WIFO ■ WORKING PAPERS

698/2025

Challenges in Long-term Care: Modelling and Quantifying Future Care Needs, Arrangements and Gaps in Ageing, Low-fertility Societies

A Novel Comparative Approach Applied in Microsimulation Projections for Austria and Italy

Philipp Warum
Fabrizio Culotta
Ulrike Famira-Mühlberger
Thomas Horvath
Thomas Leoni
Martin Spielaue

Challenges in Long-term Care: Modelling and Quantifying Future Care Needs, Arrangements and Gaps in Ageing, Low-fertility Societies

A Novel Comparative Approach Applied in Microsimulation Projections for Austria and Italy

Philipp Warum (WIFO), Fabrizio Culotta (UNIMIB),
Ulrike Famira-Mühlberger, Thomas Horvath (WIFO),
Thomas Leoni (FH Wiener Neustadt), Martin Spielauer (WIFO)

WIFO Working Papers 698/2025
January 2025

Abstract

Population ageing will reshape economies around the world, with particular implications for long-term care (LTC) systems. As a result of past fertility decline, reflected in high levels of childlessness and smaller family networks, the growing demand for care is confronted by a declining supply of informal care. This paper presents a novel quantitative framework for cross-country comparative analysis and projections of the long-term care sector. The central innovation of this framework is the standardised assessment of care needs in hours, complemented by the modelling of care arrangements, distinguishing between nursing homes, formal home care, informal care provided by a partner, informal care provided by others and care gaps. Modelling at the individual level requires microsimulation for projections that simultaneously consider individual-level characteristics, socio-demographic dynamics and institutional factors, and scenarios such as the role and expansion paths of formal care services. Our work builds on and extends the comparative microsimulation model microWELT, which uses Eurostat population projections while adding key characteristics such as educational differences in fertility, mortality, partnerships and family size. We demonstrate the approach using projections for Austria and Italy. In Austria, the total demand for long-term care is projected to almost double by 2070, while in Italy, where the ageing process is more advanced, the total increase is much lower at around 44 percent. However, in Italy, due to lower fertility and greater reliance on informal care, most of the increased demand would remain unmet under current informal care provision patterns, suggesting a potential care gap larger than that projected for Austria.

E-Mail: philipp.warum@wifo.ac.at, ulrike.famira-muehlberger@wifo.ac.at, thomas.horvath@wifo.ac.at, martin.spielauer@wifo.ac.at

2025/1/W/0

Media owner (publisher), producer: Austrian Institute of Economic Research
1030 Vienna, Arsenal, Objekt 20 | Tel. (43 1) 798 26 01 0 | https://www.wifo.ac.at
Place of publishing and production: Vienna

Challenges in long-term care: Modelling and quantifying future care needs, arrangements and gaps in ageing, low-fertility societies

A novel comparative approach applied in microsimulation projections for Austria and Italy

Philipp Warum*[a], Fabrizio Culotta[b], Ulrike Famira-Mühlberger[a], Thomas Horvath[a], Thomas Leoni[c], and Martin Spielauer[a]

[a]Austrian Institute of Economic Research (WIFO)
[b]Department of Economics, Management and Statistics (DEMS), University of Milan - Bicocca
[c]University of Applied Sciences Wiener Neustadt

January 27, 2025

Abstract

Population ageing will reshape economies around the world, with particular implications for long-term care (LTC) systems. As a result of past fertility decline, reflected in high levels of childlessness and smaller family networks, the growing demand for care is confronted by a declining supply of informal care. This paper presents a novel quantitative framework for cross-country comparative analysis and projections of the long-term care sector. The central innovation of this framework is the standardised assessment of care needs in hours, complemented by the modelling of care arrangements, distinguishing between nursing homes, formal home care, informal care provided by a partner, informal care provided by others and care gaps. Modelling at the individual level requires microsimulation for projections that simultaneously consider individual-level characteristics, socio-demographic dynamics and institutional factors, and scenarios such as the role and expansion paths of formal care services. Our work builds on and extends the comparative microsimulation model microWELT, which uses Eurostat population projections while adding key characteristics such as educational differences in fertility, mortality, partnerships and family size. We demonstrate the approach using projections for Austria and Italy. In Austria, the total demand for long-term care is projected to almost double by 2070, while in Italy, where the ageing process is more advanced, the total increase is much lower at around 44%. However, in Italy, due to lower fertility and greater reliance on informal care, most of the increased demand would remain unmet under current informal care provision patterns, suggesting a potential care gap larger than that projected for Austria.

Keywords: population ageing, long-term care, care gap, projections, dynamic microsimulation
JEL codes: C53, I11, J14

*Corresponding Author. philipp.warum@wifo.ac.at, Austrian Institute of Economic Research (WIFO), Arsenal Object 20, 1030 Vienna, Austria

Acknowledgements

We thank Lydia Grandner for excellent research assistance as well as seminar participants at the 9th World Congress of the International Microsimulation Association 2024 and the 22nd ESPAnet Annual Conference 2024 for helpful comments and suggestions. This paper is part of the JPI MYBL project WellCARE. Grant PCI2021-121913 funded by the AEI 10.13039/501100011033 by the JPI More Years Better Life by the European Union. The Austrian part of the project is funded by the Austrian Federal Ministry of Education, Science and Research. No party had the right to review this paper prior to its publication and the content is solely the responsibility of the authors.

1 Introduction

Population ageing, i.e. the combined demographic effect of reduced fertility and increased longevity, is expected to increase the proportion of functional dependency in the population as the risk of cognitive and physical impairment increases with age. An increase in the overall dependency ratio of the population is expected to drive up demand and expenditure in the long-term care (LTC) sector, which includes formal care, provided by professional caregivers in institutions or at home, and informal (home) care. The latter includes care provided by household members as well as other relatives and external non-medical caregivers (Commission, 2021*a*; OECD, 2024). Ageing societies will face not only higher costs to meet the additional demand for care, but also new constraints resulting from high levels of childlessness and smaller family networks, which will reduce the number of people able to provide informal care.

Long-term care dependency is not a binary status but comes in different degrees of intensity which, in combination with the specific institutional features of national LTC systems, determine the mix in care provision. Estimating future trends in the demand for and supply of long-term care (LTC) services, and understanding whether and how supply will adjust to meet this demand and the resulting potential gaps in care, is crucial to informing national and supranational policy makers. This study aims to contribute to this goal by providing a model to project future demand for care by intensity, and by improving our understanding of the different factors driving the emergence of care gaps and the levers for addressing them.

From a methodological point of view, two main approaches have been used to project long-term care needs: cell-based macrosimulation models (Commission, 2021*a*), and individual based microsimulation models (Astolfi et al., 2012; Spielauer, 2007; Schofield et al., 2018; Belmonte et al., 2023). In this paper, we rely on dynamic microsimulation models because they provide a framework in which demographics and health status interact at the individual rather than the group level.

The other major difference between the two approaches is their data requirements. Microsimulation models rely on microdata to simulate individual life cycles. In comparative microsimulation studies, the availability of microdata is crucial to ensure comparability across countries. The lack of microdata on the use and expenditure of long-term care (LTC) services often hampers the modelling of the LTC sector, which includes a comprehensive mix of inpatient care, formal care and informal home care. On the other hand, the existence of different, non-harmonised national microdata limits the possibility of conducting cross-country studies on LTC issues. For example, Atella et al. (2021) uses harmonised microdata sources from the Gateway to Global Aging Data project to compare projected LTC needs for a pool of OECD countries. However, the authors do not analyse the dynamics of care provision, and thereby do not take into account the significant role of informal home care (Barczyk and Kredler, 2019; Commission, 2021*b*; OECD, 2022). In the European context, for Spain, only Spijker et al. (2022) explicitly consider the interaction between formal and informal home care.

Existing dynamic microsimulation models that examine LTC issues in a comparative perspective often limit their analysis to the oldest part of the population, either aged 50+ (Genevois et al., 2019; Atella et al., 2021; Marois and Aktas, 2021; Chen et al., 2022; Belmonte et al., 2023), or 65+ (Favreault et al., 2015; Zissimopoulos et al., 2018; Kingston et al., 2022). Only Goldman et al. (2021) extend the analysis to the U.S. population group aged 18-64 and explicitly examines the impact of population ageing on long-term care (LTC) needs, taking into account the role of family formation, dissolution, and fertility decisions that typically occur in middle age. However, in this study the authors do not distinguish between formal and informal care.

Another relevant modelling aspect of LTC needs is the intensity of care. Indeed, the intensity of LTC needs is often measured in terms of the number of limitations and related indices (e.g. Barthel, Katz, Lawton).[1] Only the work of Spijker et al. (2022) uses hours as a measure of LTC needs and further calculates the gap between care needed and care provided. Our approach is similar, but instead of estimating hours of care from national microdata sources as Spijker et al. (2022) do for Spain, we are able to offer a cross-country perspective by using a unique administrative source for converting LTC needs into hours of care needed.

The existing literature on LTC microsimulation projections still lacks a general approach capable of simultaneously accounting for the intensity of LTC needs and the mix of formal and informal care supply within a unified framework that is also suitable for comparing countries with different demographic structures. This limitation impedes the ability to perform comparative analysis and to emphasise potential differences and similarities in the care mix between countries undergoing demographic transition.[2] The present study aims to address this research gap by proposing a dynamic microsimulation approach that can model changes in care demand and supply with sufficient granularity, while being applicable for international comparisons. The method is applied to project demand, supply (and related gaps) for LTC in Austria and Italy, two European countries facing similar challenges but with different institutional settings and at different stages of the demographic ageing process.

The long-term care (LTC) systems in Austria and Italy are distinguished by their unique governance structures, financing mechanisms and service delivery models. In Austria, the LTC system is predominantly financed through general taxation, supplemented by a substantial cash-for-care allowance that provides financial assistance to individuals in need, irrespective of their income or assets. This non-means-tested allowance, which is needs-based, is complemented by a variety of services organised at the provincial level, where regional governments have discretion to design and implement care services. Although formal care arrangements are well-developed, informal care still plays a significant role, with over 40% of LTC beneficiaries receiving care exclusively from family members (Barczyk and Kredler, 2019).

In contrast, Italy's LTC system places greater emphasis on family caregivers and features a fragmented governance structure involving national, regional, and local authorities. The main intervention in Italy is the Companion Allowance, a universal cash benefit for individuals with severe disabilities that is not linked to formal care services. This cash-based approach gives rise to significant regional disparities in the availability and quality of services, with northern regions typically offering more comprehensive in-kind services than the south.

Both countries face common challenges, including workforce shortages and the necessity for structural reforms. However, Austria has made progress in integrating community-based care and supporting informal caregivers, while Italy has recently introduced reforms with the aim of improving coordination and expanding service provision, albeit with limited immediate impact. Austria's more centralised and structured approach contrasts with Italy's fragmented model (Famira-Mühlberger and

[1]See section A.1 in Appendix A on this point, where alternative indicators of dependency are compared in their distribution.

[2]Empirically, a North-South gradient among European countries is documented in Barczyk and Kredler (2019). Southern countries exhibit stronger preferences for informal care arrangements (approximately 80%, for example, Italy and Spain) in comparison to Northern countries (approximately 20%, for example, Denmark) and Continental countries (approximately 40%, for example, Austria and Germany).

Österle, 2024; Gubert and Perobelli, 2024).

The two countries' divergent demographic profiles and stages of ageing make them valuable case studies for examining LTC systems. Italy has currently the oldest population in the European Union (EU), with a median age of 47.1 years in 2020 (Eurostat, 2025). It also has one of the lowest total fertility rates in the EU (1.24 in 2020) and faces acute challenges in meeting the growing demand for LTC services (Eurostat, 2025b). Conversely, Austria's median population age is marginally below the EU average (43.4 years in 2020 as compared to 43.9 for the whole union) and its fertility rate (1.44) approximates the EU average (1.51), resulting in disparate demographic dynamics and a different level of urgency in addressing LTC needs. In Italy, population ageing, materialised in the need for care, reaches its peak around 2055 and then declines again, a point that will not be reached within our project horizon (2070) in the Austrian case. While both countries depend on family care, Italy's approach is straining family resources and associated with the exacerbation of socio-economic inequalities. The unique challenges faced by each country in reforming their LTC systems are further underscored by structural differences in governance and financing. The analysis of these systems provides insights into how demographic realities and policy frameworks shape the effectiveness and accessibility of long-term care services, offering valuable lessons for other countries facing similar challenges.

The novelty of our approach lies in the conversion of LTC needs into hours of care required by exploiting a unique administrative source, i.e. the Austrian assessment scheme for LTC allowance, which assigns to each functional limitation considered a monthly amount of hours of care required. This methodology enables the projection of demand and supply of LTC at their intensive margins, and the calculation of the corresponding gap as the amount of additional supply required to satisfy the unmet level of LTC needs.[3] Cross-country comparability is ensured using harmonised data sources. Specifically, the Survey of Health, Ageing and Retirement in Europe (SHARE) microdata is utilised to estimate the current level of LTC needs and caregiving activities. The number of hours of care required is then validated using official statistics.

The remainder of the paper is structured as follows: Section 2 comprises a review of the extant literature on microsimulation studies of long-term care, identifying gaps that this study aims to address. Sections 3 and 4 delineate the data sources and projection methods employed in our analysis. The results of the study are presented in Section 5, and a conclusion is offered in Section 6.

[3] See Dunatchik et al. (2019) and and Malisauskaite et al. (2021) for definitions of unmet LTC needs.

2 Literature review

During the 1990s, the literature on projections of LTC demand, supply and expenditure emerged from a macrosimulation (cell-based) framework (Spielauer, 2007; Schofield et al., 2018). Subsequently, macrosimulation models of healthcare have been combined with microsimulation models, giving rise to partial-microsimulation models. An early example of this approach is Kennell et al. (1992), who combine for the US the PRISM microsimulation model with the LTC Financing macrosimulation model to estimate the level of disability for individuals aged 65+, changes in the health status and recoveries. Disability levels are modelled as functions of the number of limitations in Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs). Expenditure projections are based on data from MediCare and MedicAid. Another example is provided by Wittenberg et al. (2007), who combine the PSSRU model with the CARESIM microsimulation model (Hancock et al., 2003). See Hancock et al. (2007) for an analysis on the effects of a range of options for paying for LTC in the UK. See also Wittenberg et al. (2018) for a similar contribution on England.

In contrast to the macro and partial-micro approaches, Schofield (1998) develop a pure microsimulation model using Australian microdata on the utilisation of hospital services (the Australian National Health Survey) and impute health expenditure at the individual level based on information on cost and subsidies. This approach has inaugurated a lifetime analysis framework of health expenditure, moving beyond macrosimulation models (Schofield et al., 2018).

Since then, a prominent example of a microsimulation model that has been widely adopted in studies on LTC is the Future Elderly Model (FEM).[4] The FEM model has been utilised to project future trends in Alzheimer's disease (Zissimopoulos et al., 2015) and dementia in the US (Zissimopoulos et al., 2018). FEM has also been adopted to single-country settings like England (Archer et al., 2021), Ireland (May et al., 2022), Mexico (Gonzalez-Gonzalez et al., 2017), Japan (Chen et al., 2016; Kasajima et al., 2021, 2022), and Taiwan (Chen, 2024). Two notable multi-country applications are documented in Atella et al. (2017) and Atella et al. (2021). Atella et al. (2017) analyses the effect of different eligibility rules for LTC benefits across five European countries. The authors also discuss and use the Austrian care need assessment scheme, however their focus is on studying the eligibility for receiving LTC allowance and not on measuring care need intensity or quantifying care needs in hours. Atella et al. (2021) project the prevalence of chronic diseases and disabilities across twelve OECD countries by gender and education. Similarly, Chen et al. (2022) compares South Korea and Singapore, highlighting differences and similarities in patterns of long-term illness and disability.

Another dynamic microsimulation model adopted to analyse LTC issues is PACSim (Population Ageing and Care Simulation) for England (Kingston et al., 2018, 2022). Other microsimulation models have been created or, if existing, extended, to analyse future trends in population LTC needs and their coverage. Examples are Baldini et al. (2008) with CAPP_DYN for Italy, Favreault et al. (2015) with DYNASIM for the US, Genevois et al. (2019) with DyMH_LU for Luxembourg, Jiang and Li (2024) build CHARISMA for China, Spijker et al. (2022) adopt the hybrid agent-based DEMOCARE for Spain, and van de Ven et al. (2024) use SimPaths for the UK. Marois and Aktas (2021) augment CEPAM-Mic with a health module to build ATHLOS-MIC for a set of European countries. See also

[4]FEM (Goldman et al., 2004) is a dynamic microsimulation model designed to project the future health status and related cost of the elderly in the US. It draws on the Health and Retirement Survey (HRS) to estimate demographic (age, sex, ethnicity) and socioeconomic factors (education, past employment), health status (chronic health conditions, functional limitations) and risk factors (smoking, drinking, exercise) to project health outcomes (conditions, functionality, mortality) and economic outcomes (health care use, income, assets, pensions).

Belmonte et al. (2023) for a similar projection exercise. Marois and Aktas (2021) and Belmonte et al. (2023) are the only studies at the EU level. Both project the future health status of old Europeans (aged 55+ and 50+, respectively) and analyse the positive effects of healthier lifestyles and educational expansion. The authors present pooled results without an analysis of cross-country variation. Furthermore, as illustrated in Table 1, none of these publications differentiate between all the various types of care, nor do they conduct a thorough analysis on measuring long-term care needs in hours.

Table 1 highlights a further common limitation shared by many of the aforementioned studies as they analyse the implications of population ageing simulating only individuals aged either 50+ (Chen et al., 2016; Gonzalez-Gonzalez et al., 2017; Atella et al., 2017; Genevois et al., 2019; Archer et al., 2021; Atella et al., 2021; Marois and Aktas, 2021; Chen et al., 2022; May et al., 2022; Spijker et al., 2022; Belmonte et al., 2023; Jiang and Li, 2024), 60+ (Kasajima et al., 2021, 2022) or 65+ (Kennell et al., 1992; Wittenberg et al., 2007; Hancock et al., 2007; Favreault et al., 2015; Zissimopoulos et al., 2015; Kingston et al., 2018; Zissimopoulos et al., 2018; Kingston et al., 2022). In these works, population ageing is studied for the most part in relation to old individuals, thereby largely disregarding the impact of changes in fertility and family patterns over time.

However, Goldman et al. (2021) and van de Ven et al. (2024) represent two exceptions. Goldman et al. (2021) introduces the Future Adult model (FAM) to project health expenditure in the US for the population aged 25+ (65+ in FEM). In addition to modelling health, health care costs, and economic outcomes, FAM also models life events such as changes in marital status and childbearing. See also Baldini et al. (2008) for Italy and Wittenberg et al. (2018) for England for extended life cycle microsimulation models projecting LTC needs and expenditure. However, these models do not distinguish between nursing homes, formal and informal home care. In doing so, they do not capture the full set of LTC types. van de Ven et al. (2024) use the SimPaths microsimulation model to project child care and social care distinguishing between formal and informal home care, while excluding institutional care. Hence, the care mix is not yet fully incorporated in the two microsimulation studies that also consider the population aged 18+.

In the European context, only Spijker et al. (2022) explicitly model the mix between formal and informal LTC (but again without explicit consideration of nursing homes). Moreover, like van de Ven et al. (2024) for the UK, the authors express the intensity of LTC needs in terms of hours of care needed. This innovative feature enables the integration of informal home care provided by household and non-household members into the analysis of LTC provision, and the estimation of the unmet component in hours for which future coverage will be additionally required. Furthermore, both works exploit the availability of national microdata, given their focus on single countries.

We make a twofold contribution to the literature on LTC microsimulation. Firstly, we develop a method to quantify care needs in hours and model both LTC needs and their coverage across the full spectrum of care options at the intensive margin, thereby identifying the additional required supply or care gap. Secondly, we demonstrate the applicability of this method for cross-country comparisons, using Austria and Italy as case studies.

Table 1: *Microsimulation studies on LTC.*

REFERENCE	COUNTRY	MODEL	AGE	CARE MIX	LTC NEEDS
Kennell (1992)	USA	PRISM+LTCF	65+	NH, FH	ADL counting
Hancock (2007)	UK	PSSRU+CARESIM	65+	NH, FH, IH	ADL and IADL counting
Wittenberg (2007)	ENGLAND	PSSRU+CARESIM	65+	NH, FH, IH	ADL and IADL counting
Baldini (2008)	ITALY	CAPP_DYN	0+	X	ADL and IADL counting
Zissimopoulos (2015)	USA	FEM	65+	NH, FH, IH	ADL and IADL counting, Hours (IH)
Favreault (2015)	USA	DYNASIM3	65+	NH, FH	ADL counting
Chen (2016)	JAPAN	FEM	50+	X	ADL and IADL
Atella (2017)	10 EU countries	EU-FEM	50+	X	Regulation-based index
Gonzalez (2017)	MEXICO	FEM-Mexico	50+	X	X
Kingston (2018)	ENGLAND	PACSim	65+	X	Interval of Needs (IONs)
Zissimopoulos (2018)	USA	FEM	65+	X	X
Genevois (2019)	LUXEMBOURG	DYMH_LU	51+	X	Multidimensional Index
Archer (2021)	ENGLAND	FEM	50+	X	ADL and IADL counting
Atella (2021)	12 OECD countries	EU-FEM	50+	X	X
Goldman (2021)	USA	FAM	25+	X	X
Kasajima (2021)	JAPAN	FEM	60+	X	ADL and IADL counting
Marois (2021)	14 EU countries	ATHLOS-MIC	55+	X	Health Metric
Chen (2022)	SINGAPORE, SOUTH KOREA	FEM	50+	X	ADL and IADL counting
Kasajima (2022)	JAPAN	FEM	60+	NH, FH, IH	ADL and IADL counting
Kingston (2022)	ENGLAND	PACSim - CPEC	65+	NH, FH	IoN (PACSIM), ADL and IADL counting (CPEC)
May (2022)	IRELAND	FEM-IFOAM	50+	X	ADL and IADL counting
Spijker (2022)	SPAIN	DEMOCARE	50+	FH, IH, Gap	Hours
Belmonte (2023)	19 EU countries	CEPAM-Mic	50+	X	ADL and IADL counting
Chen (2024)	TAIWAN	FEM	50+	X	ADL and IADL counting
Jiang (2024)	CHINA	CHARISMA	50+	X	ADL and IADL counting
Van den Ven (2024)	UK	SIMPATHS	18+	FH, IH	Hours
This work	**2 EU countries (AT, IT)**	**microWELT**	**0+**	**NH, FH, IH, Gap**	**Austrian Care Need Assessment Scheme**

Source: author's own elaboration. **REFERENCE**: first author (year of publication). **COUNTRY**: country of study. **MODEL**: name of microsimulation model. **AGE**: population age group. **CARE MIX**: type of care provided (Nursing Home, NH, Formal Home care, FH, Informal Home care, IH). **LTC NEEDS**: unit of measure for LTC needs (ADL and IADL counting: counting of limitations in ADLs and IADLs; Multidimensional: see Alperin (2016); Health Metric: see Caballero et al. (2017) and de la Fuente et al. (2018); Interval Of Needs: daily frequency (Isaacs and Neville, 1976); Hours: hours of care needed.

