Life-course health inequalities in European welfare states

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Le doyen

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Impression d'après le manuscrit de l'auteur

Statement

The present work is a cumulative dissertation based on three articles. It has been prepared as a self-contained work and all chapters were composed specifically for this dissertation. Furthermore, all articles were written by me as first author according to the APA author guidelines with edits from my co-authors. The articles are included in this thesis as they were submitted to the respective journals. The articles in Chapters 2 and 3 have been published, while Chapter 4 has been submitted. Terminological and formatting inconsistencies may occur due to the different journal publishing policies.

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Résumé

Les sociétés européennes vieillissent rapidement. Par conséquent, la proportion de personnes âgées de 65 ans et plus devrait croître jusqu'à être bientôt deux fois plus importante que celle des personnes de moins de 15 ans. Cette évolution de la structure par âge de la population représente une menace majeure pour la viabilité des systèmes de santé et de protection sociale. C'est pourquoi les mesures visant à augmenter les chances que les gens passent une plus grande partie de leur vie en bonne santé font partie des actions proposées pour relever ce défi. Cependant, les inégalités en matière de santé sont une réalité dans l'Union européenne. En effet, les personnes ayant un faible niveau d'éducation, un revenu plutôt bas ou appartenant à une classe professionnelle peu élevée ont tendance à mourir plus jeunes et à souffrir d'une incidence plus élevée de la plupart des types de maladies. La recherche sur les parcours de vie montre de plus en plus que le fait de cibler les personnes aux premiers stades de leur vie est l'un des moyens les plus efficaces de promouvoir un vieillissement sain. Les désavantages socio-économiques dans l'enfance peuvent avoir un impact durable sur la santé à un stade ultérieur de la vie.

Les objectifs de la présente thèse de doctorat étaient d'examiner les inégalités sociales de santé dans la vieillesse et d'évaluer les différents processus de parcours de vie qui pouvaient les expliquer. En suivant une approche de recherche comparative, cette thèse a également voulu étudier l'impact des dispositifs de protection sociale des divers pays européens sur les différences en termes d'inégalités de santé. Du point de vue de l'approche par les parcours de vie, trois modèles peuvent expliquer les inégalités en matière de santé : le modèle de la période critique ou sensible, le modèle de la trajectoire et le modèle de l'accumulation. Ces modèles ne s'excluent pas mutuellement et peuvent façonner simultanément des inégalités de santé tout au long de la vie. Outre ces processus au niveau individuel, des facteurs macrosociaux, tels que les politiques sociales et les dispositifs de protection sociale, peuvent avoir un impact sur la manière dont les conditions socio-économiques se traduisent en états et en inégalités de santé. Les différences entre les États-providence peuvent expliquer pourquoi les inégalités sociales de santé sont plus importantes dans certains pays que dans d'autres. Trois grandes questions de recherche ont été abordées dans trois chapitres empiriques.

Premièrement, nous avons cherché à savoir si les conditions socio-économiques et les expériences (de santé) défavorables durant l'enfance étaient associées aux états et aux trajectoires de santé durant la vieillesse. Ensuite, nous nous sommes intéressés au rôle que les conditions socio-économiques de la vie adulte jouaient dans les associations entre les désavantages de l'enfance et la santé à un âge avancé. Enfin, nous avons cherché à savoir s'il existait des différences entre les régimes d'aide sociale dans les associations entre les désavantages dans le parcours de vie et l'état et les trajectoires de santé à un âge avancé. Utilisant de l'enquête SHARE (Survey of Health, Ageing and Retirement in Europe), une grande base de données basée sur la population des plusieurs pays européens, les analyses de cette thèse ont abordé ces questions de recherche de différentes manières. Les informations rétrospectives incluses dans la base de données SHARE ont permis d'étudier les conditions socio-économiques des individus interrogés tout au long de leur vie. La caractéristique longitudinale des données a également permis d'étudier les trajectoires de santé à travers le vieillissement, ce qui est plutôt rare dans la littérature existante en recherche comparative.

Les résultats indiquent que les désavantages socio-économiques et les expériences négatives vécues pendant l'enfance sont associés à des niveaux de santé auto-évalués plus faibles, mais pas aux trajectoires dans la vieillesse. En outre, les personnes ayant déclaré des expériences négatives en matière de santé dans leur enfance ont un plus mauvais état de santé auto-évalué durant leur vieillesse, mais, avec l'âge, leur état de santé se dégrade moins rapidement que celui des personnes n'ayant pas déclaré d'expériences négatives en matière de santé. Si l'on ajoute les conditions socio-économiques de la vie adulte à l'analyse, des différentiels lié aux régimes d'aide sociale apparaissent. Alors que dans les régime sociaux bismarckien ou d'Europe de l'Est les effets néfastes des désavantages de l'enfance sur la santé auto-évaluée à la vieillesse ne sont que partiellement compensés par les conditions socio-économiques de la vie adulte, nous avons trouvé des preuves d'une plus grande mobilité sociale dans les régimes sociaux scandinaves et du Sud, où ces effets négatifs ont pu être largement compensés. En termes de trajectoires de la santé auto-évaluée, les inégalités entre les catégories socio-économiques de la vie adulte sont restées stables ou se sont

réduites avec l'âge, ce qui confirme l'hypothèse de "l'âge comme niveleur". En outre, nous avons trouvé des preuves que l'accumulation de désavantages socio-économiques au cours de la vie conduit à des niveaux inférieurs de santé subjective (santé auto-évaluée) et objective (force de préhension) dans la vieillesse. Alors que pour la santé subjective, les inégalités entre les niveaux de désavantage socio-économique diminuent avec l'âge, elles restent stables pour la santé objective. Une plus grande générosité en matière de protection sociale réduit les inégalités entre les niveaux de désavantage socio-économique chez les femmes mais pas chez les hommes pour la santé subjective, et chez les deux catégories pour la santé objective. En outre, des dépenses de protection sociale plus élevées ont tendance à ralentir l'effet réducteur d'inégalité de l'âge en matière de santé subjective. Cela indique que les dépenses de protection sociale peuvent réduire les processus de sélection de la mortalité en maintenant en vie les individus en plus mauvaise santé pendant une plus longue période.

Ces résultats constituent des preuves de validation des trois modèles de parcours de vie. L'association robuste entre les désavantages de l'enfance et la santé durant vieillesse, sans être compensée par les facteurs de la vie adulte, soutient en effet le modèle de la période sensible. Selon ce modèle, l'enfance est une période sensible pour le développement humain et la santé future. En outre, l'explication partielle des effets de l'enfance par les conditions socio-économiques de la vie adulte soutient le modèle de la trajectoire, indiquant que certaines parties des effets néfastes des désavantages de l'enfance passent par des facteurs de la vie adulte pour atteindre la santé des personnes âgées. Enfin, les résultats soutiennent le modèle d'accumulation dans la première moitié de la vie des individus, mais pas dans la vieillesse. Les processus de désavantage cumulatif peuvent expliquer les fortes inégalités socioéconomiques en matière de santé que nous constatons au début des trajectoires de santé des individus. Cependant, nous n'avons pas trouvé de preuves d'une augmentation supplémentaire des inégalités au cours du vieillissement, dans la seconde moitié de la vie.

En conclusion, cette thèse met en évidence la longue portée des conditions et expériences socio-économiques de l'enfance sur la santé des personnes âgées, tout en montrant également que certains des résultats

défavorables peuvent être traités tout au long de la vie. En outre, elle démontre que des dispositions plus généreuses en matière de protection sociale ont un impact avantageux sur les inégalités socioéconomiques en matière de santé pendant la vieillesse. Toutefois, certains des résultats liés aux différences entre les régimes de protection sociale ne sont pas concluants et doivent faire l'objet d'une étude plus approfondie afin de déterminer les facteurs spécifiques qui les sous-tendent.

Abstract

The European societies are ageing rapidly. As a consequence, the share of people aged 65 or more is projected to grow to twice as many as people younger than 15 years. This shift in the age structure represents a major threat for the sustainability of health and welfare systems. Therefore, measures that increase the chances that people spend a larger share of their life in good health are among the proposed actions to tackle this challenge. However, health inequalities in the European Union are a reality, where people with lower education, with lower income, or who are from a lower occupational class tend to die younger and suffer from higher incidences of most types of diseases. Life-course research has been increasingly showing that targeting people in early life stages is one of the most effective ways to promote healthy ageing. Socioeconomic disadvantages in childhood can have a long lasting impact on health in later life stages.

This dissertation's objectives were to examine the social health inequalities in old age and assess the different life-course processes that may explain these health inequalities. Furthermore, following a comparative research approach, we were interested to study whether there were differences in these health inequalities across welfare arrangements in the multiple European countries assessed. From a life-course perspective, three models may explain health inequalities: the critical or sensitive period model, the pathway model, and the accumulation model. These models are not mutually exclusive and may be simultaneously shaping health inequalities throughout the life course. In addition to these individual-level processes, macro-social factors such as social policies and welfare arrangements can have an impact on how socioeconomic conditions translate into health status and health inequalities. Differences between countries' welfare states may explain why social health inequalities in certain countries are higher than in others. Three main research questions were addressed across three empirical chapters. First, we examined whether childhood socioeconomic conditions and adverse (health) experiences were associated with health status and trajectories in old age. Second, we were interested in the role that adult-life socioeconomic conditions played in the

associations between childhood disadvantages and health in old age. Finally, we investigated whether there were differences between welfare arrangements in the life-course associations with health status and trajectories in old age. With the use of the Survey of Health, Ageing and Retirement in Europe (SHARE), a large population based database across multiple countries, the studies included in this dissertation addressed these research questions in various ways. The retrospective information included in the SHARE database enabled the analyses of socioeconomic conditions throughout the life course. Furthermore, the longitudinal characteristic of the data allowed for the investigation of health trajectories across ageing, which is a rather scarce feature of existing studies in comparative research.

The findings indicated that childhood socioeconomic disadvantages and adverse experiences were associated with lower self-rated health levels but not with trajectories in old age. In addition, people who reported adverse health experiences in childhood had a worse self-rated health status in old age but with increasing age their health status decreased less quickly compared to those who did not report adverse health experiences. With the addition of adult-life socioeconomic conditions, differences between welfare regimes became apparent. While in the Bismarckian and Eastern European welfare regime the detrimental effects of childhood disadvantages on self-rated health in old age could only partly be compensated by adult-life socioeconomic conditions, we found evidence for more social mobility in the Scandinavian and Southern welfare regime, where these negative effects could be largely offset. In terms of self-rated health trajectories, the inequalities between adult-life socioeconomic categories remained stable or reduced with increasing age, which supports the ‘age-as-leveller’ hypothesis. Furthermore, we found evidence that the accumulation of socioeconomic disadvantages over the life course lead to lower levels of both subjective (self-rated health) and objective (grip strength) health in old age. While for subjective health the inequalities between levels of socioeconomic disadvantage reduced over ageing, they remained stable for objective health. Higher welfare generosity decreased the inequalities between levels of socioeconomic disadvantage in women but not in men for subjective

health, and in both for objective health. Furthermore, higher social protection expenditure slowed down the inequality-reducing effect of age in subjective health. This indicates that social protection expenditure may reduce mortality selection processes by keeping individuals in worse health alive over a longer period of time.

These findings are evidence for all three life-course models. The robust association of childhood disadvantage with health in old age without being compensated by adult-life factors supports the sensitive period model. The model states that childhood consists of a sensitive period for human development and future health. Furthermore, the partial explanation of the childhood effects by adult-life socioeconomic conditions supports the pathway model, indicating that parts of the detrimental childhood disadvantages effects go through adult-life factors to old-age health. Finally, the findings supported the accumulation model in the first half of people's life but not in old age. Cumulative disadvantage processes may explain the robust socioeconomic health inequalities we found at the beginning of people's health trajectories. However, we did not find evidence for further increasing inequalities across ageing in the second half of life.

In conclusion, this dissertation evidences the long reach of childhood experiences and socioeconomic conditions to health in old age, while also showing that some of the unfavourable outcomes can be addressed throughout the life course. Furthermore, more generous welfare arrangements are shown to have an advantageous impact on socioeconomic health inequalities in old age. However, some of the findings related to differences between welfare regimes are inconclusive and need further investigation to carve out the specific drivers behind them.

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Chapter 1. General Introduction

1.1 Ageing in Europe

The European continent is experiencing unprecedented ageing of its population with people living longer and healthier lives (European Commission, 2014; Rechel et al., 2013). Due to the increased life expectancy and low fertility rates, the structures of European societies have been rapidly changing over the past decades. The age structure is continuously shifting towards a growing share of people aged 65 or more in these societies. This pattern is expected to continue due to medical advances and improved standards of living (European Commission, 2014). It is forecasted that by 2060 twice as many people will be aged 65 years or older in comparison with people younger than 15 years (European Commission, 2009). The ageing of the societies will impact on the countries' economy, labour market, social security and health care systems (European Commission, 2014). Projections expect that welfare expenditure in pensions and long-term care will increase considerably by 2060.

This shift in the age structure implies that a declining share of the population needs to bear the increasing costs of pension and public health financing (Rechel et al., 2013). This represents a major threat for the sustainability of health and welfare systems. Proposed actions to tackle this challenge include measures to increase the chances that people spend a larger share of their life in good health (healthy ageing), improve societal systems' efficiency to better cope with the needs of older people, and introduce policies that increase participation to the labour force (Rechel et al., 2013). Policies related to health promotion and disease prevention can contribute to healthy ageing. Although most of these policies are targeted at older people, they would benefit people of all ages (Rechel et al., 2013). Consequently, life-course research has been increasingly showing that one of the most effective ways to promote healthy ageing is to target people in very early life stages, such as childhood and young adulthood. Evidence shows that factors like socioeconomic position and general living conditions at early life stages can

have a long lasting effect through the life course on later health (Rechel et al., 2013).

A glance at recent reports reveals socioeconomic and demographic inequalities in health within and between European countries (European Commission, 2013, 2014). For instance, throughout the European Union a social gradient in health status exists, where people with lower education, with lower income, or who are from a lower occupational class tend to die younger and suffer from a higher incidence of most types of diseases (European Commission, 2013). To be concrete, men with a university degree had a life expectancy at 30 which was 3 to 17 years higher compared to men with basic or lower secondary education in 2010. For women this gap ranged between 1 to 9 years (European Commission, 2013). These numbers evidence that there are large differences in the healthy-ageing prospects for people with regards to their socioeconomic background. As a consequence, tackling social inequalities is crucial in ageing European societies in order to ensure fair healthy-ageing chances for all, thereby minimising the impact of poor health on increasingly challenged health and welfare systems. Indeed, the European Union's report on health inequalities states "the need to achieve an equitable distribution of health as part of overall social and economic development" (European Commission, 2013).

1.2 Health inequalities

In order to make social inequalities in health visible, we need to think about how to measure social inequalities in the first place. Over the past decades of research on social inequalities in general and social inequalities in health in particular, researchers have been using a myriad of different measures while essentially trying to study the same thing (Bartley, 2017). Often enough, findings based on different measures of social inequalities are compared without paying attention to them potentially not measuring the same underlying social processes. The wealth of studies published on social inequalities in health in the past 10 years has made it clear that confusion around how we should understand social inequality has major implications for research on health

inequalities (Bartley, 2017). Therefore, the following section's aim is to clarify the use of social inequality measures which were used in the empirical chapters presented below in this dissertation (Chapters 2, 3, and 4).

1.2.1 Measuring social inequalities

The measurement of social inequalities is usually performed by focusing on indicators of social position (Bartley, 2017). Social position can be assessed in two ways: social class and social status. Although in many studies the two concepts are used interchangeably, they do not have the same influence on different types of health outcomes (Bartley, 2017). This is due to the distinctive underlying social concepts they represent. Most of the measures of social class used in studies in the US and UK are based on theories of social structure linked to the thinking of Marx and Weber (Bartley, 2017; Galobardes et al., 2006; Krieger et al., 1997; J. W. Lynch & Kaplan, 2000). As such, their focus lies on the dimension of occupation, which they divide into groups according to employment conditions and employment relationships. These groups represent the social classes, which are not intended to be ordered into 'lower' or 'higher' classes by the underlying concepts. The construction of these classes is based on two factors (Bartley, 2017; Krieger et al., 1997). Firstly, the ownership of assets, such as property, factory, or firms, which determines whether an individual needs to work for his or her living or whether these assets make working for a wage obsolete. Secondly, for those who do need to engage in paid work, their relationship with those who own and manage their work places, with those who supervise their work, and with those whose work they supervise in turn are taken into account for classification. Consequently, the people are most commonly grouped into classes consisting of 'owners', with sub-groups according to the number of employees they contract, and classes consisting of employees with sub-groups according to the skill level needed to practise their work (Bartley, 2017).

As opposed to social class without inherent ordering of the different classes into 'low' or 'high', social status involves the concept of applying a hierarchy to the society (Bartley, 2017). The hierarchy is used to rank the people

in a society from low to high or from bottom to top. This status order reflects perceived, and to a certain degree accepted, social superiority, equality, or inferiority among individuals of a society, which is not based on personal qualities (Chan & Goldthorpe, 2007). While social class is essentially related to occupation, social status is independent of occupation and often related to purely ascribed attributes derived from an individual's family, religious, or ethnic background (Bartley, 2017). Thus, the hierarchy is derived from the level of 'social honour' linked to these attributes (Chan & Goldthorpe, 2007). The differentiating factors between the various levels of the hierarchy ladder are the different types of lifestyles that are seen as appropriate to the status levels. The sources of social status are specific to historical time and place, whereas this is not the case for social class (Chan & Goldthorpe, 2007).

By the above accounts describing the different measures of social position, namely social class and social status, it becomes apparent that neither education nor income have been considered so far in the construction of these measures. While social class is usually based on occupation, social status is derived from attributes ascribed to an individual that have no relation to personal merits, such as ethnicity and family background. However, education, income, and wealth have been used extensively in research, particularly in relation to health outcomes, to measure people's position in society and have been shown to make important contributions as social determinants of health in studies from the US and Europe (Mackenbach et al., 2003; R. Wilkinson & Marmot, 2003). Consequently, a strand of research has coined the term 'socioeconomic position' to include a broader range of indicators of social position. "[The term] refers to the social and economic factors that influence what position individuals or groups hold within the structure of a society" (Galobardes et al., 2006, p. 7). Socioeconomic position can be measured through various indicators related to aspects of socioeconomic stratification (Galobardes et al., 2006; Krieger et al., 1997; Lynch & Kaplan, 2000). Especially when measuring life-course socioeconomic position, indicators with varying importance at different life stages are very powerful in describing a socioeconomic gradient (i.e. the hierarchical ordering of individuals of different position in an outcome)

(Galobardes et al., 2006). Such indicators can include parent's occupation, household condition in childhood, education, occupation in middle age, and household income in old age. Note that the life-course concept and its implications in health research is introduced in more detail in section 1.3.

In this dissertation we follow the concept of socioeconomic position to describe people's position in society and the general conditions they live in. Moreover, this concept seems best adapted to capture a large part of social inequalities, as using only one indicator might come short of representing an individual's socioeconomic living conditions. Thus, it is suggested to use a broad range of socioeconomic position indicators, preferably measured across the life course, to capture as much of people's social circumstances as possible and reduce residual confounding by unmeasured social stratification processes (Bartley, 2017; Galobardes et al., 2006).

1.2.2 Social inequalities in health

Research in health inequalities is now about 40 years old. Differences in health by social position have gained a lot of traction with the publication of the famous Black Report in 1980 (Department of Health and Social Security, 1980). At the time, the report brought health inequalities on the map of both public policy and academic research by outlining the health disparities in England and Wales from the 1950s to the 1970s (Bartley, 2017). The report's key contribution was to display the links between health and social class. The focus of the report lied on comparing different types of geographical areas, such as poorer and richer areas or rural and urban areas (Bartley, 2017; Department of Health and Social Security, 1980). The findings had initiated dedicated debates that are still ongoing about why people from disadvantaged areas and social classes were showing higher mortality rates and worse health in multiple indicators. Since the publication of the Black Report a few decades have passed, and with them many more reports have been published and the body of research in this topic has grown considerably (Mackenbach et al., 2003; Wilkinson & Marmot, 2003).

The initial findings from England and Wales have been replicated all over Europe as well as in other industrialised societies over the past decades

(Bartley, 2017; Mackenbach, 2019). For instance, the report on health inequalities in the European Union states that the gap in life expectancy at birth between men with the lowest and those with the highest socioeconomic position was 11.8 years in 2011 for its 27 member states (European Commission, 2013). For women this figure was 7.9 years of difference in life expectancy at birth. While it has now been widely established that health is distributed along a social gradient, going from the best health status for the most advantaged individuals according to their socioeconomic position to the worst health for the most disadvantaged, the explanations for how social inequalities translate into health inequalities is still subject to ongoing debates within the academic community (Bartley, 2017; Mackenbach, 2019).

Since the Black Report and the many other reports that have followed, numerous European countries have started to tackle social inequalities by means of social policies (Mackenbach, 2019). Through the strengthening of their welfare states by progressive taxation and social security arrangements they have succeeded in reducing inequalities in income, living conditions, and access to services (Kersbergen & Vis, 2013; Mackenbach, 2012, 2019). However, socioeconomic inequalities in health have persisted until today, and in some countries have even widened, which represents a big puzzle in the field of health-inequality research (Bambra, 2011; Bartley, 2017; Mackenbach, 2019).

There are three main models explaining how social inequalities become health inequalities: the behavioural and ‘cultural’ model, the psychosocial model, and the materialist model (Bartley, 2017). The following section will go through each of them and outline their theoretical explanations for the existence of health inequalities. In addition, as each of the main models is now agreed to be active over the whole life course (Bartley, 2017), a life-course approach in health inequalities research became increasingly important over the past 20 years and has been integrated with the main explanations (Shuey & Willson, 2014). We will discuss the life-course explanation for health inequalities in section 1.3. Moreover, as opposed to the focus on individual factors proposed by the main models, a growing body of research has developed on the macro-social explanation for health inequalities (Bergqvist et al., 2013; Mackenbach,

2019; R. Wilkinson & Pickett, 2009). The basic idea of this approach is that countries with more generous welfare provision tend to have lower income inequality, better public health, education, housing and transport services (Bartley, 2017). As a consequence, health inequalities are expected to be lower in countries with more generous welfare states than in countries with less generous welfare provision (Bartley, 2017; Mackenbach, 2019). This explanation is discussed in section 1.4.

