ИКОНОМИЧЕСКИ ИЗСЛЕДВАНИЯ
ECONOMIC STUDIES

Volume 34(2), 2025

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LONGITUDINAL STUDIES BASED ON SHARE PROJECT DATA – METHODOLOGICAL GUIDELINES[2]

The purpose of this paper is to summarise the methodological process of performing longitudinal research based on data from several waves of the Survey of Health, Ageing and Retirement in Europe (SHARE). The current research presents a standardized approach – an algorithm for better public policies that could be used in future longitudinal studies focused on different socio-economic problems.
Results could be useful for all researchers and national authorities that aim to identify the changes in the behaviour and attitudes of people in Europe aged 50 and over as well as for the development of science capacity for working with big data – a baseline for knowledge-based solutions and coping strategies.
Keywords: SHARE; Europe; older people; longitudinal research; public policies; knowledge-based solutions
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1. Introduction

The SHARE project is a unique multidisciplinary, cross-national project involving panel microdata on the health, socioeconomic status, and social and family networks of individuals aged ≥50 years. From 2004 to date, over 530,000 in-depth interviews have been conducted with 140,000 people from 28 European countries and Israel (waves 1-8, plus waves 8-9 Corona). The study is representative of the population aged 50 and over, harmonized, and comparable for all countries. In 2011, SHARE became the first-ever European Research Infrastructure Consortium (ERIC). In 2018, the National Roadmap for Scientific Infrastructure (NPKNI) at the Ministry of Education and Science financed the creation of a national infrastructure site SHARE ERIC Bulgaria. Since SHARE is the largest pan-European panel survey and the only international panel survey in which Bulgaria participates, increasing the technical and scientific capacity to work with the data from the different waves of the survey is one of the key tasks of national importance.

In a number of countries within the framework of the SHARE project (Latvia, Estonia, Germany, Switzerland, Croatia, Slovenia, etc.[3]), effective social policies based on knowledge

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[2] This paper should be cited as: *Angelova, M. (2025). Longitudinal Studies Based on SHARE Project Data – Methodological Guidelines. – Economic Studies (Ikonomicheski Izsledvania), 34(2), pp. 37-52.*
[3] *Socio-economic Impact (share-eric.eu)*

and in response to specific problems have already been developed, which shows that research and follow-up measures and policies are working not only in theory but also in practice. The present study takes a step in this direction, both for Bulgaria and in a transnational context, aiming to present the main steps and give practical examples of conducting longitudinal research on SHARE data as a basis for making better management decisions based on both professional experience and knowledge derived from data.

While most studies in the literature focus on specific issues at one point in time, there are also a number of longitudinal studies that track changes in respondents' behaviours and attitudes over time across two or more survey waves. None of the available publications on SHARE data, however, offer a standardized methodology such as an algorithm for conducting a longitudinal study that can be used by national and local authorities to track changes and make informed decisions and increase administrative capacity for the purposes of better public policies.

For the current research, numerous longitudinal studies based on the SHARE project data are examined and the main steps for performing longitudinal research on the SHARE data are summarised in the form of methodical guidelines. Apart from that author's methodology – algorithm for better public policies is presented, supported by practical examples from Wave 7, Wave 8 and Wave 8-Corona of the survey.

Despite of the fact that there are many existing longitudinal research available based on the SHARE data, none of them suggests a methodological framework that could be observed when a researcher needs to investigate the changes over time regarding specific problems concerning people aged 50 and over in Europe.

The research presents a unique toolkit based on the specifics of the SHARE project data, that to the best of the author’s knowledge could not be found in any other existing research on the SHARE data and that could be used in future longitudinal studies using the upcoming waves of the research focused on different socio-economic problems.

The current study generates two main contributions. On one hand, it provides structured methodological guidelines for conducting longitudinal research based on two or several waves of the SHARE data. On the other hand, it suggests a standardized approach – an algorithm that could be used for better public policies focused on people aged 50 and over and their effective inclusion in the socio-economic life.

