. The PCA was used to group the predictors according to their underlying factors. Only factors with eigenvalues ≥1 were considered.(Guttman, 1954; Kaiser, 1960). Examination of Kaiser's criteria and the scree-plot provided empirical justification for retaining four factors. The PCA identified four factors, which were labelled as function, values and lifestyle, autonomy and contentment, and biological-somatic (Table 1) and included the following variables:

2.4.2.1. Function predictors. Function, defined by the ability to perform activities of daily living (ADL) without assistance, was composed of: "Instrumental ADL (iADL)", "Basic ADL (bADL)", "level of care" and "care use". The "level of care" refers to the German health care insurance definition. The latter two variables are indirect indicators of functional health (Milstein and Blankart, 2016).

2.4.2.2. Values and lifestyle predictors. The values and lifestyle predictors included the following: "Value of Self-determination", "Value of benevolence", "Awareness of age-related change", "Generativity", "Positive affect", "Lifestyle: Frequency", "Lifestyle: subjective importance", "Activities: execution".

Table 1
Results of the factor analysis (PCA) and their distribution according to the latent underlying factors.

Factor group number	variables/ predictors	1	2	3	4	Factor group name
1	Instrumental ADL	-0,863	-0,014	-0,148	-0,102	Function
	Basic ADL	-0,855	0,024	-0,085	-0,117	
	Level of care need	0,819	0,121	0,222	0,182	
	Care use	0,861	0,067	0,148	0,196	
2	Value of self-direction	0,378	0,482	0,086	0,214	Values and lifestyle
	Value of benevolence	0,246	0,709	0,127	0,195	
	Awareness of age-related change: positive experiences	0,127	0,83	0,007	0,101	
	Generativity	-0,104	0,452	0,03	-0,132	
	Positive Affect	-0,095	0,51	0,275	-0,049	
	Lifestyle: Subjective importance	0,042	0,631	0,026	0,063	
	Lifestyle: Frequency	0,041	0,475	0,113	-0,083	
	Activities: Execution	0,052	0,65	0,292	0,175	
3	Autonomy	0,368	0,189	0,543	-0,093	Autonomy and contentment
	General satisfaction	-0,203	0,064	-0,692	-0,083	
	Appreciation by others	0,279	0,261	0,611	0,084	
	Valuation of life	0,041	0,4	0,572	0,327	
	External locus of control	-0,048	0,315	0,328	0,311	
	Internal locus of control	0,042	0,18	0,615	0,291	
4	General evaluation of health	0,161	0,114	0,178	0,717	Biologic-somatic
	Pain	-0,208	0,058	-0,106	-0,676	
	Multimorbidity	-0,131	0,004	-0,067	-0,769	

2.4.2.3. Autonomy and contentment predictors. The autonomy and contentment predictors contained "Autonomy", "General Satisfaction", "Appreciation by others", "Valuation of life", "Internal Locus of control", "External Locus of control".

2.4.2.4. Biological-somatic predictors. The following variables were included in the biological-somatic predictors: "multimorbidity", "pain", "general feeling of health".

2.4.3. Weighted mean composite score (CS)

Moreover, we calculated weighted mean composite scores (CS) for the predictor groups of the above mentioned PCA. CS can be used to combine multiple variables into a single index to represent a concept or construct that is believed to be reflected by those variables. In order to calculate the weighted mean CS, each z-transformed predictor (except the binary variable "care use") was multiplied by its PCA factor load.

2.4.4. Regression analyses

A binary logistic regression analysis was then performed separately for each weighted mean CS to predict the presence of a depressive state and to estimate the variance explained. The analyses were performed for each of the clusters and on the entire sample. The dependent variable was defined as the presence of a depressive state as assessed by the DIA-S with a score ≥ 2. The proportion of variance was estimated using the pseudo-R^2 estimate Nagelkerke's R^2.

All variables are presented as means, standard deviations (SD), frequencies of occurrence and percentages (%). Odd ratios (OR) and 95 % confidence intervals (95 % CI) were calculated for the predictors. For most scales, cut-offs to distinguish between a normal and an abnormal score are not defined. We therefore used the median split for dichotomise continuous variables. We compared each predictor between clusters using chi-square test and Fisher's *t*-test.