1.2.3 Explanatory models of health inequalities

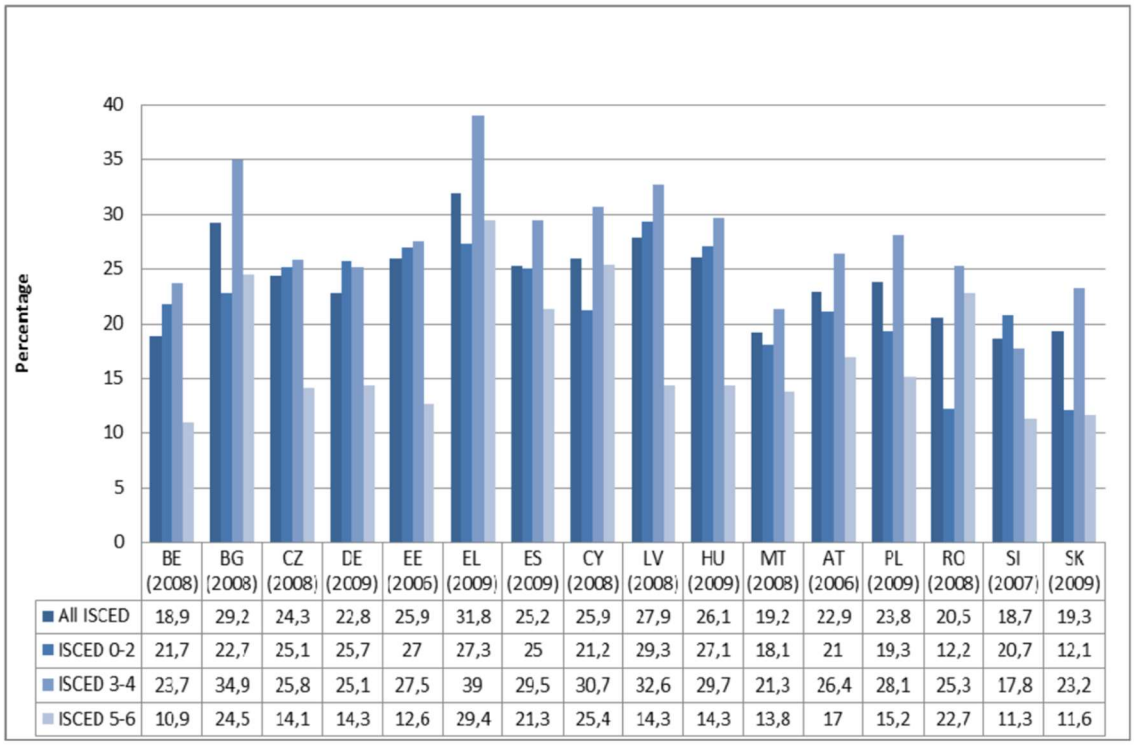
This section will present the three main types of explanatory models influencing health inequalities. These explanatory models are fundamental in understanding health inequalities in the European context (Bartley, 2017). It is important to note that the three types are not mutually exclusive and can be simultaneously responsible for health inequalities. Moreover, they might not have an identical influence on different health outcomes and may account for a varying share of health inequalities according to the diseases studied (Bartley, 2017).

The behavioural and cultural explanation

The behavioural and cultural explanation focuses on types of consumption and leisure activities related to health (Bartley, 2017). The most prominent among these are risky behaviours linked to smoking, alcohol consumption, physical inactivity, and unhealthy diet (too much fat, sugars, and salt). It is well established by existing research that these kinds of risky behaviours can have negative consequences on a wide range of health outcomes, such as cardiovascular disease and cancer as evidenced by European and US data as well as worldwide data from the World Health Organization (Mackenbach, 2019; Mozaffarian Dariush et al., 2008; Weiderpass, 2010), both in terms of health status and decline of health in old age (Foraker et al., 2011). Research in health inequalities has shown that these behavioural determinants of health are distributed unequally in European populations (European Commission, 2013; Mackenbach, 2019). The more socioeconomically disadvantaged an individual’s position in a society is, the

more likely it is that he or she engages in unhealthy behaviours. In sum, these behaviours decrease the probability to maintain a healthy functioning of the body over the life course and up to an advanced age and might even accelerate health decline due to ageing. For instance, the European Commission's report on health inequalities and their underlying determinants states that smoking rates are highly socially patterned when looking at educational level (European Commission, 2013). With the exception of Bulgaria, Cyprus, Greece, and Romania, smoking rates for those with a university degree were lower than for those with secondary or primary education (see Figure 1).

The links between risky behaviours and worse health in combination with the social patterns of such behaviours do not, however, explain why socioeconomically disadvantaged individuals tend to engage in such health-worsening behaviours. Generally, there are two different strands of explanations for the social patterns in health behaviours. One explanation focuses on individual characteristics and the other on cultural differences between social groups. The 'individualized behavioural model' suggests that individuals with



	BE (2008)	BG (2008)	CZ (2008)	DE (2009)	EE (2006)	EL (2009)	ES (2009)	CY (2008)	LV (2008)	HU (2009)	MT (2008)	AT (2006)	PL (2009)	RO (2008)	SI (2007)	SK (2009)
All ISCED	18,9	29,2	24,3	22,8	25,9	31,8	25,2	25,9	27,9	26,1	19,2	22,9	23,8	20,5	18,7	19,3
ISCED 0-2	21,7	22,7	25,1	25,7	27	27,3	25	21,2	29,3	27,1	18,1	21	19,3	12,2	20,7	12,1
ISCED 3-4	23,7	34,9	25,8	25,1	27,5	39	29,5	30,7	32,6	29,7	21,3	26,4	28,1	25,3	17,8	23,2
ISCED 5-6	10,9	24,5	14,1	14,3	12,6	29,4	21,3	25,4	14,3	14,3	13,8	17	15,2	22,7	11,3	11,6

Figure 1 Daily smokers by educational level (ISCED) in selected EU Member States (Source: European commission's report on health inequalities in the European Union, 2013)

lower socioeconomic position are endowed with certain types of personal characteristics distinguishing them from higher socioeconomic groups (Goldberg, 2012). These individual characteristics are related to concepts like ‘general skills, ‘coping skills’, or personal resilience as pointed out by US and European research (Mackenbach, 2010; Pulkki et al., 2003). The assumption is that people with lower socioeconomic position have done less well in school and as a result of this are not able to follow the health education messages communicated by their governments (Mackenbach, 2012). Further, socially disadvantaged people may not have the cognitive abilities and personal characteristics (self-control) to grasp the long-term impact of their risky health behaviours that may be giving them short-term pleasure (Bartley, 2017). While there is some limited evidence for this model from US and French studies, unambiguous and robust results are still scarce, partly because this hypothesis is difficult to test (Bartley, 2017; Chapman et al., 2010; Nabi et al., 2008). Furthermore, criticism with regards to this explanation has pointed out that research into non-modifiable individual characteristics can have dangerous consequences if not carefully carried out (Mackenbach, 2005). Potentially misinterpreted findings and incautious discussions of them might lead to the erroneous conclusion that health inequalities are inevitable and irremediable (Dorfman, 1995; Mackenbach, 2005).

On the other hand, the cultural explanation takes a more structural angle. This explanation goes back to the influential work of French sociologist Pierre Bourdieu. According to his theory, a wide range of behaviours, such as leisure activities and diet, are part of strategies that people adopt in order to display their membership in higher status social groups, while at the same time distancing themselves from lower status groups (Abel, 2008; Bourdieu, 1986). The adoption of specific health behaviours may serve as a means to induce social distance and signal the membership to a high status social group. This in turn can have beneficial effects both on physiological health by healthy behaviour and subjective health by inducing a feeling of privilege (Abel, 2008).

The materialist explanation

The materialist explanation of health inequalities has its roots in the observation that Finnish people with less income and wealth than others also showed worse health and had lower life expectancy (Aittomäki et al., 2012), as well as faster declining health over the ageing process in US individuals (Koster et al., 2005). In contrast to the behavioural and psychosocial explanations of health inequalities, the materialist explanation emphasises the role of negative exposures (such as health risks at the workplace and unfavourable housing conditions) and lack of resources (e.g. money) (J. W. Lynch et al., 2000). Not only are individual-level indicators of material deprivation important but also macro-level determinants of material living conditions, such as underinvestment in public infrastructure and services (Kawachi & Kennedy, 1999; Mackenbach, 2019). One of the obvious ways in which material resources affect health is through the direct pathway of deprivation. People who live in poverty or severe deprivation do not have the means to sustain a healthy life due to inadequate housing (cold, damp, or infested with mould) and insufficient calories and nutrients as compared to people with sufficient resources to do so. Despite the vast success of industrialised countries to tackle poverty in the 20st century, there is still a considerable share of people living in conditions deemed insufficient. The report on health inequalities in the European Union includes a figure (see Figure 2) showing the percentage of people living with severe material deprivation defined as experiencing at least four out of nine of the following deprivation items (European Commission, 2013): they cannot afford (1) to pay rent/mortgage or utility bills on time, (2) to keep home adequately warm, (3) to face unexpected expenses, (4) to eat meat, fish or a protein equivalent every second day, (5) a 1-week holiday away from home, (6) a car, (7) a washing machine, (8) a colour TV or (9) a telephone (including mobile phone). The report states that there was a 5 times higher risk of people living in severe material deprivation reporting their health as poor or very poor compared to people with zero deprivation items.

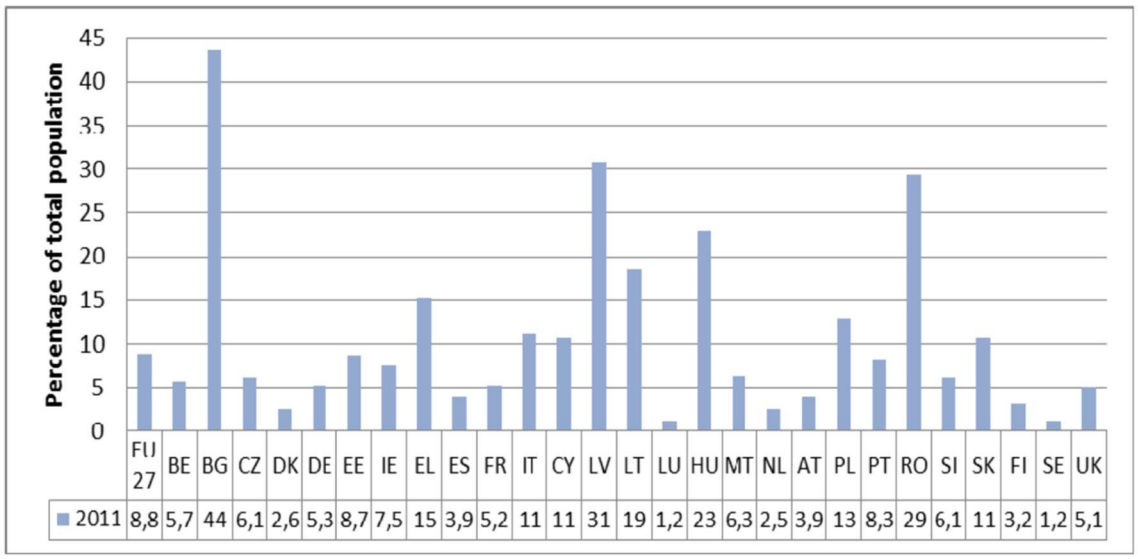


Figure 2 Percentage of the population with severe material deprivation in the EU, 2011. (Source: European commission's report on health inequalities in the European Union, 2013)

While poverty and severe deprivation were shown to be associated with health, studies suggest that not only these extreme material conditions affect health in a negative way. In other words, poor health and mortality are not just more prevalent among the 'poor' and average among the rest of the population. Rather, it has been evidenced in the US, Canada, England, and Germany that with each step up the income ladder people show better health (Bartley, 2017; Waldron, 2013). Researchers have been trying to find plausible explanations for why income is associated with health in this graded way. It appears that this is the case because income serves as a cause and indicator to exposure of physical hazards (Bartley, 2017). For instance, the higher people's income, the better will be their housing conditions, the better will be the neighbourhood they live in protecting them from pollution and other nuisances and the less will they be in contact with physical hazards at work (Benzeval et al., 2014; Martikainen et al., 2001).

The psychosocial explanation

The psychosocial explanation of health inequalities is based on the observation that differences in health between socioeconomic groups seem to be too big to be purely explained by material factors only (Bartley, 2017). Due to the rise of

the welfare state and economic development, literal starvation and direct mortal threats linked to severely precarious economic conditions are seldom in the industrialised countries of Europe. Thus, there must be another explanation than a purely material one in order to account for the ubiquitous and striking health inequalities found all over European countries (Marmot & Wilkinson, 2001). As a consequence, a prominent alternative has been proposed by the psychosocial model. The idea behind this model is that there is not only the direct effect of the absolute level of material living standards (e.g. income) on health outcomes but also a psychosocial pathway related to relative disadvantage (e.g. income inequality) (Marmot & Wilkinson, 2001). Accordingly, the psychosocial model suggests that social inequalities have an impact on how people feel about these inequalities. Feelings that may arise due to social inequalities include domination or subordination and may directly affect biological processes (Bartley, 2017).

The pathway through which the feelings related to relative disadvantage transform into biological responses and turn into measurable poorer health outcomes involves stress (Steptoe & Willemsen, 2002). To explain this, we need to take a few steps back in human evolutionary history. Our ancestors would deal with threats by triggering the fight-or-flight response (Steptoe & Willemsen, 2002). After a quick evaluation of the situation, individuals would either fight the threat or choose to run away. Either behavioural choice is followed by the release of adrenaline and cortisol into the blood system to support the vigorous physical activity needed for the response. Any excessive amount of adrenaline would have been burned off by this activity needed to carry out the fight-or-flight response. However, in modern times, feelings of fear or anger must often be endured without being able to respond adequately and in timely manner as it was the case for our ancestors (Bartley, 2017). Examples of modern-time stressors include situations as mundane as being trapped in nerve-wrecking traffic jams or being bullied by a superior at work as well as social inequalities. These kind of situations do not come with the prospect of finding a physical answer to them and, hence, need to be endured. As a consequence, prolonged stress endured over a long period of time is thought to be able to reset an

individual's blood pressure to a chronically high level (Bartley, 2017; Kubzansky et al., 2014). High blood pressure, in turn, has been associated with a range of cardiovascular diseases in the US and Scotland (Blane et al., 1996; Delpierre, Lauwers-Cances, Datta, Berkman, et al., 2009) and faster deteriorating health in old age in Sweden (Hassing et al., 2004).

1.3 The life-course approach

In the accounts of the explanatory models above, the life course has not yet been given attention. So far, we have not introduced a concept of time or development in the formation of health inequalities. Rather, we suggested that social and material circumstances may have an 'immediate' effect on health. However, in the past 20 years or so it has become apparent that the life-course framework is crucial in understanding the powerful effects socioeconomic position has on health (Bartley, 2017; Shuey & Willson, 2014). The life-course framework is not an explanatory model as such. It enhances the previously described health-inequalities explanations with the dimension of time and space. Consequently, the explanatory models all fit into the life-course approach, which suggests that stressful events and hazardous exposures do not have their effect at a single time point, but are experienced by people with a biography which they lived in specific contexts (Bartley, 2017; Elder, 1974, 1998, 1999; Elder et al., 2003). The central building block of the life-course approach is that human development happens as a consequence of the interplay between the growing human organism and the changing environments and social contexts in which it grows and lives throughout the life span (Bronfenbrenner, 1977, 1979; Krieger, 2001, 2005). The life-course approach in epidemiology has its roots in the observation that some factors examined as early as gestation and birth showed long-lasting effects on later health outcomes. For instance, low birth weight and premature birth seem to be associated with health problems in adult life in Sweden (Crump et al., 2011). Although this is a purely biological example, linking biological factors at a very early age with health at a more advanced age, social epidemiologist have

Figure 3 The revised Strachan-Sheik model of life-course health trajectories. (Source: Vineis et al., 2016)

become interested in what was causing low birthweight and premature birth in the first place. It has been found that mothers in poorer socioeconomic circumstances were showing higher risks of giving birth to low weight babies in Finland (Räisänen et al., 2013). Accordingly, the poor socioeconomic circumstances at birth seem to cause poor childhood health, which then has negative consequences on health in later life. Simultaneously, poor childhood health may lead to poor educational outcomes, which then in turn lower the chances to fare well in socioeconomic terms later in life (Case et al., 2005).

The life-course approach offers a useful tool to examine not only the health status at a certain point in time of an individual's life but also the trajectory or evolution of this health status over the ageing process. Life-course models suggest that health in old age results from both the maximum level of health attained during early adult life but also from the rate of decline as a consequence of the ageing process (Kuh & Ben-Shlomo, 2004; Vineis et al., 2016). In terms of socioeconomic disadvantages endured over the life course, these models hypothesise that disadvantages not only negatively influence the level of health but also accelerate the decline of health in older age. The revised Strachan-Sheikh model of life-course functioning (Figure 3) illustrates how socioeconomic factors are a major driver of ageing trajectories (Strachan & Sheikh, 2004). This model broadly divides the life course in two processes: build-up and decline (Vineis et al., 2016). Exposure to socioeconomic disadvantage in the build-up stage can have consequences on the maximum

level of health attained during early life, whereas exposure in the decline stage can influence the rate at which health is lost in the ageing process.

There are three main models in the life-course approach that explain how socioeconomic position translates into health inequalities in later life: the critical and sensitive period model, the accumulation model, and the pathway model (Blane et al., 2007). Each of these three models is presented in the following sections.

The critical and sensitive period model

The critical and sensitive period model hypothesizes that health inequalities arise because of exposure to hazards happening in periods which are critical for human development. The idea behind this model is based on biological studies, which established that certain developmental processes have to happen at very specific points in time of the development of a living being (Blane et al., 2007). These critical periods are mainly situated in early life stages, such as foetal or child development (or 'early life' in Figure 3), as these life phases are crucial for further development of human beings (Barker, 1998). Biological systems are more prone to be impacted by external influences during developmental processes. Thus, when the system is exposed to hazards during these periods, they might cause long lasting biological damage hindering the developmental processes to carry out fully (Ben-Shlomo & Kuh, 2002). The critical period model suggests that certain hazards only affect health if they happen in these specific periods (Kuh & Ben-Shlomo, 2004). For instance, if a pregnant mother is exposed to German measles it can be dangerous to the foetus, but this same exposure may not be dangerous to the child at any other age (Bartley, 2017).

The sensitive period model is a less strict variant of the critical period concept (Kuh & Ben-Shlomo, 2004). As opposed to stating that certain hazards only have an impact on health if they happen in specific critical periods, the sensitive period model suggests that there are certain times in human development when an exposure has a bigger probability of causing harm compared to other times (Bartley, 2017). The sensitivity of these periods is

determined by social and biological factors. Examples of social factors which affect the sensitivity of a period include phases of transition, such as entry into or exit from the labour market, educational transitions, or leaving the parental home. For instance, if parental divorce happens right at the time of exams important for an educational transition, this exposure may have a much bigger impact on further educational development than in times where no crucial exams take place (Bartley, 2017). Furthermore, Norwegian studies have shown that poor living conditions in childhood were associated with arteriosclerotic heart disease later in life even when these poor living conditions were followed by prosperity (Forsdahl, 1977, 1978). Another study in England and Wales suggests that poor nutrition in early life increases the susceptibility to the effects of an affluent diet which leads to a higher prevalence in ischaemic heart disease (Barker & Osmond, 1986).

The accumulation model

The accumulation model assumes that the negative impact adverse exposures have on health accumulates over the life course. This model was formalized when Scottish studies started to show that individuals who spent more time in an adverse socioeconomic position were at higher risk of all-cause mortality than those who spent less time in an unfavourable position (Davey Smith et al., 1997; Hart et al., 1998). Hence, in this model the timing of adverse exposures is not crucial, but the number or duration of experienced exposures is. The more and the longer an individual is exposed to hazards, the bigger the adverse impact on health outcomes will be. This implies that the effect of one hazard adds to the effect of other hazards (Chen et al., 2007).

The accumulation model has both cross-sectional and a longitudinal aspects (Blane et al., 2007). The cross-sectional aspect describes how a person who lives on a high income is in turn likely to reside in a neighbourhood with low levels of pollution, and work a job with low exposure to hazards, thereby accumulating advantageous living conditions. Longitudinally, a child raised in a favourable accommodation is more likely to proceed to achieve a higher education level, which in turn increases the opportunity for jobs with low levels

of exposure to hazards. With regard to the longitudinal aspect of the accumulation model, the cumulative dis/advantage theory by sociologist Dale Dannefer has gained a lot of attention in the past 20 years (Dannefer, 2003). This theory essentially argues that social differences early in life can widen over the life course and translate into sizeable health inequalities, even if they are relatively small at start. The main drivers of this effect are early dis/advantages that give rise to further dis/advantages, a process that continues over the whole life course, increasing health inequalities across the ageing process.

The pathway model

The pathway model is closely linked to the above described accumulation model and has been defined as a special version of it (Kuh & Ben-Shlomo, 2004). The model assumes that one adverse exposure has a high probability of being followed by another, which in turn increases the probability of the next and so on. These 'pathways' essentially lead to impaired health function and increased risk of disease. It is implied that each exposure does not automatically cause the next exposure in a deterministic way, rather exposures are linked probabilistically, with one exposure increasing the risk of the subsequent one. Moreover, an exposure does not only increase the probability of the next one, but may also have an independent 'additive effect' on later health (Kuh & Ben-Shlomo, 2004). As an example of such a pathway, educationally successful women tend to delay their first pregnancy to a later age, which increases their risk of developing breast cancer later in life as shown by studies from the US (Blane et al., 2007; Power & Hertzman, 1997; Pudrovska & Anikputa, 2012). An interesting feature of this model is its implication that these pathways leading to a vicious circle of ever more adverse exposures can be broken. This concept is closely linked to social mobility, which suggests that people are mobile between socioeconomic positions (e.g. parental vs. offspring socioeconomic position) and can, for example, (partially) compensate for a bad start in life by acquiring a higher social position in adult life as evidenced by European data (Campos-Matos & Kawachi, 2015). This has been supported by a Finnish study looking at income as a measure of socioeconomic position and mortality in adult life (J. W.

Lynch et al., 1994). The study found that mortality in adult life was only higher for individuals with lower income in childhood who also had lower incomes in adult life. Those who started with a low income but ended with high income in adult life had the same mortality risk as those who had high incomes throughout their lives.