The rest of the paper is structured as follows: the next section provides a short review of the nature of the SHARE data and the significance of the necessity of research capacity able to deal with it, Section 3 reveals the research methodology and main steps of a longitudinal study based on SHARE data supported by a literature review. Section 4 presents the main results, followed by a discussion. Section 5 concludes the research.

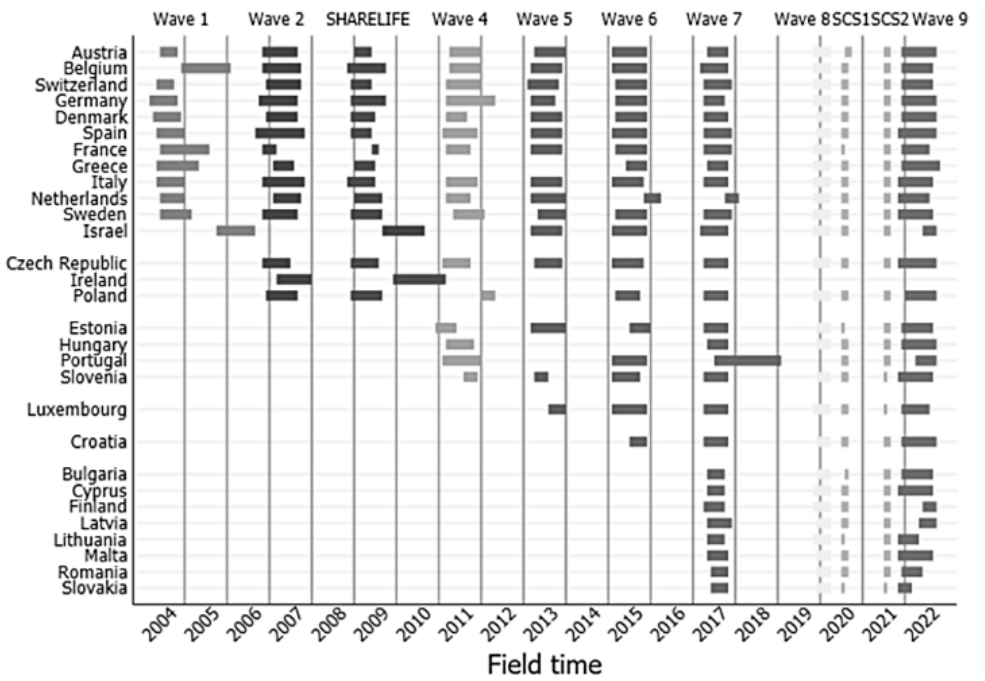
2. SHARE data – overview and significance

The SHARE project data is publicly available on the project website http://www.share-project.org/ after prior registration of interested parties. As of April 2024, over 4,000

publications based on SHARE data have been published worldwide, with over 18,000 registered scientific users of the data.

The graph of the phased inclusion (Figure 1) shows that at the time of the first wave, about 12 countries were included and their number gradually increased, with Bulgaria being included only in the studies of Wave 7, realized immediately before the outbreak of the global pandemic of COVID-19.

Figure 1. Development and phased inclusion of individual countries in the SHARE project



Source: www.share-project.org

The database includes about 50 data modules including main modules (Figure 2) and generated variable modules (Figure 3) represented to varying degrees in the different waves of the survey with the participation of over 27 countries from Europe and Israel, included in stages in the different waves of the SHARE survey.

Figure 2. Representation of the main modules across the waves of the SHARE survey

	Content of regular Questionnaire Modules	W1	W2	W4	W5	W6	W7	W8
CV_R	Coverscreen on individual level	x	x	x	x	x	x	x
DN	Demographics and Networks	x	x	x	x	x	x	x
SN	Social Networks			x		x		x
CH	Children	x	x	x	x	x	x	x
PH	Physical Health	x	x	x	x	x	x	x
BR	Behavioral Risks	x	x	x	x	x	x	x
CF	Cognitive Function	x	x	x	x	x	x	x
MH	Mental Health	x	x	x	x	x	x	x
HC	Health Care	x	x	x	x	x	x	x
EP	Employment and Pensions	x	x	x	x	x	x	x
IT	Computer Use				x	x	x	x
MC	Mini Childhood				x			
GS	Grip Strength	x	x	x	x	x	x	x
WS	Walking Speed	x	x					
CS	Chair Stand		x		x			
BS	Blood Sample					x		
PF	Peak Flow		x	x		x		
SP	Social Support	x	x	x	x	x	x	x
FT	Financial Transfers	x	x	x	x	x	x	x
HO	Housing	x	x	x	x	x	x	x
HH	Household Income	x	x	x	x	x	x	x
CO	Consumption	x	x	x	x	x	x	x
AS	Assets	x	x	x	x	x	x	x
AC	Activities	x	x	x	x	x	x	x
EX	Expectations	x	x	x	x	x	x	x