3 Data

The dynamic microsimulation model microWELT draws on various comparative European data sources to obtain starting populations and parameters for individual countries. The core socio-demographic processes, including fertility, mortality, education, partnerships and migration, are parameterised using survey data from the European Union Statistics on Income and Living Conditions (EU-SILC), as well as national statistics. The starting populations for each country consist of pooled EU-SILC waves from 2014-2018 reweighted to match the population in the base year (2018). While the subsequent discussion centres on the data pertinent to the LTC module, supplementary information regarding microWELT can be found in Section 4.4 below.

The primary data source for the parameterisation of the LTC module in microWELT for Austria and Italy is the Survey of Health, Ageing and Retirement in Europe (SHARE)[5]. SHARE is a harmonised panel survey that provides representative data for the 50+ population of many EU countries. As a member of the US Health and Retirement Study (HRS) family of surveys, SHARE is also comparable with countries such as Mexico, South Korea, the United Kingdom, and the United States (see e.g. Atella et al. (2021)). A notable distinction of SHARE is its status as the sole comparative survey that provides a comprehensive overview of demand and supply of long-term care (LTC) in Austria and Italy. This feature enables the analysis of the predominant forms of care provision, categorised as nursing homes, formal home care, and informal home care. The estimation of parameters is conducted using a pooled cross-section of SHARE waves 1 (2004) to 9 (2022).[6]

Respondents residing in nursing homes tend to be underrepresented in SHARE due to differential attrition (See e.g. Barczyk and Kredler (2019)). We thus follow Banks et al. (2023); Brugiavini et al. (2023) and recalibrate SHARE cross-sectional survey weights to match the institutionalised population in Austria and Italy. For Austria, the number of people living in nursing homes in 2021 by sex and age is obtained from Austrian care services statistics. Since the official age groups do not align with the lower bound of our analysis age window (60-74 vs. 65+), we apply a nonlinear optimisation strategy to interpolate the population in the 65-74 age group. Appendix Section A.2 shows the resulting shares of the 65+ population by age, sex and nursing home status for Austria and reproduces values from Brugiavini et al. (2023) for Italy both of which are subsequently used in an iterative proportional fitting algorithm to adjust SHARE survey weights.

In the final step of the parameterisation of the LTC module, it is necessary to supplement SHARE with an additional data source. This step concerns average hours of care provided informally to adults outside the household and in contrast to the other parameters it is not only relevant for the 65+ population. Although SHARE provides data on hours of outside informal care provided, it does not cover the population under the age of 50. However, related comparative data sources that cover the entire age range do not clearly differentiate care provided to people outside the household and do not allow for the measurement of hours (EHIS[7], EQLS[8]) or may underestimate the amount of informal care people provide outside of the household (EU-SILC[9]) (ECORYS, 2021). Given that EHIS provides large samples and measures hours in intervals, it is hypothesised that it is best suited to obtain estimates of

[5]See Börsch-Supan et al. (2013); Gruber et al. (2014); Bergmann et al. (2019).

[6]Wave 3 (SHARELIFE) is excluded as it focuses on respondents' life histories and does not include the regular questions we use for parameterisation.

[7]European Health Interview Survey

[8]European Quality of Life Survey

[9]European Union Statistics on Income and Living Conditions

hours of care given below 50 years of age that are comparable to SHARE estimates. We thus combine EHIS and SHARE in the parameterisation of LTC giving below.

4 Method

This section delineates the quantitative framework for cross-country comparative analysis and projections of the LTC sector that has been developed with this paper. The dynamic microsimulation model microWELT is extended by a new module which captures both the demand for and supply of LTC. This enables the projection of the potential future evolution of care gaps. As a preliminary step, it is necessary to quantify care gaps. To this end, a standardised assessment of care needs in hours is developed in Subsection 4.1. Subsection 4.2 discusses the merits of measuring care needs in hours compared to alternative indicators. Subsequently, Subsection 4.3 describes the parameterisation of the LTC module in microWELT and discusses parameter estimates for the two countries included in this application. Subsection 4.4 provides further details on microWELT and the implementation of the LTC module.

4.1 Care need assessment

Modelling demand, supply and eventually the cost of care at the micro level requires the quantification of care in hours. Yet, obtaining comparable data on individual care needs in hours is one of the major challenges our analysis confronts, since SHARE and other relevant surveys available for EU countries lack direct measures of care hours needed. While care hours received can be partially observed in SHARE, care need in hours is not directly available. Nevertheless, SHARE addresses a significant proportion of the key questions frequently utilised by governments to assess the eligibility for public long-term care insurance programmes. The approach adopted in this study to quantify individual care need in hours involves subjecting SHARE respondents to a standardised care need assessment based on the Austrian care allowance system.

The Austrian system is a universal care allowance system designed to support individuals who require regular assistance due to physical, mental, or psychological impairments (Trukeschitz et al., 2022; Famira-Mühlberger and Österle, 2024). The system operates on a tiered structure, in which recipients are assessed and granted an allowance based on their level of dependency, categorised across seven different levels (ranging from a minimum care need of 65 hours per month in level 1 to 180+ hours in levels 5-7). Payments are determined by the degree of care required rather than the recipient's income, ensuring that the support is targeted toward the individual's specific needs. This allowance can be used to cover various services, including home care, professional care services, or assistance from family members. The system aims to improve the quality of life for the elderly, allowing them to maintain independence for as long as possible while securing the necessary care and support.

The care need assessment required before being placed in the care allowance system is done by trained and qualified experts (doctors or nurses) (Trukeschitz et al., 2022). This assessment is governed by the principles and guidelines outlined in the Federal Care Allowance Act, the classification regulation[10], the directive for the uniform application[11] of the Federal Care Allowance Act and the Consensus paper "A working document for assessors for the uniform medical and nursing assessment

[10] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10009142

[11] https://www.ris.bka.gv.at/Dokumente/Avsv/AVSV_2012_0084/AVSV_2012_0084.pdfsig

in accordance with the Federal Care Allowance Act". For the purpose of this paper, we implement a simplified version of the Austrian care need assessment for SHARE respondents based on these documents.[12]

The simplified Austrian care need assessment (ACNA) scheme is outlined in Table 2, and the monthly care need in hours is obtained by summing the hours for stated limitations for each respondent. The upper part of the table, termed "basic assessment scheme", corresponds closely to the official assessment scheme and is mostly based on questions regarding limitations in Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs). The official assessment scheme also provides hours for motivational dialogue to support people with mental health limitations in their independence in coping with everyday life. We proxy the need for motivational dialogue by IADL questions related to cognitive status. Furthermore, we proxy the hardship supplement provision for severe mental health limitations by questions capturing whether respondents have been diagnosed with severe mental illness such as dementia or psychiatric problems by a doctor.[13] In our "full assessment scheme", we also include the supplementary items in the lower part of the table to adjust the assigned hours to those observed in the Austrian population.

[12] Austrian care need assessment rules are also discussed and used in Atella et al. (2017), however their focus is on studying the eligibility for receiving LTC allowance and not on measuring care need intensity or quantifying care needs in hours.

[13] A limited number of variables used in the assessment scheme is not available across all SHARE waves and therefore imputed or proxied. Further details on this point are provided in Appendix Section A.3.

Table 2: *Austrian care need assessment scheme.*

LIMITATION	SHARE VARIABLE	MONTHLY HOURS
Basic Assessment Scheme		
Activities of Daily Living (ADLs)		
Dressing	ph049d1	20
Walking AND getting up	ph049d2, ph049d5	30
Walking AND NOT getting up	ph049d2, ph049d5	15
NOT Walking AND getting up	ph049d2, ph049d5	22.5
Daily hygiene and bathing	ph049d3	35
Eating	ph049d4	30
Using the toilet	ph049d6	30
Instrumental Activities of Daily Living (IADLs)		
Preparing a hot meal	ph049d8	30
Shopping	ph049d9	10
Taking medication	ph049d11	3
House or garden work	ph049d12	10
Leaving home independently	ph049d14	10
Laundry	ph049d15	10
Motivational talk (Using a map OR Telephone calls OR Managing money)	ph049d7, ph049d10, ph049d13	10
Severe mental health limitations		
Dementia	ph006d16 (imputed)	45
Psychiatric problem	ph006d18, mh022 (proxied)	45
Supplementary Items		
Extra hours 1 (Climbing several flights of stairs without resting OR Stooping, kneeling, or crouching OR Reaching or extending your arms above shoulder level OR Pulling or pushing large objects like a living room chair OR Lifting or carrying weights over 5 kilos)	ph048d4, ph048d6, ph048d7, ph048d8, ph048d9	5
Extra hours 2 (Walking 100 metres OR Sitting for about two hours OR Getting up from a chair after sitting for long periods OR Climbing one flight of stairs without resting OR Picking up a small coin from a table)	ph048d1, ph048d2, ph048d3, ph048d5, ph048d10	10
Conditional Age Trend		
IF any limitation OR Global Activity Limitation Indicator (GALI)	gali, age	$(age-65)*0.73+(age-65)^2*0.042$

Notes: The basic assessment scheme is based on Austrian LTC legislation and guidelines, i.e. the Federal Care Allowance Act, the classification regulation, the directive for the uniform application and a consensus paper of institutional stakeholders. Our full assessment scheme additionally includes extra hours for additional limitations and a conditional age trend that is calibrated against Austrian care allowance statistics.

A comparison of the results obtained from utilising the basic assessment scheme with the Austrian care statistics, as illustrated e.g. in Appendix Figure A.6, reveals that too few people are assigned hours based on (I)ADLs alone and that too few hours are assigned. The analysis suggests that this discrepancy may be attributable to several factors. Firstly, the official assessment scheme provides assessors with a degree of flexibility to assign more or fewer hours for specific limitations, if there are substantial deviations from the default values. Furthermore, health-related attrition (Muszyńska-Spielauer and Spielauer, 2022) and under-reporting of limitations in SHARE may also contribute to the under-assignment of hours.

We therefore assign additional hours based on two approaches in our full assessment scheme. Firstly, hours are allocated to respondents with limitations on an additional battery of functional limitation questions included in SHARE. Secondly, a quadratic age term is incorporated into the assessment scheme to capture unobserved factors driving the nonlinear increase in care need by age. To illustrate this, consider a person aged 66 who is solely limited in the activity of dressing (SHARE variable $ph049d1$ equals 1). In this instance, the assigned amount of care needed is $20 + (0.73 + 0.042) = 20.772$ hours a month. The polynomial is calibrated to approximate three alignment targets based on Austrian care allowance statistics for 2021. The target population is defined as individuals aged 65 and over with assigned hours of care need, which corresponds to the entry threshold of the Austrian system. We also target the distribution of hours observed in the Austrian population, conditional on age and sex, both for the binary prevalence of 65+ hours of care need and the average number of hours. Furthermore, the conditional age trend is assigned only to individuals who report limitations on any of the other indicators used in the algorithm or, in addition, who report any limitation on the General Activity Limitation Indicator (GALI). Thus, we do not assign hours of care need to individuals who, based on a broad set of indicators, remain healthy and without limitations throughout their lives.

As shown and further discussed in Appendix Section A.3, our calibrated full assessment scheme assigns hours of care need to Austrian SHARE respondents that closely correspond to the three alignment targets from Austrian statistics. In principle, once calibrated, the scheme presented here can be applied to all SHARE countries to obtain care need in hours. The basic assumptions for comparative analysis are that respondents across countries tend to provide similar answers to the relevant questions based on their limitations and that the care need that corresponds to a given limitation is the same across countries. The application of the comprehensive assessment scheme to a sample of Italian SHARE respondents yields analogous outcomes with respect to the distribution of hours required (Appendix Figure A.5), the prevalence of individuals aged 65 and over requiring 65 or more hours of care by age and sex (Appendix Figure A.8) and average hours required by age and sex (Appendix Figure A.9). While the prevalence of needing 65+ hours in Italy closely tracks those observed in Austria, the consistently higher average hours may reflect the lower levels of education in Italy (as discussed in Section 4.3).

4.2 Measuring care needs in hours

The conversion of LTC needs in hours is advantageous for the analysis and projections of LTC needs. Firstly, adopting a rich yet official reference scheme to convert LTC needs in hours allows us to shift the support of LTC needs to a finer-grained level than discrete-valued indicators. As demonstrated in Appendix A, section A.1, the distribution of LTC hours closely follows those of other indicators of dependency commonly used in the literature on LTC needs[14].

Secondly, the adoption of a common measure for LTC needs is compatible with the different forms of LTC provision (namely nursing homes, formal and informal home care). Although the LTC sector provides different services to individuals with different levels of care need intensity, assistance provided can be measured in terms of time needed to undertake a specific personal care activity. The expression of LTC needs in terms of hours of care required not only accommodates for different forms of LTC provision, but also for their complementarities, e.g. between formal and informal home care services.

[14]There is no consensus in the literature on the definition of dependent population. Most EU countries define LTC needs in terms of physical disability (Gonzalez-Aquines et al., 2024). In Appendix A, section A.1, we provide a comparative overview of the main dependency indices used in the literature on LTC needs.

Thirdly, once the LTC need is quantified and LTC provision is comparably considered in all of its forms, the required additional hours of care (gap), can be ascertained. The identification of potential gaps in the demand for LTC is of significance from a policy perspective, as they represent the unmet (unsatisfied) side of demand (Dunatchik et al., 2019; Malisauskaite et al., 2021). However, as reported in Table 1, no microsimulation study has hitherto projected the amount of care needed and not covered by the actual provision except for Spijker et al. (2022).

Lastly, as shown in this paper, advantages in modelling LTC in hours also extend to cross-country comparisons. The proposed framework is applied to compare two European countries experiencing population ageing at different stages, i.e. Austria and Italy. In summary, the proposed measurement framework offers the opportunity to model demand and supply of LTC services and related expenditure further allowing for cross-country comparison.

4.3 Parameterisation

Subsequent to the determination of requisite hours of individual care, a five-step process is initiated to ascertain suitable parameters for microWELT. This section provides a brief overview of the parametrisation of the LTC module while Appendix Section A.4 discusses each step in detail and provides estimation results.

Firstly, estimates were obtained for the probability of requiring any care by age, sex and education as shown in Figure 1. ISCED 1997 levels were grouped into the categories low (0,1,2), medium (3,4) and high (5,6) education. The results show that the prevalence of having any care need at age 65 is somewhat lower in Italy than in Austria. In both countries, the probability of requiring any care decreases with increasing educational attainment, with the difference between medium and high education being less pronounced in Austria.

Secondly, we estimated parameters for the number of hours of care required by age, sex and education. Figure 2 below shows decile means of assessed monthly hours based on predictions from quantile regressions. For both countries, we observe that the monthly care need tends to be lower for more educated individuals. Furthermore, we note that there are relatively few respondents with medium or high education in Italy.

In the third step, we turn to care received and first consider nursing home care. In Appendix Figure A.10, we show that nursing home probabilities predicted from logistic regressions align well with Austrian statistics and that those observed for Italy are significantly lower. Appendix Figure A.11 shows the predicted nursing home probabilities that are used as parameters to assign nursing home status in the microsimulation model, by age, sex, care need, presence of a partner and number of children. In comparison to Austria, Italy exhibits a substantially lower prevalence of nursing home admission, with a less pronounced increase with age. The figure further highlights higher nursing home probabilities for individuals with higher care needs and without a partner in their household. Furthermore, the data show that in Austria, having one child is associated with a lower probability of nursing home residence, while the presence of two or more children is associated with an even lower probability. In Italy, however, the effects of having one or more children appear similar.

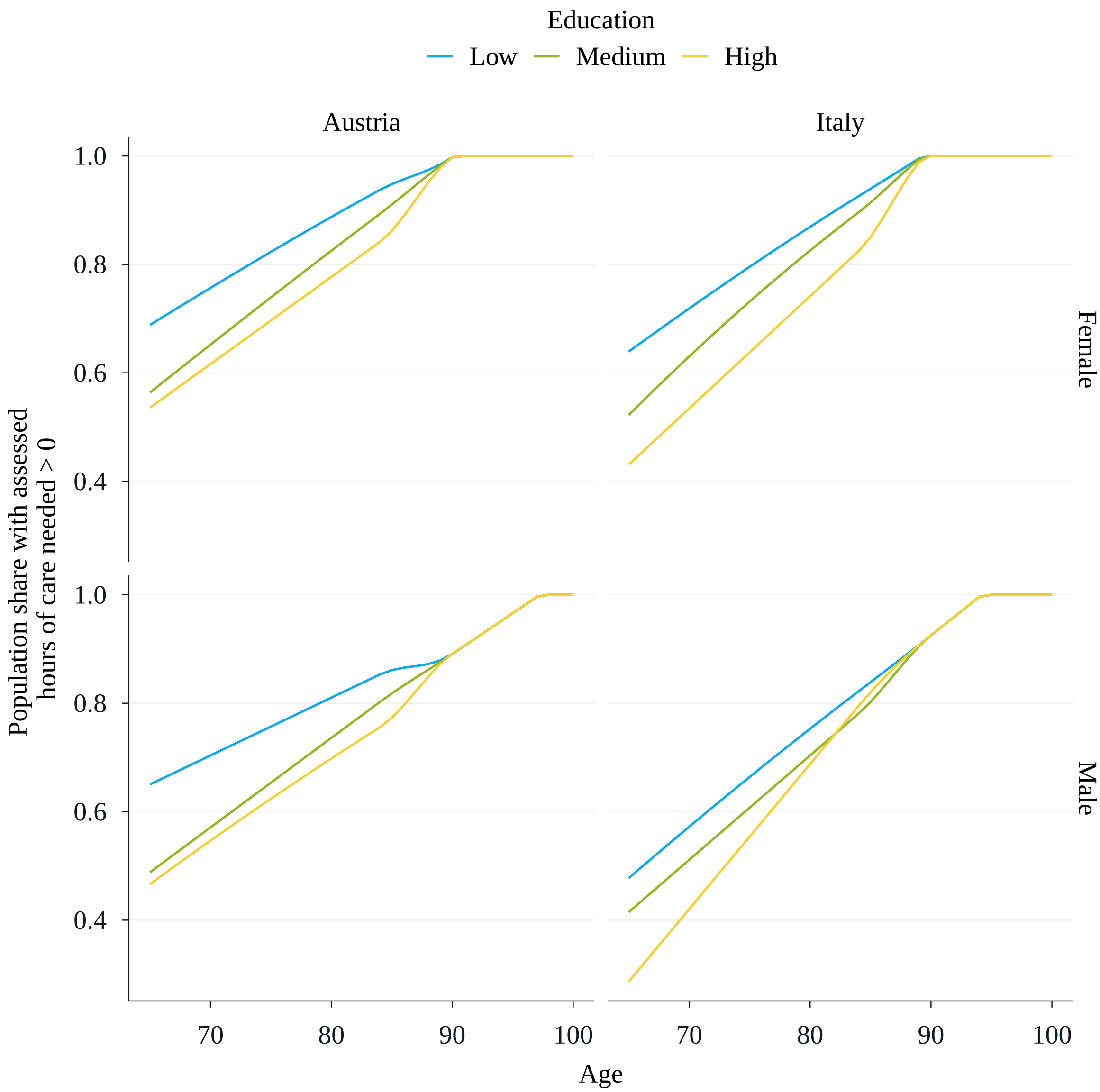


Figure 1: Step 1 - Prevalence of positive assessed monthly care need by age, sex, education in Austria and Italy (weighted). *Notes:* We use monotone increasing P-splines to estimate smooth functions and stop differentiating by education from age 90 due to data sparsity at the upper end of the age range.