The authors declare that all procedures contributing to this work complied with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All procedures involving human subjects were approved by the University of Cologne.

3. Results

3.1. Model overview

In our analyses, the number of variables was reduced from 95 to 21 by a first TSCA based on the criterion of an importance score of >0.25. Variables which were excluded by the first TSCA included demographics (e.g., age, sex, family status), values and spirituality, lifestyle variables (e.g., media use, health competence), social support, loneliness and interpersonal conflicts. A second TSCA applied to these 21 variables revealed two clusters. Cluster 1 contained 78 % ($N = 688$ of 879) of the participants, while cluster 2 included 22 % (191 of 879). The silhouette coefficient was 0.3 and can therefore be interpreted as a fair quality cluster solution. The following four variables had an importance factor > 0.9: bADL (1.00), care use (0.96), level of long-term care (0.95) and iADL (0.94), indicating the greatest distinction between the two clusters. The remaining variables had an importance score of <0.17.

3.2. Description of the clusters

The proportion of participants with depressive symptoms was significantly higher in cluster 2 with 39 % compared to cluster 1 with 15 % (OR = 3.6; 95 % CI 2.5–5.1; $p < .001$). In addition, we observed a significantly higher mean in the DemTect score in cluster 1 with 16.5 ($SD = 1.68$) compared to cluster 2 with 15.7 ($SD = 1.9$; $p < .001$).

The demographic, socio-demographic and clinical variables for each cluster are shown in Table 2. Participants in cluster 2 were significantly older ($p < .001$), with a higher proportion of females (OR = 1.5; 95 % CI 1.1–2.0; $p = .016$), had a higher BMI ($p = .017$) and had lower financial resources (OR = 2.3; 95 % CI 1.6–3.5; $p < .001$). In addition, we observed a significantly higher percentage of participants with 8 years or less education (OR = 1.8; 95 % CI 1.2–2.5; $p = .002$) and fewer participants with 12-years of education (secondary school) in cluster 2 (OR = 0.4; 95 % CI 0.2–0.7; $p = .002$) compared to cluster 1. With regard to socio-demographic characteristics, cluster 2 included a higher proportion of single, separated or widowed participants (OR = 1.9; 95 % CI 1.3–2.6; $p < .001$) and a smaller mean social network ($p = .044$). We found no significant differences between the clusters in the proportion of people living in cities with >100,000 inhabitants, in the proportion of people with a monthly income of <968 Euro or in the proportion of people with migration background. There were also no significant differences in the number of children or the mean household size between the clusters.

Fig. 1 and Supplementary Table 3 shows the comparison of clusters 1 and 2 in terms of the 21 variables of the TSCA.

For the function predictors, the proportion of participants with lower ADLs, IADLs and a level of care (grade ≥ 1) and care users was higher in cluster 2 compared to cluster 1, indicating lower functional ability.

For the values and lifestyle factor, cluster 2 had a significantly higher proportion of people who scored lower on the variables value of benevolence, awareness of age-related changes, positive affect, lifestyle

Table 2
Demographic, sociodemographic, somatic, clinical and behavioural data.