Source: SHARE_release_guide_8-0-0.pdf (share-eric.eu) (Börsch-Supan, 2022b)

Figure 3. Generated variable modules of waves 1 to 8

Generated-Variable-Modules	Content	W1	W2	W3	W4	W5	W6	W7	W8
gv_allwaves_cv_r	Coverscreen information across waves	Cross-wave module							
gv_longitudinal_weights	Longitudinal weights	Cross-wave module							
gv_weights	Cross-sectional sampling design and calibrated weights	X	X	X	X	X	X	X	X
gv_imputations	Multiple Imputations	X	X		X	X	X	X	
gv_isced	International Standard Classification of Education (ISCED-97/since wave 5 additionally ISCED-11)	X	X		X	X	X	X	X
gv_health	Physical and mental health variables and indices like BMI, EURO-D depression scale, etc.	X	X		X	X	X	X	X
gv_housing	Housing and NUTS codes	X	X		X	X	X	X	X
gv_networks	Information on social networks				X		X		X
gv_exrates	Exchange rates for all waves, incl. nominal and ppp-adjusted exchange rates	Cross-wave module							
gv_job_episodes_panel	Labour market status of each SHARELIFE respondent throughout her/his life	Cross-wave module							
gv_grossnet	Net income measures derived from reported gross incomes	X							
gv_isco	Classification of occupations via ISCO and of industries via NACE codes	X							
gv_ssw	Social security wealth				X				

Source: SHARE_release_guide_8-0-0.pdf (share-eric.eu) (Börsch-Supan, 2022b)

SHARE data are big data hard to model. Knowledge of artificial intelligence and big data is required to create domain- and data-driven prototyping using various analytical techniques and machine learning algorithms. As we live in the era of big data, management decisions should be made based on professional experience and knowledge derived from data. Therefore, it is necessary to create and update scientific capacity and scientific publications to serve as a basis for training for public authorities. In this sense, the present study is an example not of abstract science, but of science with added value since the achievement of the results is related to the design and implementation of national public policies.

The next section provides a critical review on the methodology and main steps of a longitudinal study based on SHARE data.

3. Research Methodology

3.1. Definitions

According to the "Encyclopedia of Social Measurement" (Kempf, 2005) longitudinal studies are studies (also known as panel studies) that are widely used in scientific research to measure changes over time in relation to certain factors or groups of people.

The longitudinal research based on SHARE data aims at identifying changes in the behaviour of people aged 50 and over in Europe in the period between two or more consecutive independent waves of the SHARE survey.

3.2. Methodological guidelines

A longitudinal study of the SHARE data should involve analysis of data from two or more waves of the survey. In preparing and conducting a longitudinal study on SHARE data, researchers should first answer several basic questions, namely:

- What do we want to explore?
- What does the literature review tell us about the topic?
- Do we have all the necessary data? – Within this question, researchers should spend sufficient time examining the SHARE data in module-by-module detail, as there may be surprises regarding large numbers of missing observations or missing entire data modules.
- What are the potential predictive features that we could include in a predictive model? What factors have been analyzed in the literature on the subject?
- What analytical techniques can we apply to test the statistical significance of the selected characteristics?
- How can we formulate additional synthetic and synergistic features? Are there examples of such features generated in the literature review on the topic? What does the decision tree show us? What do experts say on the subject?
- Which prediction algorithm to apply – regression or classification? Quantitative or qualitative target characteristic we want to predict? What techniques are used in the literature on the subject?
- What conclusions can we formulate as a result of the tested models?