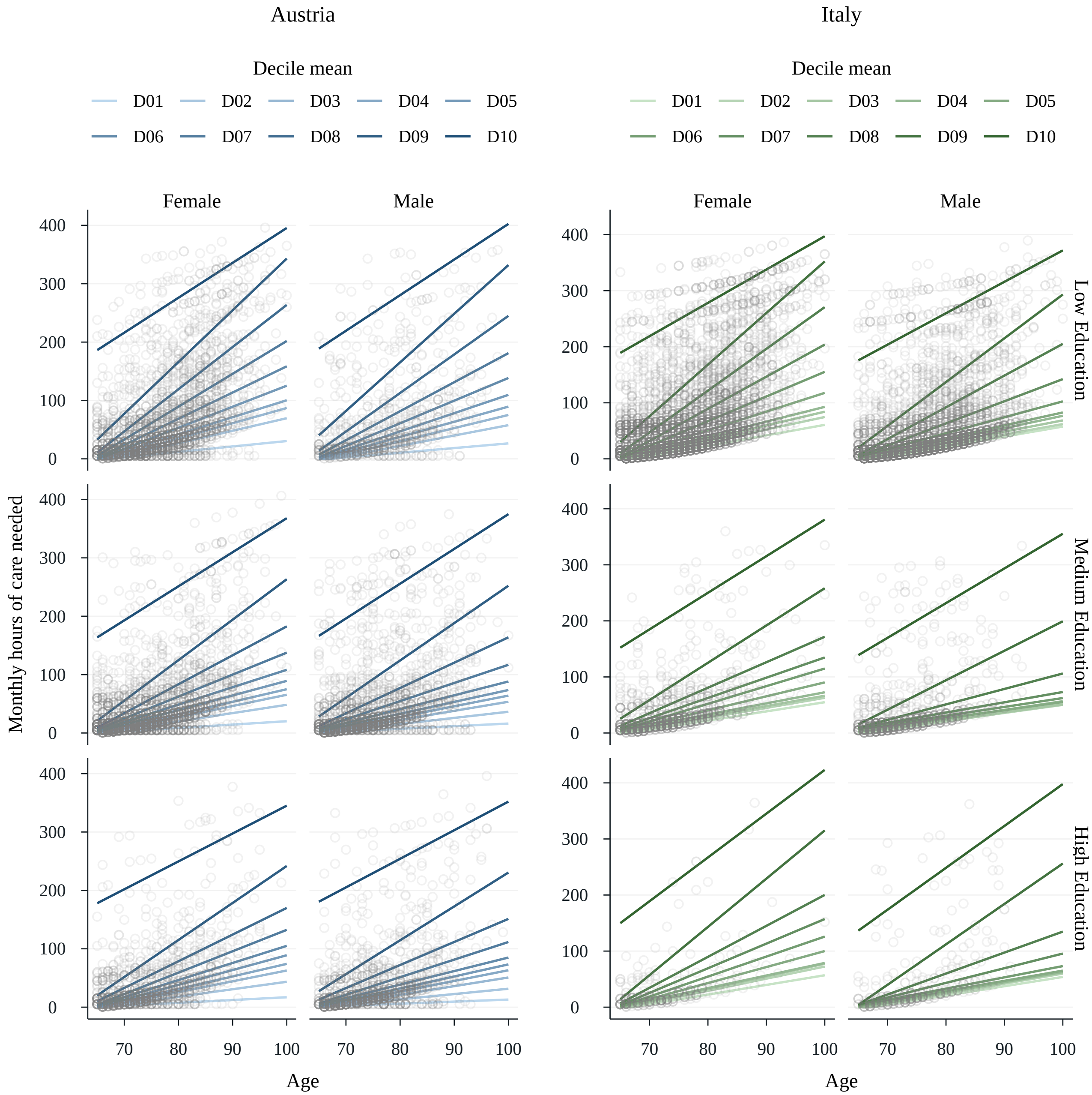


Figure 2: Step 2 - Distribution of care need in hours by age, sex, education in Austria and Italy (weighted). *Notes:* Subsample: respondents with positive care need. Decile means computed from predictions of quantile regressions. As independent variables, we include age, sex and education as well as interaction terms between age and sex as well as age and education.

The fourth step of the process pertains to care received at home. We assess the likelihood of receiving care and the composition of care among individuals based on family characteristics and care needs. We differentiate between care received from partners, informal care from others, formal care services, and identify any care gaps. The analysis excludes individuals with no care needs and focuses on SHARE waves that include questions on receiving help with (I)ADLs and the sufficiency of received help. The hours of formal home care and outside informal care received are observed only in a more limited number of SHARE waves and imputed for other waves. We also estimate care provided by partners and other household members by assuming they fill any remaining care needs. The objective of the present study is to leverage the extensive information available in SHARE to develop a methodology for the construction of a decision tree. This tree is intended to categorise respondents based on the type of care received and the presence of care gaps. The methodology utilises both direct responses and inferred data to determine the care mix and identify any discrepancies between care needed and care received. Illustrations of this categorisation can be found in Figures A.16 and A.17.

Following the establishment of the individual care mix at home, we proceeded to estimate parameters, commencing with the probability of receiving any care. Appendix Figure A.12 shows predicted care receipt probabilities for Austria and Italy from logit models interacting the covariates assessed care need, partner and children. As a consequence of our assumptions, virtually all people with partners in their household receive care and only few partners are classified as unable to care. Conversely, individuals lacking a partner in their household are observed to have a significantly higher probability of not receiving care, particularly at lower levels of care need. It is noteworthy that these observations are consistent in both Austria and Italy. Furthermore, the presence of children has been found to enhance the likelihood of receiving care. The estimates of care receipt probabilities for individuals without partners are utilised as parameters in the microsimulation model.

In the subsequent stage of the analysis, the care mix across groups of care recipients is calculated depending on their care need, the presence of a caring partner and their number of children (see Figure 3). For this purpose, we compute the share of total hours received for each care type within each group. In both countries, the share of formal home care (FHC) rises with the number of hours of care required. Furthermore, having two or more children seems to increase the share of outside informal care (OIC) across almost all groups. For those with a partner able to provide care, the share of partner care declines with increasing care need, except for very low levels of care need. Conversely, individuals lacking a spouse or partner with caregiving capabilities demonstrate the most pronounced disparities at moderate levels of care need. It is within this demographic that the most substantial disparities emerge between the two countries, with Austria providing significantly more formal care to individuals without a spouse or partner compared to Italy.

In the fifth step of the methodology, the parameters on average hours of outside informal care (OIC) provided to adults outside the household for Austria and Italy by age and sex are obtained, as illustrated in Figure A.13. We combine age group averages below 50 from EHIS with SHARE microdata above 50 and apply statistical smoothing techniques. Furthermore, we impose that people at age 100 provide no hours of care. It is evident from the data that the average hours of care peak earlier in Italy than in Austria and at higher levels (particularly for women).

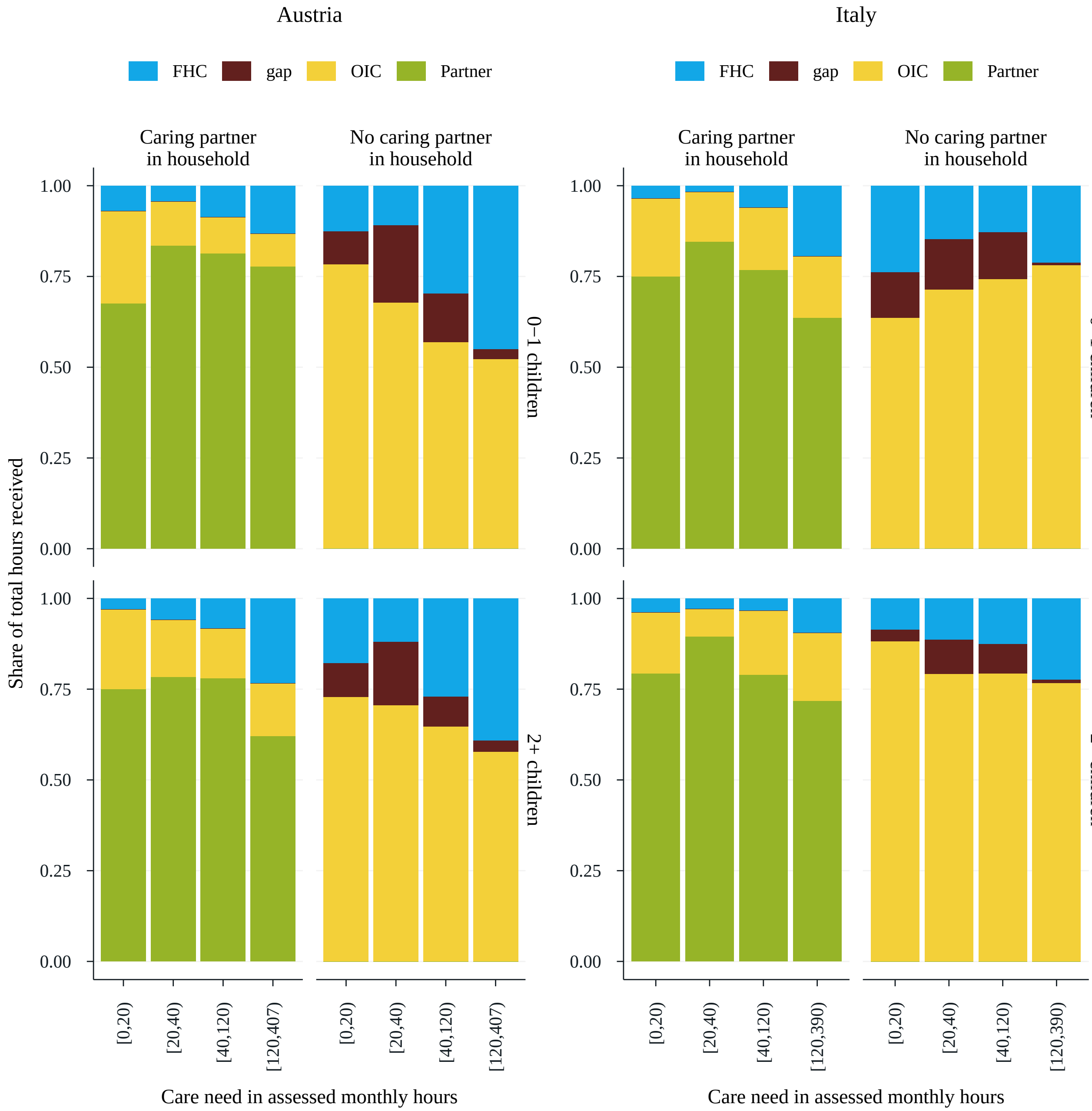


Figure 3: Step 4 - Care mix in Austria and Italy by grouped assessed hours of care need, presence of a caring partner and the number of children. *Notes:* Subsample: respondents who receive home care. We report shares of total hours received by type of care and distinguish Formal Home Care (FHC), the care gap, Outside Informal Care (OIC) and care received from partners.

4.4 Dynamic microsimulation with microWELT

To project future care needs and scenarios for meeting them, the dynamic microsimulation model microWELT (www.microWELT.eu) is applied and extended. MicroWELT is a modelling platform explicitly designed for comparative studies, using readily available comparative data sources such as EU-SILC and - at the aggregate level - reproducing existing (in this case Eurostat) population projections while adding individual-level details such as education, partnership status and parenthood. MicroWELT provides a representative cross-section of a country's population in the base year and simulates individual life histories in their family context over time. The core of microWELT consists of demographic modules, complemented by socioeconomic processes (such as education and employment) and the modelling of individual health status. microWELT explicitly models mortality, fertility and migration consistent with external population projections, as well as partnership formation and dissolution, partner matching, education, health and labour force participation.

The modelling platform has been successfully deployed in a variety of contexts that illustrate the use of microWELT for scenario analysis: Applications range from detailed labour force projections for Austria, Germany, and the US focusing on the intersection of health, education, and ethnicity (Böheim et al., 2024, 2023; Horvath et al., 2022), socioeconomic inequality and public health expenditure over the life course and the future development of health expenditure (Horvath et al., 2023, 2024) or the interplay between demography, economy and welfare state (Spielauer et al., 2023, 2022). The scenario presented here is our base scenario, which is mainly used for illustrative purposes in this paper. A detailed description of the model and a range of alternative scenarios are available on the project website. The following discussion focuses on the processes most relevant for the modelling of long-term care and related scenario assumptions.

A key factor in the model is education, and three levels of education are distinguished: namely compulsory education (ISCED 2), secondary education (ISCED 3-4), and tertiary education (ISCED 5+). It is assumed that educational differences persist over time in fertility, mortality, partnerships, and care. For birth cohorts up to 2010, observed and pro-rated trends are utilised; for birth cohorts after 2010, any further educational expansion is driven entirely by the intergenerational transmission of education, and thus educational progressions are held constant for a given parental education.

With regard to mortality and fertility, microWELT follows Eurostat's population projections at the aggregate level, yet adds detail at the individual level by accounting for variations in first birth cohort rates and resulting childlessness, progression to second births, and longevity by education. In terms of mortality, the observed disparities in mortality risks by education observed today are assumed to persist, while the baseline rates are calibrated by the simulation model to align with the overall mortality targets, as outlined in the Eurostat projections. With regard to fertility, the central assumption in the baseline scenario is that the marked educational differences in childlessness and parity progression to second births persist at the level observed for the 1981 birth cohort. For later cohorts, the increase in childlessness is driven only by compositional effects (childlessness is higher among women with higher education). Thus, while Eurostat fertility projections determine the number of births by age, our refinements distribute these births among women of a given age, taking into account educational differences in the quantity and timing of first and second births.

Partnerships are modelled from the female perspective, taking into account age, the presence and age of children in the family, and education. Partners are matched by assortative mating, using current distributions of age differences and education. Caregiving arrangements and projections are sensitive to the availability of a partner, with changes in partnership status at older ages driven primarily by mortality, i.e., widowhood. Departing from current age-specific probabilities of being in a partnership, our baseline scenario assumes that at age 65+ people remain in existing partnerships, reflecting the fact that with increasing longevity the probability of having a surviving partner at a given age increases. In this sense, longevity is also a mitigating factor for the need for formal care.

In terms of care needs, our baseline scenario applies status quo assumptions: individual care needs by age, gender, and education remain constant over time, as does the mix of care received for given needs and family characteristics such as having a care-giving partner and having one or more children. The scenario implicitly assumes that the supply of formal institutional and home care, as well as informal care received from someone other than a partner, adjusts to provide care according to currently observed patterns. This implies, for instance, that the number of available nursing home places will increase by a corresponding amount to meet the demand, as determined by the observed individual-level probabilities of residing in a nursing home.

While this scenario provides an intuitive baseline, including from a comparative perspective, by keeping differences in institutional factors such as formal care services and nursing homes across countries intact over time (and projecting the necessary expansion of such services to maintain current standards at the individual level), it projects informal care provided by someone other than a partner that far exceeds supply based on current patterns. We account for this fact by explicitly distinguishing in simulation outputs between care that would be available based on current supply and care that exceeds that supply. The current supply by others than a spouse is calculated according to parametrisation step 5 and - at the start of the simulation - calibrated to current demand.[15]

In our scenario, the main drivers of changes in individual and aggregate care needs and the care mix are population ageing (the size and age distribution of the 65+ population), increasing longevity, increasing childlessness, and - the only mitigating factor for total hours of care - the expansion of education. With respect to longevity, we assume that the decline in mortality will not lead to changes in age-specific care needs in addition to those driven by education. With respect to education, it is assumed that the observed differences – namely, that those with higher education are less likely to require care and have lower care needs in hours – persist as currently observed.

MicroWELT provides scenario support for a number of alternative assumptions along different dimensions. These include (1) alternative scenarios of the evolution of needs equivalent to modelling compression or expansion of morbidity and convergence scenarios as applied in (Horvath et al., 2023, 2024), (2) demographic scenarios such as alternative mortality projections or concerning partnership formation and dissolution, and (3) scenarios that change the supply of nursing homes, formal care, and care provided by others than a partner. In the latter category (3), current patterns are contrasted with changes in supply, identifying the proportion of hours of care that are still covered by existing supply, hours that are no longer covered and represent a potential care gap (and, in the case of an expansion of supply, hours that exceed current supply). In the case of care gaps resulting from changes in supply, the model also assesses whether there is a spouse who could potentially provide such additional care and where gaps remain. (A set of such scenarios is available on the project website.)

[15]Calibration corrects for overreporting of care provided which is a common finding across surveys and countries; Furthermore, it can be assumed that modeled care needs in hours following our approach are more strictly defined than the perceived hours of care provided.

5 Results

This section presents the findings from the application of the dynamic microsimulation model in order to examine the future of LTC in Austria and Italy. The base year of the simulations is 2018, and the projections extend to 2070, analysing LTC needs and the care mix. The results presented in this section correspond to the baseline scenario as described in the preceding section. It is important to note that all projected values represent averages over multiple (8) simulation runs with a simulated population size of initially 350.000 persons. This is a simulation size sufficiently large to eliminate Monte Carlo variation in the presented results.

Figure 4 below summarises the primary findings of this paper. The sum of all shaded areas in each country graph corresponds to the total hours of care required in a given year (scaled to 100 % in 2018). Each shaded area indicates how many hours of care need are covered by each type of care, with any residual gap indicating the unmet need. We distinguish hours received in institutions as well as through formal home care, from partners or other informal caregivers. Note that the baseline scenario operates under status quo assumptions, i.e. that the care mix received by an individual with given characteristics remains constant over time. Changes in the overall care mix thus reflect changes in population characteristics such as increased longevity, higher education or lower fertility. While we generally assume that care giving expands proportionally to current patterns, concerning informal care provided by others than a spouse we distinguish between care covered by current supply, and hours exceeding this supply, labeled "hours informal home others − additional required supply" in the figures.

As demonstrated in Figure 4, a pronounced discrepancy emerges in the relative increase of total hours of care required. While the projected increase in Austria is 92 %, Italy's increase is estimated at 44 %. As shown by Appendix Figure A.18, the increase in total hours of care need closely follows the increase in the 65+ population in both countries. This result illustrates that countries that are further advanced in the ageing process face relatively smaller, yet still considerable, increases in LTC needs in the future. Furthermore, Appendix Figure A.18 shows that the education level of the 65+ age group rises relatively more in Italy, thereby also contributing to the distinct evolution of care needs observed in both countries.

Figure 4 also shows that the development of the care mix varies significantly across countries. While in Austria nearly all categories appear to expand proportionally at the first glance, we observe that in Italy the entire increase in needed hours of care would have to be covered by what we call "additional required supply" of other informal home care. The size of this category is disproportionately high in Italy, where most of the increased demand would remain unmet under current informal care supply patterns. This suggests a potential care gap exceeding the corresponding projected care gap for Austria. This - besides an overall higher reliance on informal care - is a direct result of lower fertility and a more advanced ageing process in Italy. These factors are projected to result in a smaller but older population in 2070, which would provide less care under current care-giving patterns, but would require considerably more care. Given that our projection of the care mix already reflects a proportional expansion of care in institutions, formal home care and the current care gap, it is evident that formal care would need to be expanded considerably to avoid major increases in hours of informal care-giving or further unmet needs.

In Austria, the proportionately largest projected increase in hours by type (based on current totals) is in hours provided in nursing homes, which more than double, followed by the care gap, which doubles in both countries. In Italy, the expansion of the care gap represents the largest increase, while hours in nursing homes increase by 88%. On the other hand, the projected hours of care provided by partners - where care provision is more specifically modelled, as it requires the presence of a spouse who is able to provide care - increase by only about 53% in Austria and decrease by -13% in Italy.

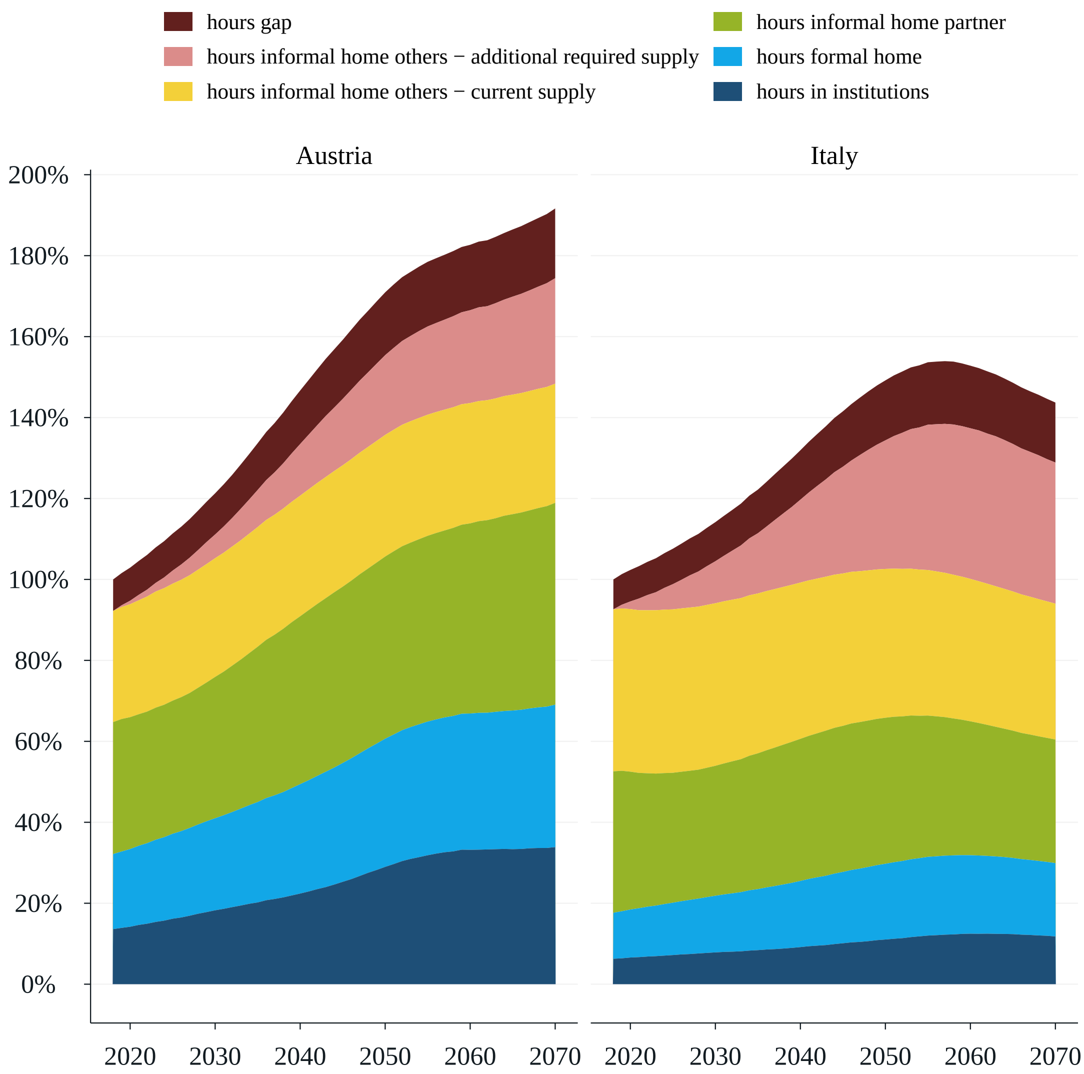


Figure 4: Projected changes in hours of care needed and the care mix received in Austria and Italy relative to the base year 2018. *Notes:* We report baseline projections from microWELT under status quo assumptions, i.e. the care mix at the individual level is assigned as observed today. The split between current supply and additional required supply for informal care by others highlights the increase in care giving above currently observed levels that would be necessary to maintain the current care mix at the individual level.

Under our status quo assumptions, the overall care mix - Figure 5 - changes only slightly, with higher childlessness and the eventual increase in the proportion of older cohorts in the 65+ population leading to a proportional increase in formal - and here specifically institutional - care. Comparing Austria and Italy, the most striking difference concerns nursing homes, which cover more than twice the hours of care need in Austria as compared to Italy, a difference that in Italy is covered by informal care provided by others than the partner (presumably mostly children). Another effect of increased longevity that is more pronounced in Italy is the expansion of informal care from outside the household and the decline in informal care provided by partners, as fewer people in old age have partners capable of providing care.