1.4 Macro-social factors and health

The above presented explanatory mechanisms of health inequalities focus on the individual level. In health inequalities research, however, it is now widely established that health is not only affected by processes that take place on the individual level, but also by higher-level factors, such as the neighbourhood or country level (Bartley, 2017; Mackenbach, 2019). Moreover, factors at a higher level seem to interact with individual-level factors, thereby shaping differential effects on health (Beckfield et al., 2015; Krieger, 2005). The basic idea behind this is that the context in which people live can play a major role in how socioeconomic position eventually translates into health status and health inequalities (Bartley et al., 1997; Krieger, 2005). People live in different countries with different political and economic systems that determine the countries' welfare state, which in turn can have an impact on how they experience their socioeconomic position throughout their lives. A person living in bad conditions as well as in an 'unsupportive' context without being able to expect help will not have the equal experience as the same person living in a context offering favourable material and psychosocial conditions.

An influential and early strand of this type of research, linking contextual factors with individual-level health experiences, examined the role of income inequality at different area units (US states, English counties, countries, neighbourhoods etc.) on health at individual level (Ben-Shlomo et al., 1996; R. G. Wilkinson, 1992). These studies found that in areas where income is distributed more equally, overall life expectancy is higher. This research implies that in affluent industrial societies increases in the absolute level of individual income have a far smaller impact on health than the distribution of income in these societies does (Pickett & Wilkinson, 2015). What seems to be crucial is

that absolute levels of material resources only have a positive influence on health up to a certain point. From that point on, an individual's relative level of deprivation compared to others becomes key in shaping his or her experience in a society. However, these findings have been highly debated in the past years. Recent studies using more sophisticated approaches argue that the relationship between income inequality and health at the individual level is at least small or inconsistent (Leigh et al., 2011; Pförtner et al., 2019).

Macro-social factors have become increasingly important in health inequalities research, since it has become apparent that there are significant differences in general health and health inequalities between countries (Bartley, 2017; Mackenbach, 2019). One of the many ways to look at these differences, is to examine dissimilarities in welfare states and regimes (groups of countries with similar organization of the welfare state), which is also closely linked to issues related to income inequality. Although there is still no accepted standard definition of the welfare state, the term is conventionally used to refer to the various post World War II measures for the provision of key welfare services and social transfers (Eikemo & Bambra, 2008). Hence, the term means the role that the state played in education, health, housing, poor relief, social insurance, and public health services in developed capitalist countries during the post-war period (Eikemo & Bambra, 2008; Ginsburg, 1979). While many European countries already had implemented rudimentary welfare arrangements before World War II, the 'Golden Age' of the welfare state started only after the war, with the creation of the National Health Service in the United Kingdom as the key example (Hemerijck, 2013; Mackenbach, 2019). Elsewhere in Europe similar welfare arrangements have been put in place to varying extents, including policies related to income redistribution, protection of workers against labour market risks, and family support. These policies are designed to address different types of market and family failures and, thus, have an important influence on people's experience of adversities (Lundberg et al., 2008). By extension, the magnitude to which individuals experience these adversities and receive support to address them, depending on the welfare state arrangements, has an effect on health and health inequalities.

The rise of the welfare state in western societies after World War II and its 'retrenchment' since the 1970s due to neo-liberal economic policies aiming at saving welfare costs and enhancing competitiveness (Hemerijck, 2013), have led many researchers to examine the effects of the welfare state on health and health inequality. It has been argued that a strong and generous welfare state improves general health and reduces health inequalities in the society. However, recent research has shown that the latter has not been the case, which has become known as the big 'paradox' in health inequalities research (Bambra, 2011; Mackenbach, 2019). For instance, it has been evidenced that the North European countries with their generous and universal welfare arrangements do not have smaller health inequalities than other European countries with less generous welfare states (Beckfield & Krieger, 2009; Bergqvist et al., 2013; Brennenstuhl et al., 2012; Muntaner et al., 2011). This puzzling finding is subject to extensive debates in the research community. While there is still no explanation that is agreed on and has been supported by clear evidence, a few attempts have been made to clarify the causes of this paradox. One of the perhaps most often mentioned explanations distinguishes between absolute and relative health inequalities (Bambra, 2011). Health inequalities can be expressed in absolute terms by indicating, for example, the difference between the morbidity and mortality rates of the highest and lowest social group, or in relative terms as the ratio of the morbidity or mortality between these two groups (Mackenbach, 2019). Indeed, the paradox is particularly observed when looking at relative health inequalities, where the Nordic countries fare worse than expected in comparison to other countries (Lundberg, 2008). Yet, the situation looks much better for Nordic countries when absolute health inequalities are considered. The lowest socioeconomic groups in the Scandinavian countries are better off in absolute terms than the lowest socioeconomic groups in the other welfare state regimes (Bambra, 2011; Fritzell & Lundberg, 2005).

These ambiguous findings and ongoing discussions demonstrate that research examining the influence of macrosocial factors on health inequalities

remains important, despite of the more than 20 years of exploration into the topic.

1.4.1 Mechanisms linking contextual factors with health inequalities

Similar to the discussion on how social inequalities eventually translate into health inequalities, the mechanisms behind the influence that contextual factors have on health and health inequalities are important to examine in order to understand the underlying processes. The following paragraphs present two of the potential pathways explaining how country-level factors may affect health at the individual level, namely the *psychosocial model* and the *neo-material model*.

Psychosocial model

In the psychosocial explanation of how macro-level factors affect health and health inequalities, the key to understanding the mechanism lies in the relative socioeconomic position an individual has in comparison to others in the same society. As outlined above, relative deprivation causes negative emotions such as stigmatization, feeling of loss of control, which in turn have a negative impact on health through psycho-neuro-endocrine mechanisms involving stress (J. W. Lynch et al., 2000). Following this explanatory model of health inequalities, countries with more generous welfare states, which more effectively redistribute income from those that have a lot to those that have less, may be better in lowering relative levels of deprivation (Bartley, 2017). By extension, according to the psychosocial model, lower levels of social inequalities eventually lead to lower levels of health inequalities.

US studies looking at the effects of unequal societies on individual lives have also argued that where people feel unequal, they are less likely to participate in community organizations and less likely to get together to improve their local environment (Kaplan et al., 1996; Kawachi et al., 1997). In addition, it has been suggested that unequal societies are more competitive and less cooperative in many ways, while there being less trust between people and more criminal behaviour (Kawachi & Kennedy, 1997; R. Wilkinson & Pickett, 2009). These negative effects on ‘social capital’ are detrimental for everyone in

the society, not just the ones that are relatively deprived (Bartley, 2017). For instance, everyone suffers from an unsafe environment, with more pollution and traffic hazards, although certain individuals with the necessary means may be better able to protect themselves from these stressors than others. Moreover, it has been shown that crime has a strong effect on quality of life, even when people are not in fact at risk (Bartley, 2017).

In general, countries with more generous welfare systems have been shown to create a more beneficial psychosocial environment for their citizens including those that are not in direct need of support (Bartley et al., 1997). The mere knowledge of a strong welfare state providing a functioning safety net for people in need can alleviate the stress related to the insecurity of potentially harmful situations.

Neo-material model

The neo-material explanation of how country-level factors affect health at individual level, focuses on the provision of economic support and services. The neo-material model argues that people in more unequal societies consistently have worse health outcomes compared to more equal societies because the provision of public services, such as education and health care, is better in the latter (Coburn, 2000; Ross et al., 2000). Policies designed to ensure or enhance public services provision tend to be stronger in less unequal societies. Moreover, countries with a more generous welfare state have a stronger focus on providing public services to as many citizens as possible, instead of keeping it at a minimum and handing over the service provision to private companies. In such a case, consumption of these services depends much more on an individual's income as compared to when services are funded and provided by the welfare state (Bartley, 2017).

Furthermore, welfare systems are designed to provide a safety net for the people living in the country (Bartley et al., 1997). People finding themselves in difficult material conditions, such as loss of job and income, can revert to the welfare state in order to alleviate their material shortcomings. For instance, if an

individual is not able to generate enough (or any) income on the labour market, there may be support in the form of monetary or in-kind benefits to cover for appropriate housing and compensate for the loss in income. This in turn can have a very direct effect on health, permitting people to keep socially active, acquire appropriate food, and seek medical treatment in settings where out-of-pocket payments are required. A generous welfare state with strong social policies supporting people in need and beyond, is thus assumed to reduce health inequalities (Álvarez-Gálvez & Jaime-Castillo, 2018; Dahl & van der Wel, 2013; de Breij et al., 2020).

1.4.2 Methodological approaches to compare welfare states

In terms of contextual factors, this dissertation focuses on the country-level factors describing welfare states. In the study of within- and between-country differences, the welfare state has been identified as a key factor offering new insights into socioeconomic health inequalities (Thomson et al., 2016). Through its potential to shape individual lives and health prospects via social policies, healthcare, and public health, the welfare state has been acknowledged to be a relevant factor influencing health outcomes (Pförtner et al., 2019). In general, three approaches have been proposed to characterise western welfare states and study differences in health between countries.

The regime approach

The regime approach assumes that countries can be clustered in different groups based on similar ideologies and policies or political traditions (Bergqvist et al., 2013). These typologies form groups of countries with similar ‘welfare state regimes’. The general idea is that specifying typologies of welfare regimes enables the examination of commonalities and principles of social structures and welfare institutions shared by countries in the same cluster (Dahl & van der Wel, 2013). While there are many approaches in specifying typologies with different theoretical and empirical foundations, one has been most widely used (Ólafsdóttir & Beckfield, 2020). Based on the notion of ‘de-commodification’ developed by Esping-Andersen in 1990, many similar ways of clustering

countries building on his original work have been proposed (Esping-Andersen, 1990). He used a measure describing the proportion of the average wage of a worker which is replaced by welfare benefits in case this worker is unable to work due to different reasons including unemployment, illness, maternity leave, old age etc (Bartley, 2017). This measure expresses the extent to which individuals in a society are dependent on an income from paid work in order to pay their bills and participate in social activities. Hence, the less people are dependent on an income, the more they are de-commodified in the sense that they are less reliant on selling their workforce on the labour market.

According to this measure, Esping-Andersen created the 'de-commodifaction index', which he then used to classify countries in three different welfare types (Esping-Andersen, 1990). First, the 'social democratic' regime includes countries based on the principle of 'universalism', granting access to benefits and services to all citizens. This welfare regime is financed through taxes and has a high degree of de-commodification by removing supply and demand of services from the market (Mackenbach, 2019). North European countries such as Finland, Sweden, Norway, and Denmark are typical countries included in this type. Second, the 'conservative' regime limits the role of the state to what private companies cannot offer (Esping-Andersen, 1990). This principle of subsidiarity is financed through social insurance schemes and has a medium degree of de-commodification. Countries in this type include the Netherlands, Belgium, Luxembourg, Germany, Austria, Switzerland, and France. Third, the 'liberal' regime is based on the principle of market dominance and private provision of services. The state takes only a subordinate role and intervenes only to alleviate poverty and provide basic needs on a 'means-tested' basis (Mackenbach, 2019). This regime is characterised by a very limited degree of de-commodification. Countries include, the US, the United Kingdom, and Ireland.

This original welfare regime classification has been enhanced by others to include Mediterranean (Spain, Portugal, Italy, Greece) and Central and Eastern European (Czech Republic, Poland etc.) countries. The Mediterranean welfare regime is characterised by similarities with the conservative regime, with

the difference of peaks of generosity in certain welfare domains (e.g. pensions) (Ferrera, 1996). In addition, there are large gaps in welfare coverage which are due to the reliance on the family as a first pillar of support. The Central and Eastern European welfare regime includes the post-communist countries of that region (Bambra & Eikemo, 2009). Their welfare systems have been rapidly changing since the end of the Soviet Union, shifting from a Communist universalism to a marketized and decentralized welfare state. While welfare provision came with job security during socialism, the transition to capitalism led to high unemployment and the need to adjust social policies (Jutz, 2020; Kuitto, 2016).

While providing a comprehensive framework for the comparison of different welfare types, the typology of countries comes at the expense of between-country variance within the groups (de Breij et al., 2020; Lundberg et al., 2015). Countries in the same group may have very diverse welfare arrangements. These variations are somewhat diluted by the clustering process. Drawing on the advantages of this approach, while not dismissing its shortcomings, this dissertation makes use of the welfare regime approach to analyse differences in health inequalities. The articles in Chapters 2 and 3 base their methodology on this approach.

The expenditure approach

The expenditure approach uses information on the public spending on social protection and services to examine welfare state effort and generosity (Dahl & van der Wel, 2013; de Breij et al., 2020). Often the spending on social protection and services is expressed in terms of percentage of the Gross domestic product (GDP). The rationale for this is that countries with the same level of spending on social protection in relation to their economic capacities can be regarded as providing an equivalent degree of generosity and protection to their citizens (N. Gilbert, 2009). Spending areas include sickness and health care, disability, old age, survivors, family and children, unemployment, housing, and social exclusion.

The expenditure approach has become widely used in the past decade through the proliferation of good quality country-level data disseminated by entities such as the Organisation for Economic Co-operation and Development (OECD) or the statistical office of the European Union Eurostat. The focus on a specific characteristic of the welfare state and the fact that there is no clustering involved have drawn a lot of attention to this approach in comparative health inequalities research. However, it has been argued that the expenditure approach is unable to differentiate between effort and need (Bergqvist et al., 2013). A large spending on unemployment may simply reflect a larger share of unemployed and not necessarily a higher ambition in terms of coverage and replacement rates in case of unemployment. However, recent European studies have tried to overcome these problems by appropriately adjusting their models and by showing that the results are very little impacted by the different choices regarding the spending variable (absolute/relative, net/gross) (Dahl & van der Wel, 2013; de Breij et al., 2020).

The ambiguous findings of the research employing the welfare regime approach have led to the conclusion that future research may “need to concentrate more on specific policies than on the broader notion of ‘de-commodification’ ”(Bartley, 2017, p. 135). Hence, in an effort to try to enhance the findings of the studies using the welfare regime approach presented in Chapters 2 and 3, the third study in Chapter 4 makes use of the expenditure approach.

The institutional approach

The institutional approach is not methodologically used in this dissertation to analyse the effect of the welfare state on health and health inequalities. However, for the sake of completeness and to offer a full account of the different existing approaches, it is briefly introduced here.

The institutional approach focuses on the design of welfare institutions and social policies and on how they translate into population health (Beckfield et al., 2015; Bergqvist et al., 2013). It emphasises specific social policy program

characteristics and is based on the premise that social citizenship is key to the examination of the welfare state (Dahl & van der Wel, 2013). These characteristics include qualifying criteria, conditions of receipt, replacement rates (the share of employment income that is replaced by retirement income), duration and coverage of programs such as pensions, sickness pay, unemployment benefit, family policies and work accidents (Korpi & Palme, 2007). To ensure comparability across welfare states, assumptions are made with regards to a 'standard worker' (e.g. in the manufacturing industry with an average production worker's wage, 30 years of age, has worked ten years of which five at the same place of employment) and a standard family (e.g. married couple with one full-time wage-earner and two minor children aged 2 and 7) (Korpi & Palme, 2007). This 'standard worker' typically represents only a small share of the real examined population, which questions the generalisability of this approach (Dahl & van der Wel, 2013).

The three methodological concepts described in this section exhibit the richness of approaches in cross-country comparative research. Each of the approaches comes with its own methodological and theoretical strengths, but also with particular shortcomings which are partially addressed by the other approaches. As one of the aims of this dissertation was to assess differences in European welfare states and their impact on individual life-course health inequalities, this dissertation makes use of the regime (Chapters 2 and 3) and the expenditure approach (Chapter 4) to examine these associations.

1.5 Research context and data

1.5.1 Context of this thesis

This dissertation has been conducted as an integral part of the LIFETRAIL project which investigated life-course influences on health status and trajectories at older age (Cullati et al., forthcoming). The project, led by Dr. Stéphane Cullati (University of Fribourg) and in close collaboration with Prof. Claudine Burton-Jeangros (University of Geneva), received funding from the Swiss National Centre of Competence in Research LIVES - Overcoming

Vulnerability: Life Course Perspectives (NCCR LIVES) and ran from the end of 2016 to the beginning of 2019. The aim of the LIFETRAIL project was to study the health status and trajectories in different outcomes of people aged 50 years and older. Furthermore, the project aimed at assessing the different elements of the life course that influence these health outcomes at old age. These life course influences included different socioeconomic exposures in childhood and adulthood and various adverse experiences in childhood, such as parental death or serious health conditions.

Studies conducted within the LIFETRAIL project have taken different angles in analysing the associations between socioeconomic and adverse experiences exposure and various health outcomes. In terms of the level of health, LIFETRAIL research has shown a persistent and gradual association of disadvantage in childhood socioeconomic conditions with different health outcomes at old age, including cognition (Aartsen et al., 2019), respiratory function (Cheval, Chabert, Orsholits, et al., 2019), physical inactivity (Cheval, Sieber, et al., 2018), disability (Landös et al., 2018), sleeping problems (van de Straat et al., 2020), cancer onset (van der Linden et al., 2018), frailty (van der Linden et al., 2020), and depressive symptoms (von Arx et al., 2019). Similarly, having had general or health-related adverse experiences in childhood has been shown to be negatively related with low muscle strength and frailty in old age (Cheval, Chabert, Sieber, et al., 2019; van der Linden et al., 2020). LIFETRAIL research articles have shown that adverse adult-life socioeconomic conditions are also gradually and negatively associated with health at old age. However, a bad start into life cannot be compensated by socioeconomic conditions in adult life, which is especially true for women (Cheval, Boisgontier, et al., 2018; Landös et al., 2018). While these health inequalities in the level of health are clear and persistent, inequalities in health trajectories in old age could not be found (Cheval, Orsholits, Sieber, et al., 2019).

The research focus of this dissertation within the LIFETRAIL project lied in examining the macro-social effects on socioeconomic health inequalities. While the other projects within LIFETRAIL had a mostly individual-level approach looking at life-course socioeconomic disadvantage and its effects on

health in old age, this dissertation adopted another angle by examining higher-level factors and their influence on this association.

1.5.2 Aims of this dissertation

This dissertation's objective is to contribute to the increasing number of studies in health inequalities research with a specific focus on the influence of macro-social factors on the association between life-course socioeconomic disadvantage and health in old age. In addition, this dissertation aims at shedding some light on the paradox that generous welfare regimes (e.g. the social democratic regime including Scandinavian countries) do not seem to have less health inequalities compared to less generous regimes (e.g. the Mediterranean regime). Three main research questions are examined in the studies presented in Chapters 2, 3, and 4:

1. How are disadvantages in childhood, such as socioeconomic conditions and traumatic experiences, related to health in old age?
    a. What is their relation with the level of health in old age?
    b. What is their relation with the decline of health in old age?
2. What is the role of socioeconomic disadvantages in adult life in the relationship between childhood disadvantages and old-age health?
    a. Do they influence the associations of childhood disadvantages with level of health in old age?
    b. Do they influence the associations of childhood disadvantages with the decline of health in old age?
3. What is the role of the welfare state in the relationship between life-course disadvantage and health in old age?
    a. Does the welfare state moderate the associations of life-course disadvantage with level of health in old age?
    b. Does the welfare state moderate the association of life-course disadvantage with the decline of health in old age?

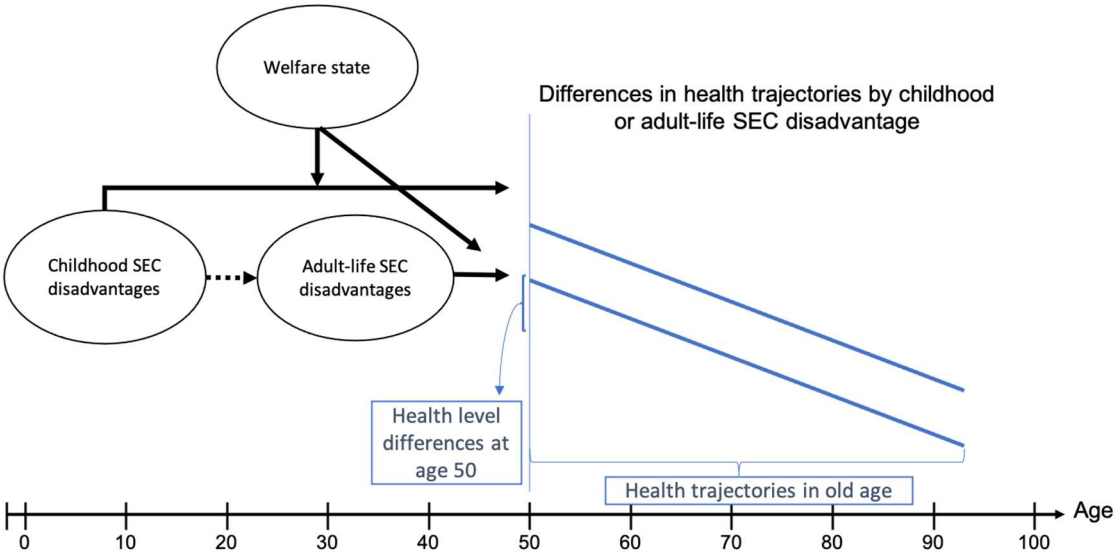


Figure 4 Theoretical model of this dissertation. Notes: SEC = Socioeconomic. Dashed line represents an association not examined in this dissertation.

Figure 4 is a visual representation of the research questions presented above and depicts the theoretical model used in this dissertation. In the figure, the life course is represented by childhood disadvantages, composed of socioeconomic conditions and adverse experiences, and socioeconomic disadvantage in different stages of the adult life. These different stages are comprised of young adult life (education), middle age (main occupational position), and old age (household income). As indicated by the arrows in the figure, both childhood and adult-life factors are hypothesised to individually impact the health status of people at age 50, thereby creating differences in health according to the people's socioeconomic position. In addition, according to the pathway model, adult-life socioeconomic factors may be on the pathway between childhood and health in old age, thereby mediating the impact of childhood disadvantages on health. Furthermore, we are not only interested in the health inequalities at age 50 but also in their evolution across the ageing process (trajectories). Finally, the welfare characteristics of the different countries included in the analyses are thought to moderate the impact of life-course socioeconomic factors on health status and trajectories in old age, either increasing or reducing health inequalities, or not having an impact at all.