3.3. Methodological framework

Figure 4 presents the main steps of the methodological framework applied to the Wave 7 and Wave 8 data of the SHARE project.

The first step in solving the problem at hand involves importing and preprocessing the data. The purpose of this step is to obtain clean data in the correct format and with missing observations filled. Within this step several sub-steps are performed like importing the data, getting to know the information about the different modules and variables, modules selection, data recoding with natural ranking, and merging data from different SHARE modules. The result is a clean data set ready for further analysis.

The second step is related to data analysis, calculation of summary statistics and visualizations of selected characteristics. As a result of the implementation of this step, conclusions on various indicators are formulated for the respondents.

The third step is related to factor analysis for each of the selected modules. The goal is to reduce the dimensionality of the data and generate factors that influence respondents in their responses to the SHARE questionnaire. As a result, a set of factors that are used for subsequent analyses is generated. For development purposes, data from both waves of the SHARE survey (Wave 7 and Wave 8 during) need to be treated identically, with the same factors being formed from both waves.

The next step involves selecting the target characteristic and predictor characteristics in a baseline model on SHARE wave 7 data to achieve the main objective of the specific study and based on the literature review on the topic. For this purpose, techniques for best subset selection are applied to select the most relevant and significant predictive characteristics, where the factors generated at the previous stage are also used. Within this step, an integrated (summary) table is created with the inclusion of additional characteristics related to demographics, employment, mental health, housing conditions of the respondents, etc. again based on the availability of the variables and missing values and depending on the literature review on the topic. At this stage, additional processing of the data is carried out with a view to achieving statistically significant dependencies. The better the data is processed at this step the better results can be obtained from the research. As a result, an analysis of the factors that positively and negatively influence the target characteristic is performed using SHARE Wave 7 data.

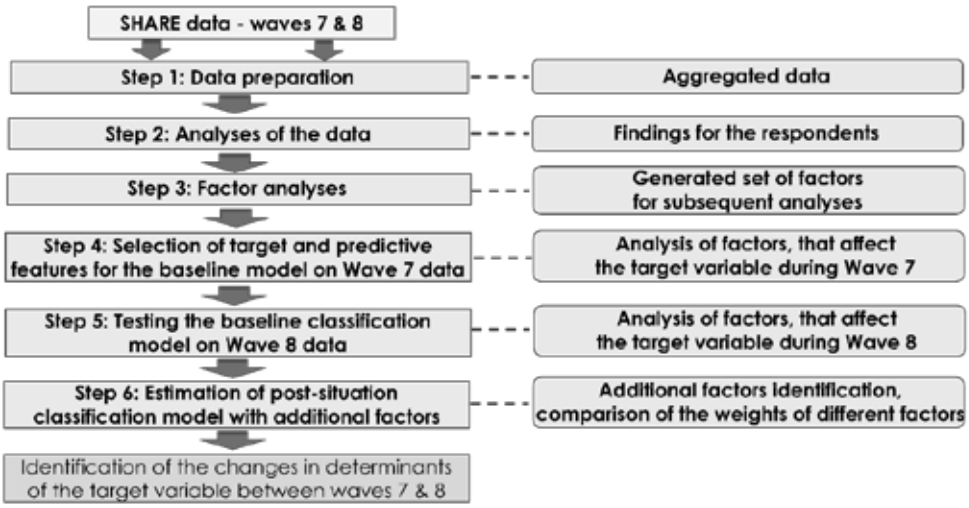
At the next stage, the base model needs to be tested on the SHARE data from wave 8. Analogous to the process regarding the data from Wave 7, the factors generated in the previous step need to be used in the data from Wave 8. Within this step, the same additional processing of the data analogous to those implemented on the data from Wave 7 needs to be carried out to achieve statistically significant dependencies. As a result, an analysis of the changes that occurred in the factors that positively and negatively affect the target characteristic is conducted using SHARE wave 8 data.