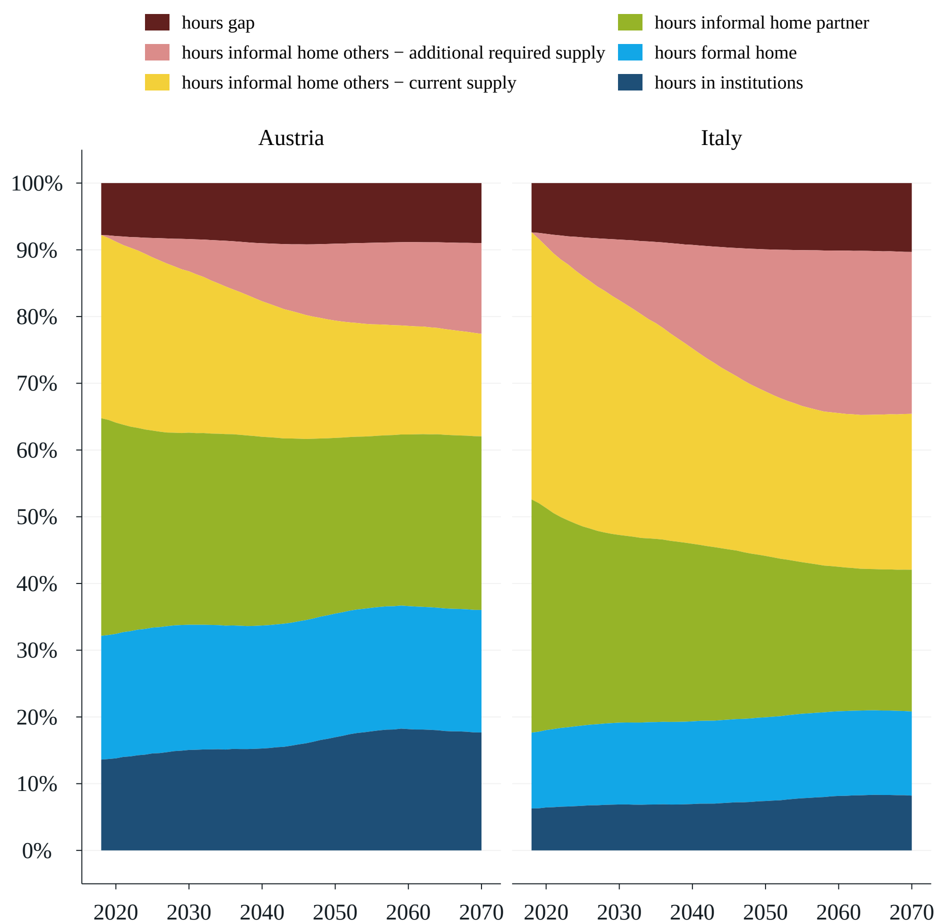


Figure 5: Projected changes in the aggregate care mix received in Austria and Italy. *Notes:* We report baseline projections from microWELT under status quo assumptions, i.e. the care mix at the individual level is assigned as observed today. The split between current supply and additional required supply for informal care by others highlights the increase in care giving above currently observed levels that would be necessary to maintain the current care mix at the individual level.

Figure 6 illustrates the decreasing probability of needing more than 65 hours/month of care by age group as a result of educational expansion. For the cohorts in question, the educational expansion in Italy has been much stronger than in Austria, which is why the need for care in Italy also declines more strongly than in Austria. At the aggregate level, shifts in the age structure of the population aged 65 and over (baby boomers moving to higher ages) will reverse the modestly declining trend in the need for 65+ hours of care in both countries after about 2040.

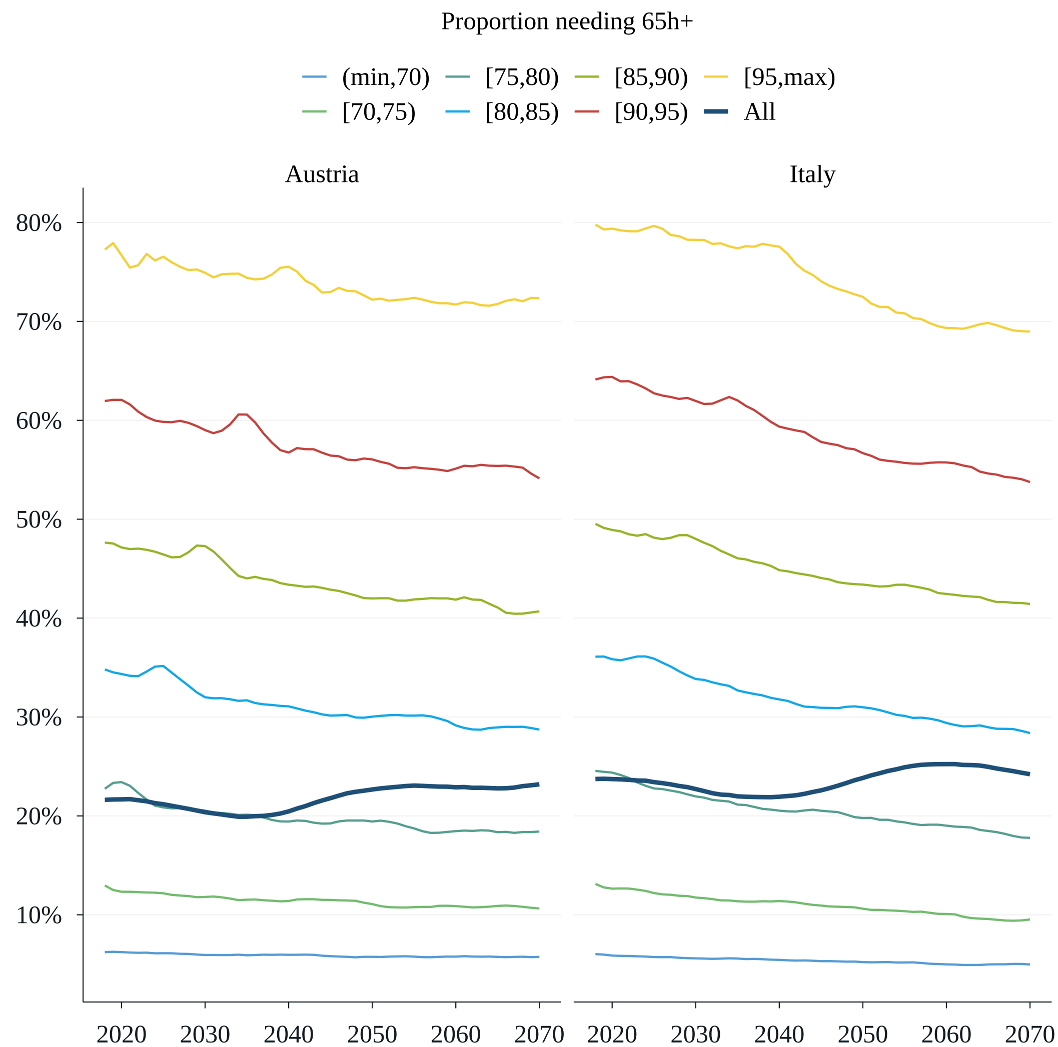


Figure 6: Projected changes in population proportions with care need of 65+ hours by age group in Austria and Italy. *Notes:* We report baseline projections from microWELT.

6 Conclusions

This paper contributes to the literature on long-term care (LTC) microsimulation by providing a comparative approach to address critical gaps in our understanding of how demographic trends, in particular population ageing and declining fertility, will affect care needs and arrangements in ageing societies. Our novel quantitative framework allows for a detailed assessment of future LTC demand, distinguishing between different forms of care, including nursing homes, formal home care and informal care provided by family members.

Using harmonised data sources, we develop a standardised methodology that supports robust cross-country comparative analysis. This is exemplified by our application to Austria and Italy, where we demonstrate the effectiveness of our framework in capturing the nuances of each country's LTC landscape. The methodology can be extended to other countries or used in a comparative multi-country approach, making it a versatile tool for policy makers and researchers alike.

In our projections, we build on and extend the existing microsimulation platform microWELT, which has been successfully applied in various contexts, including labour force projections, public health assessments, and analyses of the interplay between demographics, the economy, and the welfare state in EU countries and the United States. Our results show that total hours of care required in Austria are expected to almost double by 2070, reflecting the increasing dependency of an ageing population. In contrast, Italy, which is more advanced in the ageing process, will experience a more modest increase of around 44%. Italy's more advanced stage in the ageing process is reflected in a lower overall increase in LTC demand, which is expected to peak around 2055. However, due to its low fertility rates and high reliance on informal care, Italy is likely to face significant unmet care needs, highlighting a potential care gap that could arise as family structures become smaller and less able to provide informal support. The combination of declining fertility and a shrinking pool of potential informal caregivers underlines the urgency of addressing these challenges.

The policy implications of these findings are profound. Policymakers should improve support for informal caregivers, including financial incentives, training and respite care, without risking a reduction in the overall labour supply, particularly for women. In addition, the expansion of formal care services, especially in regions with high unmet need, is essential to ensure that the growing demand for long-term care is adequately met. A balanced approach to public and private financing is crucial; our analysis suggests that relying solely on public funding may not be sufficient to cover the projected gaps in care, and that innovative financing solutions that integrate both public and private resources will be needed.

While our study benefits from the integration of different data sources and the Austrian Care Need Assessment Scheme to model care needs in hours, it also has limitations. The reliance on SHARE data limits the validation of our findings, particularly with regard to measures of dependency and the nuances of informal care provided by family members. Our focus on informal care provided by partners and children may not fully capture the complexity of care dynamics in different family and community structures.

In future work, our approach can be adapted to model different scenarios, allowing for a deeper understanding of the individual determinants of care gaps and the potential impact of different policy interventions. The proposed framework lends itself to the inclusion of relevant issues such as morbidity and health care, labour supply for informal home care, or taxation in the projections and is adaptable for use in both single- and multi-country settings, allowing for comparative analyses that take into account different demographic contexts and institutional frameworks. This can further advance the academic discourse on long-term care policy, helping to identify measures to address the challenges posed by low fertility and ageing populations, and to ensure that care systems are equipped to meet the evolving needs of society.

7 SHARE Acknowledgements

This paper uses data from SHARE Waves 1 (SHARE-ERIC, 2024*b*), 2 (SHARE-ERIC, 2024*c*), 3 (SHARE-ERIC, 2024*d*), 4 (SHARE-ERIC, 2024*e*), 5 (SHARE-ERIC, 2024*f*), 6 (SHARE-ERIC, 2024*g*), 7 (SHARE-ERIC, 2024*h*), 8 (SHARE-ERIC, 2024*i*) and 9 (SHARE-ERIC, 2024*j*). See Börsch-Supan et al. (2013) for methodological details.

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 N°211909, SHARE-LEAP: GA N°227822, SHARE M4: GA N°261982, DASISH: GA N°283646) and Horizon 2020 (SHARE-DEV3: GA N°676536, SHARE-COHESION: GA N°870628, SERISS: GA N°654221, SSHOC: GA N°823782, SHARE-COVID19: GA N°101015924) and by DG Employment, Social Affairs & Inclusion through VS 2015/0195, VS 2016/0135, VS 2018/0285, VS 2019/0332, VS 2020/0313, SHARE-EUCOV: GA N°101052589 and EUCOVII: GA N°101102412. Additional funding from the German Federal Ministry of Education and Research (01UW1301, 01UW1801, 01UW2202), 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, BSR12-04, R01_AG052527-02, R01_AG056329-02, R01_AG063944, HHSN271201300071C, RAG052527A) and from various national funding sources is gratefully acknowledged (see www.share-eric.eu).

This paper uses data from the generated easySHARE data set (SHARE-ERIC, 2024*a*), see Gruber et al. (2014) for methodological details. The easySHARE release 9.0.0 is based on SHARE Waves 1, 2, 3, 4, 5, 6, 7, 8 and 9.

References

Alperin, M. N. P. (2016), 'A multidimensional approach to measure health', *Economics Bulletin* **36**(3), 1553–1568.

Archer, L., Lomax, N. and Tysinger, B. (2021), 'A dynamic microsimulation model for ageing and health in england: the english future elderly model', *International Journal of Microsimulation* **14**(3), 2–26.

Astolfi, R., Lorenzoni, L. and Oderkirk, J. (2012), 'Informing policy makers about future health spending: a comparative analysis of forecasting methods in oecd countries', *Health Policy* **107**(1), 1–10.

Atella, V., Belotti, F., Carrino, L. and Piano Mortari, A. (2017), 'The future of long term care in europe. an investigation using a dynamic microsimulation model'.

Atella, V., Belotti, F., Kim, D., Goldman, D., Gracner, T., Piano Mortari, A. and Tysinger, B. (2021), 'The future of the elderly population health status: filling a knowledge gap', *Health Economics* **30**, 11–29.

Baldini, M., Mazzaferro, C. and Morciano, M. (2008), 'Assessing the implications of long-term care policies in italy: a microsimulation approach', *Politica Economica* **24**(1), 47–72.

Banks, J., French, E. and McCauley, J. (2023), Long-term care in england, Technical report, National Bureau of Economic Research.

Barczyk, D. and Kredler, M. (2019), 'Long-term care across europe and the united states: the role of informal and formal care', *Fiscal Studies* **40**(3), 329–373.

Belmonte, M., Grubanov-Boskovic, S., Natale, F., Conte, A., Belanger, A., Sabourin, P. et al. (2023), 'Demographic microsimulation of long-term care needs in the european union'.

Bergmann, M., Kneip, T., De Luca, G. and Scherpenzeel, A. (2019), Survey participation in the survey of health, ageing and retirement in europe (share), wave 1-7, Technical Report 41-2019, MEA, Max Planck Institute for Social Law and Social Policy, Munich. Based on Release 7.0.0.

Böheim, R., Horvath, T., Leoni, T. and Spielauer, M. (2023), 'The impact of health and education on labor force participation in aging societies: projections for the united states and germany from dynamic microsimulations', *Population Research and Policy Review* **42**(3), 39.

Böheim, R., Horvath, T., Leoni, T. and Spielauer, M. (2024), The power of inclusive labor force participation for mitigating population aging: Closing gaps at the intersection between race/ethnicity and gender in the united states, Technical report, National Bureau of Economic Research.

Brugiavini, A., Carrino, L. and Pasini, G. (2023), Long-term care in italy, Technical report, National Bureau of Economic Research.

Börsch-Supan, A., Brandt, M., Hunkler, C., Kneip, T., Korbmacher, J., Malter, F., Schaan, B., Stuck, S. and Zuber, S. (2013), 'Data resource profile: The survey of health, ageing and retirement in europe (share)', *International Journal of Epidemiology* **42**(4), 992–1001.

Caballero, F. F., Soulis, G., Engchuan, W., Sánchez-Niubó, A., Arndt, H., Ayuso-Mateos, J. L., Haro, J. M., Chatterji, S. and Panagiotakos, D. B. (2017), 'Advanced analytical methodologies for measuring healthy ageing and its determinants, using factor analysis and machine learning techniques: the athlos project', *Scientific Reports* **7**(1), 43955.

Chen, A. (2024), 'A dynamic microsimulation model for aging and health in taiwan: the taiwan future elderly model - forecasting future population with dementia and functional limitations and its implications for formal long-term care capacity'.

Chen, B. K., Jalal, H., Hashimoto, H., Suen, S.-c., Eggleston, K., Hurley, M., Schoemaker, L. and Bhattacharya, J. (2016), 'Forecasting trends in disability in a super-aging society: adapting the future elderly model to japan', *The Journal of the Economics of Ageing* **8**, 42–51.

Chen, C., Lim, J. T., Chia, N. C., Kim, D., Park, H., Wang, L., Tysinger, B., Zhao, M., Cook, A. R., Chong, M. Z. et al. (2022), 'Educational gradients in disability among asia's future elderly: Projections for the republic of korea and singapore', *Asian Development Review* **39**(01), 51–89.

Commission, E. (2021*a*), 'Long-term care report. trends, challenges and opportunities in an ageing society'.

Commission, E. (2021*b*), 'Study on exploring the incidence and costs of informal long-term care in the eu'.

de la Fuente, J., Caballero, F. F., Sánchez-Niubó, A., Panagiotakos, D. B., Prina, A. M., Arndt, H., Haro, J. M., Chatterji, S. and Ayuso-Mateos, J. L. (2018), 'Determinants of health trajectories in england and the united states: an approach to identify different patterns of healthy aging', *The Journals of Gerontology: Series A* **73**(11), 1512–1518.

Dunatchik, A., Icardi, R. and Blake, M. (2019), 'Predicting unmet need for social care', *Journal of Long-Term Care* **2019**, 194–205.

ECORYS (2021), *Study on exploring the incidence and costs of informal long-term care in the EU.*, Publications Office of the European Union.
URL: *https://data.europa.eu/doi/10.2767/06382*

Eurostat (2025), 'Demographic balances and indicators by type of projection'. Accessed on 09.01.2025.
URL: *https://ec.europa.eu/eurostat/data/database*

Eurostat (2025b), 'Fertility indicators'. Accessed on 09.01.2025.
URL: *https://ec.europa.eu/eurostat/data/database*

Famira-Mühlberger, U. and Österle, A. (2024), Long-term care system profile: Austria, Technical report, Global Observatory of Long-Term Care, Care Policy & Evaluation Centre, London School of Economics and Political Science.

Favreault, M. M., Gleckman, H. and Johnson, R. W. (2015), 'Financing long-term services and supports: Options reflect trade-offs for older americans and federal spending', *Health Affairs* **34**(12), 2181–2191.

Genevois, A.-S., Liegeois, P. and Pi Alperin, M. (2019), 'Dymh_lu: a simple tool for modelling and simulating the health status of the luxembourgish elderly in the longer run'.

Goldman, D. P., Leaf, D. E. and Tysinger, B. (2021), The future adult model: technical documentation, Technical report, Technical report.

Goldman, D., Shekelle, P., Bhattacharya, J., Hurd, M., Joyce, G., Lakdawalla, D., Matsui, D., Newberry, S., Panis, C. S. and Shang, B. (2004), 'Health status and medical treatment of the future elderly'.

Gonzalez-Aquines, A., Singh, S., Krol-Jankowska, A. G. and Koziel, A. (2024), 'Defining long-term care in european union countries: a review of policy documents', *Journal of Long-Term Care* .

Gonzalez-Gonzalez, C., Tysinger, B., Goldman, D. P. and Wong, R. (2017), 'Projecting diabetes prevalence among mexicans aged 50 years and older: the future elderly model-mexico (fem-mexico)', *BMJ open* **7**(10), e017330.

Granger, C. V., Hamilton, B. B., Linacre, J. M., Heinemann, A. W. and Wright, B. D. (1993), 'Performance profiles of the functional independence measure', *American Journal of Physical Medicine & Rehabilitation* **72**(2), 84–89.

Gruber, S., Hunkler, C. and Stuck, S. (2014), Generating easyshare: guidelines, structure, content and programming, Technical Report 17-2014, MEA, Max Planck Institute for Social Law and Social Policy, Munich.

Gubert, E. and Perobelli, E. (2024), 'Long-term care system profile: Italy', Global Observatory of Long-Term Care, Care Policy & Evaluation Centre, London School of Economics and Political Science.
URL: *https://goltc.org/system-profile/italy/*

Hancock, R., Comas-Herrera, A., Wittenberg, R. and Pickard, L. (2003), 'Who will pay for long-term care in the uk? projections linking macro-and micro-simulation models', *Fiscal studies* **24**(4), 387–426.

Hancock, R., Pickard, L., Wittenberg, R., Comas-Herrera, A., Juarez-Garcia, A., King, D. and Malley, J. (2007), 'Paying for long-term care for older people in the uk: modelling the costs and distributional effects of a range of options'.

Hobart, J. and Thompson, A. (2001), 'The five item barthel index', *Journal of Neurology, Neurosurgery & Psychiatry* **71**(2), 225–230.

Horvath, T., Hyll, W., Mahringer, H., Lutz, H. and Spielauer, M. (2022), Ältere am arbeitsmarkt: eine vorausschau bis 2040 als grundlage für wirtschaftspolitische maßnahmen (older persons in the labour market: A forecast until 2040 as a basis for economic policy measures), Technical report, WIFO Studies.

Horvath, T., Leoni, T., Reschenhofer, P. and Spielauer, M. (2023), 'Socio-economic inequality and healthcare costs over the life course – a dynamic microsimulation approach', *Public Health* **219**, 124–130.
URL: *https://www.sciencedirect.com/science/article/pii/S0033350623001166*

Horvath, T., Leoni, T., Spielauer, M. and Reschenhofer, P. (2024), The impact of ageing, inequality and the evolution of morbidity on future health expenditure, Technical report, WIFO Working Papers.

Isaacs, B. and Neville, Y. (1976), 'The needs of old people. the'interval'as a method of measurement.', *Journal of Epidemiology & Community Health* **30**(2), 79–85.

Jiang, Y. and Li, L. (2024), 'Projections of functional dependence among the late middle-aged and older population from 2018-2048 in china: a dynamic microsimulation', *Global Health Research and Policy* **9**(1), 15.

Kasajima, M., Eggleston, K., Kusaka, S., Matsui, H., Tanaka, T., Son, B.-K., Iijima, K., Goda, K., Kitsuregawa, M., Bhattacharya, J. et al. (2022), 'Projecting prevalence of frailty and dementia and the economic cost of care in japan from 2016 to 2043: a microsimulation modelling study', *The Lancet Public Health* **7**(5), e458–e468.

Kasajima, M., Hashimoto, H., Suen, S.-C., Chen, B., Jalal, H., Eggleston, K. and Bhattacharya, J. (2021), 'Future projection of the health and functional status of older people in japan: A multistate transition microsimulation model with repeated cross-sectional data', *Health Economics* **30**, 30–51.

Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A. and Jaffe, M. W. (1963), 'Studies of illness in the aged: the index of adl: a standardized measure of biological and psychosocial function', *JAMA* **185**(12), 914–919.

Kennell, D., Alecxih, L., Wiener, J. and Hanley, R. (1992), 'Brookings/icf long term care financing model: Model assumptions'.

Kingston, A., Comas-Herrera, A. and Jagger, C. (2018), 'Forecasting the care needs of the older population in england over the next 20 years: estimates from the population ageing and care simulation (pacsim) modelling study', *The Lancet Public Health* **3**(9), e447–e455.