1.5.3 Survey of Health, Ageing and Retirement in Europe (SHARE)

The three research projects presented in Chapters 2, 3, and 4 base their statistical analyses on the same database. The Survey of Health, Ageing and Retirement in Europe (SHARE) started in 2004 and released a new wave every 2 years. Data for the latest wave 7 was collected in 2017. This multidisciplinary and longitudinal database includes information on health, socio-economic position and social and family networks of about 140,000 respondents aged 50 or older (A. Börsch-Supan et al., 2013). SHARE is a European database covering 27 countries including Israel (Figure 5). Data are collected using computer-assisted personal interviewing (CAPI). Not included are persons who were incarcerated, hospitalized or out of the country during the entire survey period, unable to speak the country's language(s) or have moved to an unknown address. As a core feature of the survey, SHARE includes a retrospective questionnaire called SHARELIFE with questions on childhood

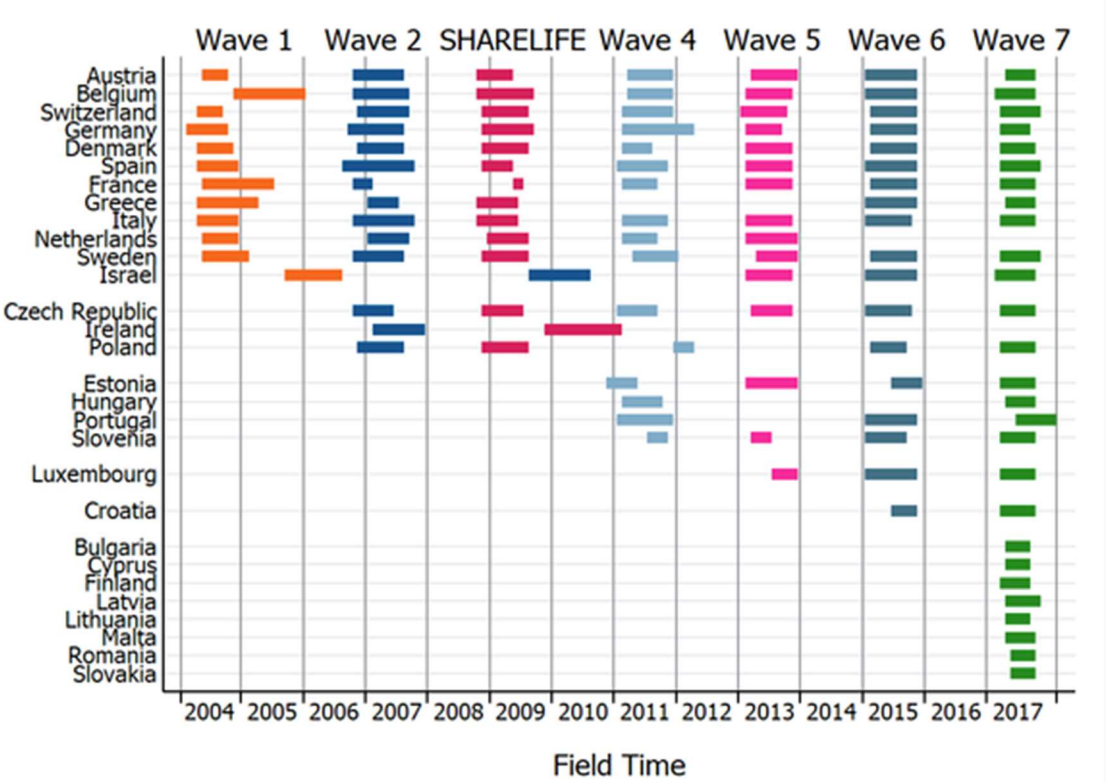


Figure 5 Overview of data collection of the Survey of Health, Ageing and Retirement in Europe. (Retrieved on 5 March 2021 from: http://www.share-project.org/data-documentation/waves-overview.html)

living circumstances, partners, children, accommodation, employment, socio-economic and health conditions up until the age of 50 (SHARE's age of inclusion). SHARELIFE was carried out in wave 3 for the first time and refreshed in wave 7 for those participants who did not yet respond. Data in SHARELIFE are collected by the means of a "Life History Calendar", which gives an accurate picture of the respondents' life course. This feature of the SHARE survey allows for identifying individuals' socioeconomic circumstances as well as adverse experiences over the life course from childhood to old age. This information can then be used to assess the associations of life-course disadvantage with health in old age.

The SHARE study is subject to continuous ethics review (A. Börsch-Supan et al., 2013). It was reviewed and approved by the Ethics Committee of the University of Mannheim during waves 1 to 4. From Wave 4 on the project was reviewed and approved by the Ethics Council of the Max Planck Society. In addition, the country implementations of SHARE were reviewed and approved by the respective ethics committees or institutional review boards whenever this was required.

1.5.4 Main predictors

In this section the main life-course predictors used in all of the research articles presented in Chapters 2 to 4 are described in chronological order, from childhood to adult life.

Childhood socioeconomic conditions

Childhood socioeconomic conditions were operationalised according to Wahrendorf and Blane's indicator of childhood circumstances (Wahrendorf & Blane, 2015). This multidimensional construct developed by the two researchers has been widely used and shown to consistently predict a wide range of physical and mental health indicators in European data, such as muscle strength (Cheval, Boisgontier, et al., 2018), the onset of cancer (van der Linden et al., 2018), lung functioning (Cheval, Chabert, Orsholits, et al., 2019), cognition (Aartsen et al., 2019), disability (Landös et al., 2018), physical

inactivity (Cheval, Sieber, et al., 2018), and depressive symptoms (von Arx et al., 2019).

This indicator is composed of four binary items of adverse socioeconomic conditions at the age of 10: 1) occupational position of the main breadwinner, 2) number of books in the home, 3) a measure of overcrowding, 4) and quality of the household. Occupational position of the main breadwinner was composed by reclassifying the 10 main occupational groups of the International Standard Classification of Occupations (ISCO) according to their skill levels (Wahrendorf et al., 2013). While the first and second skill levels were combined in the 'low' occupational position category, the third and fourth skill levels were grouped in the 'high' category. The measure for number of books indicated a socially disadvantaged position when less than 11 books were present in the household (Evans et al., 2010). Overcrowding was calculated by combining the number of people living in the household with the number of rooms (excluding kitchen, bathrooms, and hallways). Individuals who lived in households with more than one person per room were classified as socially disadvantaged (Marsh, 1999). Finally, the measure for the quality of the household indicated social disadvantage when all of the following items were absent: fixed bath, cold running water supply, hot running water supply, inside toilet, and central heating (Dedman et al., 2001). For the analyses in the research articles, these four binary items were combined to create a score indicating the level of socioeconomic disadvantage in childhood, resulting in a 5-level categorical variable ranging from 'most disadvantaged', 'disadvantaged', 'middle', 'advantaged', to 'most advantaged'. While this score is a comprehensive description of people's socioeconomic circumstances in childhood, it may mask differing effects and contribution of the single items to the association between socioeconomic circumstances and health in old age (Wahrendorf & Blane, 2015). A study using the single items instead of the score revealed that the number of books had the most prevailing influence on emotional functioning, and physical and cognitive health (Cheval, Orsholits, Sieber, et al., 2019).

Adult-life socioeconomic conditions

The socioeconomic conditions in adult life consisted of three predictors, which were used separately in the statistical analyses. First, representing young adult life, people's highest educational attainment was operationalised according to the International Standard Classification of Education (ISCED), resulting in the three levels 'primary', 'secondary', and 'tertiary' education (Dahl & van der Wel, 2013). Second, as an indicator of socioeconomic conditions in middle age, main occupational position measured the skill level of people's main job over the life course. Similarly to the occupational position of the main breadwinner in the childhood socioeconomic measure, the skill level was obtained according to ISCO's classification system, whereby skill levels 1 and 2 indicated 'low' and skill levels 3 and 4 'high' occupational position (Wahrendorf et al., 2013; Wahrendorf & Blane, 2015). Finally, satisfaction with household income was used an indicator of old age socioeconomic conditions since it was measured longitudinally in all of the waves. Based on the survey question "Is the household able to make ends meet?" participants answered on a four-point scale ranging from 1 "easily" to 4 "with great difficulty" (Neuberger & Preisner, 2018).

1.5.5 Outcomes

Self-rated health

Self-rated health (SRH) was used in all three research articles presented in Chapters 2 to 4. As a measure of subjective perception of one's general health status it is one of the most ubiquitous measures in epidemiological, clinical and social research (Kananen et al., 2021). Part of the reason for its wide use in surveys is its simple and cost-effective administration. In SHARE, the variable was operationalised by asking the participants to rate their current general health on a 5-point Likert scale, with responses ranging from 1, 'poor', to 5, 'excellent' (Ware & Gandek, 1998). Previous research has shown that SRH predicts a variety of objectively measured health outcomes, such as mortality, future functional status, and outcome of treatment in populations varying in age, gender, social class, health status, country, and culture (Idler & Benyamini,

1997; Jylhä, 2009; Kananen et al., 2021). However, another study has found that the impact of health problems on SRH is stronger among better educated individuals, indicating that the impact of the same disease on SRH depends on the health expectations people have, which are associated with social characteristics (Delpierre, Lauwers-Cances, Datta, Lang, et al., 2009). While SRH is a comprehensive and inclusive measure of health, it is also non-specific (Jylhä, 2009). On the one hand, the generality of the SRH measure allows to capture health dimensions that would be ignored by more specific and detailed health measures. On the other hand, this gives the researcher no control over which aspects of health are emphasized in the individual SRH assessment (Jylhä, 2009).

Grip strength

In order to include a more specific measure of health, the study presented in Chapter 4 enhanced the analyses by incorporating the objectively measured grip strength. This allowed to have a direct comparison between a subjectively and an objectively measured health outcome, which revealed interesting differences. Grip strength is an indicator of physical health, more precisely muscular strength, and a strong predictor of morbidity and mortality (Leong et al., 2015). In SHARE, grip strength was obtained with the help of a handheld dynamometer (Smedley, S Dynamometer, TTM, Tokyo, 100 kg). Alternating between the two hands, grip strength was measured in kilograms twice on each hand. Similar to the SRH measure, it is inexpensive and quick to administer in surveys and a reliable marker of ageing (Syddall et al., 2003). However, a recent study pointed out that changing assessors within a survey can affect the reliability of the measurement, which might apply to the context of the SHARE survey as it takes place in different countries with multiple changing assessors (Nolan et al., 2020).

1.5.6 Statistical analyses

The data analysis in the three studies presented in Chapters 2 to 4 shared some commonalities, with certain adjustments according to the treatment of the

outcome, the specific research question examined, and the approach used to describe welfare characteristics. Since the SHARE study is not a single cohort study but includes multiple single cohorts, each one starting at a different age, we analysed the data using an accelerated longitudinal design (Galbraith et al., 2017). The advantage of such an analysis approach lies in its ability to extend the relatively short survey period of 13 years (2004 to 2017) to the much larger range of people with different ages included in the study (50 to 96 years in our studies) (Galbraith et al., 2017; Moerbeek, 2011). This would not be possible with a single cohort study, as the included participants all share the same age, leading to the age range being the same as the survey period range. Using age as the time basis an accelerated longitudinal design means that each participant contributes to a part of the modelled trajectories over the ageing process. This may not be a valid representation of the whole age range if cohort effects are present (Galbraith et al., 2017). To limit this bias, our models were adjusted for participants' birth cohorts.

Generally, we used logistic (Chapters 2 and 3) and linear (Chapter 4) mixed effects models with observations nested within individuals. In Chapters 2 and 3 the welfare regime differences were analysed by stratifying the models according to the four different regimes examined. In Chapter 4, we added a third level to the analyses by further nesting the individuals within countries. The welfare state differences were examined through cross-level interactions between the country-level and the individual-level indicators. Furthermore, interactions between the life-course socioeconomic factors and age allowed the analysis of change in effects of these factors over the ageing process, i.e. the evolution of health inequalities with ageing.

1.6 Outline of this dissertation

The following three chapters are each composed of original research articles. The first two have been published in scientific journals while the third one is ready to be submitted.

The study presented in *Chapter 2* examined the effects of childhood socioeconomic circumstances on the level and trajectories of self-rated health in

old age. In addition, we analysed whether adult-life socioeconomic circumstances, such as education, occupation, and household income, attenuated the effects of childhood socioeconomic circumstances on self-rated health in old age. Finally, we studied how these effects differed across four European welfare regimes (Scandinavian, Bismarckian, Southern European, Eastern European).

The study in *Chapter 3* has a strong focus on the cumulative dis/advantage theory, with the goal to examine whether it proves useful in explaining health inequalities in old age. In order to do so, the study employs a strong, specifically adapted methodological framework to analyse the evolution of self-rated health across the ageing process in different welfare regimes. In addition, the study takes a broader approach of childhood misfortune by including traumatic events along with the socioeconomic conditions experienced in this early life phase to analyse their effects on health in old age.

The third article presented in *Chapter 4* takes a different angle in studying the influence of the welfare state on the individual-level relationship between life-course disadvantage and health in old age. While the other studies made use of the regime approach, this article employs the expenditure approach to describe the welfare state in a more specific way. Furthermore, this article not only looks at a subjective indicator of health (self-rated health), but also at an objectively measured health outcome (grip strength).

Chapter 2. Welfare regimes modify the association of disadvantaged adult-life socioeconomic circumstances with self-rated Health in old age (Article 1)

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International Journal of Epidemiology. (2019); *48*(4), 1352–1366

Abstract

Background. Welfare regimes in Europe modify individuals' socioeconomic trajectories over their life-course, and, ultimately, the link between socioeconomic circumstances (SECs) and health. This paper aimed to assess whether the associations between life-course SECs (early-life, young adult-life, middle age and old age) and risk of poor self-rated health (SRH) trajectories in old age are modified by welfare regime (Scandinavian [SC], Bismarckian [BM], Southern European [SE], Eastern European [EE]).

Methods. We used data from the longitudinal SHARE survey. Early-life SECs consisted of 4 indicators of living conditions at age 10. Young adult-life, middle-age, and old-age SECs indicators were education, main occupation and satisfaction with household income, respectively. The association of life-course SECs with poor SRH trajectories was analysed by confounder-adjusted multilevel logistic regression models stratified by welfare regime. We included 24,737 participants (3,626 in SC, 10,256 in BM, 7,617 in SE, 3,238 in EE) aged 50 to 96 years from 13 European countries.

Results. The risk of poor SRH increased gradually with early-life SECs from most advantaged to most disadvantaged. The addition of adult-life SECs differentially attenuated the association of early-life SECs and SRH at older age across regimes: education attenuated the association only in SC and SE regimes and occupation only in SC and BM regimes; satisfaction with household income attenuated the association across regimes.

*Conclusions***.** Early-life SEC has a long-lasting effect on SRH in all welfare regimes. Adult-life SECs attenuated this influence differently across welfare regime.

Introduction

With an ageing European population signalling a demographic transition, research on ageing and the factors influencing how people age is becoming increasingly relevant (Rechel et al., 2013). The society in which people live and age has a crucial influence on how their health declines in old age (Bambra, 2016; Ploubidis et al., 2012). In this regard, welfare regimes (WRs) can have a decelerating or accelerating effect on the rate of health decline through differing welfare programmes and measures (Bartley et al., 1997; Bloom et al., 2015).

Disadvantaged socioeconomic circumstances (SECs) in early and adult life are associated with adverse health outcomes, including poor self-rated health (SRH) (Pakpahan et al., 2017), chronic disease (Ben-Shlomo & Kuh, 2002), lower quality of life (Niedzwiedz et al., 2012; Wahrendorf & Blane, 2015), lower well-being (Niedzwiedz et al., 2015), greater risk of cardiovascular diseases (Blane et al., 1996), physical inactivity (Cheval, Sieber, et al., 2018), lower muscle strength (Cheval, Boisgontier, et al., 2018), higher mortality rates (Burton-Jeangros et al., 2015; Juárez et al., 2016), low respiratory function (Cheval, Chabert, Orsholits, et al., 2019), and disability (Landös et al., 2018). However, health in old age is not only affected by an individual's SECs over the life-course but also by factors at the societal level such as the welfare state (Bartley et al., 1997; Eikemo, Bambra, et al., 2008; Niedzwiedz et al., 2014a). Social transfers and welfare services provided by the state are designed to address socioeconomic inequalities, which influence health status (Kawachi et al., 1997; Mackenbach et al., 1997). Research on WRs and health remains particularly important because inequalities in Europe have persisted or even widened despite the expansion of the welfare state (Kibele et al., 2013; Mackenbach, 2012; Seniori Costantini et al., 2015). Some studies have shown that WRs modify the impact of life-course SECs on health (Bartley et al., 1997; Eikemo, Bambra, et al., 2008; Eikemo, Huisman, et al., 2008; Espelt et al., 2008; Kunst, 2005). However, as a major gap in the literature, this modification has not been examined over the whole life-course, from early life to old age.

The modifying effects of WRs are thought to occur because social policies alleviate adversities in an individual's life. More generous welfare regimes,

providing higher levels of benefits, reduce social stratification and have a positive effect in situations of need by absorbing the impact of material shortfalls in terms of diet, heating, and housing quality (Bartley et al., 1997; Raphael & Bryant, 2015). Moreover, it has been shown that redistributive policies create a more stable psychosocial environment, even for those not in direct need of benefits (Bartley et al., 1997). As such, this research indicates that not only adverse socioeconomic circumstances per se but also the anticipation of this adversity can impact health (Bartley et al., 1997). Social services influence the degree to which people experience insecurity and uncertainty when confronted with adverse circumstances. By extension, the influence of insecurity and uncertainty on SECs and health substantially differs across types of welfare state provisions (Bartley et al., 1997; Eikemo, Huisman, et al., 2008; Regidor et al., 2011). Life-course models suggest that these influences of social services impact health trajectories in old age through pathways from early through adult life (Figure 1) (Ben-Shlomo & Kuh, 2002).

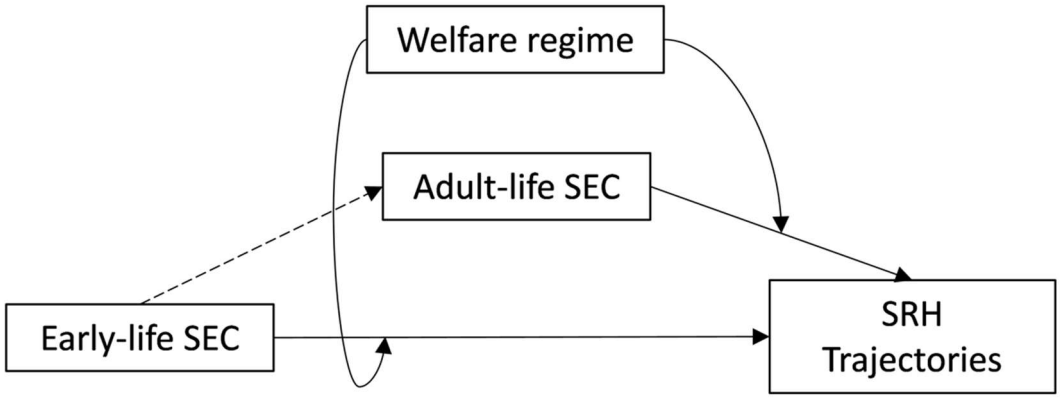

Figure 1 The arrows represent associations tested in this study including the direct effect of early-life (model 1) and adult-life (model 2, 3, and 4) socioeconomic circumstances (SEC) on self-rated health (SRH) trajectories as well as the moderating effect of welfare regime on these associations. The dashed arrow represents the direct effect of early-life SEC on adult-life SEC, which was not tested in this study.

To reflect similarities in terms of the relative roles of the state, family, and market in the providing of welfare, countries were grouped in WRs according to Ferrera's typology augmented by the Eastern European WR (Eikemo, Bambra, et al., 2008; Esping-Andersen, 1990; Ferrera, 1996). Ferrera's typology focuses on different dimensions of how social benefits are granted and organised and is considered as one of the most accurate typologies (Eikemo, Huisman, et al., 2008). The Scandinavian WR promotes equality of the highest standard unlike other WRs where the objective is equality of minimal needs (Bambra & Eikemo, 2009). This WR is characterised by a strong interventionist state that promotes social equality through a comparatively generous redistributive social-security system and universal coverage (Esping-Andersen, 1990; Kawachi et al., 1997). The Bismarckian WR is characterized by a minimal redistributive impact, with an emphasis on the role of the family. The benefits are often related to earnings and administered by the employer, which distinguishes this WR from others by its "status-differentiating" welfare programmes (Bambra & Eikemo, 2009; Eikemo, Bambra, et al., 2008; Esping-Andersen, 1990). The Southern European WR is characterized by a fragmented system of welfare provision with a strong reliance on the family and charitable sector and only limited and partial healthcare coverage (Eikemo, Bambra, et al., 2008; Ferrera, 1996). This WR is considered a "rudimentary" type of welfare state, which consists of diverse income maintenance schemes ranging from basic to generous (Bambra & Eikemo, 2009). The Eastern European WR consists of the formerly Communist countries of East Europe that experienced a shift from universalism of the Communist welfare state to a welfare state characterized by marketisation and decentralisation (Bambra & Eikemo, 2009). The Eastern European WR is distinguished from others by limited health service provision and poor overall population health (Eikemo, Huisman, et al., 2008).

Recent research on wellbeing suggests that WR explained a higher proportion of between-country differences than any other measure of social protection effort, emphasis, or expenditure (Richardson et al., 2018). In addition, WR has proven to explain between-country variations in quality of work and in the association of work-life balance and health (Dragano et al., 2011; Lunau et al.,

2014). Furthermore, variations in the self-rated health outcome have been shown across different WRs (Bambra et al., 2009). These findings confirm the usefulness of the WR typology when trying to explain differences between countries.

In this study, we used a life-course approach to examine, to our knowledge for the first time, whether the association between life-course SECs (early life, young adult life, middle age, and old age) and the risk of poor SRH trajectories in old age are modified by WR.

Methods

Study design and participants

This study uses data from SHARE, a cross-national and longitudinal survey that gathered data on health and SECs of more than 120,000 individuals aged 50 years and older in 27 European countries. Between 2004 and 2016, SHARE collected 6 waves of data in intervals of 2 years. Retrospective life-course data including early- and adult-life SECs were collected in wave 3. In our study, we included data for participants between 50 and 96 years old who participated in the third wave (including 13 countries in the analyses) and provided at least one SRH measure over the survey. More details on the study are available in its data-resource profile (A. Börsch-Supan et al., 2013).

Welfare regimes

In our study, we used Ferrera's typology expanded by the Eastern European WR as proposed by Eikemo et al (Eikemo, Bambra, et al., 2008; Esping-Andersen, 1990; Ferrera, 1996). We classified countries into 4 WRs: Scandinavian (Denmark, Sweden), Bismarckian (Austria, Belgium, France, Germany, the Netherlands, Switzerland), Southern European (Greece, Italy, Spain), Eastern European (Czech Republic, Poland) (Eikemo, Bambra, et al., 2008; Ferrera, 1996). WRs were investigated at follow-up, as a proxy for an individual's life-course regime. To avoid misclassification bias because respondents may have changed WRs during follow-up, we compared WRs at

baseline and the last follow-up and found no participant who had changed. In addition, we compared the regime participants lived in at follow-up with the regime they lived in at age 10 (early life). Only 3.7% of the participants had a different WR in these 2 life stages, so changes across regimes were few in the analysed cohorts. Additional models controlling for early-life WR did not change the results (data not shown).