Next, a post-situation (like COVID crisis, war conflict, economic recession, etc. crucial event) classification model is created with additional factors that show statistical significance in preliminary analyses of Wave 8 data and that the literature review indicated as possible additional factors during the life-changing event. As a result, additional factors that influence

the target characteristic are identified and a comparative analysis of the effects of changing the weights of the individual factors is carried out.

As a final step, the changes that have occurred in the factors on which the target characteristic depends as a result of the critical event are identified and public policies are formulated, based on a literature review on the topic, targeting each factor.

Figure 4. Methodological framework



Source: Author's graph

3.4. Main steps of a longitudinal study based on SHARE data

The current study suggests the following main steps to be observed when conducting a longitudinal study related to the SHARE data in accordance with the results of empirical research (Angelova, 2021; Angelova, 2024) and supported by a comprehensive literature review:

Step 1: Processing the same (equivalent) data modules as well as the same (equivalent) features

This is also among the main steps, followed by numerous researchers that were examining different problems related to people aged 50 and over in Europe based on the SHARE data (Kim & Park, 2024; Werneck at al., 2022; Ogliari at al., 2021; Marques et al., 2020; Palladino et al., 2023; Peralta et al., 2023; Hajek & König, 2021; Veronese et al., 2022; Baumann et al., 2022; Tosheva, Yordanova & Markova, 2021).

The preprocessing of the same modules and characteristics is decisive for the possibility of doing parallel studies and comparative analyses with conclusions about the changes that have occurred over time. To enrich the study, additional characteristics that were not included in

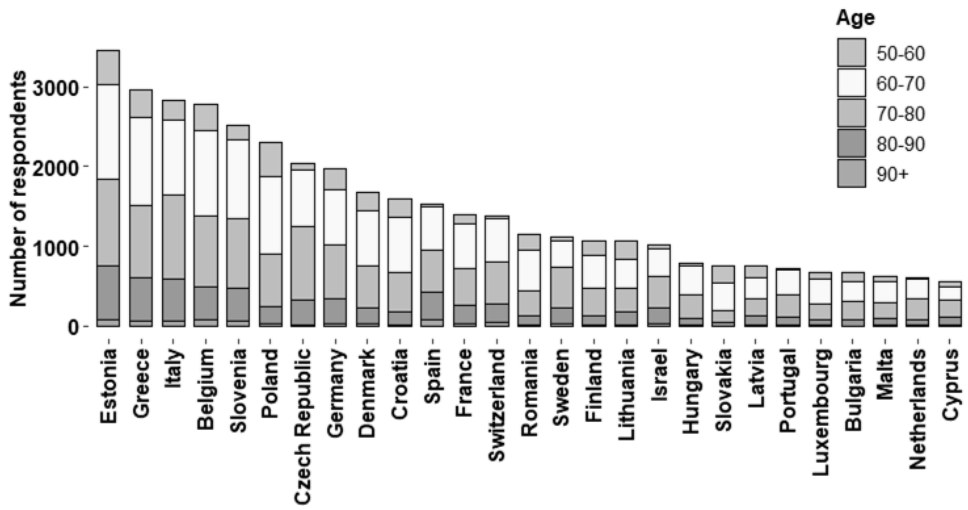
the first of the research waves can also be pre-processed and included in the data of the subsequent waves.

Step 2: Processing the data in the same way in both (or more) waves

This step is in line with numerous longitudinal studies based on the SHARE data (Kim & Park, 2024; Benke et al., 2023; Werneck at al., 2023; Werneck at al., 2022; Marques et al., 2020; Palladino et al., 2023; Peralta et al., 2023; Veronese et al., 2022; Baumann et al., 2022; Tosheva, Yordanova & Markova, 2021).

This step aims to prepare the data in the individual waves with respect to the individual features in an equivalent manner. For example, in the studies of Angelova (2021) and Angelova (2024), for the purposes of the empirical study, a number of characteristics are binned in the same way in the data from two consecutive waves of the survey. For example, age is binned into several age bins with a step of 10 years (Figure 5), education is binned into several categories in accordance with accepted norms for years of education at different levels of education, etc.