Kingston, A., Wittenberg, R., Hu, B. and Jagger, C. (2022), 'Projections of dependency and associated social care expenditure for the older population in england to 2038: effect of varying disability progression', *Age and Ageing* **51**(7), afac158.

Lawton, M., Brody, E. and Médecin, U. (1969), 'Instrumental activities of daily living (iadl)', *Gerontologist* **9**, 179–186.

Mahoney, F. I. and Barthel, D. W. (1965), 'Functional evaluation: the barthel index: a simple index of independence useful in scoring improvement in the rehabilitation of the chronically ill.', *Maryland State Medical Journal* .

Malisauskaite, G., Lau, Y., Brookes, N., Hussein, S. and Sutton, M. (2021), 'Measuring unmet health and care needs among older people using existing data brief'.

Marois, G. and Aktas, A. (2021), 'Projecting health-ageing trajectories in europe using a dynamic microsimulation model', *Scientific reports* **11**(1), 1785.

May, P., Normand, C., Matthews, S., Kenny, R. A., Romero-Ortuno, R. and Tysinger, B. (2022), 'Projecting future health and service use among older people in ireland: an overview of a dynamic microsimulation model in the irish longitudinal study on ageing (tilda)', *HRB Open Research* **5**.

Muszyńska-Spielauer, M. and Spielauer, M. (2022), 'Cross-sectional estimates of population health from the survey of health and retirement in europe (SHARE) are biased due to health-related sample attrition', **20**, 101290.

OECD (2022), 'Supporting informal carers of older people: policies to leave no carer behind'.

OECD (2024), 'Public expenditure projections for health and long-term care'.

Schofield, D. (1998), 'Public expenditure on hospitals: Measuring the distributional impact'.

Schofield, D. J., Zeppel, M. J., Tan, O., Lymer, S., Cunich, M. M., Shrestha, R. N. et al. (2018), 'A brief, global history of microsimulation models in health: past applications, lessons learned and future directions', *International Journal of Microsimulation* **11**(1), 97–142.

SHARE-ERIC (2024*a*), 'easyshare', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*b*), 'Survey of health, ageing and retirement in europe (share) wave 1', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*c*), 'Survey of health, ageing and retirement in europe (share) wave 2', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*d*), 'Survey of health, ageing and retirement in europe (share) wave 3 – sharelife', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*e*), 'Survey of health, ageing and retirement in europe (share) wave 4', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*f*), 'Survey of health, ageing and retirement in europe (share) wave 5', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*g*), 'Survey of health, ageing and retirement in europe (share) wave 6', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*h*), 'Survey of health, ageing and retirement in europe (share) wave 7', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*i*), 'Survey of health, ageing and retirement in europe (share) wave 8', Data set. Release version: 9.0.0.

SHARE-ERIC (2024*j*), 'Survey of health, ageing and retirement in europe (share) wave 9', Data set. Release version: 9.0.0.

Spielauer, M. (2007), 'Dynamic microsimulation of health care demand, health care finance and the economic impact of health behaviours: survey and review', *International Journal of Microsimulation* **1**(1), 35–53.

Spielauer, M., Horvath, T., Fink, M., Abio, G., Souto, G., Patxot, C. and Istenič, T. (2022), 'Measuring the lifecycle impact of welfare state policies in the face of ageing', *Economic Analysis and Policy* **75**, 1–25.

Spielauer, M., Horvath, T., Fink, M., Abio, G., Souto, G., Patxot, C. and Istenič, T. (2023), 'The effect of educational expansion and family change on the sustainability of public and private transfers', *The Journal of the Economics of Ageing* **25**, 100455.

Spijker, J., Devolder, D. and Zueras, P. (2022), 'The impact of demographic change in the balance between formal and informal old-age care in spain. results from a mixed microsimulation–agent-based model', *Ageing & Society* **42**(3), 588–613.

Trukeschitz, B., Österle, A. and Schneider, U. (2022), 'Austria's long-term care system: Challenges and policy responses.', *Journal of Long-Term Care* .

van de Ven, J., Bronka, P. and Richiardi, M. (2024), The life course effects of care, Technical report, CeMPA Working Paper Series.

Wittenberg, R., Hancock, R., Comas-Herrera, A., King, D., Malley, J., Pickard, L., Juarez-Garcia, A. and Darton, R. (2007), Model 11: Pssru long-term care finance model and caresim: Two linked uk models of long-term care for older people, *in* 'Modelling Our Future: Population Ageing, Health and Aged Care', Emerald Group Publishing Limited, pp. 489–496.

Wittenberg, R., Hu, B. and Hancock, R. (2018), 'Projections of demand and expenditure on adult social care 2015 to 2040'.

Zissimopoulos, J., Crimmins, E. and St. Clair, P. (2015), The value of delaying alzheimer's disease onset, *in* 'Forum for Health Economics and Policy', Vol. 18, De Gruyter, pp. 25–39.

Zissimopoulos, J. M., Tysinger, B. C., St. Clair, P. A. and Crimmins, E. M. (2018), 'The impact of changes in population health and mortality on future prevalence of alzheimer's disease and other dementias in the united states', *The Journals of Gerontology: Series B* **73**(suppl_1), S38–S47.

A Appendix

A.1 Alternative measures of dependency

The aim of this section is to provide graphical insights on the validity of the hours conversion scale, namely the Austrian Care Need Assessment scheme (ACNA) as reported in Table 2.

Although most of European countries define LTC mainly based on physical disabilities (ADLs and IADLs) and mental capacities (e.g. dementia), there is lack of a common definition across EU member states (Commission, 2021*a*; Gonzalez-Aquines et al., 2024). This translates in the absence of a commonly adopted measure to identify the target population in LTC microsimulation studies (Atella et al., 2017; Belmonte et al., 2023). Some microsimulation studies even adopt synthetic indicators and continuous measures of health status as Genevois et al. (2019) and Marois and Aktas (2021).

As an exercise, in this section we compare a given distribution of hours as defined by the ACNA scheme to other measures of dependency commonly adopted in the literature of LTC needs. Measures differ in the set of physical limitations considered in their construction. The following indexes are compared: the Barthel index (Mahoney and Barthel, 1965), its 5-item version (Hobart and Thompson, 2001), the Katz index (Katz et al., 1963), the Lawton index (Lawton et al., 1969) and the Functional Independence Measure (Granger et al., 1993).

It is possible to observe that all measures of dependency share a positively skewed distribution over their own support (Figure A.1). The age profile of the prevalence in score is age-increasing, being steeper for females in the age bracket 80-90 (Figure A.2). The age distributions of the average score present a similar age-trend, with profiles being slightly higher for men aged 65-75 years (Figure A.3).

Interestingly, what differs is the probability of receiving care at a given age (figure A.4). Despite probabilities increase by age and decrease by education, it emerges that the ACNA measure is associated with higher profiles for younger ages for both sexes and across educational levels when compared to other measures of dependency. Under this result, investigating the sensitivity of LTC assessments to various measures of dependency is left to further research.

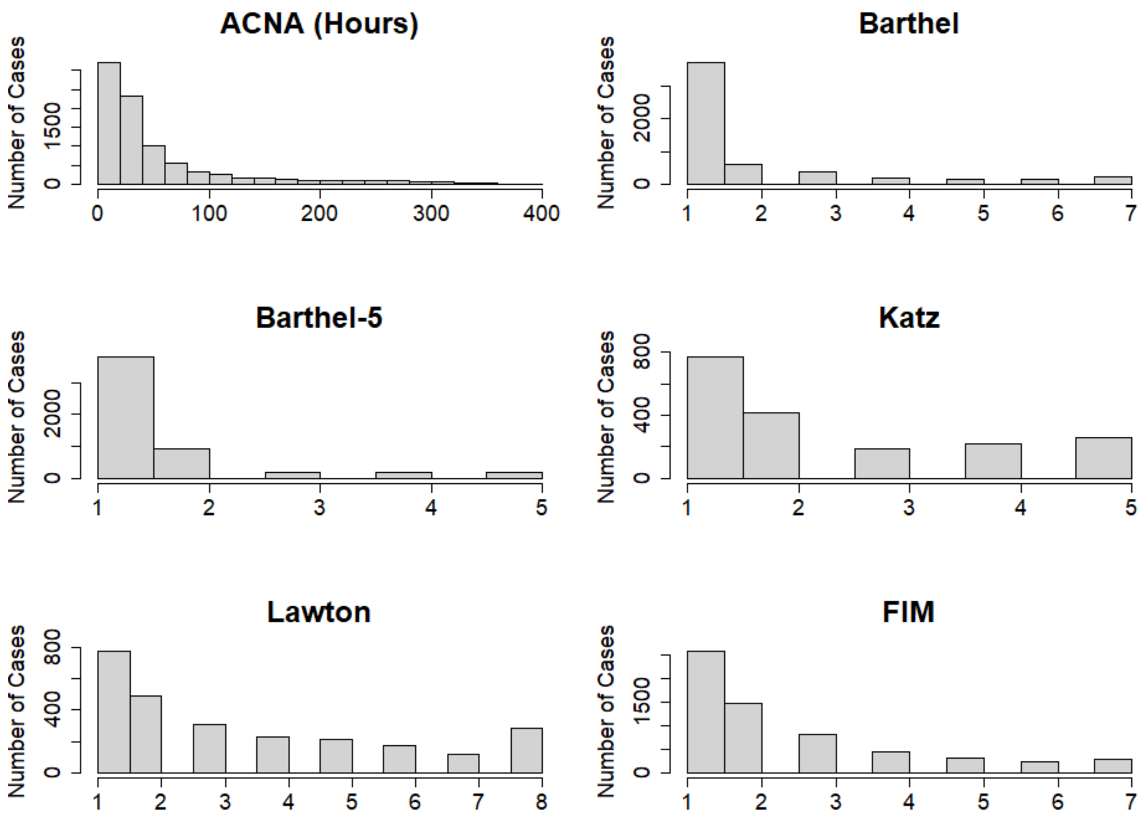


Figure A.1: Distribution of the number of cases across measures of dependency. *Notes:* The comparison of frequently used care need indicators with hours assigned by our Austrian care need assessment scheme (ACNA) is based on SHARE data.

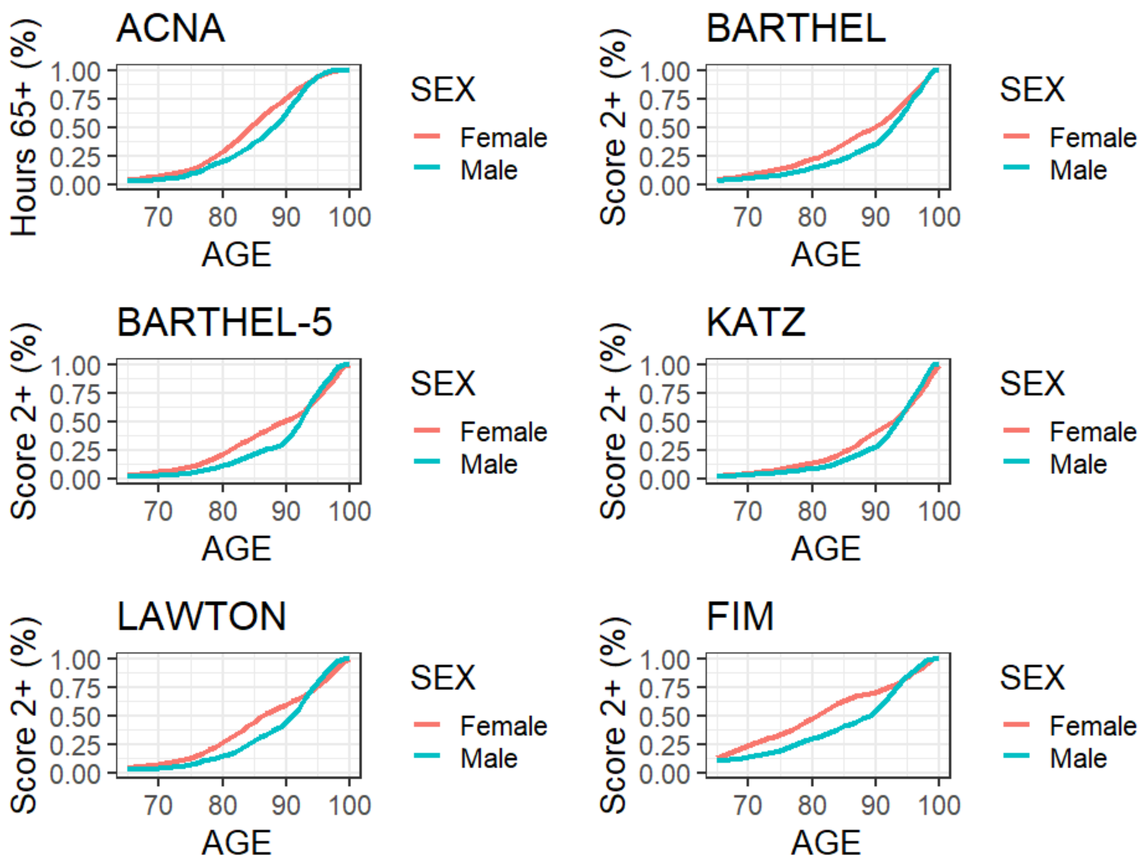


Figure A.2: Age profile of the prevalence in score by sex across different measures of dependency. *Notes:* The comparison of frequently used care need indicators with hours assigned by our Austrian care need assessment scheme (ACNA) is based on SHARE data.

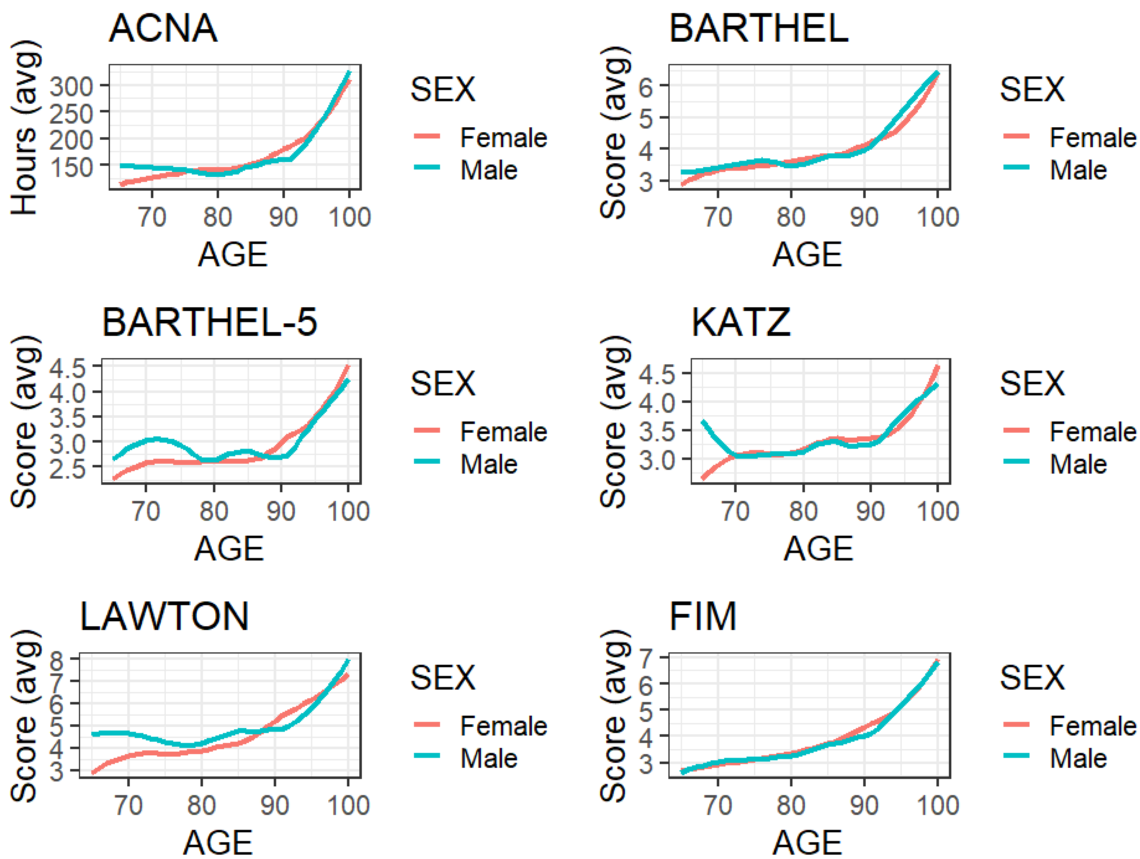


Figure A.3: Age profile of the average score by sex across different measures of dependency. *Notes:* The comparison of frequently used care need indicators with hours assigned by our Austrian care need assessment scheme (ACNA) is based on SHARE data.

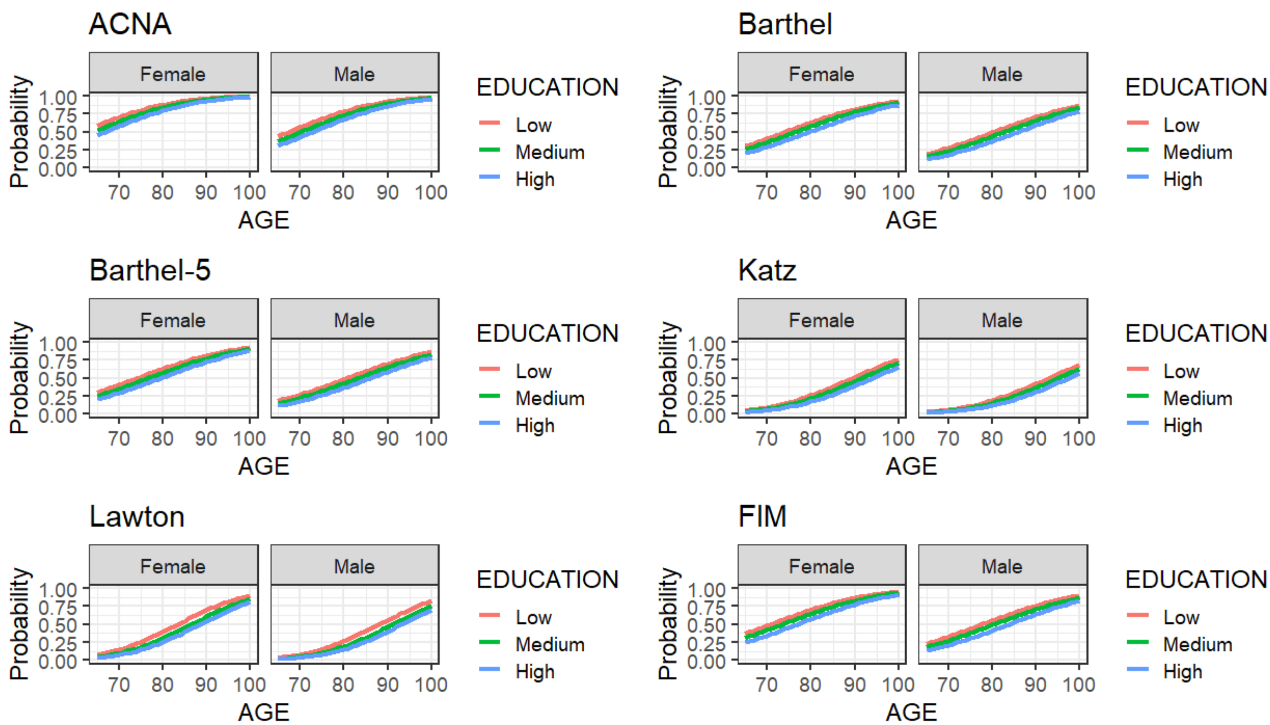


Figure A.4: Age profile of care-receiving probability by sex and education across different measures of dependency. *Notes:* The comparison of frequently used care need indicators with hours assigned by our Austrian care need assessment scheme (ACNA) is based on SHARE data.

A.2 Nursing home population statistics used in reweighting

Table A.4: Austrian population proportions by age, sex and nursing home status (share of the total 65+ population in 2021).

	65-74	75-84	85+	Sum
In Nursing Home, Female	0.004	0.012	0.022	0.038
In Nursing Home, Male	0.003	0.006	0.006	0.014
Not in Nursing Home, Female	0.269	0.193	0.063	0.526
Not in Nursing Home, Male	0.237	0.148	0.037	0.422
Sum	0.513	0.359	0.128	1.000

Table A.4: Italian population proportions by age, sex and nursing home status (share of the total 65+ population) as provided in Brugiavini et al. (2023). The reference year is missing, but is presumably 2015 or later.

	65-80	80+	Sum
In Nursing Home, Female	0.004	0.012	0.016
In Nursing Home, Male	0.001	0.004	0.005
Not in Nursing Home, Female	0.373	0.182	0.555
Not in Nursing Home, Male	0.321	0.103	0.424
Sum	0.699	0.301	1.000

A.3 Care need assessment

The distribution of hours of monthly care need our full assessment scheme assigns to AT SHARE respondents can be seen in a histogram in Appendix Figure A.5. As discussed above, this allocation results from calibration using Austrian care allowance statistics. Our first alignment target is the population share with 65+ assigned hours, which is the threshold to be placed in level 1 of the Austrian care allowance system. In 2021, the share with 65+ monthly care hours (level 1 or higher) in the population of age 65+ is about 20 percent. The basic assessment scheme assigns 65+ hours to only 10.94 percent of our sample or a weighted population share of 12.39 percent. The corresponding shares of our full assessment scheme amount to 17.46 percent and 19.47 percent, respectively.