Measures

Outcome: Self-reported Health

Respondents rated their present general health on a 5-point Likert scale ranging from 1, “poor”, to 5, “excellent” (Ware & Gandek, 1998). We grouped the answer categories “poor” and “fair” to indicate poor SRH as compared with “good”, “very good” and “excellent”, indicating good SRH.

Early-life SECs

Early-life SECs was computed according to Wahrendorf and Blane’s measure of childhood circumstances, combining the following 4 binary indicators of adverse SECs at age 10 into an index: 1) occupational position of the main breadwinner, 2) number of books in the home, 3) a measure of overcrowding, 4) and quality of the household (Wahrendorf & Blane, 2015). This index consisted of a 5-level categorical variable including “most disadvantaged”, “disadvantaged”, “middle”, “advantaged”, and “most advantaged”. Because of lack of observations in the “most advantaged” category for the Eastern European WR, we merged this category with the “advantaged” category to obtain more consistent results. Consequently, early-life SECs for the Eastern European WR had only 4 categories ranging from “most disadvantaged” to “advantaged”. A sensitivity analysis including the 5 categories for the Eastern European WR showed similar results. A detailed description of the early-life SEC measure can be found elsewhere (Cheval, Boisgontier, et al., 2018; Cheval, Sieber, et al., 2018).

Prior confounders

Three confounders were included in all models: sex, birth cohort [1919–1928/1929–1938 (Great Depression)/1939–1945 (World War II)/post-1945], and whether participants were living with biological parents at age 10 (both parents/one parent/no parent).

Mediators

Adult-life SEC. Three potential mediators were considered. First, representing young adult life, we included participants' highest educational attainment during follow-up by coding tertiary education according to the International Standard Classification of Education as highly educated, with primary and secondary education coded as low level of education. Second, we coded main occupation according to the International Standard Classification of Occupations (ISCO) classification of an individual's main job over the life-course, which represents middle-age SECs. The 10 main occupational groups in ISCO were reclassified according to their skill levels. Skill level one and two were grouped into "low" and the third and fourth levels grouped into "high" main occupation. Participants who never had paid work were included in the low occupational position. Third, we used satisfaction with current household income based on the question "Is the household able to make ends meet?" as an indicator for old-age SECs. Answers ranged from 1 "with great difficulty" to 4 "easily". We calculated the mode over all waves for each individual to keep as many observations as possible.

Covariates

Unhealthy behaviour index. This index combines 4 binary indicators of detrimental health behaviours. By taking the mean of 1) physical inactivity, 2) unhealthy eating, 3) smoking, and 4) alcohol consumption across waves for each participant, we obtained a continuous variable ranging from 0, none of the 4, to 1, all 4 unhealthy behaviours (Eriksen et al., 2013; Södergren et al., 2012; Todorova et al., 2013).

Living without partner. Independent of individuals' marital status, we measured whether the person was living with a partner during follow-up, coded 0, mostly living alone, and 1, mostly living with a partner (Cullati et al., 2014; Knöpfli et al., 2016).

Statistical Analysis

Data were analysed by using logistic mixed-effects models with a random intercept for participants. Our models revealed significant interactions between adult-life SECs and WRs, confirming the interest to examine the associations between life-course SEC and SRH separately by WR. Model 1 tested the association between early-life SECs and the odds of poor SRH in older age, adjusting for prior confounders. We centred age at the midpoint of the sample (i.e., 73 years). In addition, to test whether early-life SECs moderated the association of ageing and the odds of poor SRH, an interaction term between early-life SECs and age was included in all models. Adult-life SEC indicators were added sequentially in model 2 (educational attainment), model 3 (main occupation), and model 4 (satisfaction with current household income) for young adult-life, middle age, and old age, respectively. When adding the adult-life SEC indicators sequentially, we follow the chronological order of the indicators in the life-course (Cheval, Boisgontier, et al., 2018; Landös et al., 2018; van der Linden et al., 2018). The attenuation effects were calculated by comparing the raw estimates of early-life SECs of the models with mediators (models 2 to 4) with model 1 without mediators. This allowed to calculate a percentage of decrease of the effect of early-life SECs on SRH trajectories in old age when including the

different mediators. Model 5 included the unhealthy behaviour index and living without a partner covariates. All models were adjusted for participant attrition [no dropout/dropout (participants who did not respond to waves 5 and 6)/death (participants who died during follow-up)]. Finally, we performed sensitivity analyses excluding participants 1) older than 90 years because the descriptive statistics showed that observations above this age were few, 2) who died during the survey, 3) who dropped out, and 4) who lived in a different WR in childhood

than at follow-up and one that used a 5-level early-SEC variable for the Eastern European WR.

Results

Participants

The study sample included 24,011 participants (3,626 in Scandinavian, 10,256 in Bismarckian, 6,891 in Southern European, 3,238 in Eastern European WRs) aged 50 to 96 years and living in 13 European countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Italy, The Netherlands, Poland, Spain, Sweden, and Switzerland). Descriptive statistics showed a gradient relation between early-life SECs and the prevalence of poor SRH across WRs (Table 1), with the more advantaged participants showing lower prevalence of poor SRH.

Effect of early-life SECs on risk of poor self-rated health during ageing (Table 2, model 1)

For all WRs, early-life SECs was associated with risk of poor SRH at age 73 (centered age). A gradient indicated decreasing risk of poor SRH with increasing early-life SEC categories (Figure 2). The interaction of early-life SECs and age had no effects except for the Bismarckian WR. The adverse effect of ageing was higher with middle, advantaged, and most advantaged early-life SECs versus the most disadvantaged.

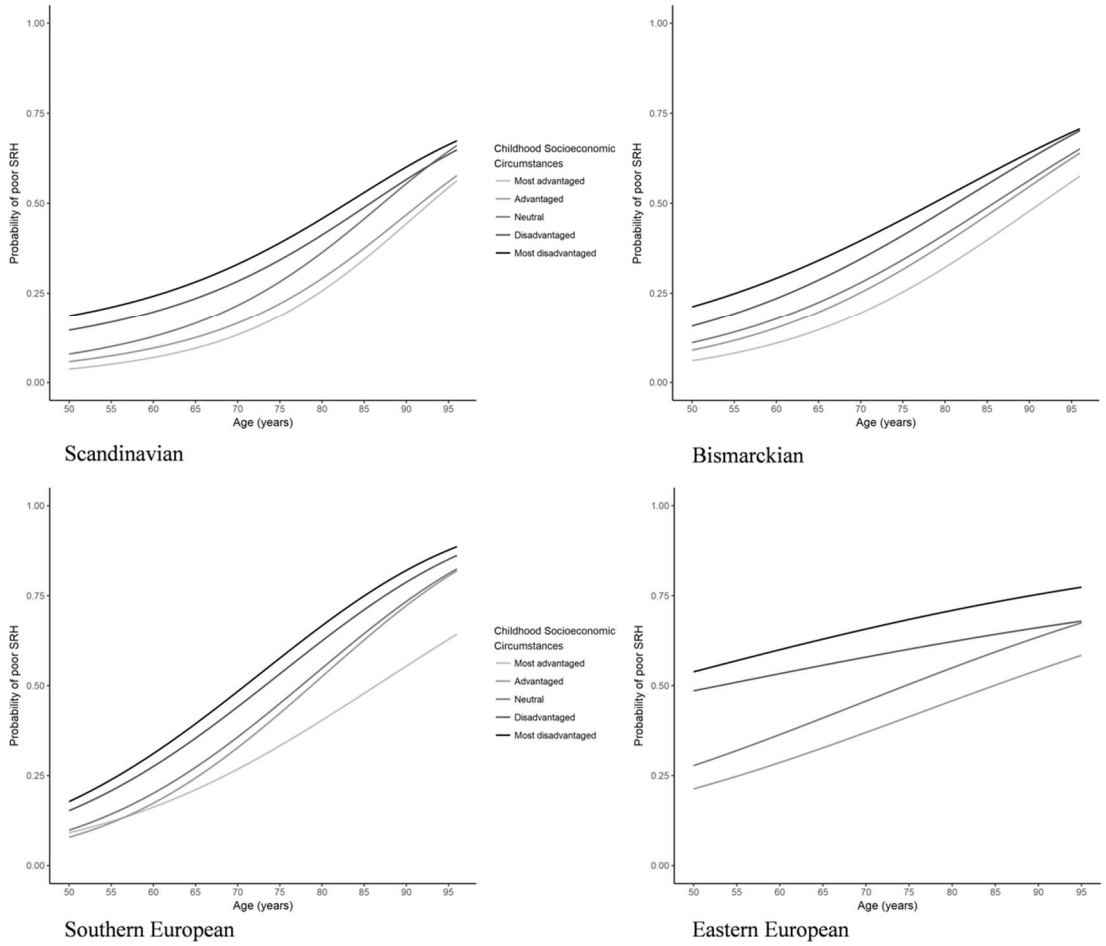

Figure 2 Predicted probability of poor SRH across age by early-life SEC and welfare regime.

Table 1. Participant characteristics by welfare regimes and early-life socioeconomic circumstances (SECs) at baseline.

	Scandinavian (n= 3,626)					Bismarckian (n= 10,256)					Southern European (n= 6,891)					Eastern European (n= 3,238)			
	MD	D	M	A	MA	MD	D	M	A	MA	MD	D	M	A	MA	MD	D	M	A
N	217	545	1,397	1,081	386	1,063	2,378	3,579	2,414	822	2,266	2,359	1,614	556	96	966	761	1,119	392
Outcome																			
Self-rated health																			
Poor	58 (27%)	119 (22%)	202 (14%)	120 (11%)	31 (8%)	395 (37%)	707 (30%)	866 (24%)	493 (20%)	135 (16%)	940 (41%)	803 (34%)	410 (25%)	139 (25%)	16 (17%)	626 (65%)	435 (57%)	444 (40%)	129 (33%)
Good	159	426	1,195	961	355	668	1,671	2,713	1,921	687	1,326	1,556	1,204	417	80	340	326	675	263
Prior confounders																			
Age, years (SD)	70.3 (8.3)	66 (9.0)	61.8 (8.7)	60.2 (8.5)	60.3 (8.7)	67.0 (9.2)	64.3 (9.1)	61.2 (8.7)	60.7 (8.9)	61.3 (9.4)	66 (9.0)	62 (9.0)	60 (8.8)	60 (8.4)	62 (9.0)	66 (9.4)	63 (9.1)	61 (8.6)	60 (8.1)
Sex																			
Women	118 (54%)	309 (57%)	764 (55%)	595 (55%)	211 (55%)	599 (56%)	1327 (56%)	2021 (56%)	1311 (54%)	456 (55%)	1,246 (55%)	1,316 (56%)	935 (58%)	320 (58%)	52 (54%)	527 (55%)	445 (58%)	659 (59%)	229 (58%)
Men	99	236	633	486	175	464	1,051	1,558	1,103	366	1,020	1,043	679	236	44	439	316	460	163
Birth cohort																			
After 1945	20 (9%)	137 (25%)	613 (44%)	566 (52%)	206 (53%)	244 (23%)	789 (33%)	1,738 (49%)	1,253 (52%)	395 (48%)	600 (27%)	1,070 (45%)	907 (56%)	304 (55%)	40 (42%)	358 (37%)	361 (47%)	625 (56%)	242 (62%)
1939 to 1945	40 (19%)	134 (25%)	374 (27%)	266 (25%)	94 (24%)	217 (20%)	586 (25%)	837 (24%)	539 (22%)	196 (24%)	540 (24%)	539 (23%)	304 (19%)	131 (24%)	23 (24%)	208 (22%)	182 (24%)	248 (22%)	87 (22%)
1929 to 1938	96 (44%)	173 (32%)	295 (21%)	177 (16%)	54 (14%)	388 (37%)	690 (29%)	729 (20%)	430 (18%)	150 (18%)	791 (35%)	560 (24%)	297 (18%)	91 (16%)	23 (24%)	292 (30%)	152 (20%)	189 (17%)	45 (12%)
1919 to 1928	61 (28%)	101 (18%)	115 (8%)	72 (7%)	32 (9%)	214 (20%)	313 (13%)	275 (7%)	192 (8%)	81 (10%)	335 (14%)	190 (8%)	106 (7%)	30 (5%)	10 (10%)	108 (11%)	66 (9%)	57 (5%)	18 (4%)
Living with biological parents																			
Both parents	183 (84%)	465 (85%)	1249 (90%)	972 (90%)	341 (88%)	942 (89%)	2,095 (88%)	3,215 (90%)	2,147 (90%)	756 (92%)	2,118 (93%)	2,209 (94%)	1,532 (95%)	517 (93%)	90 (94%)	854 (88%)	668 (88%)	1013 (91%)	363 (92%)
One biological parent	22 (10%)	57 (11%)	114 (8%)	80 (7%)	27 (7%)	98 (9%)	229 (10%)	295 (8%)	213 (8%)	54 (7%)	126 (6%)	116 (5%)	59 (4%)	24 (4%)	3 (3%)	104 (11%)	84 (11%)	92 (8%)	26 (7%)
No biological parent	12 (6%)	23 (4%)	34 (2%)	29 (3%)	18 (5%)	23 (2%)	54 (2%)	69 (2%)	54 (2%)	12 (1%)	22 (1%)	34 (1%)	23 (1%)	15 (3%)	3 (3%)	8 (1%)	9 (1%)	14 (1%)	3 (1%)
Attrition																			
No drop out	134 (62%)	391 (72%)	1092 (78%)	887 (82%)	308 (80%)	670 (63%)	1,605 (67%)	2,500 (70%)	1,718 (71%)	570 (69%)	1,607 (71%)	1,726 (73%)	1,217 (75%)	421 (75%)	77 (80%)	668 (69%)	501 (66%)	739 (66%)	265 (68%)
Drop out	28 (13%)	78 (14%)	179 (13%)	134 (12%)	38 (10%)	275 (26%)	601 (25%)	910 (25%)	573 (24%)	195 (24%)	333 (15%)	391 (17%)	271 (17%)	92 (17%)	8 (8%)	118 (12%)	139 (18%)	261 (23%)	92 (24%)
Deceased	55 (25%)	76 (14%)	126 (9%)	60 (6%)	40 (10%)	118 (11%)	172 (7%)	169 (5%)	123 (5%)	57 (7%)	326 (14%)	242 (10%)	126 (8%)	43 (8%)	11 (12%)	180 (19%)	121 (16%)	119 (11%)	35 (8%)
Adult-life SEC																			
Educational attainment																			
High education	16 (7%)	75 (14%)	404 (29%)	474 (44%)	250 (65%)	69 (6%)	254 (11%)	796 (22%)	845 (35%)	454 (55%)	71 (3%)	149 (6%)	265 (16%)	164 (29%)	51 (53%)	35 (4%)	44 (6%)	128 (11%)	78 (20%)
Low education	201	470	993	607	136	994	2,124	2,783	1,569	368	2,195	2,210	1,349	392	45	931	717	991	314

Main occupational class																				
High	28 (13%)	90 (17%)	451 (32%)	482 (45%)	249 (65%)	82 (8%)	353 (15%)	884 (25%)	882 (36%)	462 (56%)	104 (5%)	179 (8%)	280 (17%)	169 (30%)	54 (56%)	69 (7%)	121 (16%)	294 (26%)	172 (44%)	
Low	189	455	946	599	137	981	2,025	2,695	1,532	360	2,162	2,180	1,334	387	42	897	640	825	220	
Satisfaction with household income ("make ends meet")																				
Easily	117 (54%)	322 (59%)	967 (69%)	782 (72%)	287 (74%)	378 (36%)	991 (42%)	1,770 (49%)	1,337 (55%)	510 (62%)	239 (11%)	314 (13%)	328 (20%)	130 (23%)	30 (31%)	68 (7%)	96 (13%)	198 (18%)	68 (17%)	
Fairly easily	70 (32%)	161 (29%)	328 (23%)	218 (20%)	77 (20%)	420 (40%)	890 (37%)	1209 (34%)	725 (30%)	210 (26%)	559 (25%)	632 (27%)	510 (32%)	214 (38%)	42 (44%)	279 (29%)	243 (32%)	385 (34%)	166 (42%)	
With some difficulty	21 (10%)	52 (10%)	77 (6%)	71 (7%)	19 (5%)	188 (17%)	356 (15%)	452 (13%)	262 (11%)	82 (10%)	857 (37%)	849 (36%)	519 (32%)	142 (26%)	21 (22%)	399 (41%)	298 (39%)	414 (37%)	127 (32%)	
With great difficulty	9 (4%)	10 (2%)	25 (2%)	10 (1%)	3 (1%)	77 (7%)	141 (6%)	148 (4%)	90 (4%)	20 (2%)	611 (27%)	564 (24%)	257 (16%)	70 (13%)	3 (3%)	220 (23%)	124 (16%)	122 (11%)	31 (9%)	
Covariates																				
Living with a partner																				
Without	75 (35%)	159 (29%)	321 (23%)	249 (23%)	83 (22%)	344 (32%)	701 (29%)	887 (25%)	585 (24%)	221 (27%)	493 (22%)	464 (20%)	349 (22%)	110 (20%)	21 (22%)	253 (26%)	220 (29%)	318 (28%)	123 (31%)	
With	142	386	1,076	832	303	719	1,677	2,692	1,829	601	1,773	1,895	1,265	446	75	713	541	801	269	
Unhealthy behaviour index*	0.25 (0.3)	0.26 (0.3)	0.24 (0.2)	0.23 (0.2)	0.22 (0.2)	0.23 (0.2)	0.24 (0.3)	0.22 (0.2)	0.22 (0.2)	0.22 (0.2)	0.31 (0.3)	0.29 (0.3)	0.31 (0.3)	0.28 (0.3)	0.23 (0.3)	0.43 (0.3)	0.40 (0.3)	0.39 (0.3)	0.38 (0.3)	

MD, most disadvantaged; D, disadvantaged; M, middle; A, advantaged; MA, most advantaged

* range: 0, none of the 4 health-detrimental behaviours, to 1, all of the 4 health-detrimental behaviours

Effect of adult-life mediators on risk of poor SRH during ageing (Table 2, models 2 to 5)

The associations of the mediators with risk of poor SRH differed across WRs. High educational attainment was associated with reduced risk of poor SRH for all WRs (model 2) and it attenuated the association (compared to model 1) of early-life SECs with risk of poor SRH (model 2) for the WRs Scandinavian (reduced the effect of disadvantaged, middle, advantaged, and most advantaged early-life SECs by 12%, 15%, 18%, and 23%, respectively) and Southern European (reduced the effect by 8%, 13%, 23%, 35%, respectively). For the Bismarckian WR, the adverse effect of ageing was greater with high versus low educational level (interaction of age with educational level).

Main occupation position was associated with risk of poor SRH in Scandinavian and Bismarckian WRs but attenuated the association (compared to model 1) of early-life SECs with risk of poor SRH (model 3) for all WRs: Scandinavian (reduced the effect of disadvantaged, middle, advantaged, and most advantaged early-life SECs by 10%, 22%, 25%, and 32%, respectively), Bismarckian (reduced the effect by 12%, 14%, 21%, and 25%, respectively), Southern European (reduced the effect by 5%, 13%, 22%, and 34%, respectively), and Eastern European (reduced the effect by 8%, 8%, and 11% for disadvantaged, middle, and advantaged, respectively) (Figure 3). Low main occupation was associated with risk of poor SRH for Scandinavian and Bismarckian WRs, with 74% and 69% greater odds of poor SRH, respectively (model 3). The adverse effect of ageing was lower with low (vs high) main occupation position in Scandinavian and Eastern European WRs (interaction of age with low main occupation position).

Table 2. Associations between early-life SECs and poor self-rated health (SRH) at older age, by welfare regime.