	Cluster 1 (n = 688)	Cluster 2 (n = 191)	OR (95 % CI)	*p* value
Demographics				
Age in years *M* (SD)	85 (0.1)	88 (0.3)		<.001***
Female participants *N* (%)	318/688 (46)	107/191 (56)	1.5 (1.1–2.0)	.016*
Sociodemographics				
Marital status: "single/ separated/widowed" N (%)	345/688 (50)	128/191 (67)	1.9 (1.3–2.6)	<.001***
Household size *M* (SD)	1.6 (0.0; *n* = 686)	1.5 (0.0; *n* = 169)		.467
Number of children *M* (SD)	2.3 (0.0; *n* = 615)	2.4 (0.1; *n* = 173)		.180
Size of social Network *M* (SD)	8.7 (9.9)	7.2 (7.0)		.044*
Membership in a club/ association *N* (%)	234/688 (34)	32/191 (17)	0.4 (0.3–0.6)	<.001***
Resident in a city >100,000 inhabitants *N* (%)	525/688 (76)	144/191 (75)	0.9 (0.7–1.4)	.793
8-year or less education N (%)	354/654 (54)	118/175 (67)	1.8 (1.2–2.5)	.002**
12-year / secondary school education N (%)	126/654 (19)	16/175 (9)	0.4 (0.2–0.7)	.002**
Migration background *N* (%)	31/688 (5)	11/191 (6)	1.3 (0.6–2.6)	.130
Low-income <968 Euro *N* (%)	60/613 (10)	21/141 (15)	1.6 (0.9–2.8)	.078
Capital <12,500 Euro *N* (%)	179/509 (35)	65/116 (56)	2.3 (1.6–3.5)	<.001***
Behavioural, cognitive and somatic data				
Depressive symptoms *N* (%)	105/688 (15)	75/191 (39)	3.6 (2.5–5.1)	<.001***
DemTect M (SD)	16.5 (1.68)	15.7 (1.9)		<.001***
BMI (kg/m^2) *M* (SD)	25.8 (3.5)	26.6 (4.6)		.017*

* $p < .05$ (significant).
** $p < .01$ (highly significant).
*** $p < .001$ (very highly significant).