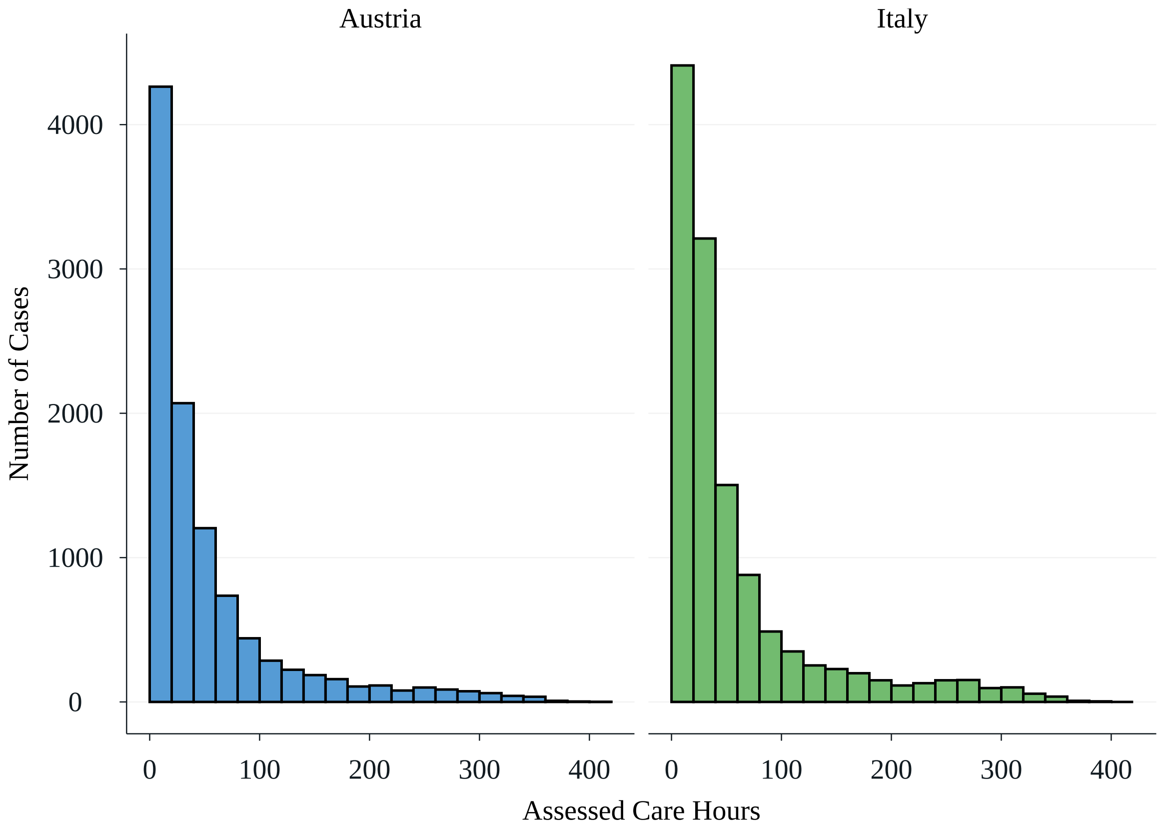


Figure A.5: Histograms of assigned monthly hours of care need for SHARE respondents in Austria and Italy.

The second alignment target used for calibrating our assessment scheme is the conditional distribution of needing 65+ hours of care by age and sex. Appendix Figure A.6 shows the prevalence of receiving care allowance by age and sex (in black), which is equivalent to a care need of 65 hours or more. The blue and green lines contrast the results from the basic and full assessment schemes and are obtained by applying locally estimated scatterplot smoothing (LOESS) to weighted shares of survey respondents with 65+ assessed hours by age in years and sex.

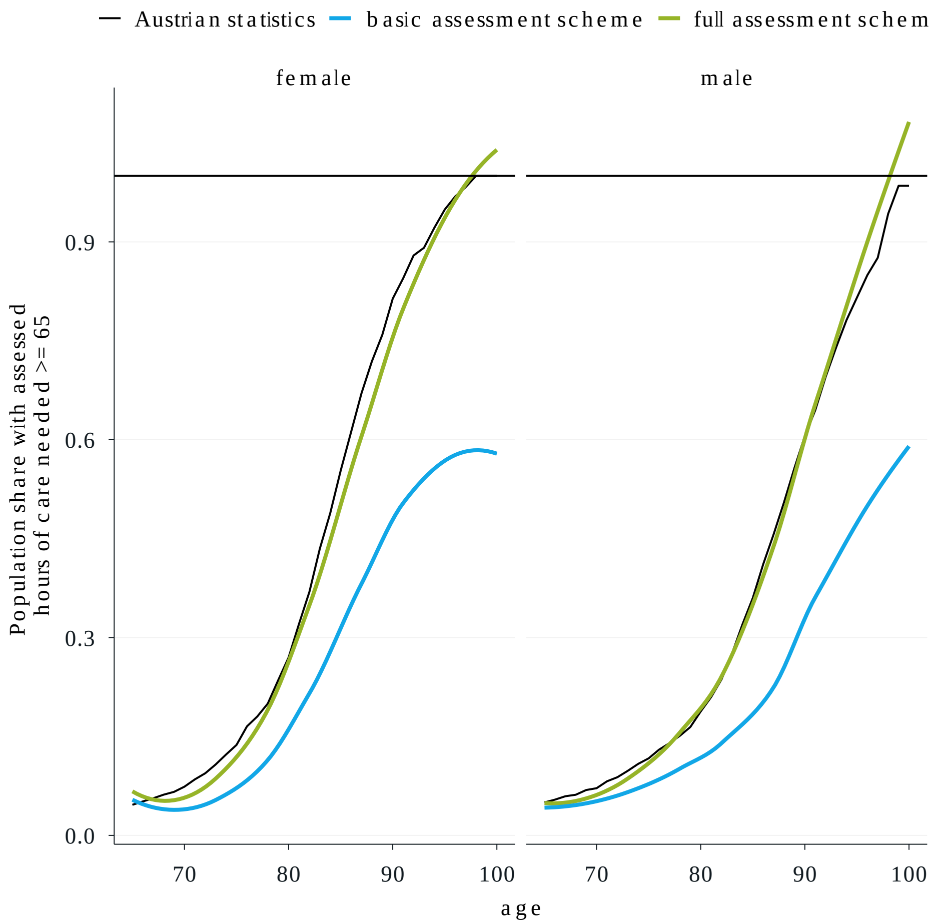


Figure A.6: Prevalence of assessed monthly care need larger or equal to 65 hours in Austria by age and sex (weighted). *Notes:* We apply locally estimated scatterplot smoothing (LOESS) to weighted shares of survey respondents with 65+ assessed hours by age in years and sex. The black line provides a comparison with Austrian statistics on care allowance prevalence of level 1 or higher, which is equivalent to a care need of 65 hours or more. The basic assessment scheme assigns hours solely based on Austrian regulations while our full assessment scheme adds extra hours for additional limitations and is calibrated against the Austrian statistics by a conditional age trend.

Lastly, we align our assessment scheme to the conditional distribution of average hours of care need by age and sex. We obtain monthly average hours from Austrian care allowance statistics by multiplying the prevalence of each care allowance level by its allotted minimum monthly care hours. The black line in Figure A.7 below represents the results. In order to facilitate a meaningful comparison with our assessed hours, we restrict the sample to individuals with assessed hours above 65 and decrease individual care hours to the threshold applicable to each respondent. We then calculate averages of minimum monthly assessed hours by age and sex and apply LOESS (blue and green lines). The average hours from the basic scheme are consistently too high in this case because only more severe cases with multiple limitations qualify for the threshold. The results from the full scheme show a better fit, but indicate that we may assign too few hours to women at the lower and upper ends of the age range and too many hours to men at the lower end. However, we need to caution that deviations at the boundaries of the age range may also be related to sample size limitations. Furthermore, the higher average hours for men at the lower end of the age range may also be indicative of lower take up of care allowance in this group, as, in some cases, care work for these men may be provided informally by their partners and without applying for care allowance.

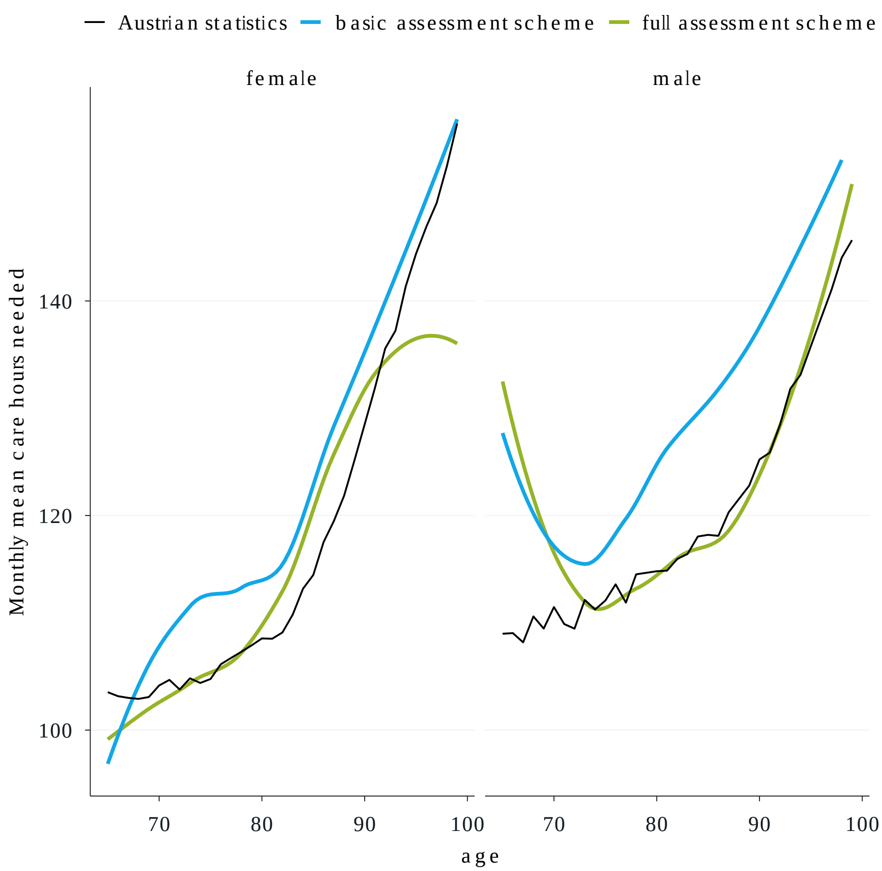


Figure A.7: Average assigned hours in Austria for those with 65+ hours of care need by age and sex (weighted). *Notes:* Comparison of assessed hours with average hours from Austrian statistics (black line) calculated by multiplying the minimum hours per care allowance level times its prevalence. Subsample: respondents with 65+ hours of care need. Comparability with Austrian statistics is enhanced by assigning each assessed value of monthly hours into a care allowance level before calculating weighted averages and applying LOESS. The basic assessment scheme assigns hours solely based on Austrian regulations while our full assessment scheme adds extra hours for additional limitations and is calibrated against the Austrian statistics by a conditional age trend.

Since not all variables used in our care need assessment scheme are consistently available across all waves of SHARE, we resort to imputations and proxies in a limited number of cases. First, the IADL questions on difficulties with ”leaving the home independently” and with ”doing the laundry” are only available in waves 6-9. We therefore impute these variables in waves 1-5 using a logit model that draws on (I)ADLs and additional functional limitation questions available in all waves to predict the individuals most likely to have these additional limitations. Second, information on dementia and psychiatric conditions is not directly available in wave 1. Regarding dementia, we again use a logit model to impute likely candidates in wave 1 using as covariates IADL questions related to cognitive limitations as well as questions that assess an individual's orientation with respect to the current date. Finally, we proxy psychiatric problems in wave 1 by utilising a question on whether respondents take drugs against anxiety or depression at least once a week, which identifies a similar (and also very small) share of respondents compared to the diagnosed psychiatric condition variables used in other waves.

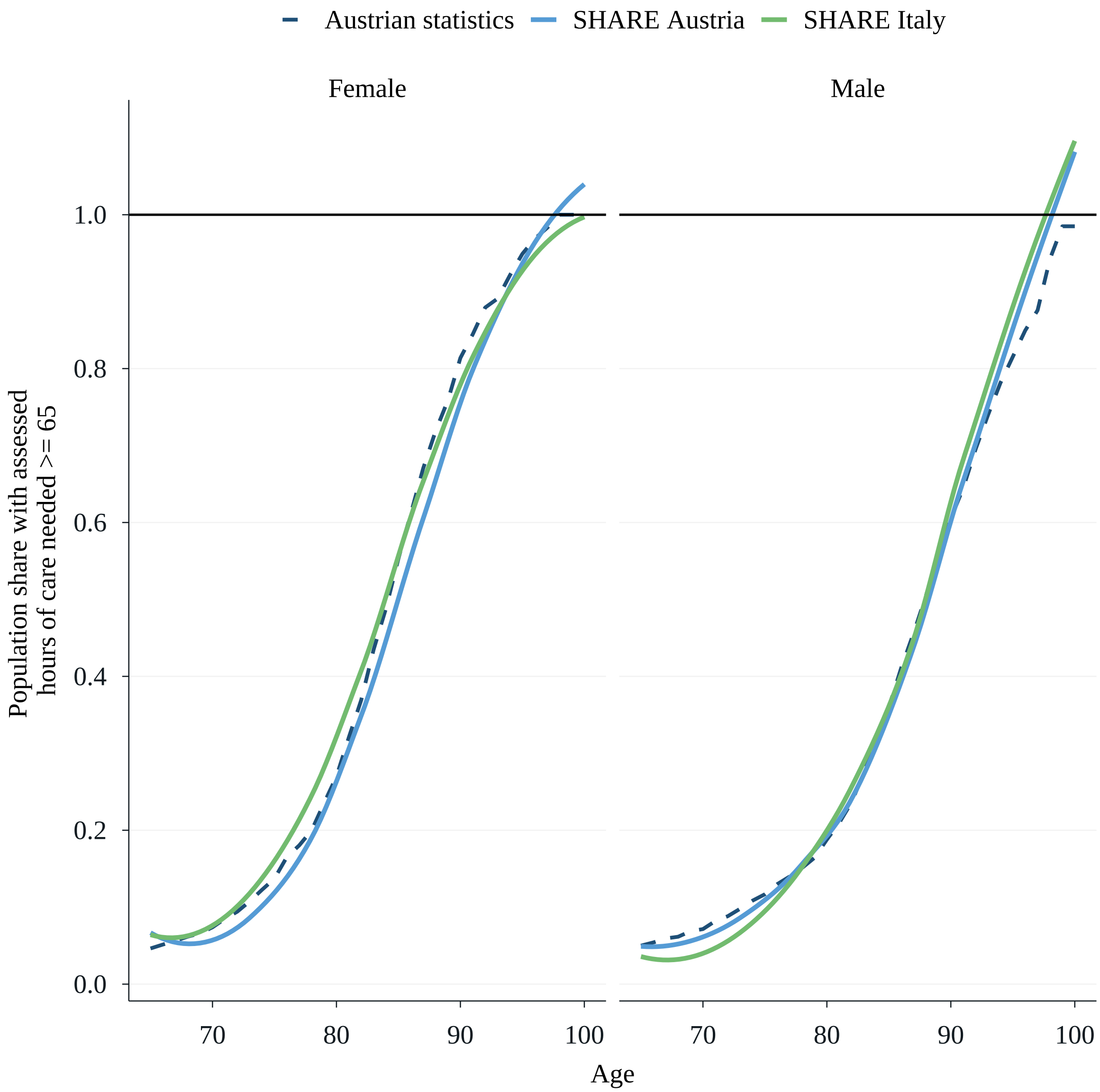


Figure A.8: Validation: Prevalence of assessed monthly care need larger or equal to 65 hours in Austria and Italy by age and sex (weighted). *Notes:* We apply locally estimated scatterplot smoothing (LOESS) to weighted shares of survey respondents with 65+ assessed hours by age in years and sex. The dotted line provides a comparison with Austrian administrative data on care allowance prevalence of level 1 or higher, which is equivalent to a care need of 65 hours or more.

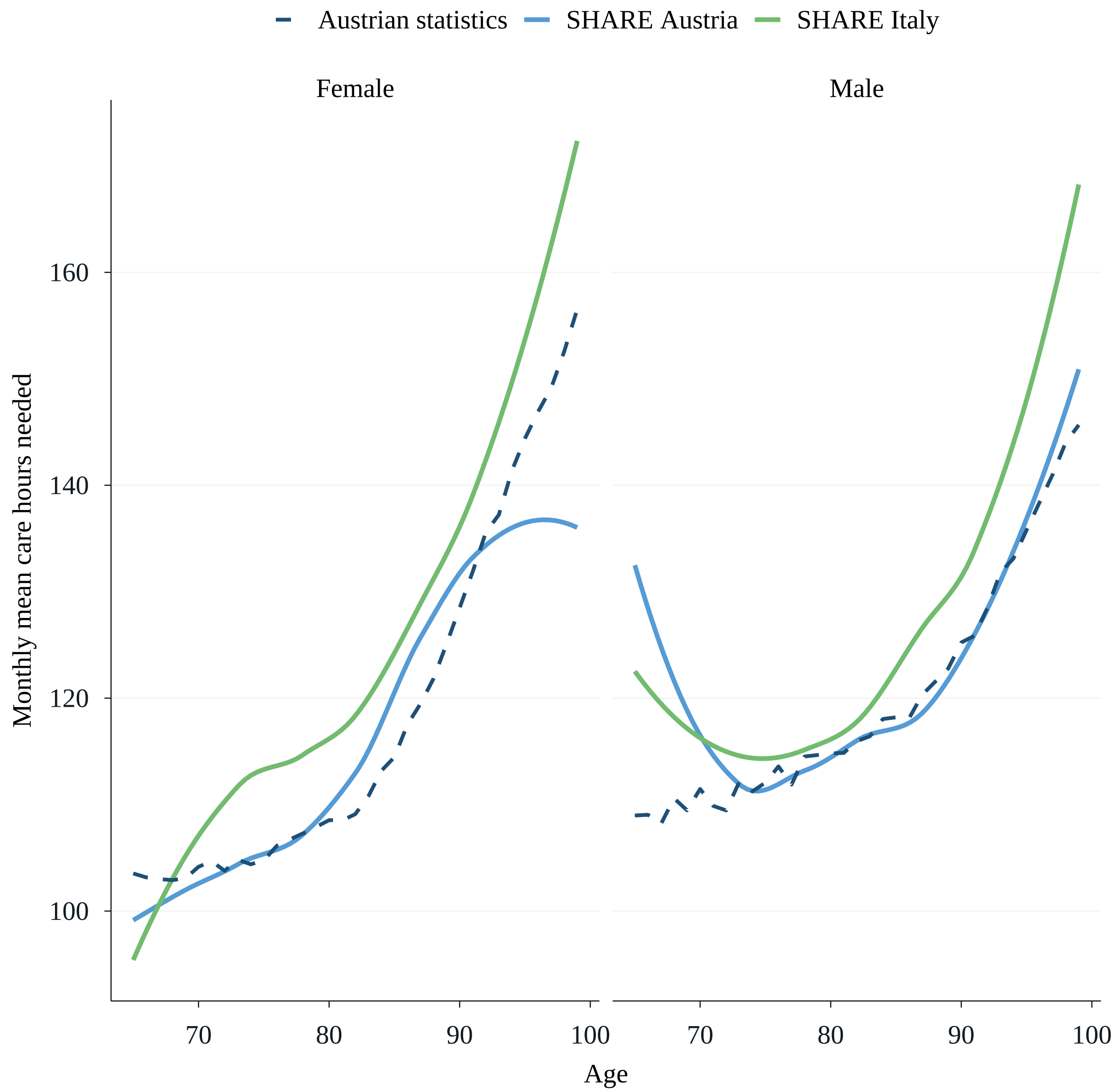


Figure A.9: Validation: Average assigned hours for those with 65+ hours of care need in Austria and Italy by age and sex (weighted). *Notes:* Comparison of assessed hours with average hours from Austrian statistics (dotted line) calculated by multiplying the minimum hours per care allowance level times its prevalence. Subsample: respondents with 65+ hours of care need. Comparability with Austrian statistics is enhanced by assigning each assessed value of monthly hours into a care allowance level before calculating weighted averages and applying LOESS.

A.4 Parameterisation

In a first step, we obtain estimates for the probability of needing care by age (in years), sex and education (three levels).[16] This is achieved by fitting weighted shape constrained additive models within subgroups to the dummy dependent variable of having positive assessed hours of care need, using monotone increasing P-splines to estimate smooth functions. Due to the limited number of very old medium and highly educated respondents, we do not differentiate by education from age 90 and implement a smooth transition from age 85 using LOESS. Figure 1 shows the resulting predicted probabilities of having any care need. These probabilities are directly used as input parameters in the microsimulation model. The figure shows the expected strong rise in the probability of having any care need with age across all groups. The less educated group has a somewhat higher chance of needing care over the entire age span.

To obtain estimates for care need in hours by age, sex and education, we restrict the analysis to the subsample with positive assessed hours. In our regression specification, we use assessed monthly hours as dependent variable. As independent variables, we include age, sex and education as well as interaction terms between age and sex as well as age and education. Since we are not only interested in average hours by age, sex and education but also in their distribution, we estimate quantile regressions at decile cutoff values. Subsequently, we calculate decile means for the assessed monthly hours of care need. Due to the linear model specification, we encounter a limited number of negative predicted hours at low ages which we set to zero. Since this concerns only care needs close to zero hours and since the linear specification delivers more comparable and realistic results across countries (observations with high education are limited e.g. in Italy and Spain) we refrain from using non-linear specifications. Figure 2 shows the resulting decile means of assessed monthly hours of care need by age, sex and education which we use as input parameters for microsimulation. The results appear intuitive, i.e. education does not only impact the probability of needing care, but the monthly care need in hours also tends to be lower for more educated individuals.

We next turn to the question of who will be admitted to nursing homes. To facilitate comparability of survey questions in SHARE with Austrian care service statistics, we construct a broadly defined nursing home dummy that encompasses nursing homes and residential homes. Depending on the nursing home definitions in other countries, this indicator could also be narrowed down. Cross-country differences in definitions of what legally counts as a nursing home should ideally be considered and harmonised in our comparative analysis. In the third step of our analysis for Austria, the nursing home indicator is the dependent variable in a logistic regression that controls for age, sex, assessed hours of care need and whether an individual's partner is living in the household[17]. The previous terms are allowed to vary by sex via an interaction term and we also add a separate categorical variable for the number of children. Compared to previous steps, we drop respondents who participated in the SHARELIFE interview in wave 7, because child related questions differ and do not allow for the construction of an indicator for the number of children that is consistent with the regular questionnaire.

In Figure A.10 below, we compare the predictions of nursing home status from our model to Austrian care service statistics. We plot smoothed (LOESS) trend lines through average predicted nursing

[16] Regarding education, we group ISCED 1997 levels into the categories low (0,1,2), medium (3,4) and high (5,6).