	Scandinavian N = 3,626		Bismarckian N = 10,256		Southern European N = 6,891		Eastern European N = 3,238	
Model 1	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Early-life SECs								
Most advantaged	0.17 (0.10-0.29)	<0.001	0.21 (0.15-0.28)	<0.001	0.24 (0.13-0.43)	<0.001	-	-
Advantaged	0.24 (0.15-0.38)	<0.001	0.35 (0.28-0.44)	<0.001	0.40 (0.29-0.53)	<0.001	0.21 (0.15-0.30)	<0.001
Middle	0.41 (0.27-0.63)	<0.001	0.44 (0.35-0.54)	<0.001	0.47 (0.39-0.57)	<0.001	0.34 (0.27-0.44)	<0.001
Disadvantaged	0.70 (0.45-1.11)	0.128	0.72 (0.58-0.90)	0.003	0.78 (0.66-0.91)	0.002	0.63 (0.48-0.81)	<0.001
Most disadvantaged	(ref)		(ref)		(ref)		(ref)	
Age x early-life SECs								
age x most adv	1.05 (1.00-1.10)	0.063	1.03 (1.00-1.05)	0.020	0.98 (0.94-1.03)	0.457	-	-
age x adv	1.03 (0.99-1.08)	0.112	1.03 (1.01-1.05)	0.010	1.01 (0.99-1.04)	0.295	1.02 (0.99-1.04)	0.292
age x middle	1.03 (1.00-1.08)	0.085	1.02 (1.00-1.04)	0.039	1.01 (0.99-1.02)	0.395	1.02 (1.00-1.04)	0.089
age x disadv	1.01 (0.97-1.05)	0.719	1.01 (0.99-1.03)	0.186	1.00 (0.99-1.01)	0.979	0.99 (0.97-1.01)	0.470
age x most disadv	(ref)		(ref)		(ref)		(ref)	
Model 2								
Early-life SECs								
Most advantaged	0.25 (0.14-0.44)	<0.001	0.26 (0.19-0.36)	<0.001	0.39 (0.21-0.73)	0.003	-	-
Advantaged	0.31 (0.20-0.49)	<0.001	0.40 (0.32-0.51)	<0.001	0.49 (0.36-0.66)	<0.001	0.23 (0.16-0.33)	<0.001
Middle	0.47 (0.31-0.72)	0.001	0.47 (0.38-0.58)	<0.001	0.52 (0.43-0.63)	<0.001	0.36 (0.28-0.46)	<0.001
Disadvantaged	0.73 (0.47-1.15)	0.175	0.73 (0.59-0.91)	0.005	0.79 (0.67-0.93)	0.004	0.63 (0.49-0.82)	0.001
Most disadvantaged	(ref)		(ref)		(ref)		(ref)	
Educational attainment								
High	0.44 (0.34-0.57)	<0.001	0.61 (0.51-0.73)	<0.001	0.36 (0.26-0.50)	<0.001	0.62 (0.43-0.90)	0.012
Low	(ref)		(ref)		(ref)		(ref)	
Age x early-life SECs								
age x most adv	1.04 (0.99-1.09)	0.094	1.02 (0.99-1.04)	0.166	0.98 (0.93-1.03)	0.461	-	-
age x adv	1.03 (0.99-1.08)	0.125	1.02 (1.00-1.04)	0.056	1.01 (0.98-1.03)	0.574	1.01 (0.98-1.04)	0.375
age x middle	1.04 (1.00-1.08)	0.080	1.02 (1.00-1.03)	0.091	1.00 (0.99-1.02)	0.746	1.02 (1.00-1.04)	0.121
age x disadv	1.01 (0.97-1.06)	0.568	1.01 (0.99-1.03)	0.176	1.00 (0.99-1.01)	0.930	0.99 (0.97-1.01)	0.427
age x most disadv	(ref)		(ref)		(ref)		(ref)	
Age x educ attainment								
age x high	1.01 (0.99-1.03)	0.214	1.02 (1.01-1.04)	0.001	1.01 (0.99-1.04)	0.282	1.02 (0.99-1.05)	0.290
age x low	(ref)		(ref)		(ref)		(ref)	
Model 3								
Early life SECs								
Most advantaged	0.29 (0.17-0.51)	<0.001	0.31 (0.22-0.42)	<0.001	0.39 (0.21-0.73)	0.003	-	-
Advantaged	0.34 (0.22-0.54)	<0.001	0.44 (0.35-0.55)	<0.001	0.49 (0.36-0.66)	<0.001	0.25 (0.17-0.36)	<0.001
Middle	0.50 (0.33-0.76)	0.001	0.49 (0.40-0.61)	<0.001	0.52 (0.43-0.63)	<0.001	0.37 (0.29-0.48)	<0.001
Disadvantaged	0.73 (0.46-1.14)	0.165	0.75 (0.60-0.93)	0.009	0.79 (0.68-0.93)	0.004	0.65 (0.50-0.84)	0.001
Most disadvantaged	(ref)		(ref)		(ref)		(ref)	
Educational attainment								
High	0.56 (0.42-0.74)	<0.001	0.74 (0.61-0.90)	0.003	0.36 (0.26-0.50)	<0.001	0.72 (0.48-1.08)	0.116
Low	(ref)		(ref)		(ref)		(ref)	
Main occupation								
Low	1.74 (1.33-2.27)	<0.001	1.69 (1.40-2.04)	<0.001	1.01 (0.77-1.31)	0.945	1.31 (0.97-1.76)	0.076
High	(ref)		(ref)		(ref)		(ref)	
Age x early-life SECs								
age x most adv	1.04 (0.99-1.09)	0.160	1.01 (0.99-1.04)	0.288	0.98 (0.93-1.03)	0.439	-	-
age x adv	1.03 (0.99-1.07)	0.171	1.02 (1.00-1.04)	0.107	1.01 (0.98-1.03)	0.668	1.01 (0.98-1.04)	0.656
age x middle	1.03 (0.99-1.07)	0.097	1.01 (0.99-1.03)	0.157	1.00 (0.99-1.02)	0.749	1.01 (0.99-1.03)	0.213
age x disadv	1.01 (0.97-1.06)	0.521	1.01 (0.99-1.03)	0.219	1.00 (0.99-1.01)	0.983	0.99 (0.97-1.01)	0.322
age x most disadv	(ref)		(ref)		(ref)		(ref)	
Age x educ attainment								
age x high	1.00 (0.98-1.03)	0.735	1.02 (1.01-1.04)	0.008	1.01 (0.99-1.04)	0.306	1.01 (0.97-1.04)	0.750
age x low	(ref)		(ref)		(ref)		(ref)	
Age x main occup pos								
age x low	0.98 (0.96-1.00)	0.039	0.99 (0.97-1.00)	0.148	1.00 (0.98-1.02)	0.927	0.98 (0.95-1.00)	0.046
age x high	(ref)		(ref)		(ref)		(ref)	
Model 4								
Early-life SECs								
Most advantaged	0.35 (0.20-0.60)	<0.001	0.38 (0.28-0.52)	<0.001	0.51 (0.28-0.94)	0.032	-	-
Advantaged	0.40 (0.25-0.62)	<0.001	0.53 (0.42-0.67)	<0.001	0.56 (0.41-0.75)	<0.001	0.30 (0.21-0.43)	<0.001
Middle	0.59 (0.39-0.89)	0.012	0.58 (0.47-0.71)	<0.001	0.57 (0.47-0.70)	<0.001	0.44 (0.34-0.56)	<0.001
Disadvantaged	0.80 (0.51-1.25)	0.329	0.81 (0.66-1.00)	0.054	0.81 (0.69-0.95)	0.010	0.72 (0.56-0.93)	0.011
Most disadvantaged	(ref)		(ref)		(ref)		(ref)	
Educational attainment								
High	0.61 (0.46-0.81)	0.001	0.86 (0.71-1.04)	0.125	0.42 (0.30-0.59)	<0.001	0.80 (0.53-1.19)	0.269
Low	(ref)		(ref)		(ref)		(ref)	
Main occupation								

	Scandinavian N = 3,626		Bismarckian N = 10,256		Southern European N = 6,891		Eastern European N = 3,238	
Low	1.63 (1.25-2.12)	<0.001	1.48 (1.23-1.78)	<0.001	0.91 (0.70-1.18)	0.457	1.20 (0.90-1.61)	0.210
High	(ref)		(ref)		(ref)		(ref)	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Satisfaction with household income								
Great difficulty	13.34 (5.99-29.71)	<0.001	8.96 (6.39-12.57)	<0.001	3.02 (2.39-3.80)	<0.001	3.82 (2.55-5.74)	<0.001
Some difficulty	3.63 (2.45-5.39)	<0.001	4.21 (3.44-5.16)	<0.001	2.00 (1.62-2.48)	<0.001	1.57 (1.15-2.15)	0.004
Fairly easily	1.91 (1.49-2.45)	<0.001	2.02 (1.75-2.34)	<0.001	1.18 (0.95-1.47)	0.126	1.00 (0.73-1.36)	0.995
Easily	(ref)		(ref)		(ref)		(ref)	
Age x early-life SECs								
age x most adv	1.03 (0.98-1.08)	0.186	1.01 (0.99-1.04)	0.418	0.98 (0.93-1.03)	0.486	1.01 (0.98-1.03)	0.738
age x adv	1.02 (0.98-1.07)	0.243	1.01 (0.99-1.03)	0.185	1.00 (0.98-1.03)	0.748	1.01 (0.99-1.03)	0.298
age x middle	1.03 (0.99-1.07)	0.120	1.01 (0.99-1.03)	0.265	1.00 (0.99-1.02)	0.869	0.99 (0.97-1.01)	0.309
age x disadv	1.01 (0.97-1.05)	0.713	1.01 (0.99-1.03)	0.302	1.00 (0.99-1.01)	0.887	1.01 (0.98-1.03)	0.738
age x most disadv	(ref)		(ref)		(ref)		(ref)	
Age x educ attainment								
age x high	1.01 (0.98-1.03)	0.651	1.02 (1.00-1.03)	0.021	1.02 (0.99-1.04)	0.198	1.00 (0.97-1.04)	0.820
age x low	(ref)		(ref)		(ref)		(ref)	
Age x main occup pos								
age x low	0.98 (0.96-1.00)	0.029	0.99 (0.98-1.01)	0.326	1.00 (0.98-1.02)	0.985	0.98 (0.96-1.01)	0.153
age x high	(ref)		(ref)		(ref)		(ref)	
Age x household income								
age x great diff	1.01 (0.95-1.08)	0.673	0.95 (0.93-0.98)	<0.001	1.01 (0.99-1.03)	0.534	0.98 (0.95-1.01)	0.158
age x some diff	1.00 (0.96-1.03)	0.840	1.00 (0.98-1.01)	0.600	1.01 (0.99-1.03)	0.283	0.98 (0.96-1.01)	0.187
age x fairly easily	1.02 (1.00-1.04)	0.075	1.00 (0.99-1.02)	0.499	1.00 (0.98-1.02)	0.948	0.98 (0.96-1.01)	0.133
age x easily	(ref)		(ref)		(ref)		(ref)	
Model 5								
Early-life SECs								
Most advantaged	0.34 (0.20-0.58)	<0.001	0.36 (0.27-0.49)	<0.001	0.52 (0.28-0.95)	0.034	-	-
Advantaged	0.39 (0.25-0.60)	<0.001	0.52 (0.41-0.65)	<0.001	0.57 (0.42-0.76)	<0.001	0.30 (0.21-0.44)	<0.001
Middle	0.56 (0.37-0.85)	0.010	0.58 (0.47-0.71)	<0.001	0.58 (0.48-0.70)	<0.001	0.45 (0.35-0.57)	<0.001
Disadvantaged	0.75 (0.49-1.15)	0.190	0.78 (0.64-0.96)	0.020	0.84 (0.72-0.98)	0.019	0.73 (0.57-0.94)	0.016
Most disadvantaged	(ref)		(ref)		(ref)		(ref)	
Educational attainment								
High	0.64 (0.49-0.85)	0.002	0.91 (0.76-1.10)	0.338	0.43 (0.31-0.60)	<0.001	0.85 (0.57-1.27)	0.420
Low	(ref)		(ref)		(ref)		(ref)	
Main occupation								
Low	1.52 (1.17-1.96)	0.002	1.40 (1.17-1.68)	<0.001	0.88 (0.68-1.14)	0.343	1.20 (0.90-1.61)	0.207
High	(ref)		(ref)		(ref)		(ref)	
Satisfaction with household income								
Great difficulty	8.36 (3.79-18.42)	<0.001	7.01 (5.02-9.80)	<0.001	2.76 (2.19-3.47)	<0.001	3.53 (2.35-5.31)	<0.001
Some difficulty	2.92 (1.98-4.31)	<0.001	3.57 (2.92-4.37)	<0.001	1.93 (1.56-2.38)	<0.001	1.49 (1.09-2.04)	0.012
Fairly easily	1.78 (1.39-2.28)	<0.001	1.92 (1.66-2.21)	<0.001	1.18 (0.95-1.46)	0.133	0.97 (0.71-1.32)	0.839
Easily	(ref)		(ref)		(ref)		(ref)	
Age x early-life SECs								
age x most adv	1.03 (0.98-1.08)	0.190	1.01 (0.99-1.04)	0.416	0.98 (0.93-1.03)	0.422	-	-
age x adv	1.02 (0.98-1.06)	0.260	1.01 (1.00-1.03)	0.139	1.00 (0.98-1.03)	0.770	1.01 (0.98-1.04)	0.686
age x middle	1.03 (0.99-1.07)	0.130	1.01 (0.99-1.03)	0.196	1.00 (0.99-1.02)	0.653	1.01 (0.99-1.03)	0.228
age x disadv	1.01 (0.97-1.05)	0.700	1.01 (0.99-1.03)	0.224	1.00 (0.99-1.01)	0.963	0.99 (0.97-1.01)	0.369
age x most disadv	(ref)		(ref)		(ref)		(ref)	
Age x educ attainment								
age x high	1.00 (0.98-1.03)	0.761	1.02 (1.00-1.03)	0.030	1.02 (0.99-1.05)	0.125	1.01 (0.97-1.04)	0.663
age x low	(ref)		(ref)		(ref)		(ref)	
Age x main occup pos								
age x low	0.98 (0.96-1.00)	0.028	0.99 (0.98-1.01)	0.220	1.00 (0.98-1.02)	0.948	0.99 (0.96-1.01)	0.239
age x high	(ref)		(ref)		(ref)		(ref)	
Age x household income								
age x great diff	1.02 (0.96-1.09)	0.530	0.96 (0.93-0.98)	<0.001	1.01 (0.99-1.03)	0.435	0.98 (0.95-1.01)	0.140
age x some diff	1.00 (0.97-1.04)	0.875	1.00 (0.98-1.01)	0.824	1.01 (0.99-1.03)	0.190	0.98 (0.96-1.01)	0.139
age x fairly easily	1.02 (1.00-1.04)	0.053	1.00 (0.99-1.01)	0.589	1.00 (0.98-1.02)	0.876	0.98 (0.96-1.01)	0.122
age x easily	(ref)		(ref)		(ref)		(ref)	

Abbrev: CI, confidence interval; OR, odds ratio; P, p-value

Model 1: adjusted for prior confounders and attrition
Model 2: M1 + adjusted for educational attainment
Model 3: M2 + adjusted for main occupation
Model 4: M3 + adjusted for satisfaction with household income
Model 5: M4 + adjusted for living without partner and unhealthy behaviour index

Satisfaction with household income was associated with risk of poor SRH for all WRs. The effects for disadvantaged, middle, advantaged and most advantaged early-life SECs were reduced (model 4 compared to model 1) with the addition of household income for the WRs Scandinavian (by 38%, 40%, 35%, and 41%, respectively), Bismarckian (by 37%, 34%, 39%, and 38%, respectively), Southern European (by 18%, 26%, 37%, and 53%, respectively), and Eastern European (by 30%, 23%, 23%, for disadvantaged, middle, and advantaged, respectively). For the Bismarckian WR, the adverse effect of ageing was reduced with greater difficulty making ends meet (interaction terms of age with satisfaction with household income).

The addition of the unhealthy behaviour index and living without a partner (model 5) did not change the association of early-life SECs and risk of poor SRH or any of the other mediators.

Sensitivity analyses

Overall, sensitivity analyses revealed consistent results with those of the main analyses, with gradually attenuated associations between early-life SECs and risk of poor SRH in old age with the addition of adult-life SECs across WRs. In contrast, the interactions between age and early-life SECs as well as age and adult-life SECs seemed not to be robust in the different analyses. Thus, the associations of early- and adult-life SECs with the evolution of poor SRH with ageing seemed less robust than their associations with level of poor SRH.

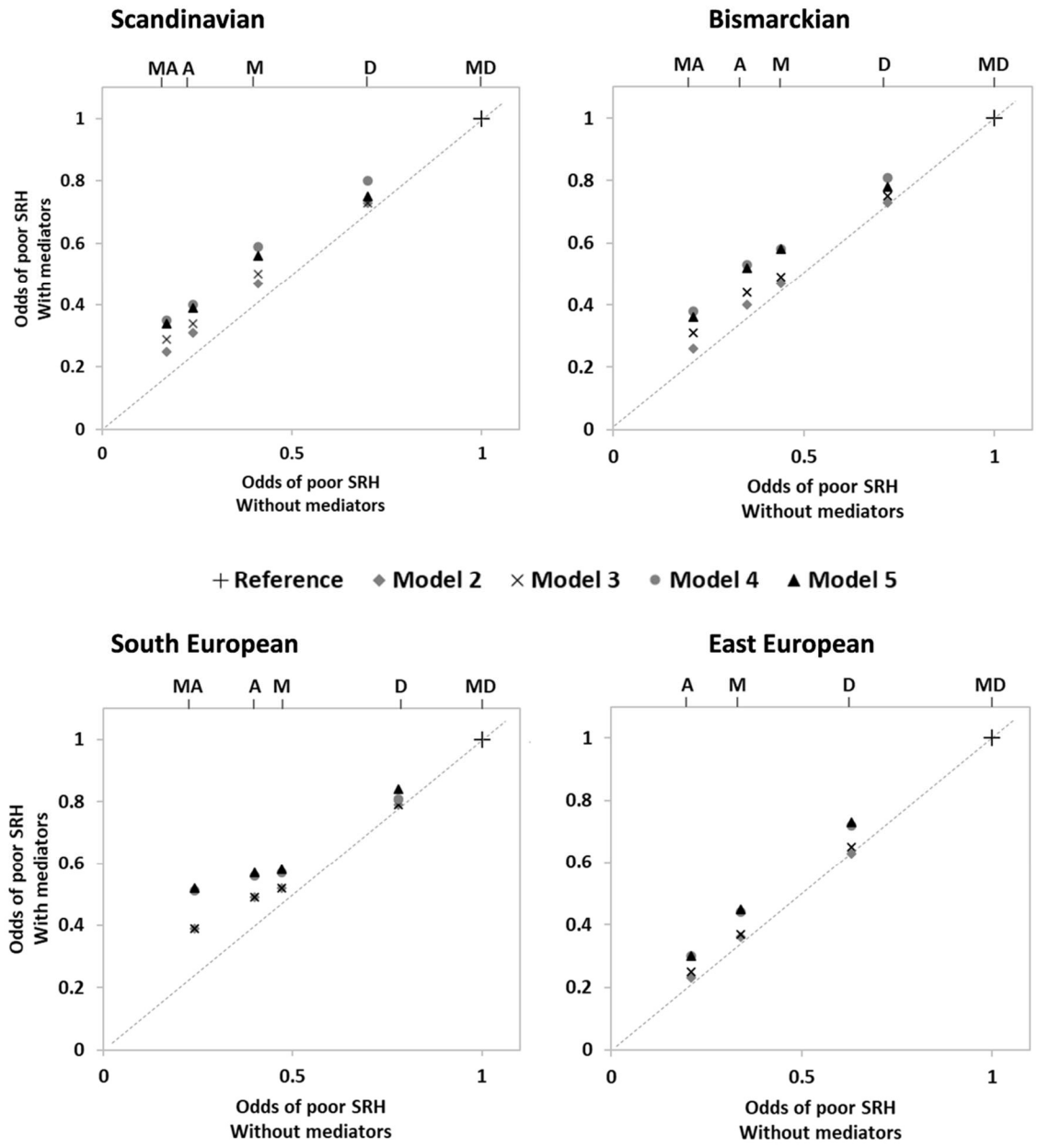

Figure 3 Effect of early-life SECs on poor SRH mediated by adult-life SECs, living without a partner and unhealthy behaviour index. Above the dotted line, the effect of early-life SECs decreases when the indicators are included in the model (i.e. attenuation effect). Below the dotted line, the effect of early-life SECs increases (i.e. suppressive effect). Model 1 tested the association between early-life SECs and risk of poor SRH. Model 2 added educa- tion. Model 3 added main occupation. Model 4 added satisfaction with household income. Model 5 added living without partner and unhealthy be- haviour index. Here, the adult-life indicators attenuated the association between early-life SECs and risk of poor SRH across welfare regimes. MD, most disadvantaged (reference; black plus sign); D, disadvantaged; M, middle; A, advantaged; MA, most advantaged.

Discussion

One of the main novel results of this cross-national and multi-measurement longitudinal study was the persisting association of early-life SECs with risk of poor SRH in older age across all WRs. This pattern has important implications, suggesting that the welfare context did not differentially modify the association between early-life SECs and SRH at old age. The association showed a social gradient in risk of poor SRH in old age, from the lowest risk for the most advantaged individuals to the highest risk for the most disadvantaged in terms of early-life SECs. These associations remained significant after full adjustment for adult-life mediators.

In contrast to early-life SECs, adult-life SECs were associated differently with risk of poor SRH across WRs and had varying attenuation effects on the relation between early-life SECs and SRH, which agrees with the original analysis before stratification including interaction terms of life-course SECs with WRs. Satisfaction with household income had the most important attenuation effect while also being associated with risk of poor SRH for all WRs. Low main occupation position had an attenuating effect for all WRs except the Southern European WR, and was associated with high risk of poor SRH in only Scandinavian and Bismarckian WRs. Education attenuated the association only in the Scandinavian and Southern European WRs, where it remained associated with low risk of poor SRH after full adjustment. We did not find changing patterns with ageing for early- and adult-life SECs. The few interaction terms that were significant proved not to be robust with further adjustments or on sensitivity analyses.

Previous studies showing that early-life SECs are associated with adulthood SRH were based on cross-sectional data and could therefore not account for SRH trajectories (Guimarães et al., 2014; Lindström et al., 2012; S. K. Mckenzie et al., 2011; Niedzwiedz et al., 2014a, 2015). In addition to support previous results (Case & Paxson, 2011; Das-Munshi et al., 2013; Dundas et al., 2014; Guimarães et al., 2014; Hagger-Johnson et al., 2011; Hyde, Jakub, Melchior, Oort, et al., 2006; Johnson et al., 2012; Lindström et al., 2012; S. K. Mckenzie et al., 2011), our results extend them to the population of old adults and account

for SRH trajectories. Our results corroborate findings showing that adult-life SECs mediate the association between early-life SECs and SRH later in life. In contrast to Mckenzie et al., who, in a study of adult SRH, suggested that educational attainment mediated most of the association (S. K. Mckenzie et al., 2011), we found that satisfaction with household income was the strongest mediator. Studies investigating the mediating role of adult-life SECs on the association of early-life SECs and SRH in old age are few. The existing literature shows that WRs affect the association of life-course SECs and health or life satisfaction differently. In general, socioeconomic inequalities in health exist across all WRs, but they are narrower in Scandinavian and Bismarckian than Southern and Eastern European WRs (Cambois et al., 2016; Mackenbach, 2012; Niedzwiedz et al., 2014a, 2014b, 2015). Furthermore, previous studies found that the financial situation in adult life is a strong predictor of health inequalities in old age, which agrees with our study (Niedzwiedz et al., 2014a, 2014b, 2015). However, previous studies did not use a life-course approach for measuring SECs, which allowed for the analysis of the mediating role of adult-life SECs on the association of early-life SECs and poor SRH trajectories. Rather, they used a measure for life-course SECs that mixed early- and adult-life SECs. Our study allowed for disentangling the effects of these different periods, showing the differential modifying influence of WRs on early- and adult-life SECs.

The strengths of this study include the large sample size, a follow-up of 12 years with repeated measurements every 2 years, and combined and comprehensive early- and adult-life SEC measures that allow for an analysis of varying life-course influences on SRH in old age across different WRs. Furthermore, this study considered a structural determinant of health by including WR rather than focusing on only the role of individual factors such as education, occupation, and income. However, one limitation is the self-reported and retrospective data used for early-life SECs and main occupation, which may be influenced by recall bias or social desirability. However, previous studies have shown adequate validity for recall measures of SEC (Barboza Solís et al., 2015; Lacey et al., 2012). Second, attrition in this longitudinal study may imply a selection bias in

the remaining sample. We accounted for this potential limitation by adjusting our models for attrition and conducting sensitivity analyses excluding participants who died and dropped out during follow-up. Third, we merge respondents in the "most advantaged" early-life SEC with the previous category "advantaged" in Eastern WR, because of the lack of observations in the former category that caused inconsistent results due to a strong selection effect. However, because we were interested in the gradient between the lowest and highest early-life SECs as opposed to single categories, this merging did not change how we approached our research questions. Fourth, we accounted for only the WR in which respondents lived in at the time of follow-up and we did not include the country they lived in during early and adult life. However, a sensitivity analysis considering WR at age 10 revealed similar results (not shown).