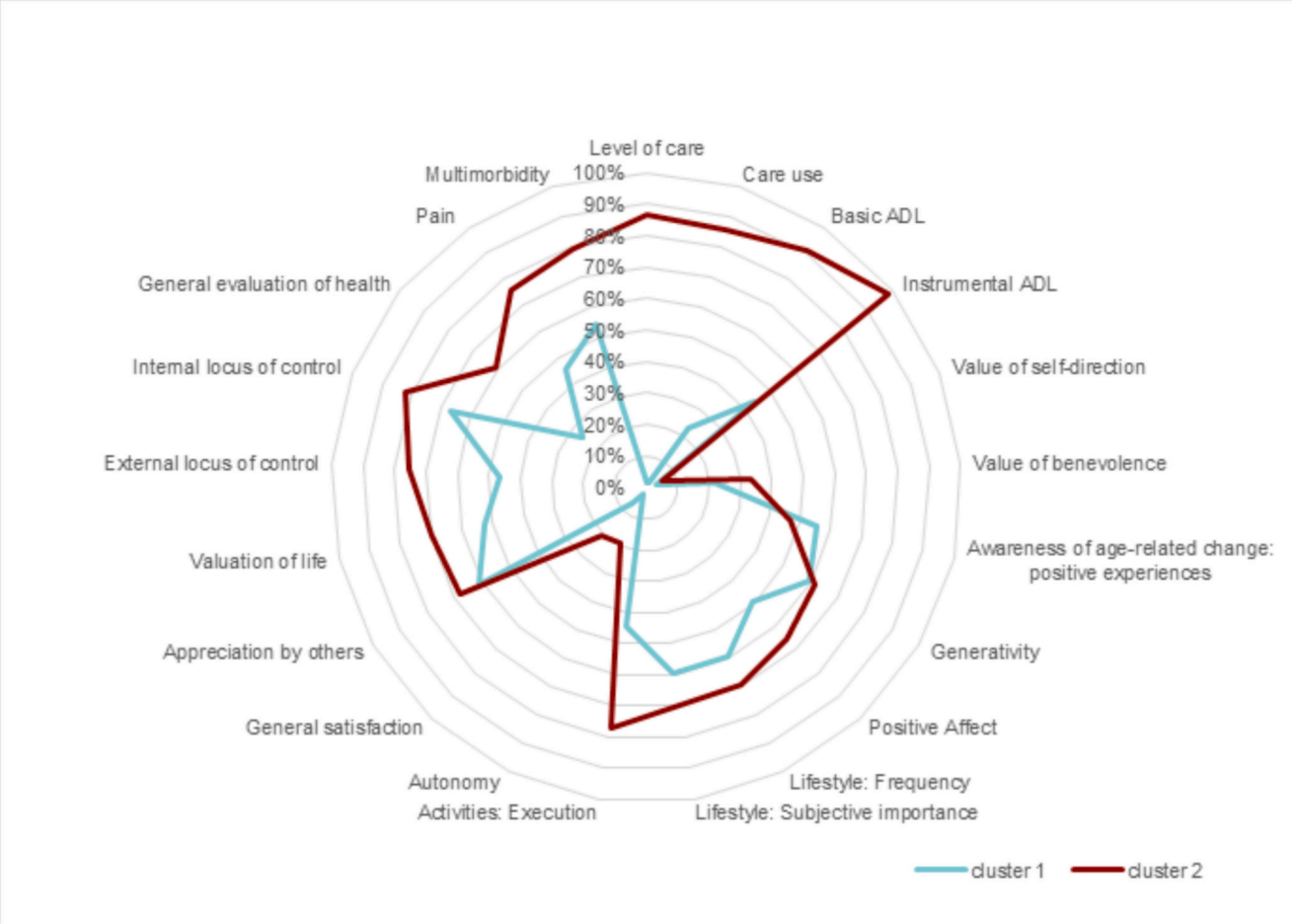

Fig. 1. Comparison of the 21 variables for cluster 1 and 2.

importance and frequency and performance of activities. No differences were found between clusters for the value of self-direction or generativity.

In terms of the autonomy and contentment predictors, cluster 2 had a higher proportion of participants who scored low on valuation of life, internal locus of control, positive affect, general satisfaction and the subjective importance of lifestyle activities compared to cluster 1. Cluster 2 also consisted of a lower proportion of participants who perceived an external locus of control. No differences were found between clusters in terms of the feeling of appreciation by others.

Regarding the biological/somatic predictors, cluster 2 included a higher proportion of participants with multimorbidity, moderate to very severe pain and lower general evaluation of health compared to cluster 1.

3.3. Binary logistic regression analyses

To predict depressive state, binary logistic regression analyses were performed for four weighted mean CS (1: function; 2: values and lifestyle; 3: autonomy and contentment; 4: biological-somatic) separately for each cluster and the total population (see Table 3).

The model including the function variables explained at most 12.3 % of the variance (Nagelkerke's $R^2 = 0.123$) in cluster 2 versus 1.4 % in cluster 1, and 8,3 % in the total population (Nagelkerke's $R^2 = 0.014$ and $R^2 = 0.083$) respectively.

The weighted mean CS for the values and lifestyle predictors explained the least amount of variance. It explained 3.1 % of the variance in cluster 1, 4.0 % of the variance in cluster 2 and 5.0 % of the variance in the total population (Nagelkerke's $R^2 = 0.031$, $R^2 = 0.040$

Table 3
Binary logistic regression analysis for the weighted mean CS according to PCA factors.

	Cluster 1	Cluster 2	Total (cluster 1 and 2)
Weighted mean CS 1 (function)[a]			
Nagelkerke's R^2	0.014	0.123	0.083
X^2 (2)	5,7	18.2	50,5
p value	.057	<.001***	<.001***
Weighted mean CS 2 (values and lifestyle)			
Nagelkerke's R^2	0.031	0.040	0.050
X^2 (1)	12.2	5.7	28.8
p value	<.001***	.017*	<.001***
Weighted mean CS 3 (autonomy and contentment)			
Nagelkerke's R^2	0.171	0.213	0.228
X^2 (1)	71.2	32.6	145.9
p value	<.001***	<.001***	<.001***
Weighted mean CS 4 (biological-somatic)			
Nagelkerke's R^2	0.101	0.074	0.130
X^2 (1)	41.0	10.7	80.5
p value	<.001***	<.001***	<.001***

* $p < .05$ (significant), ** $p < .01$ (highly significant) and ***, $p < .001$ (very highly significant).

[a] Weighted mean CS in combination with the dichotomous variables which cannot be z-transformed.

and $R^2 = 0.050$).

In contrast, the weighted mean CS including autonomy and contentment predictors explained the most variance. It explained 17.1 % of the variance in cluster 1, 21.3 % of the variance in cluster 2 and 22.8 % of the variance in the total population (Nagelkerke's $R^2 = 0.228$, $R^2 = 0.213$ and $R^2 = 0.228$).