Figure 5: Distribution of respondents per age bins with a step of 10 years per country based on the Wave 8 data



Source: Authors calculations

Step 3: Analyse the changes that occurred regarding the same respondents included in the two (or more) waves of the survey

This step is also supported by a number of studies that are exploring the changes between different waves of the SHARE data (Feng at al., 2022; Ogliari at al., 2022; Ogliari at al., 2021; Marques et al., 2020; Palladino et al., 2023; Peralta et al., 2023; Alves & Perelman, 2022; Veronese et al., 2022; Baumann et al., 2022).

According to the definition of a longitudinal study, the study should measure the changes that have occurred over time in relation to certain groups of people. In this sense, when conducting such a study on SHARE data, researchers should leave in the sample the same group of respondents in the data of the two (or more) waves of the study, using the identification numbers (merge_id) of the respondents, because according to the methodology of the SHARE project, the identification number for a given respondent is the same for all waves of the survey.

Step 4: Create the same synthetic features and synergistic features in all explored waves

This step is also in line with several longitudinal research on the SHARE data (Marques et al., 2020; Veronese et al., 2022; Alonso-Perez et al., 2022; Baranyi et al., 2022; Gao et al., 2022; Tosheva, Yordanova & Markova, 2021)

Within this step, researchers can create new synthetic features from the data (feature engineering) or features with a synergistic effect of the simultaneous manifestation of two or more factors. In the case such features are created in the first studied wave of the SHARE data then in the subsequent waves researchers need to create the same synthetic and synergistic features and test how the effect of these factors on the target variable changes.

Step 5: Create additional synthetic characteristics in the subsequent survey waves reflecting certain changes in the socio-economic status, well-being and/or behaviour of the group of people

This step is also performed in several longitudinal studies using the SHARE data (Milicev at al., 2023; Ogliari at al., 2022; Ogliari at al., 2021; Marques et al., 2020; Alves & Perelman, 2022; Alonso-Perez et al., 2022)

Within this step, researchers can focus on changes that have occurred in terms of demographics (Hajek & König, 2021), socioeconomic factors (Alves & Perelman, 2022; Hajek & König, 2021; Alonso-Perez et al., 2022) and behavioural characteristics (Hajek & König, 2021) in the more recent wave.

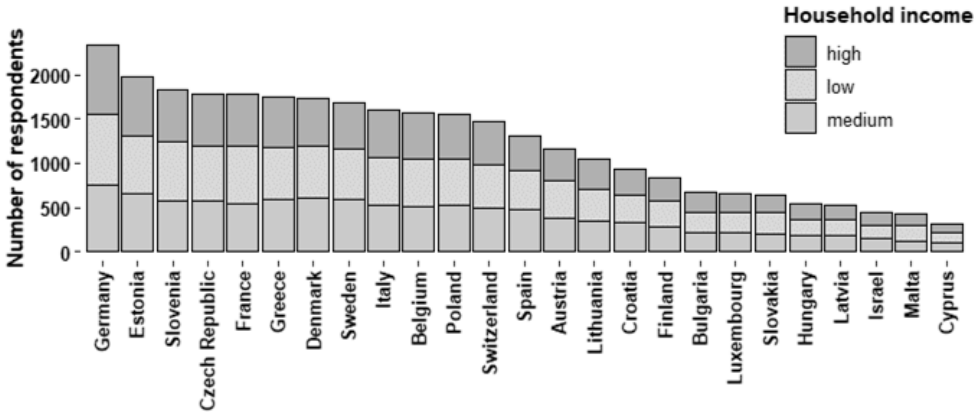
For example, a synthetic binary characteristic reflecting the ageing of people can be created when the respondent is moving into a higher age bin in the subsequent wave(s) since there is a time interval of 2-3 years between the different waves of the SHARE survey, which is a condition for some respondents to change their age group (Hajek & König, 2021; Angelova, 2024).

Another change that can again be used to create a synthetic characteristic is related to a change in the work situation (Alves & Perelman, 2022) of the respondents: for example, from working to unemployed or retired or vice versa, which is a frequently observed change, especially in critical times like the global COVID-19 pandemic.