In conclusion, this study shows long-lasting consequences of early-life SECs on adult health and reveals that socioeconomic policies of emerging WRs in the 20th century have not fully compensated for an unfavourable start in life. The associations between early-life SECs and SRH in old age remained even after adjusting for adult-life SECs. However, the varying degree by which the different mediators attenuated the associations between early-life SECs and SRH in old age across WRs indicates differing modification effects in adult life. Education (early adult-life) attenuated the association only in the Scandinavian and Southern European WRs, but satisfaction with household income (in old age) seemed to play an important role across all WRs, specifically for the Eastern European WR, where it remained the only significant mediator. The occupational position in middle age seemed to play a role only in Scandinavian and Bismarckian WRs. These findings strengthen previous evidence showing that early life has long-lasting consequences for an individual's health development during the rest of the life course. This finding supports public policies interventions in childhood to promote better health in later life regardless of the different WRs examined. Furthermore, the differing adult-life attenuation of the association between early life and health in old age across WRs underpins the importance of context-specific public policies. As main occupation attenuated the association between early-life SEC and SRH in old

age only in Scandinavian and Bismarckian WR, occupation related social insurance schemes and other strategies may be important to overcome the impact of job insecurity and loss on health. Indeed, compared to the Southern and Eastern European WR, the Scandinavian and Bismarckian WRs have stronger policies linked to decommodification, with the Scandinavian having the strongest (Raphael & Bryant, 2015). Further research is needed to identify robust policy conclusions from these findings.

Key Messages

- In all four welfare regimes, early-life socioeconomic circumstances are associated with poor self-rated health in old age, with a gradient of improving health from “most disadvantaged” to “most advantaged”.
- Early-life socioeconomic circumstances have long-lasting consequences on health in old age, irrespective of welfare regime.
- The association of early-life socioeconomic circumstances with risk of poor self-rated health in old age is attenuated differently by adult-life socioeconomic circumstances (education, occupation, household income) across welfare regimes, which suggests a differential modifying effect across adult life.

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Conflict of Interest

None declared.

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As shown in *Chapter 2*, childhood socioeconomic circumstances are associated with levels of self-rated health in old age across welfare regimes even after adjusting for adult-life socioeconomic circumstances. While the associations between childhood socioeconomic circumstances and levels of self-rated health were consistent across the four analysed welfare regimes, the extent to which these associations were attenuated by the adult-life socioeconomic circumstances differed across welfare regimes. In *Chapter 3*, the socioeconomic factors in childhood are complemented with general and health-related adverse experiences. Furthermore, since the study in the previous chapter did not find associations with the self-rated health trajectories in old age, *Chapter 3* puts greater focus on the evolution of health in old age by adapting the analysis approach and examining the data in order to put the cumulative dis/advantage theory under scrutiny.

Chapter 3. Do welfare regimes moderate cumulative dis/advantages over the life course? Cross-national evidence from longitudinal SHARE data (Article 2)

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Abstract

Objectives. This study aimed to examine the cumulative disadvantage of different forms of childhood misfortune and adult-life socioeconomic conditions with regard to trajectories and levels of self-rated health in old age and whether these associations differed between welfare regimes (Scandinavian, Bismarckian, Southern European, and Eastern European).

Method. The study included 24,004 respondents aged 50 to 96 from the longitudinal SHARE survey. Childhood misfortune included childhood socioeconomic conditions, adverse childhood experiences, and adverse childhood health experiences. Adult-life socioeconomic conditions consisted of education, main occupational position, and financial strain. We analyzed associations with poor self-rated health using confounder-adjusted mixed-effects logistic regression models for the complete sample and stratified by welfare regime.

Results. Disadvantaged respondents in terms of childhood misfortune and adult-life socioeconomic conditions had a higher risk of poor self-rated health at age 50. However, differences narrowed with aging between adverse-childhood-health-experiences categories (driven by Southern and Eastern European welfare regimes), categories of education (driven by Bismarckian welfare regime), and main occupational position (driven by Scandinavian welfare regime).

Discussion. Our research did not find evidence of cumulative disadvantage with aging in the studied life-course characteristics and age range. Instead, trajectories showed narrowing differences with differing patterns across welfare regimes.

Introduction

As European societies grow older, understanding the factors that support good health in old age becomes increasingly important (Rechel et al., 2013). The literature investigating the effect of life-course factors on different healthy aging outcomes has repeatedly shown that adversities early in life have a long-lasting detrimental effect on health (Schafer & Ferraro, 2012; Sieber et al., 2019). Childhood misfortune specifically has been shown to impact health in the long term, irrespective of adult-life socioeconomic conditions (SEC) (Aartsen et al., 2019; Cheval, Chabert, Orsholits, et al., 2019; Cheval, Chabert, Sieber, et al., 2019; Landös et al., 2018; Schafer & Ferraro, 2012; van de Straat et al., 2020). Studies showed that poor self-rated health (SRH) in adult life in general was associated with disadvantaged childhood socioeconomic conditions (CSC) (Hyde, Jakub, Melchior, Van Oort, et al., 2006; Sieber et al., 2019), adverse childhood experiences (ACE) (Felitti et al., 1998; Gilbert et al., 2015), and adverse childhood health experiences (ACHE) (Haas, 2007; Power & Peckham, 1990). Yet, evidence is lacking on whether these associations with SRH apply to adults aged 50 and over and on how they develop with aging.

As a comprehensive health measure covering different health dimensions such as physical and mental health and as a predictor of mortality (DeSalvo et al., 2006a), SRH has proven to be a relevant outcome when examining differences in older adults' health (Christian et al., 2011; O'Brien Cousins, 1997).

From a life-course perspective, the long-lasting effects of childhood misfortune on SRH in old age can be explained by the cumulative dis/advantage (CDA) model, defined as the "systemic tendency for interindividual divergence in a given characteristic (e.g., money, health, or status) with the passage of time'' (Dannefer, 2003). The CDA model posits that social conditions and events early in the life course create differences between individuals that grow over time (Dannefer, 1987; Schafer et al., 2011). These processes are intertwined with the everyday lives of individuals, generating either increasing or decreasing advantages, which lead to a consistently growing gap in health (or another characteristic) between subgroups with the passage of time (Cullati et al., 2014; Ferraro & Kelley-Moore, 2003). While the focus on the influences of childhood

misfortune on later-life health is crucial, it is important not to neglect the other life course influences. The danger of “Time-One Encapsulation” exists if the causal role of socioeconomic conditions later in life are disregarded and attention is only paid to childhood conditions (Dannefer, 2018). Dannefer (2018) uses the term “life-course reflexivity” to emphasize the necessity of considering social conditions later in life when looking at childhood effects, thus employing an encompassing life-course approach in studying CDA processes. There are two underlying elements of this principle. First, interactive dynamics in adulthood are acknowledged as having a role in producing changes in the life course in mid- and old age, and, second, human intentionality and action are considered central in shaping these changes (Dannefer, 2018).

At the same time, contrary to the CDA model, some authors posit that differences between individuals become less pronounced over the life course. This tendency could be due to health selection in old age, where only the most robust individuals of each group survive over time, leading to narrowing differences between social categories (O’Rand, 2009). This theory is also known as the age-as-leveler hypothesis (S. M. Lynch, 2003). Another explanation consists of life-course processes that have the potential to reverse the CDA mechanisms through their positive effects (O’Rand, 2009). This includes “unexpected shifts in life conditions”, such as marriage/divorce or new employment, and “personal aspirations” or individual agency to overcome disadvantaged social origins (Burton-Jeangros et al., 2015; O’Rand, 2009).

This article intends to test three aspects of the CDA theory with regard to SRH trajectories: (1) Growing differences with aging by different childhood misfortune categories, (2) The principle of life-course reflexivity by acknowledging the importance of interactive dynamics in adult-life, which produce mid- and later life changes (Dannefer, 2018), (3) The influence of large-scale social regulation of economic and policy factors within states on the variation in trajectories (Dannefer, 2018). Thus, we aim to test the CDA mechanisms at two different levels: at the micro level considering the role of childhood misfortune and adult-life SEC and at the macro level by taking into account welfare regimes.

Since the CDA processes are thought to operate not only on micro- but also macro-levels, creating distinction and stratification at each level as individuals move through the life course, it is crucial to take into account their multileveled reality (Dannefer, 2018). The CDA model is based on social dynamics driven by macro-level forces impacting individual trajectories, which are expected to vary according to economic and welfare-state policies (Cullati et al., 2014; Dannefer, 2018). These varying effects are thought to occur because social policies alleviate adversities in individuals' lives to differing degrees (Sieber et al., 2019). More generous welfare regimes reduce social stratification and absorb the impact of material shortfalls by providing higher levels of benefits to their citizens (Bartley et al., 1997). Moreover, we hypothesize that CDA processes are less pronounced or offset in more generous welfare regimes since individuals are given more opportunities to break free from a vicious cycle of cumulative disadvantage. For instance, state-level pension plans or health insurance (e.g. Medicare) may help compensate adversities experienced throughout the life course (Crystal et al., 2017; Dannefer, 2018; McWilliams et al., 2010; Myerson et al., 2019). Following previous research on the impact of life-course socioeconomic conditions on SRH at old age, countries can be grouped into four welfare regimes to reflect similarities in terms of the relative roles of the state, family, and market in the provision of welfare (Sieber et al., 2019). In that respect, Ferrera's typology derived from Esping-Andersen's and augmented by the Eastern European welfare regime, focuses on how social benefits are granted and organized, and is labelled as one of the most accurate typologies (Eikemo, Bambra, et al., 2008; Eikemo, Huisman, et al., 2008; Esping-Andersen, 1990; Ferrera, 1996). The Scandinavian welfare regime is characterised by a strong interventionist state aiming at social equality trough a generous redistributive social-security system and universal coverage (Eikemo, Bambra, et al., 2008; Esping-Andersen, 1990). The Bismarckian welfare regime is minimally redistributive with benefits being related to earnings and administered by employers, which leads to "status differentiating" welfare programs which distinguishes this welfare regime from others (Bambra & Eikemo, 2009; Eikemo, Bambra, et al., 2008; Esping-Andersen, 1990). The

Southern European welfare regime is considered a rather basic type of welfare state, with a fragmented system of welfare provision and strong reliance on family and the charitable sector as well as partial healthcare coverage (Eikemo, Bambra, et al., 2008; Ferrera, 1996). The Eastern European welfare regime is characterized by limited health service provision and poor overall population health, grouping formerly Communist countries that experienced a shift from universalism to a marketized and decentralized welfare state (Bambra & Eikemo, 2009; Eikemo, Huisman, et al., 2008).

In terms of empirical analyzes, this study has three objectives in line with the three aspects of the CDA theory. First, we aim at examining the associations of different forms of childhood misfortune (CSC, ACE, ACHE) with levels and trajectories of SRH in old age. Second, we investigate the role of adult-life SEC (education, main occupation, financial strain) in the association of childhood adversities with levels and trajectories of SRH in old age. By following the life-course reflexivity principle, we aim to take into account the whole life course and acknowledge the potential causal role of adult-life SEC, which has not been done by existing studies on CDA and SRH (Bauldry et al., 2012; Cullati et al., 2014; Mirowsky & Ross, 2008). Third, we aim to examine whether welfare regimes influence the associations of childhood misfortune and adult-life SEC with levels and trajectories of SRH in old age. To our knowledge, this is the first time the CDA hypothesis has been tested with SRH in older age with a comparative analysis strategy examining differences across welfare regimes. We hypothesize that in more generous welfare regimes with strong redistributive policies, the CDA processes are less marked, i.e. the processes that lead to growing differences between categories of childhood misfortune and adult-life SEC are absent or less discriminating. The distinction between levels and trajectories is important as the levels allow us to examine the differences in SRH at the beginning of the studied period, indicating potential CDA processes before the age of 50 which led to these differences. The trajectories, however, allow us to directly investigate whether CDA processes can be observed in the studied period between 50 and 96 years.

Methods

Study design and participants

In this study, we used cross-national and longitudinal data from the Survey of Health, Ageing and Retirement in Europe (SHARE), which collected information on health and SEC of individuals aged 50 and older in 27 European countries (Börsch-Supan et al., 2013). SHARE has collected 6 waves (every 2 years) of data between 2004 and 2015. Wave 3 includes retrospective life-course data on childhood and adult-life predictors. In our study, we included participants aged between 50 and 96 years who participated in the third wave and had at least one SRH observation over the six survey waves.

Welfare regimes

This study used the welfare regime classification as proposed by Eikemo et al. (2008), which expands Ferrera's typology with the Eastern European welfare regime (Esping-Andersen, 1990; Ferrera, 1996). Accordingly, we classified the 13 countries in the final sample into four welfare regimes: Scandinavian (Denmark, Sweden), Bismarckian (Austria, Belgium, France, Germany, the Netherlands, Switzerland), Southern European (Greece, Italy, Spain), and Eastern European (Czech Republic, Poland). See Supplemental Material for more information.

Measures

Outcome: Self-rated health

In line with a previous study (Sieber et al., 2019), we formed a binary outcome by grouping the categories "poor" and "fair" indicating poor SRH as opposed to "good", "very good" and "excellent" indicating good SRH (see Supplemental Material for more information).

Childhood misfortune

Adverse Childhood Experiences (ACE). We used a score combining a set of traumatic events (emotional, physical, or linked to household dysfunction) that occurred during childhood (from age 0 to 15) and that were outside a child's control (Felitti et al., 1998); parental death (father, mother, or both), parental mental illness, parental drinking abuse, child in care (living in a children's home or with a foster family), period of hunger, and property taken away. Following previous studies, we computed a score ranging from 0 to 7 by combining the 6 ACE indicators (see Supplemental Material for more information).

Adverse Childhood Health Experiences (ACHE) combined information on 5 indicators of childhood health problems up until the age of 15 into a binary variable (Cheval, Chabert, Sieber, et al., 2019; Cheval, Orsholits, Sieber, et al., 2019); long hospitalization (hospitalization for a month or more), multiple hospitalizations (more than three times within a 12-month period), childhood illness (including polio, asthma, or meningitis/encephalitis), serious health conditions (including severe headaches, psychiatric problem, fractures, heart trouble, cancers), and physical injury that has led to permanent handicap, disability or limitation in daily life (see Supplemental Material for more information).

Childhood Socioeconomic Conditions (CSC) is a score derived from four binary indicators of adverse socioeconomic conditions at age 10: 1) occupational position of the main breadwinner (low vs. high skill), 2) number of books in the home (≤10 vs. >10), 3) a measure of overcrowding (more than one vs. one or less persons per room in the household), and 4) housing quality (absence of all vs. presence of at least one of the following: fixed bath, cold and hot running water, inside toilet, central heating) (Wahrendorf & Blane, 2015, see Supplemental Material for more information).

Adult-life Socioeconomic Conditions (SEC). We used three indicators of adult-life SEC representing different adult-life periods (Sieber et al., 2019); education (primary, secondary, tertiary), main occupational position (low and high skill), and financial strain (Is the household able to make ends meet? easily, fairly easily, with some difficulty, with great difficulty; see Supplemental Material for more information).

Statistical Analysis

We used logistic mixed-effects models to analyze the data with observations (level 1) nested within participants (level 2). These models avoided excluding participants with missing observations as they do not require an equal number of observations for all participants. Age was centered at the beginning of the trajectory (i.e., 50 years), which allowed us to examine the differences in level of poor SRH at the youngest age of the sample's age range. In addition, age was divided by ten so that the coefficient yielded effects of increase in risk of poor SRH over a 10-year period. A quadratic term for age was not included in the models since preliminary tests revealed that it was not significant and did not improve model fit. Model 1a tested the association between childhood misfortune (CSC, ACE, ACHE) and the level of risk of poor SRH at age 50 (Table 2). In addition, model 1a included interaction terms between age and childhood misfortune to examine whether childhood misfortune influences the trajectories of poor SRH with aging. This allowed us to test whether the differences between childhood misfortune categories were growing (cumulative disadvantage) or narrowing with aging. In model 2a we added the adult-life SEC (education, main occupational position, financial strain) and their respective interactions (Table 2).

As previous research has shown that welfare regime moderates the associations between adult-life SEC and level of poor SRH (Sieber et al., 2019), we ran models including triple interactions (age x predictors x welfare regime) testing whether welfare regime also moderated the trajectories of poor SRH (data not shown). Significant triple interactions supported our decision to stratify the models by welfare regime. We ran Models 1b and 2b (Tables 3 and 4, see

Supplemental Material) separately for each welfare regime and correspond to the unstratified models 1a and 2a.

Finally, models 3a and 3b correspond to models 2a and 2b with the addition of the 'living with a partner' and 'unhealthy behavior index' covariates (without interactions, see Supplemental Material for variable description) to examine the independent effect of childhood misfortune and adult-life SEC on poor SRH as prior research has shown that these covariates influence SRH (Table S2, see Supplemental Material) (Cullati et al., 2014; Knöpfli et al., 2016; Sieber et al., 2019).

In line with previous research (Sieber et al., 2019), we adjusted all models for three prior confounders; participant attrition [no dropout/dropout (participants who did not respond to waves 5 and 6)/death (participants who died during follow-up)], sex (male/female), and birth cohort [1919–1928/1929–1938 (Great Depression)/1939–1945 (World War II)/post-1945].

Finally, we performed sensitivity analyzes excluding observations for participants 1) older than 90 years because the descriptive statistics showed that observations above this age were few, 2) participants who died during the survey, 3) and participants who dropped out. Additionally, we ran the models including a variable for number of waves interviewed replacing the attrition variable described above as well as using a stricter coding of the drop out modality including nonresponse in waves 4, 5, and 6. The sensitivity analyzes revealed consistent results with those of the main analyzes presented in the following section and did not indicate deviating findings due to very old participants or attrition. In addition, we performed two robustness analyzes, in which (1) we ran the same models treating the SRH item as a continuous variable ranging from 0, excellent to 4, poor SRH as well as (2) treating it as an ordinal variable to perform ordinal logistic regressions (data available upon request).

Results

Participants' characteristics

The final sample used for the models included 24,004 respondents (56% female); 3,626 (15.1%) in Scandinavian, 10,250 (42.7%) in Bismarckian, 6,891 (28.7%) in Southern European, and 3,237 (13.5%) in Eastern European welfare regimes (Table 1 and Figure S1, Supplemental Material). At baseline, respondents with poor SRH were on average older than respondents with good SRH. The higher the childhood misfortune, the higher the proportion of respondents with poor SRH. Similarly, the more disadvantaged the adult-life SEC, the higher the proportion of respondents with poor SRH. The proportion of respondents with poor SRH was the highest in Eastern European welfare regime (50.5%), followed by Southern European (33.5%), Bismackian (25.3%), and Scandinavian welfare regime (14.6%) (Table S1). In Figure 1 we plotted the observed evolution of poor SRH proportions with aging for each childhood misfortune and adult-life SEC variable. In general, these descriptive trajectories show a rather parallel evolution up until the age of 70 and thereafter a narrowing pattern between the categories.

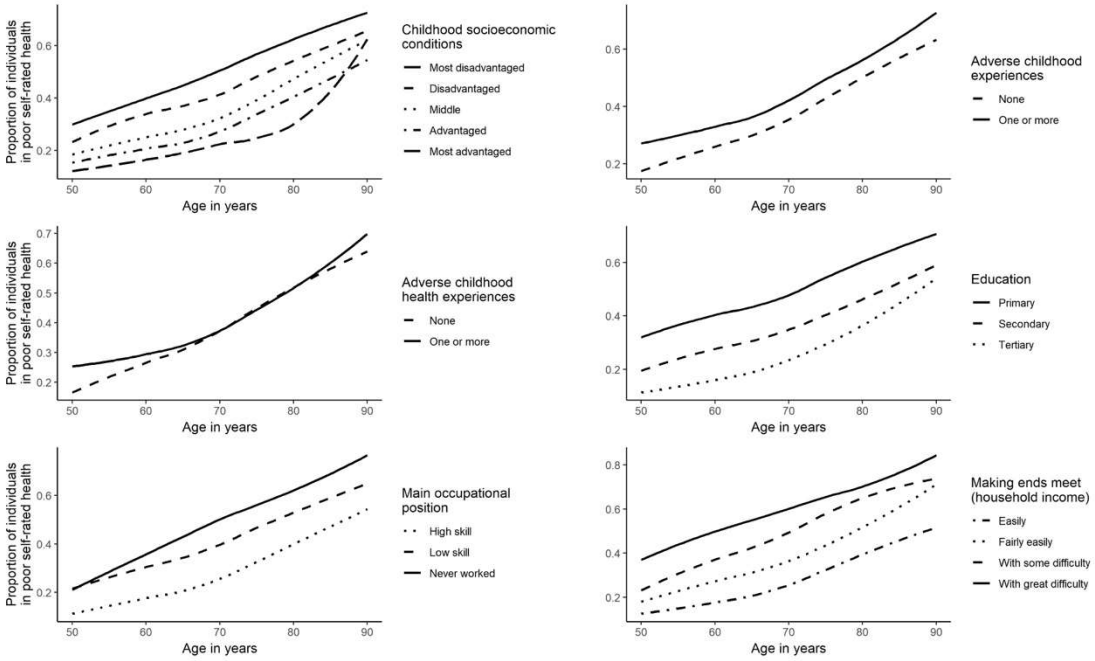

Figure 1 Descriptive plot of observed evolution of poor self-rated health proportions by age by childhood misfortune and adult-life socioeconomic conditions.

Association of childhood misfortune with levels and trajectories of poor self-rated health in old age, Objective 1 (Table 2, model 1a)

In model 1a, we found that all three childhood misfortune predictors (CSC, ACE, and ACHE) were associated with differences in the levels of SRH at the beginning of the trajectory (i.e. age 50), with more disadvantaged categories consistently having higher odds of poor SRH in old age across predictors than less disadvantaged categories. The model revealed no differing linear trajectories of poor SRH with aging by ACE and CSC categories. For ACHE, however, the interaction term with age revealed that the linear decline of poor SRH with aging for respondents that had at least one ACHE was less steep compared to those who had no ACHE.

Accumulation of disadvantage over the life course, Objective 2 (Table 2, model 2a)

Education, main occupational position, and financial strain were associated with the level of SRH at the beginning of the trajectory, with more disadvantaged categories consistently having higher odds of poor SRH at age 50 than less disadvantaged categories (model 2a). A significant interaction term revealed narrowing differences with aging between primary and tertiary education, but no change in trajectories between primary and secondary education. For main occupational position, we observed narrowing differences between high and low skill occupations as people grow older in the association with poor SRH. The trajectories between those that never worked and those with high occupational position were, however, not different with aging. For financial strain, the interaction terms did not reveal differences in the trajectories with aging.