Moreover, the biological-somatic weighted mean CS explained 10.1 % of the variance in cluster 1, 7.4 % of the variance in cluster 2 and 13.0 % of the variance in the total population (Nagelkerke's $R^2 = 0.101$, $R^2 = 0.074$ and $R^2 = 0.130$).

4. Discussion

In this study, we have shown that in the age group of 80 years and older two clusters can be identified within the study population: cluster 1 with more independent, healthier and younger participants with a higher level of education and higher socioeconomic background compared to cluster 2, which contained a higher number of subjects with depressive symptoms. Our results indicate that cluster 2, which contains a population with a higher rate of depression, poorer health and lower socioeconomic status, the variables autonomy and contentment variables are stronger predictors of a depressive state than the domains of biological-somatic conditions, functional capacities as well as value and lifestyle. In contrast, in cluster 1 each mean weighted CS explained a lower proportion of variance with the exception of the biological-somatic predictors. The main finding of this study is, that in the age group of 80 years and older psychological variables including autonomy and contentment explained a greater proportion of variance in predicting symptoms of depression than biological-somatic, functional, values and lifestyle predictors.

In a review by Laird et al., psychological predictors were divided into basic inherited/early developed psychological resilience predictors (e.g. temperament, personality and attachment) and mechanisms learned during lifetime (e.g. coping strategies and beliefs) (Laird et al., 2019). In particular, the basic inherited or in early-life developed variables predicted future depressive symptoms. In addition to these early life events, psychological mechanisms such as coping strategies and beliefs developed over the course of life, are also important predictors for depressive symptoms. These coping strategies can be divided into active problem-solving strategies and accommodative, accepting or adapting strategies to emerging stress (Laird et al., 2019).

Our findings are in line with previous studies on the importance of psychological predictors and recent cross-sectional and longitudinal studies showing that a higher external or a lower internal locus of control (Bjørkløf et al., 2018; Hovenkamp-Hermelink et al., 2019) and a lack of a sense of autonomy (Bekker and Belt, 2006) predict a higher rate and a persistence of depressive symptoms in LLD.

In our study the variable valuation of life in the autonomy and contentment factor describes attitudes towards the features of everyday life, thinking about the meaning and length of life and about autonomy including self-made decisions. It thus combines autonomy and contentment with a general valuation of life. In a previous study this variable was found to be protective in relation to depressive symptoms in later life (Gitlin et al., 2016) and is also less frequent in cluster 2 of our study. A study focusing on the role of appreciation by others found that higher appreciation is indicative of subjective reward and lower occurrence of depressive symptoms (Deichert et al., 2019). Contrary to previous studies, we showed that the majority of participants experienced low appreciation by others with no significant difference between the clusters.

The variables general evaluation of health and general satisfaction can be considered as parameters of quality of life. Poor quality of life has been shown to be associated with higher mortality and morbidity (Sivertsen et al., 2015). Similar to the findings of Sivertsen et al., we observed a significant association between the occurrence of depressive symptoms and poorer subjective quality of life variables in cluster 2, which included more subjects with depressive symptoms.

Additionally, the three lifestyle variables (lifestyle: frequency, lifestyle: subjective importance and activities: execution) in the values and lifestyle factor are surrogates for daily activity or exercise and its subjective importance. Moreover, previous evidence suggests that activity, and in particular physical exercise, may be protective against depressive symptoms, cognitive decline and physical disability (Klil-Drori et al., 2020; Neviani et al., 2017). This is consistent with our findings showing that these three variables are significantly lower in cluster 2.

Furthermore, in previous studies, higher generativity, defined as the desire to influence the next generation, had a protective effect on the development of depressive symptoms in later life (Grossman and Gruenewald, 2017). In our data, lower generativity did not differ between clusters 1 and 2 (60 % vs. 62 %). Generativity corresponds to the predictive value of benevolence, which reflects the motivation to help and care for others. Higher levels of benevolence have been shown to moderate subjective well-being in previous studies (Oishi et al., 1999). In accordance with this, in our study the expression of benevolence was significantly higher in cluster 1.