Another transformation that can be studied is related to changes in marital status (Hajek & König, 2021), for example changing the status from married to widowed or divorced, or from single to partnered, etc. Such changes are again common phenomena during the global COVID-19 pandemic, where some people lose their partner while others find a life partner to cope with loneliness during the restrictions and isolation measures related to the spread of the virus (Angelova, 2024).

Other changes that can be investigated in a longitudinal study are the change in the level of education and change in income which are captured easily in the data by checking for respondents that moved into higher or lower bins (tertiles) of the income based on the average income on the different countries (Figure 6) (Hajek & König, 2021; Alonso-Perez et al., 2022).

Figure 6. Distribution of respondents per income tertiles based on the average income in the different countries based using Wave 8 data



Source: Author's calculations.

Another common phenomenon during the global pandemic is related to a change in living environment and/or housing type. In this sense, dependencies between the relocation of people in smaller or larger cities, in taller buildings or in smaller and single-family houses can again be explored.

Other interesting phenomena that can be investigated are changes in personality characteristics (Big 5) also known by the acronym OCEAN: Openness, Conscientiousness, Extroversion, Agreeableness, Neuroticism. The literature on the subject shows that the Big 5 also changes during the different stages of a person's life, as well as during critical times such as the global COVID-19 pandemic (Angelova, 2024).

Last but not least, researchers can examine changes in respondents' health status (Peralta et al., 2023; Alves & Perelman, 2022; Hajek & König, 2021), activity level (Angelova, 2024), depression (Hajek & König, 2021), satisfaction and other behavioural aspects.

Of course, each study has its own specificity, and researchers need to carefully analyse the advantages and problems associated with the inclusion of such additional synthetic features, according to the added value that such a solution would bring.

Step 6: Conduct comparative analyses based on the same processed data in the two (or more) waves of the SHARE survey.

This step is also performed in many longitudinal research on different socio-economic problems based on the SHARE data (Kim & Park, 2024; López-Bueno et al. 2023; Palladino

et al., 2023; Peralta et al., 2023; Veronese et al., 2022; Gao et al., 2022; Tosheva, Yordanova & Markova, 2021).

In this step, researchers should analyse the changes that have occurred with respect to the various explanatory characteristics by creating a baseline model with the data from the first wave, identifying the factors that influence the target characteristic, and then including those same factors in a new model with the data from subsequent waves of the survey. In this way, the dropping of factors or the addition of new factors, as well as the change in the weights or in the signs of the weights of the β-coefficients of the individual factors need to be analysed. If new factors are added to the model on the subsequent wave of the SHARE data, researchers need to analyse the impact of the additional factors on the coefficients of the remaining characteristics (Angelova, 2021).

4. Results

4.1. Data and data preparation

For the examples provided for the purposes of the current study, Wave 7(Börsch-Supan, 2022a), Wave 8 (Börsch-Supan, 2022b) and Wave 8-Corona (Börsch-Supan, 2021) of SHARE data are used. The sample consists of 30615 adults aged ≥50 years included in all three waves, presented in the research of Angelova (2024) and Angelova (2021).

The data extraction and data preparation are presented in the study of Angelova (2024). Factor analyses are performed in line with the research of Angelova (2021).

4.2. Standardised approach – algorithm for better public policies

Based on the main steps for conducting longitudinal research and on the empirical results of Angelova (2021) and Angelova (2024), an integrated author methodology is developed that could serve as an algorithm for better management policies (Figure 6).

An important part of the author's methodology is the applied various statistical tests and analytical techniques for data preparation and checking the statistical significance of the dependence of target and response variables.

Another important part is the application of explanatory feature selection techniques, including demographic, socioeconomic, health and behavioural aspects and living environment qualities, used to subsequently analyse the determinants of the target variable that is the focus of the research.

In addition, additional post-situation models could be estimated based on specific events or life changes during the observation period like for example COVID crises, war conflicts, economic recession, etc., including factors that are crucial for examined problem based on the literature review on the topic.

The applied methodological framework has the potential for real practical application in the field of management and public policy and strategy making and can be used for monitoring

by managers as an algorithm for classification and risk identification of key aspects of the life of people aged 50 and over in Europe.