[17] Note that in contrast to step 4, we do not differentiate whether the partner is able to care in step 3.

home probabilities by age and sex (in blue) against the nursing home prevalence from official statistics (in black). The figure indicates that our model tends to capture the nursing home probability of women quite well on average. For men, we somewhat overestimate the nursing home probability for over 90-year-olds (note that only few observations are available in our SHARE sample for men in that age range, n = 100).

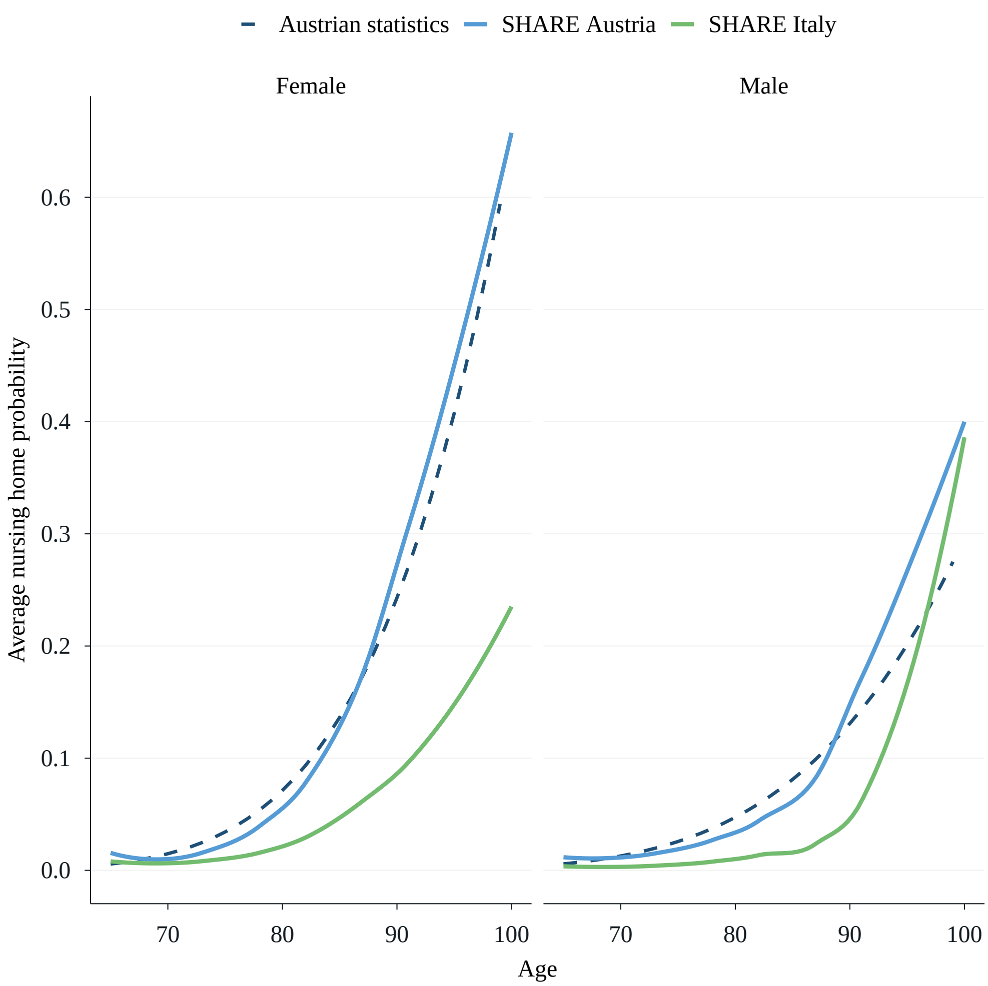


Figure A.10: Validation: Nursing home prevalence in Austria and Italy (weighted). *Notes:* The nursing home indicator is the dependent variable in a logistic regression that controls for age, sex, assessed hours of care need and whether an individual's partner is living in the household. The previous terms are allowed to vary by sex via an interaction term and we also add a separate categorical variable for the number of children. We plot smoothed (LOESS) trend lines through average predicted nursing home probabilities by age and sex against the nursing home prevalence from Austrian care service statistics (dotted line).

Figure A.11 shows the predicted nursing home probabilities that are used as parameters to assign nursing home status in the microsimulation model, by age, sex, care need, presence of a partner and number of children. The figure confirms the expectation that the model consistently assigns higher nursing home probabilities to individuals with higher care need and no partner in the household. Furthermore, we observe that having a child reduces the probability of being in a nursing home and having two or more children reduces this probability even further.

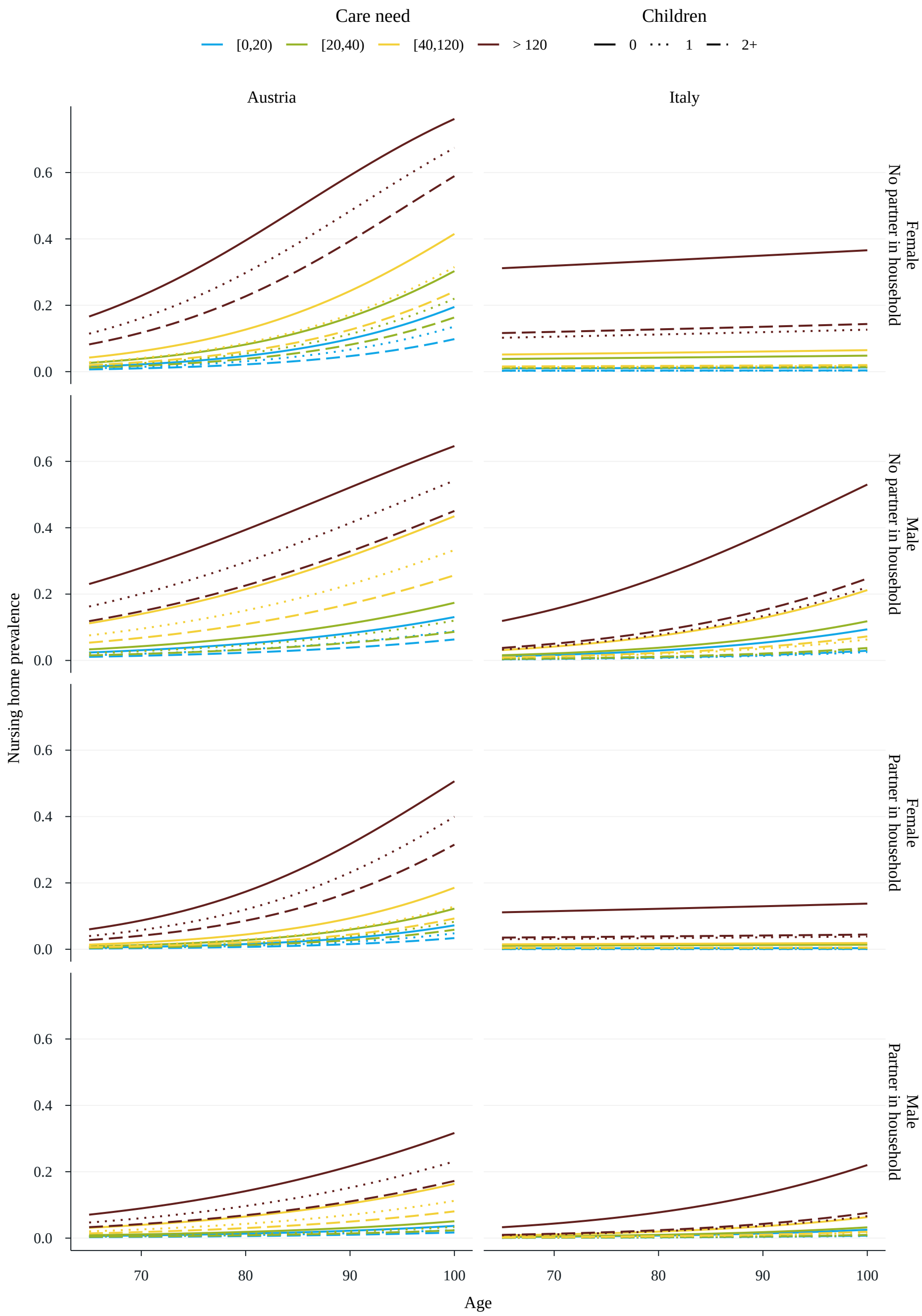


Figure A.11: Step 3 - Nursing home prevalence in Austria and Italy by age, sex, hours of care needed, partner, and children (weighted). *Notes:* The nursing home indicator is the dependent variable in a logistic regression that controls for age, sex, assessed hours of care need and whether an individual's partner is living in the household. The previous terms are allowed to vary by sex via an interaction term and we also add a separate categorical variable for the number of children.

The aim of this step is to determine the probability of receiving any type of care and the average care mix among care recipients, according to family characteristics and care needs in hours. We distinguish between care provided by a partner, informal care provided by others, formal care services and a care gap. Regarding family characteristics, we distinguish people by partnership status (having a partner able to provide care / not having such a partner) and children (no children, children). People without care needs (assessed hours equal to zero) are removed from the sample at this step.

Since home care is not measured consistently across all waves in SHARE, we further restrict the sample and rely on multiple assumptions and imputations. The ultimate goal of our analysis is to identify care gaps. We thus select SHARE waves 1, 2, and 6-9 as these waves contain questions on whether individuals receive help with (I)ADLs and whether this help is sufficient. We only use regular wave 7 participants for parameter estimation at this step since the receipt of informal care is not available for SHARELIFE respondents.

Formal home care (FHC) is measured by specific questions in SHARE. Waves 1, 2, 7, 8 and 9 include questions on how many weeks in a year personal care, domestic help, or meals-on-wheels, were received, respectively. For personal care and domestic help there is an additional question on the average number of hours received per week. We compute average monthly hours received for each care type. For meals-on-wheels, we assume 7 hours per week in line with the number of hours provided for food preparation in the Austrian care allowance system. Adding together the average hours for the different care types, we obtain the average monthly hours of formal home care received. Outliers receiving above 720 hours per month are capped (only applies to few cases). In wave 6, SHARE only contains dummy variables on whether personal care, domestic help, or meals-on-wheels were received. For respondents in wave 6, we thus assign average hours received for the respective care type, as computed from the other waves[18].

Hours of outside informal care (OIC) can also be obtained in SHARE. The relevant question asks respondents whether they receive help with (I)ADL related tasks from outside of the household and from whom. Three helpers are identified and for each of these helpers the frequency of help is established (daily, weekly, monthly, yearly). In waves 1 and 2 there are also additional questions asking for the number of hours provided for each interval. We calculate average hours received for each interval in waves 1 and 2 and assign them to individuals in waves 6-9 who receive help in the respective intervals. Total monthly average hours of outside informal care received are then calculated by adding up hours across helpers and outliers are again capped at 720 hours per month.

A large share of home care is usually provided by partners or other household members. However, SHARE does not capture help within the household in detail. The related question only asks whether one receives intensive (daily or almost daily) care from another household member. To complete the home care mix, we therefore estimate hours of care received from partners and household members.[19]

The approach we choose to obtain care hours within the household amounts to the assumption that

[18] SHARELIFE observations from wave 7 are included in the estimation of average hours by type of FHC.

[19] Note that hours of informal care estimated to be given by other household members are assigned to outside informal care below, because we only model nuclear families in microWELT.

partners and other household members cover any residual hours of care needed. To calculate the individual care mix and whether there is any care gap, we draw on the information available in SHARE and construct a large decision tree (see Figure A.16 below). We first split the sample according to the type of information available in SHARE on care received. About one third of respondents report to receive help with ADLs (question ph050), and for these respondents we also have self-reported information on whether there is a gap between the care they need and receive (addressed in question ph051). We label this group "care received: full info". Then there are about 20 percent of respondents who say that they do not get help with ADLs at the respective question, but report that they get ADL related FHC or OIC on other questions (care received: limited info). Furthermore, almost half of the respondents say that they receive none of these types of care. We next determine whether each individual has a partner in the household and whether the partner is able to provide care. The latter is given if the partner is not in a nursing home and has an assessed care need of below 180 hours per month. Care provided by other persons living in the household is treated as informal care provided by others (outside the household), because we only model nuclear families. In cases where there is no partner able to provide care, additional household members are assumed to cover any shortfall, so we assume that there is no care gap in these cases. Next, respondents may receive formal home care, outside informal care or both.

Finally, we determine whether there is a gap or not. For this purpose we subtract any hours received from the individual hours needed. We assume that there is no gap if a caring partner or other household member is present who provides all the care needed. This strong assumption may be at odds with a reality in which people with care needs may be confronted with a care gap even if they live in the same household as their partner or other persons. However, without information on the actual amount of care provided within the household, there is no way of capturing differences in care provision between households with similar characteristics. More importantly, the assumption that household members fill any existing care gap is conducive to one of the objectives of our modelling approach, namely to assess the extent to which demographic shifts and changes in household composition will increase the pressure on the provision of formal and informal care from outside the household. Furthermore, we believe that this assumption is instructive because any remaining care gap that we estimate presents a lower bound on the actual care gap.

For respondents without caring partner or other household members, we make use of the self reported gap information. In case no gap is reported, any remaining hours are allocated to OIC, if both OIC and FHC are received, or to either FHC or OIC, if only one of both is received. In the end, we obtain the individual care mix, and whether there is a full or partial gap between care hours received and needed. Figure A.16 below provides further detail and shows only the branches of the tree for which data is available.

Having obtained the individual care mix in the sample with positive care need, we next estimate the parameters for microsimulation. We start with the probability of receiving any care. Figure A.12 shows predicted care receipt probabilities from a logit model interacting the covariates assessed care need, partner and children. The results show that, as a consequence of our assumptions, virtually all people with partners in their household receive care and only few partners are classified as unable to care. For people with partners, we do not make use of these estimates as parameters, since we can determine a partner's ability to care from assessed care hours in the model. For people without partners in their household, on the other hand, we observe that there is a substantial chance of not receiving care, especially at lower levels of care need. Furthermore, having children improves the chances of receiving care. The estimates of care receipt probabilities for people without partners are used as parameters in the microsimulation model.

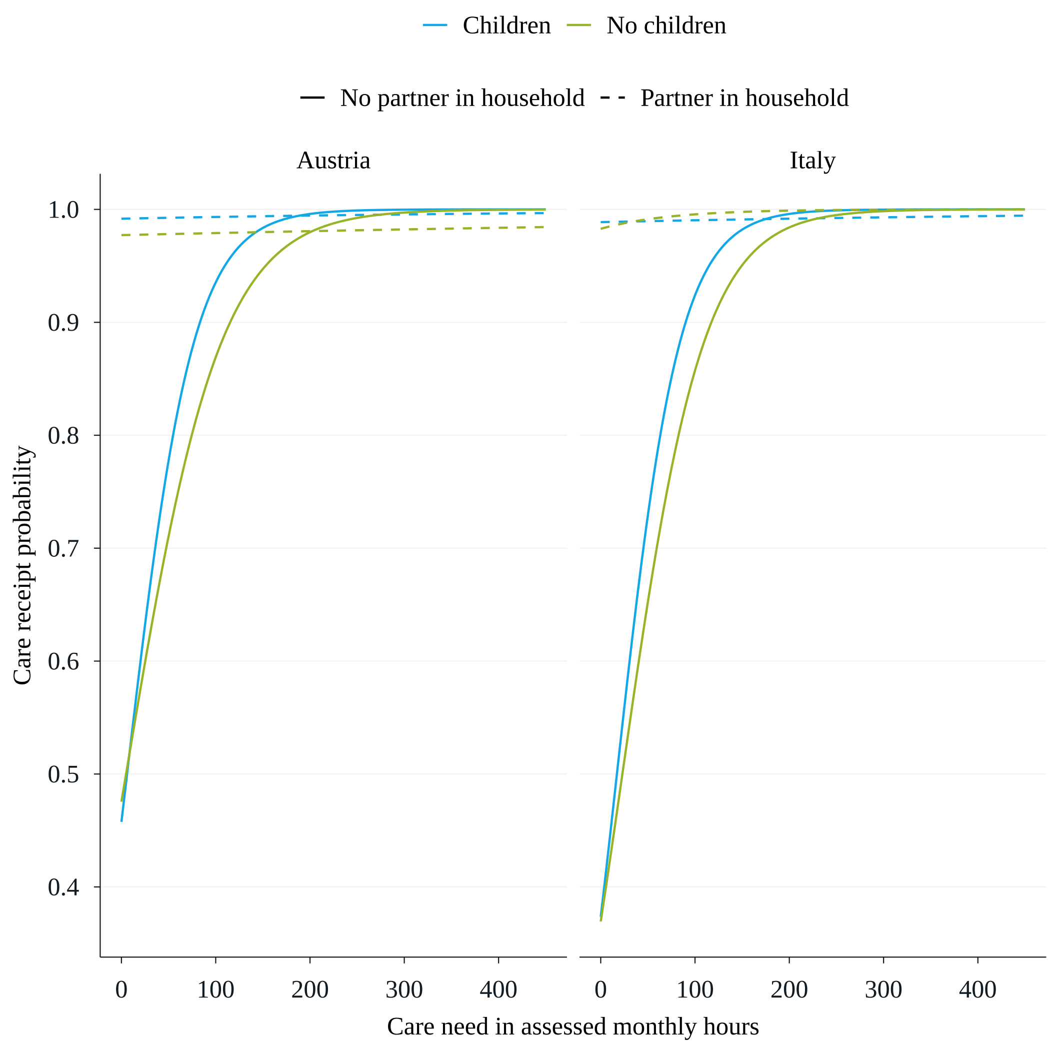


Figure A.12: Step 4 - Care receipt probability within the care need sample in Austria and Italy by assessed hours of care need, presence of a caring partner and having children (weighted). *Notes:* We report predicted care receipt probabilities from a logit model interacting the covariates assessed care need, partner and children.

In the next step, we calculate the average care mix across groups of care recipients depending on their care need, the presence of a caring partner and their number of children.[20] For this purpose, we compute the share of total hours received for each care type within each group. Since we have previously capped care hours received at care hours needed for our care receipt estimation procedure, we add back "excess" hours received at the individual level before calculating shares of total hours. This is necessary to avoid introducing gaps by our procedure and to maintain consistency with the imputation of average hours to missing observations. Figure 3 shows the resulting care mix for each group. We note that the share of formal home care rises with needed care hours. Furthermore, having two or more children vs. no children or one child somewhat increases the share of outside informal care. For those with a partner able to provide care, the share of partner care declines with increasing care need, except for very low levels of care need. On the other hand, people without partners able to care tend to experience the largest gaps at intermediate levels of care need.

In the last step, we estimate parameters on average hours of care provided informally to adults outside the household by age and sex. To obtain complete age profiles, we opt for an approach that combines estimates from SHARE for the 50+ population with estimates from EHIS for people under 50.

The questions posed to SHARE respondents regarding informal caregiving outside the household closely resemble those related to received informal care that we utilised in the previous step. Respondents report whether they have given help with (I)ADL related tasks to a family member from outside the household, a friend or neighbor (and to whom). Three care recipients are identified and for each of these the frequency of help is established (daily, weekly, monthly, yearly). In waves 1 and 2 there are also additional questions asking for the number of hours provided for each interval. We again calculate average hours given for each interval in waves 1 and 2 and assign them to individuals in waves 4-9 who provide help in the respective intervals[21]. Total monthly average hours of outside informal care given are then calculated by adding up hours across helpers and outliers are again capped at 720 hours per month.

We next turn to EHIS, which asks respondents if they provide informal care at least weekly and then discerns the intensity of weekly care in three categories: "less than 10 hours", "10-20 hours" and "20+ hours". Furthermore, EHIS does not distinguish between help that is given within or outside the household. To facilitate the comparability among measures of informal care between EHIS and SHARE, we first calculate the average weekly hours among SHARE respondents providing care at least weekly in three subgroups corresponding to the EHIS intervals. Then we use the resulting estimates to calculate average hours of care given in EHIS by age group and sex (Figures A.14 and A.15 illustrate the adjustment of EHIS hours). We draw on a pooled sample of EHIS waves 2 and 3 for this analysis. Since EHIS respondents may partially report care given within the household, we calculate the ratio of average hours given at least weekly within the 50-54 SHARE age group to the respective EHIS figure and use this ratio to discount care within the household from the EHIS estimates. We assume that the youngest possible comparable EHIS age group (50-54) exhibits the same extent of caregiving within the household than younger age groups. Finally, we compute the difference between the averages of hours given at any interval and hours given at least weekly for the 50-54 SHARE age group and add this figure to the discounted EHIS estimates, assuming that the 50-54 age group is similar to younger

[20] We refrain from modelling this step at the individual level due to sample size limitations.
[21] We only include regular respondents from wave 7.

cohorts in the extent of care given less than weekly. We thus obtain estimates from EHIS on average hours of outside informal care provided by under 50-year-olds.

Figure A.13 below shows the resulting parameters for the microsimulation model on average hours of outside informal care given by age and sex. We combine age group averages below 50 from EHIS with SHARE microdata above 50 and apply statistical smoothing techniques. Furthermore, we impose that people at age 100 provide no hours of care. We observe that average monthly care hours given for women and men peak around age 60 and at around 16 and 10 hours respectively.