Additionally, the effectiveness of adaptive strategies such as higher awareness of age-related changes (Dutt et al., 2018) has been found to be protective with respect to depressive symptoms in later life. Consistent with these findings, the awareness of age-related changes is expressed lower in cluster 2 in our study.

In our study, the variables multimorbidity, pain, level of long-term care and care use were identified as biological-somatic predictors of depressive symptoms. Studies have shown that the level of long-term care and the use of care, especially in a nursing home, are significantly correlated with multimorbidity (Koller et al., 2014). In cluster 2 in particular, we observed the combination of multimorbidity, pain, level of long-term care and care use as predictors of the occurrence of depressive symptoms. These findings are consistent with other studies, such as the longitudinal MultiCare study in Germany (Mallon et al., 2021) and UK Biobank analyses. These studies showed that an increasing number of physical conditions was associated with an increasing rate of depressive symptoms (Ronaldson et al., 2021). However, the explained variance in predicting depressive symptoms was much lower for biological-somatic predictors than for psychological predictors.

Recent studies have reported that function predictors such as impairment in ADLs and IADLs are associated with depression (Falk Erhag et al., 2021). Our study confirms these findings by significantly higher impairments in ADLs and IADLs in cluster 2. However, function predictors explained less variance in the prediction of depressive symptoms than psychological predictors.

In summary, our results strengthen the importance of psychological predictors such as autonomy and internal locus of control in the development of depressive symptoms in later life. These psychological predictors might be promising future targets for therapeutic interventions for LLD patients.

4.1. Strengths and limitations

The main strength of this study is the representative and large sample size and the age range of 80 years and older, in which the prevalence of depression is increasing. Another unique feature of the study is that it is embedded in a non-medical, but gerontological research setting with a focus on predictors of quality of life. In this regard, the study provides unique data, particularly on psychological predictors and on living conditions, that are usually not available in clinical or epidemiological studies. Nevertheless, a variety of information on the medical health status, on functional ability and on cognition is provided.

The study is limited by its cross-sectional design. This limits the interpretation of a causal inference and the investigation of a temporal relationships between outcomes (Downes et al., 2016). The restriction to cognitively unimpaired participants may introduce a selection bias,

potentially affecting the association between predictors and outcome. Furthermore, in our analyses we excluded the cognitively impaired participants with MCI and dementia in order to avoid a confounding effect. This may reduce the generalisability of our results to the whole group of people aged 80 years and older.

Our study does not contain biological data, which would be needed in order to investigate a biological model of LLD in our data. Another limitation is that depressive symptoms were assessed with the DIA-S questionnaire and not a major depressive episode with a structured clinical interview or a clinical diagnosis of a major depressive disorder. Finally, the fact that most of the questionnaires were self-ratings, reporting bias or social expectancy bias cannot be excluded.

5. Conclusions

Our study provides evidence that psychological predictors such as autonomy and contentment play a central role in the development of depressive symptoms at higher age, especially in the presence of other predictors, such as higher morbidity and impaired functional ability. This strongly supports the need for further research into interventions to strengthen psychological factors of resilience and the provision of such interventions in health care settings.

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CRediT authorship contribution statement

Philip Zeyen: Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Lena Sannemann:** Conceptualization, Methodology, Visualization, Writing – review & editing. **Xiaochen Hu:** Conceptualization, Methodology, Writing – review & editing. **Joseph Kambeitz:** Conceptualization, Methodology, Writing – review & editing. **Michael Wagner:** Conceptualization, Funding acquisition, Resources, Writing – review & editing. **Christiane Woopen:** Conceptualization, Funding acquisition, Resources, Writing – review & editing. **Susanne Zank:** Conceptualization, Funding acquisition, Resources, Writing – review & editing. **Frank Jessen:** Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Writing – review & editing. **Forugh S. Dafsari:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

All authors disclosed no relevant relationships.

Data availability

A scientific use file of the NRW80+ data is available at the GESIS data repository (https://doi.org/10.4232/1.13527).

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2024.05.059.

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