Figure 3. Integrated author methodology – algorithm for better management policies

INTEGRATED AUTHOR METHODOLOGY – ALGORITHM FOR BETTER PUBLIC POLICIES
1. Preprocessing of the SHARE data
1.1. Handling missing values
1.2. Checking the unique values of each variable
1.3. Numerical coding of multilevel response variables on an ordinal scale
1.4. Converted to factor characteristics of the multilevel response variables
1.5. Multilevel binning for demographic, social, and economic factors
2. Data analysis
2.1. Selection of a target characteristic – research problem
2.2. Selection of predictive features
2.2.1. Chi-square test and tables of proportions to test the statistical significance of factor characteristics
2.2.2. Box plots testing the discriminating power of numerical features
2.2.3. Correlation matrices for selecting variables that form latent factors
2.2.4. Factor analysis to identify latent factors
2.2.5. Decision tree for selecting the most important predictive features and discovering hidden relationships between different factors
2.2.6. Algorithms for selecting the best predictive features (Best subset selection, LASSO)
2.2.7. Creation of synthetic and synergistic features based on literature review, decision tree and expertise
3. Testing models with the selected features
4. Assessing the effects of different factors and analysing the changes that have occurred (in a longitudinal study using two or more waves of SHARE data)
5. Design and implementation of social policies targeting each factor

The author's integrated methodology can be applied to analyse data from subsequent waves of the SHARE survey.

5. Conclusion

The current research examines the existing longitudinal studies based on the SHARE project and summarises the main steps that researchers need to take in order to perform qualified longitudinal research based on two or more consecutive waves of the SHARE data. Apart

from the suggested methodological guidelines for longitudinal research, the current study presents structured integrated author methodology, already applied in two longitudinal studies (Angelova, 2021; Angelova, 2024) focused on real and significant problems of older people in Europe and based on the SHARE data, that could be used as an algorithm for better public policies both for Bulgaria and in a transnational context.

Results could be useful for a wide range of researchers and national authorities that aim to identify the changes in the behaviour and attitudes of people in Europe aged 50 and over as well as for the development of science capacity for working with big data – a baseline for knowledge-based solutions and coping strategies.

The relevance of the research is determined by the focus on people aged 50 and over in Europe, who are a vulnerable group due to advanced age and accompanying problems such as health deterioration, changes in mental health, family, daily activities, and limitations. The target group is interesting for research in the context of current events related to the emergence of new challenges such as viruses, climate change and the introduction of new technologies, from which these people are the most affected and vulnerable representatives of society.

The potential stakeholders of the research results are both SHARE researchers who address the same or similar problems in the different waves of the study, as well as EU management structures, public authorities and public bodies in the field of health and social care area that prepare and implement public policies and measures to promote an active, healthy and productive life, bringing satisfaction to older people at European and national level, which can indirectly promote economic growth.

Finally, the presented methodological guidelines and algorithm could be used as an educational toolkit in the universities in Bulgaria and around the world in connection with the preparation of graduation theses of bachelor, master and PhD students, as well as in the lectures and seminar classes related to data science analytical techniques applied for the preprocessing and modelling of the SHARE data and developing longitudinal research.

Acknowledgements

This paper uses data from SHARE Waves 7 and 8 (DOIs: 10.6103/SHARE.w7.800, 10.6103/SHARE.w8.800) see Börsch-Supan et al. (2013) for methodological details.(1) The SHARE data collection has been funded by the European Commission, DG RTD through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, SHARELIFE: CIT4-CT-2006-028812), FP7 (SHARE-PREP: GA N211909, SHARE-LEAP: GA N227822, SHARE M4: GA N261982, DASISH: GA N°283646) and Horizon 2020 (SHARE-DEV3: GA N676536, SHARE-COHESION: GA N°870628, SERISS: GA N654221, SSHOC: GA N823782, SHARE-COVID19: GA N101015924) and by DG Employment, Social Affairs & Inclusion through VS 2015/0195, VS 2016/0135, VS 2018/0285, VS 2019/0332, and VS 2020/0313. Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, HHSN271201300071C, RAG052527A) and from various national funding sources is gratefully acknowledged (see www.share-project.org).

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