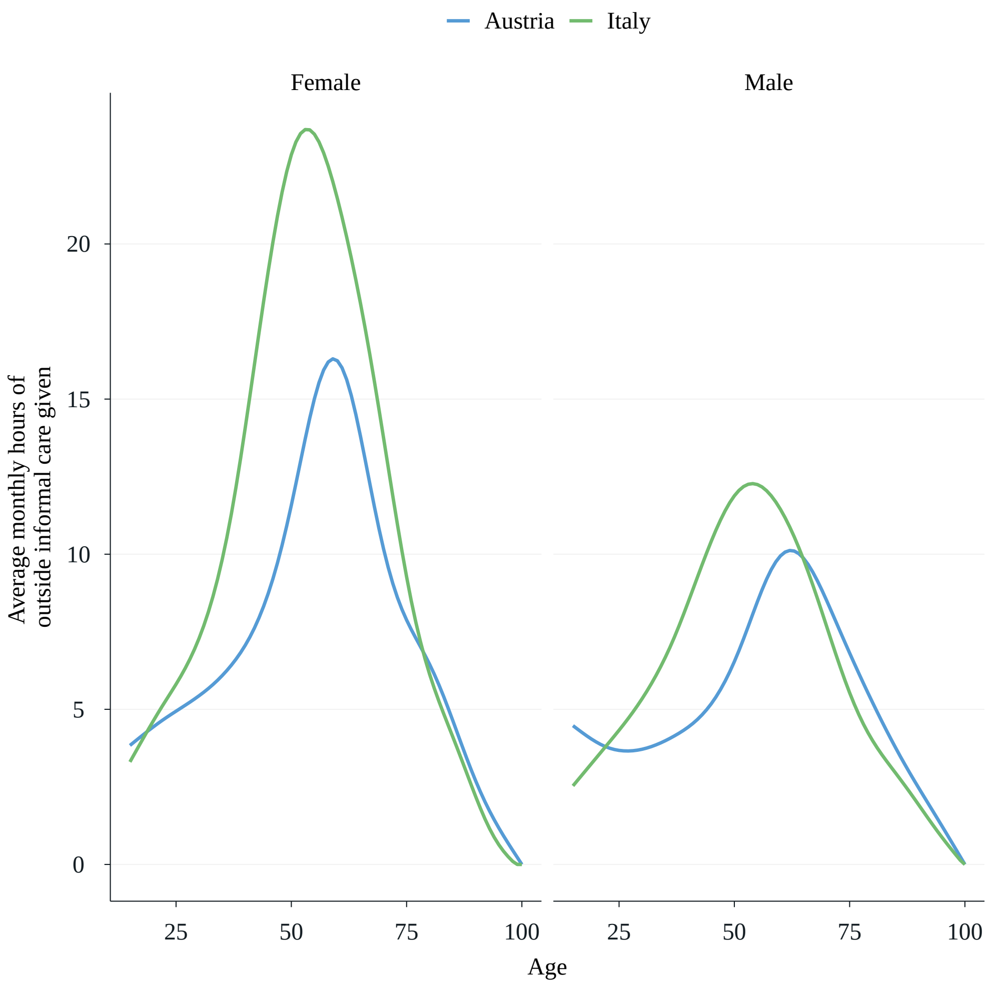


Figure A.13: Step 5 - Average hours of care given in Austria and Italy by age and sex. *Notes:* We combine data from SHARE for the 50+ population with data from EHIS for the population younger than 50 and apply statistical smoothing techniques.

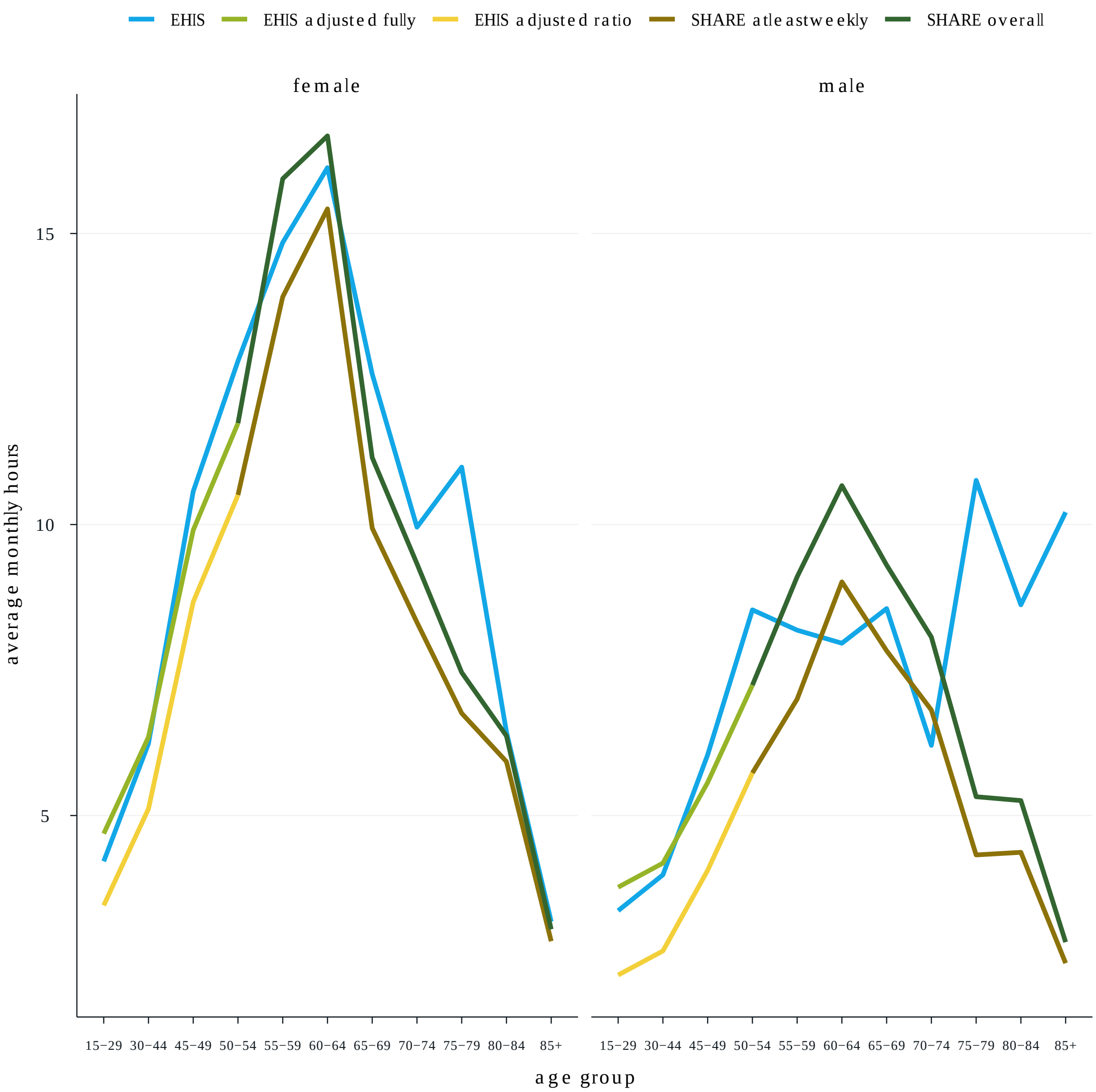


Figure A.14: Comparing and adjusting average hours of care given from EHIS and SHARE by age and sex in Austria. *Notes:* We combine data from SHARE for the 50+ population with data from EHIS for the population younger than 50.

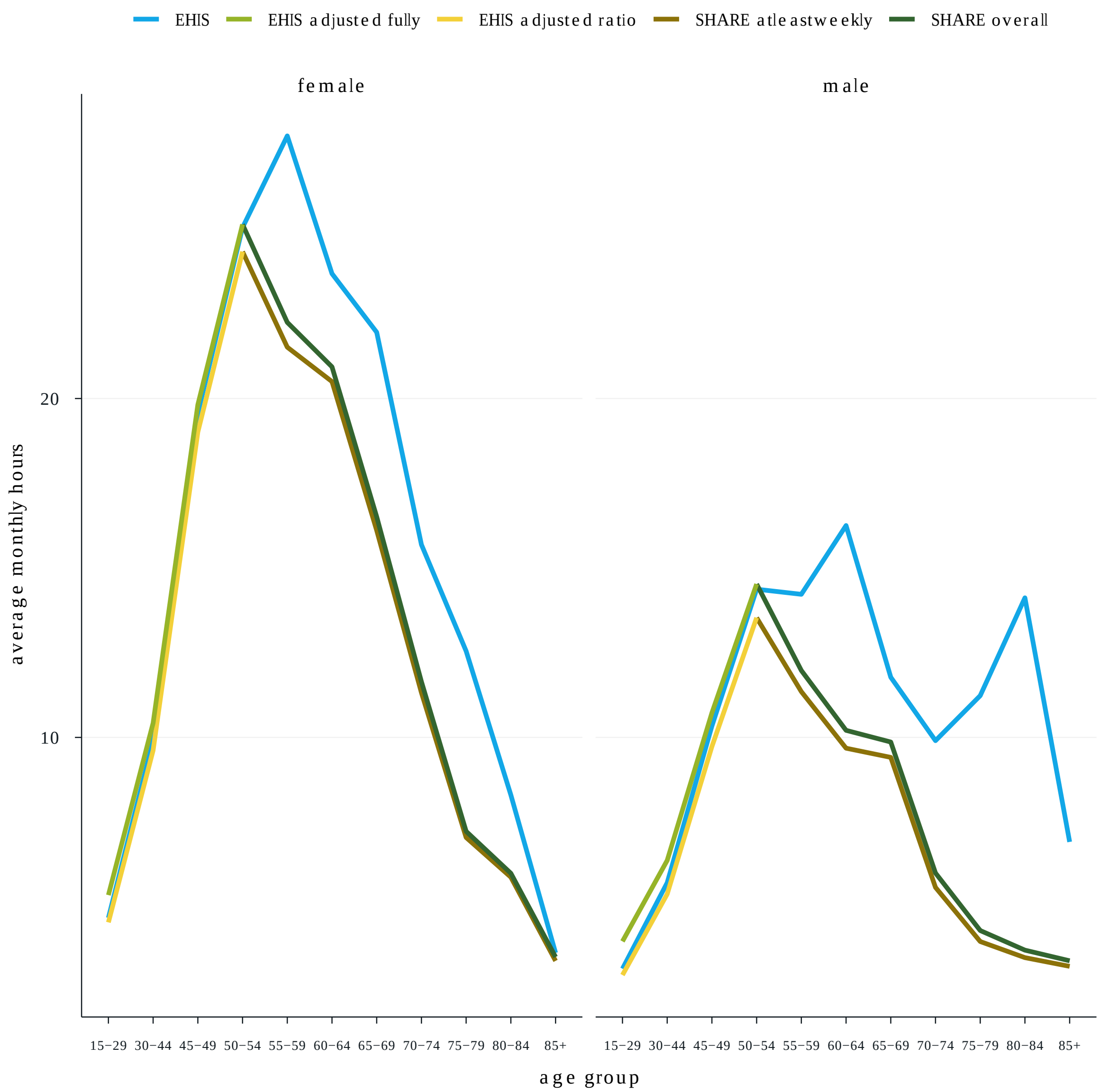


Figure A.15: Comparing and adjusting average hours of care given from EHIS and SHARE by age and sex in Italy. *Notes:* We combine data from SHARE for the 50+ population with data from EHIS for the population younger than 50.

Figure A.16: Decision tree illustration of our approach to obtain the individual care mix in hours from SHARE for Austria. *Notes:* care received: (limited info, full info, none) refers to the care variables available per respondent. We distinguish Formal Home Care (FHC), Outside Informal Care (OIC), full or partial gaps and care from partners or other household (HH) members.

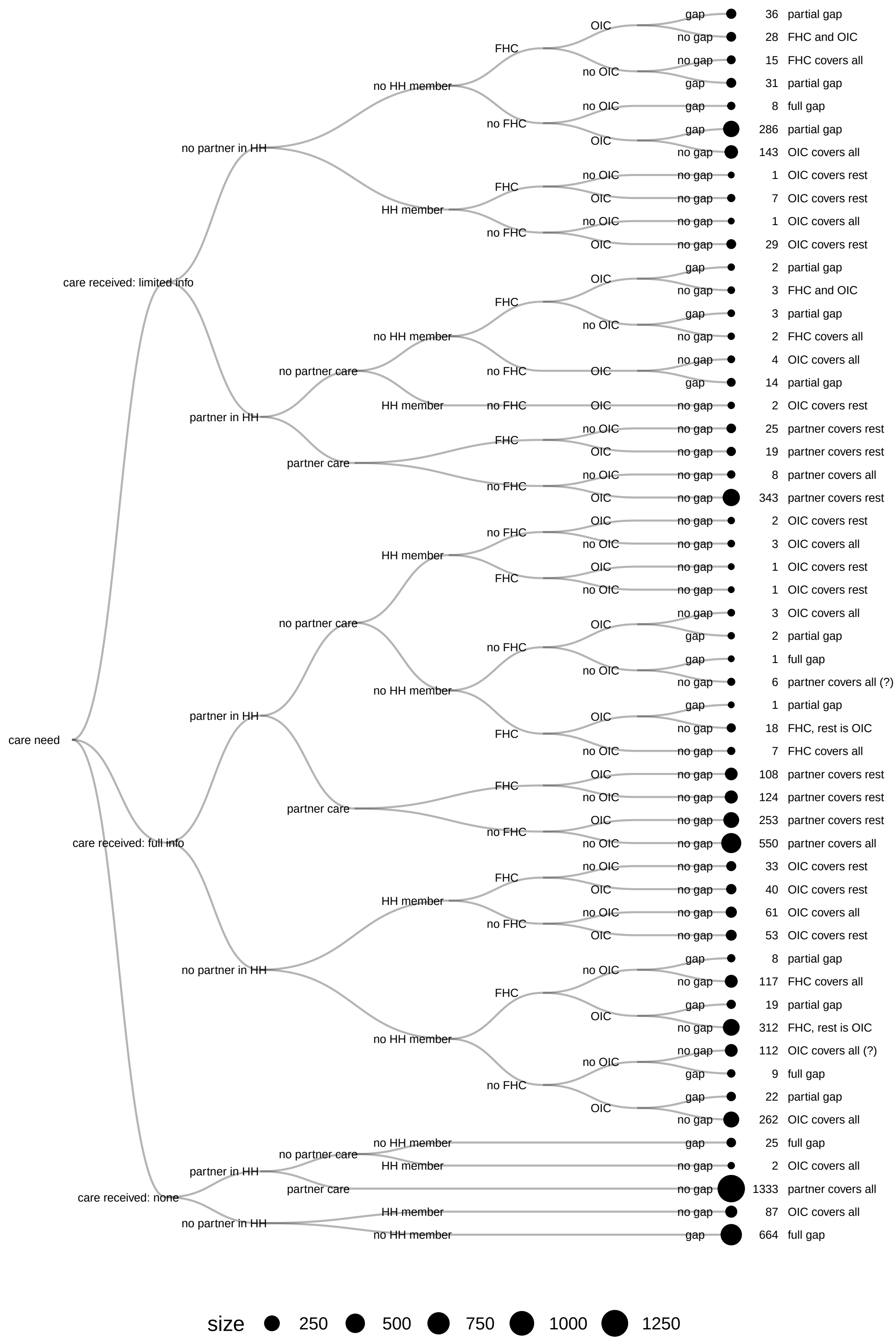
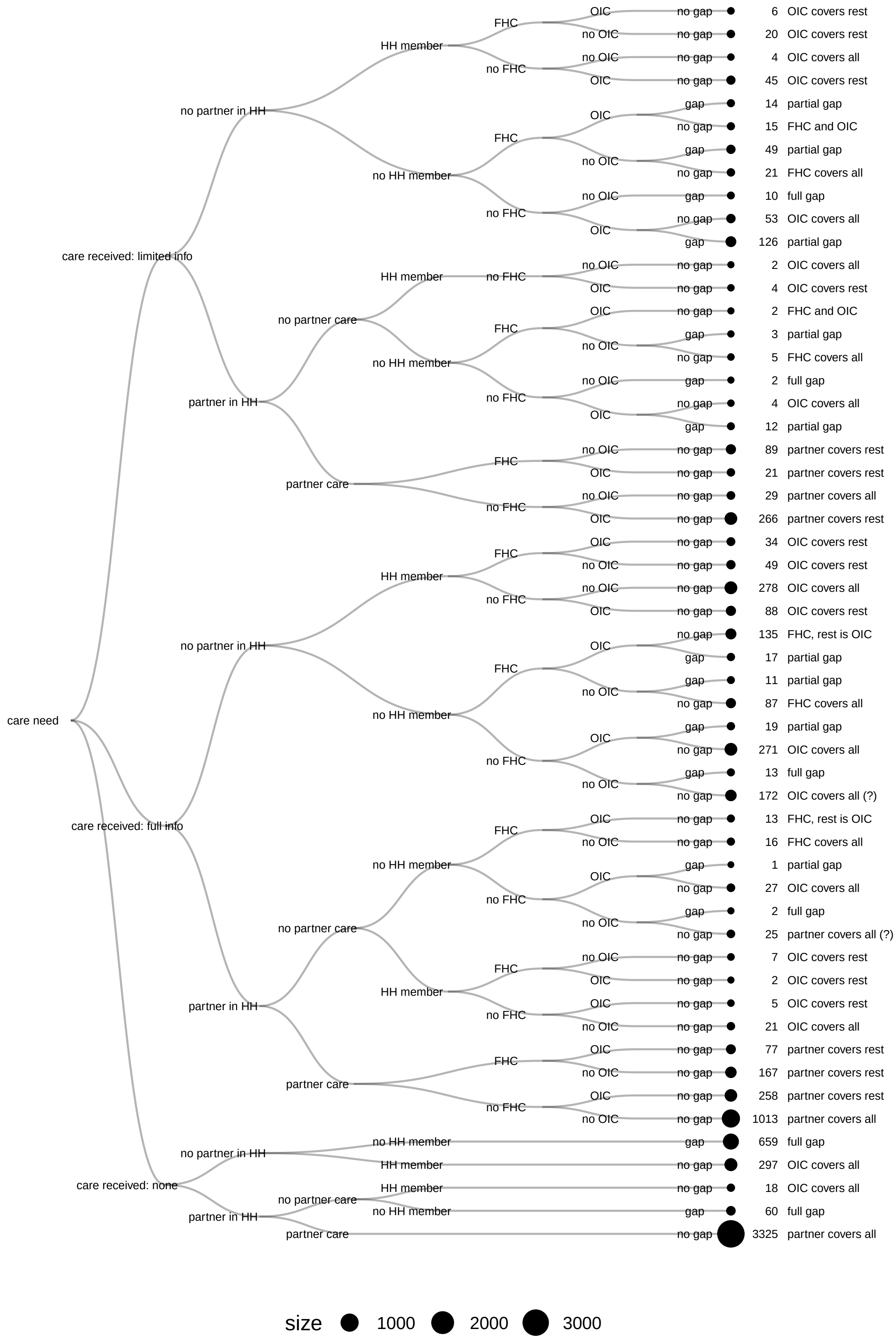


Figure A.17: Decision tree illustration of our approach to obtain the individual care mix in hours from SHARE for Italy. *Notes:* care received: (limited info, full info, none) refers to the care variables available per respondent. We distinguish Formal Home Care (FHC), Outside Informal Care (OIC), full or partial gaps and care from partners or other household (HH) members.



A.5 Simulation Results

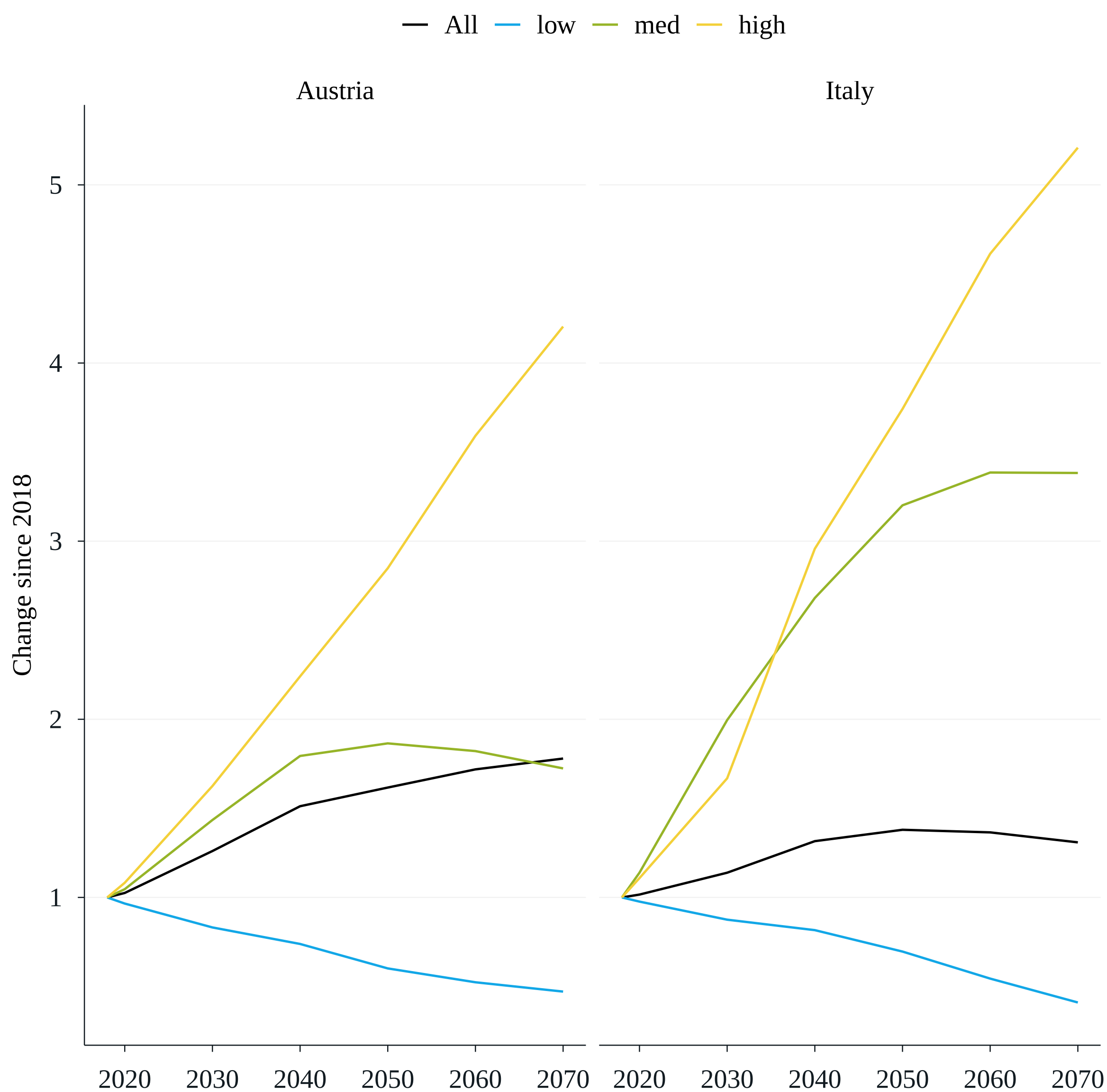


Figure A.18: Relative changes (compared to 2018) in the 65+ population by education in Austria and Italy. *Notes:* We report baseline projections from microWELT.

List of Figures