The associations of the childhood misfortune predictors with level and trajectories of poor SRH in old age stayed significant when adjusting for adult-life SEC and covariates (model 2a). The results remained unchanged after full adjustment with partnership status and the unhealthy behavior index (Table S2, see Supplemental Material).

Table 1. Baseline sample characteristics

	Good SRH N (%)	Poor SRH N (%)
Total	16939 (70.6)	7065 (29.4)
Age, mean (sd)	61.3 (8.7)	65.3 (9.6)
Scandinavian WR	3096 (85.4)	530 (14.6)
Bismarckian WR	7657 (74.7)	2593 (25.3)
Southern European WR	4583 (66.5)	2308 (33.5)
Eastern European WR	1603 (49.5)	1634 (50.5)
ACE : None	13637 (72.1)	5268 (27.9)
ACE : At least one	3302 (64.8)	1797 (35.2)
ACHE : None	12697 (70.8)	5244 (29.2)
ACHE : At least one	4242 (70)	1821 (30)
CSC : Most disadvantaged	2492 (55.2)	2019 (44.8)
CSC : Disadvantaged	3979 (65.9)	2063 (34.1)
CSC : Middle	5785 (75.1)	1922 (24.9)
CSC : Advantaged	3536 (80.3)	867 (19.7)
CSC : Most advantaged	1147 (85.5)	194 (14.5)
Education		
Primary	4108 (56.4)	3180 (43.6)
Secondary	8908 (73.6)	3188 (26.4)
Tertiary	3923 (84.9)	697 (15.1)
Main occupational position		
High skill	4439 (82.2)	964 (17.8)
Low skill	11303 (68.3)	5245 (31.7)
Never worked	1197 (58.3)	856 (41.7)
Financial strain		
Easily	7294 (81.7)	1634 (18.3)
Fairly easily	5216 (71.1)	2120 (28.9)
With some difficulty	3147 (60.5)	2058 (39.5)
With great difficulty	1282 (50.6)	1253 (49.4)
Partnership status : Alone	3831 (64.1)	2143 (35.9)
Partnership status : In couple	13108 (72.7)	4922 (27.3)
Unhealthy behavior index, mean (sd)	0.2 (0.3)	0.3 (0.3)
Female	9176 (68.3)	4259 (31.7)
Male	7763 (73.5)	2806 (26.5)
Birth cohort		
After 1945	8126 (77.6)	2339 (22.4)
Between 1919 and 1928	1274 (53.7)	1098 (46.3)
Between 1929 and 1938	3526 (62.7)	2096 (37.3)
Between 1939 and 1945	4013 (72.4)	1532 (27.6)
Attrition : No dropout	12583 (73.6)	4510 (26.4)
Attrition : Dropped	3302 (70)	1412 (30)
Attrition : Deceased	1054 (48)	1143 (52)

Note. SRH: Self-rated health, WR: Welfare regime, ACE: Adverse childhood experiences, ACHE: Adverse childhood health experiences, CSC: Childhood socioeconomic conditions.

Table 2. Associations of childhood misfortune and adult-life socioeconomic circumstances with level and trajectories of poor self-rated health at old age.

	M1a		M2a	
	OR (95% CI)	P	OR (95% CI)	P
Age (10-y period)	2.81 (2.58-3.07)	***	2.98 (2.59-3.42)	***
At least one ACE (ref. None)	1.69 (1.44-2.00)	***	1.66 (1.42-1.95)	***
At least one ACHE (ref. None)	1.82 (1.57-2.11)	***	1.85 (1.60-2.13)	***
CSC (ref. Most disadvantaged)				
Disadvantaged	0.57 (0.46-0.70)	***	0.79 (0.64-0.97)	*
Middle	0.28 (0.23-0.34)	***	0.59 (0.48-0.73)	***
Advantaged	0.18 (0.14-0.22)	***	0.53 (0.42-0.67)	***
Most advantaged	0.09 (0.07-0.13)	***	0.42 (0.30-0.59)	***
Education (ref. Primary)				
Secondary			0.67 (0.57-0.80)	***
Tertiary			0.34 (0.26-0.43)	***
Main Occupational Position (ref. High skill)				
Low skill			1.60 (1.33-1.91)	***
Never worked			0.96 (0.71-1.30)	
Financial strain (ref. Easily)				
Fairly easily			1.74 (1.48-2.04)	***
With some difficulty			3.35 (2.80-4.01)	***
With great difficulty			7.17 (5.70-9.01)	***
Interactions				
Age x at least one ACE (ref. None)	0.99 (0.91-1.07)		0.97 (0.90-1.05)	
Age x at least one ACHE (ref. None)	0.85 (0.78-0.91)	***	0.85 (0.79-0.92)	***
Age x CSC (ref. Most disadvantaged)				
Age x Disadvantaged	1.00 (0.91-1.10)		0.99 (0.90-1.09)	
Age x Middle	1.04 (0.95-1.14)		0.99 (0.90-1.09)	
Age x Advantaged	1.05 (0.94-1.17)		0.95 (0.84-1.06)	
Age x Most advantaged	1.08 (0.92-1.27)		0.93 (0.78-1.10)	
Age x Education (ref. Primary)				
Age x Secondary			1.04 (0.96-1.13)	
Age x Tertiary			1.20 (1.07-1.36)	**
Age x Main occupational position (ref. High skill)				
Age x Low skill			0.89 (0.82-0.98)	*
Age x Never worked			1.13 (0.98-1.30)	
Age x Financial strain (ref. Easily)				
Age x Fairly easily			1.04 (0.97-1.13)	
Age x With some difficulty			1.02 (0.93-1.11)	
Age x With great difficulty			0.92 (0.82-1.03)	

Note. OR: Odds ratios, CI: Confidence interval, ACE: Adverse childhood experiences, ACHE: Adverse childhood health experiences, CSC: Childhood socioeconomic conditions. All models are adjusted for sex, birth cohort and attrition. Age was centered at 50 y and divided by 10 so that the coefficients yielded the effects for a 10-year period.
***p<.001, **p<.01, *p<.05

Moderation of childhood misfortune and adult-life SEC associations with poor self-rated health by welfare regimes, Objective 3 (Table 3 and 4)

In terms of level of poor SRH at age 50, results revealed the associations between CSC and poor SRH differed across welfare regimes (Tables 3 and 4, Supplemental material). While in Scandinavian (Table 3) and Southern European welfare regime (Table 4) the association became non-significant with the addition of adult-life SEC (models 2b, with the exception of most advantaged in Scandinavian), the association stayed significant in Bismarckian (Table 3) and Eastern European welfare regimes (Table 4, though with less marked differences between the CSC categories compared to model 1b). The associations between ACE and ACHE with poor SRH did not differ across welfare regimes. However, the associations between education and main occupational position (but not financial strain) and poor SRH were different across welfare regimes (Table 3 and 4, models 2b). The results revealed no association of education with poor SRH in the Scandinavian welfare regime, whereas there was an expected gradient in the other welfare regimes. Low main occupational position was associated with higher levels of poor SRH when compared to high occupational position across welfare regimes, except in the Southern European regime. Never having done paid work was associated with higher levels of poor SRH in Bismarckian welfare regime when compared to high main occupational position, while in the Southern European welfare regime it was associated with lower levels of poor SRH. In Scandinavian and Eastern European regimes, never having done paid work was not associated with SRH. Financial strain was consistently associated with poor SRH across welfare regimes, with more disadvantaged categories showing higher levels of poor SRH (Table 3 and 4, models 2b).

In terms of trajectories of poor SRH with aging, we found no differences between the CSC and ACE categories across welfare regimes (Table 3 and 4), but the association between ACHE and SRH trajectories did differ across welfare regimes. In Southern and Eastern European welfare regimes, respondents who experienced one or more ACHE had a less steep increase of poor SRH with aging when compared to those who did not experience ACHE.

Furthermore, associations of adult-life SEC with SRH trajectories differed across welfare regimes (Table 3 and 4). The SRH trajectories between the various categories of education were not different within Scandinavian, Southern, and Eastern European welfare regimes. However, in the Bismarckian welfare regime, respondents with tertiary education had a steeper increase of poor SRH with aging when compared to primary education. Respondents with low-skill main occupational position in the Scandinavian welfare regime had a less steep increase of poor SRH with aging when compared to high-skill occupational position. Across other welfare regimes, main occupational position did not show differing trajectories with aging between the different categories. Respondents with great difficulty making ends meet in the Bismarckian welfare regime had a less steep increase of poor SRH with aging when compared to those who could make ends meet easily. Across the other welfare regimes, SRH trajectories between categories of financial strain were not different with aging.

Full adjustment of the models with partnership status and unhealthy behavior index did not change the results on level and trajectories of poor SRH (Table S2, Supplemental Material).

In the robustness analyzes, the models with a continuous and ordinal SRH outcome variable showed consistent results with the models including a binary outcome. In addition, we observed supplementary age-predictor interactions (trajectories) that supported the findings described above with one exception: In Scandinavian welfare regimes, respondents with secondary and tertiary education had a less steep increase of poor SRH with aging compared to respondents with primary education.

Table 3. Associations of childhood misfortune and adult-life socioeconomic circumstances with level and trajectories of poor self-rated health at old age stratified by Scandinavian and Bismarckian welfare regime.

	Scandinavian N = 3626				**Bismarckian** N = 10250			
	M1b		M2b		M1b		M2b	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Age (10-y period)	3.51 (2.41-5.10)	***	5.00 (3.22-7.75)	***	2.66 (2.24-3.16)	***	2.77 (2.18-3.52)	***
At least one ACE (ref. None)	2.06 (1.34-3.19)	**	1.99 (1.30-3.06)	**	1.79 (1.38-2.33)	***	1.57 (1.22-2.03)	***
At least one ACHE (ref. None)	1.47 (1.00-2.18)		1.54 (1.05-2.27)	*	1.81 (1.44-2.27)	***	1.70 (1.36-2.13)	***
CSC (ref. Most disadvantaged)								
Disadvantaged	0.77 (0.26-2.27)		0.82 (0.28-2.38)		0.66 (0.43-1.02)		0.84 (0.55-1.29)	
Middle	0.35 (0.13-0.96)	*	0.49 (0.18-1.34)		0.38 (0.25-0.58)	***	0.69 (0.45-1.05)	
Advantaged	0.24 (0.09-0.67)	**	0.41 (0.15-1.16)		0.27 (0.18-0.42)	***	0.60 (0.39-0.94)	*
Most advantaged	0.12 (0.04-0.36)	***	0.29 (0.09-0.93)	*	0.14 (0.08-0.24)	***	0.44 (0.26-0.77)	**
Education (ref. Primary)								
Secondary			1.38 (0.77-2.47)				0.57 (0.42-0.78)	**
Tertiary			0.86 (0.44-1.69)				0.35 (0.23-0.52)	***
Main Occupational Position (ref. High skill)								
Low skill			3.68 (2.37-5.71)	***			1.65 (1.25-2.17)	***
Never worked			3.94 (0.34-46.05)				2.49 (1.31-4.75)	**
Financial strain (ref. Easily)								
Fairly easily			1.25 (0.81-1.93)				1.90 (1.49-2.42)	***
With some difficulty			3.45 (1.66-7.16)	**			4.88 (3.56-6.69)	***
With great difficulty			9.04 (2.44-33.42)	**			27.02 (17.05-42.83)	***
Interactions								
Age x at least one ACE (ref. None)	0.86 (0.69-1.06)		0.86 (0.70-1.06)		1.01 (0.89-1.14)		1.04 (0.92-1.17)	
Age x at least one ACHE (ref. None)	1.00 (0.83-1.21)		0.97 (0.80-1.16)		0.91 (0.81-1.02)		0.93 (0.83-1.04)	
Age x CSC (ref. Most disadvantaged)								
Age x Disadvantaged	0.98 (0.65-1.47)		0.99 (0.66-1.50)		1.05 (0.87-1.26)		1.02 (0.85-1.23)	
Age x Middle	1.07 (0.73-1.57)		1.08 (0.73-1.60)		1.05 (0.88-1.26)		0.97 (0.81-1.17)	
Age x Advantaged	1.00 (0.67-1.48)		0.99 (0.66-1.49)		1.11 (0.92-1.35)		1.00 (0.82-1.22)	
Age x Most advantaged	1.15 (0.72-1.83)		1.07 (0.66-1.74)		1.17 (0.92-1.50)		0.99 (0.77-1.28)	
Age x Education (ref. Primary)								
Age x Secondary			0.85 (0.66-1.08)				1.07 (0.93-1.23)	
Age x Tertiary			0.82 (0.61-1.10)				1.28 (1.06-1.55)	*
Age x Main occupational position (ref. High skill)								
Age x Low skill			0.69 (0.56-0.85)	***			0.96 (0.83-1.10)	
Age x Never worked			0.60 (0.25-1.46)				0.94 (0.72-1.22)	
Age x Financial strain (ref. Easily)								
Age x Fairly easily			1.19 (0.97-1.45)				1.01 (0.90-1.13)	
Age x With some difficulty			1.01 (0.73-1.40)				0.89 (0.76-1.04)	
Age x With great difficulty			1.16 (0.62-2.16)				0.57 (0.44-0.73)	***

Note. OR: Odds ratios, CI: Confidence interval, ACE: Adverse childhood experiences, ACHE: Adverse childhood health experiences, CSC: Childhood socioeconomic conditions. All models are adjusted for sex, birth cohort and attrition. Age was centered at 50 y and divided by 10 so that the coefficients yielded the effects for a 10-year period.

***p<.001, **p<.01, *p<.05

Table 4. Associations of childhood misfortune and adult-life socioeconomic circumstances with level and trajectories of poor self-rated health at old age stratified by Southern and Eastern European welfare regime.

	Southern European N = 6891				**Eastern European** N = 3237			
	M1b		M2b		M1b		M2b	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Age (10-y period)	3.14 (2.76-3.56)	***	2.85 (2.16-3.77)	***	1.52 (1.24-1.85)	***	1.87 (1.27-2.74)	**
At least one ACE (ref. None)	1.98 (1.46-2.68)	***	1.65 (1.22-2.22)	**	1.51 (1.02-2.21)	*	1.44 (0.99-2.11)	
At least one ACHE (ref. None)	2.03 (1.53-2.70)	***	2.06 (1.56-2.73)	***	1.70 (1.21-2.38)	**	1.51 (1.09-2.11)	*
CSC (ref. Most disadvantaged)								
Disadvantaged	0.86 (0.64-1.14)		1.01 (0.76-1.35)		0.76 (0.50-1.16)		1.06 (0.69-1.62)	
Middle	0.48 (0.35-0.65)	***	0.76 (0.55-1.05)		0.23 (0.15-0.33)	***	0.40 (0.27-0.61)	***
Advantaged	0.35 (0.23-0.55)	***	0.77 (0.49-1.23)		0.14 (0.08-0.24)	***	0.31 (0.18-0.53)	***
Most advantaged	0.40 (0.15-1.08)		1.24 (0.45-3.39)		0.25 (0.07-0.92)	*	0.70 (0.19-2.58)	
Education (ref. Primary)								
Secondary			0.47 (0.36-0.61)	***			0.48 (0.33-0.71)	***
Tertiary			0.17 (0.11-0.27)	***			0.38 (0.19-0.74)	**
Main Occupational Position (ref. High skill)								
Low skill			0.86 (0.58-1.27)				1.69 (1.11-2.56)	*
Never worked			0.57 (0.36-0.90)	*			1.21 (0.42-3.45)	
Financial strain (ref. Easily)								
Fairly easily			1.08 (0.75-1.55)				1.54 (0.96-2.48)	
With some difficulty			1.49 (1.05-2.11)	*			2.22 (1.38-3.56)	**
With great difficulty			2.19 (1.49-3.22)	***			5.92 (3.37-10.38)	***
Interactions								
Age x at least one ACE (ref. None)	0.95 (0.83-1.09)		0.99 (0.86-1.13)		0.86 (0.70-1.06)		0.87 (0.71-1.06)	
Age x at least one ACHE (ref. None)	0.83 (0.72-0.96)	*	0.81 (0.70-0.94)	**	0.76 (0.62-0.92)	**	0.80 (0.66-0.97)	*
Age x CSC (ref. Most disadvantaged)								
Age x Disadvantaged	0.97 (0.85-1.11)		0.95 (0.83-1.08)		0.93 (0.74-1.15)		0.88 (0.70-1.10)	
Age x Middle	1.02 (0.87-1.18)		0.96 (0.82-1.12)		1.20 (0.98-1.48)		1.10 (0.88-1.37)	
Age x Advantaged	1.09 (0.86-1.37)		0.95 (0.75-1.21)		1.23 (0.91-1.66)		1.07 (0.78-1.46)	
Age x Most advantaged	0.85 (0.52-1.37)		0.75 (0.46-1.24)		0.67 (0.31-1.43)		0.53 (0.25-1.14)	
Age x Education (ref. Primary)								
Age x Secondary			1.11 (0.97-1.26)				1.20 (0.98-1.47)	
Age x Tertiary			1.30 (1.00-1.69)				1.23 (0.85-1.79)	
Age x Main occupational position (ref. High skill)								
Age x Low skill			0.98 (0.79-1.21)				0.84 (0.66-1.07)	
Age x Never worked			1.11 (0.87-1.40)				1.02 (0.61-1.70)	
Age x Financial strain (ref. Easily)								
Age x Fairly easily			1.02 (0.85-1.21)				0.83 (0.64-1.07)	
Age x With some difficulty			1.09 (0.92-1.30)				0.86 (0.67-1.11)	
Age x With great difficulty			1.08 (0.89-1.30)				0.80 (0.58-1.11)	

Note. OR: Odds ratios, CI: Confidence interval, ACE: Adverse childhood experiences, ACHE: Adverse childhood health experiences, CSC: Childhood socioeconomic conditions. All models are adjusted for sex, birth cohort and attrition. Age was centered at 50 y and divided by 10 so that the coefficients yielded the effects for a 10-year period.

***p<.001, **p<.01, *p<.05

Discussion

The main results of this cross-national and longitudinal study examining the associations of childhood misfortune, adult-life SEC, and welfare regime with SRH in old age are multifaceted. Independent from welfare regime, the results showed a persistent and graded association of childhood misfortune (objective 1) and adult-life SEC (objective 2) with the level of SRH, which is in line with the CDA model. The more disadvantaged respondents showed poorer SRH at the age of 50. According to the CDA model, a potential explanation for these differences could be the accumulation of disadvantages over the life course up until the age of 50. For SRH trajectories, we found that for ACHE (objective 1), education, and main occupational position (objective 2), differences in SRH between the various categories diminished with aging. Thus, when testing the hypothesis of the CDA model to health trajectories in the second half of life (50-96 years), we observed that differences in SRH diminished over time in the case of ACHE, education, and main occupational position or were maintained on the same level in the case of CSC, ACE, and financial strain. Figure 1 suggests that while the pattern of narrowing differences starts already at the beginning of the observed period for ACHE, the education and main occupational position categories seemed to approach each other from around 70 years on. These findings are in line with the age-as-leveler hypothesis, which states that differences decrease in old age due to mortality selection. Furthermore, the results showed that adult-life SEC did not explain the associations of childhood misfortune with levels of SRH, which hint at a cumulative life-course effect of adult-life SEC on the differences at age 50 in addition to the effects of childhood.

When looking at differences in the associations with levels of SRH across welfare regimes (objective 3), ACE, ACHE, and financial strain were similarly associated with more disadvantaged categories presenting poorer SRH. A potential explanation for the level differences in these latter variables could be the accumulation of disadvantages in the life course up until age 50, which seemed to lead to similar results across welfare regimes. In contrast, CSC, education, and main occupational position showed varying patterns. The

persistent associations of ACE and ACHE across welfare regimes as opposed to the varying associations of CSC may be the result of the welfare regimes' main focus on adult-life factors such as pensions and unemployment benefits rather than directly experienced childhood adversities. Since CSC is measured through parental socioeconomic circumstances and ACE and ACHE through personal experiences, this may explain the differences in the associations. In the Southern European welfare regimes, adult-life SEC seemed to explain the association between CSC and SRH, suggesting that the accumulation of disadvantage from CSC could be compensated by better outcomes in adult-life SEC. This may be the result of the expansion of welfare benefits in these welfare regimes, which mainly occurred during adult life for the included cohorts in this study (Ferrera, 1996). Education was associated with better SRH across welfare regimes, except for the Scandinavian welfare regimes where no association was found, suggesting a positive effect of more generous and redistributive welfare policies. Scandinavian countries are known to invest a significant share of their GDP in their educational system with the aim of ensuring equal access regardless of parents' status or income. Similarly, low main occupational position was associated with poorer SRH across welfare regimes, but seemed not to play a role in Southern European welfare regime. This result can be explained by differences in employment policies, family solidarity, and informal economy across European countries. In Southern European countries, workers' social protection, as well as comprehensive unemployment policies, developed quickly over the past decades (Karamessini, 2007). Moreover, people living in these countries – as well as in northern welfare regimes – can more frequently rely on intergenerational solidarity within their families compared to countries in other welfare regimes (Daatland & Lowenstein, 2005). Such solidarity within families provide people with significant additional socioeconomic resources which can compensate adversities in the life course, such as temporary job loss. In addition, familial solidarity can help building up substantial socioeconomic reserves (through financial support, heritage, or logistic support) that protect individuals from adverse events and

shocks, which are linked with the development of vulnerability (Cullati et al., 2018).

With regard to the comparison of SRH trajectories in the age range from 50 to 96 years across welfare regimes (objective 3), we found narrowing differences with aging for ACHE in Southern and Eastern European welfare regimes, which is in line with the age-as-leveler hypothesis. In other words, poor health in childhood continues to fuel health inequality in the second half of life in Bismarckian and Scandinavian welfare regimes, by maintaining health differences despite aging. In Southern and Eastern welfare regimes this inequality-generative process stopped influencing the trajectories, as differences narrowed. We have no explanation for this result, except for potential health selection bias, which could influence our findings through selection by design (respondents included in aging study) and attrition during follow-up. For the other childhood misfortune variables, we found no differing trajectories across welfare regimes. For adult-life SEC, the results showed narrowing differences with aging between primary and tertiary education in the Bismarckian welfare regime. Similarly, we found narrowing differences between low and high main occupational position within the Scandinavian welfare regime, as well as between having no and great difficulties making ends meet with household income in the Bismarckian regimes. These findings can be explained by the age-as-leveler hypothesis, which states that differences decrease with aging due to mortality selection.

Compared to previous literature, this study made use of comprehensive measures of childhood misfortune, rather than focusing on a single indicator, in order to test trajectories in SRH with aging. Our results are in line with the research of Sieber et al., 2019, which did not find robust effects of CSC on SRH trajectories with aging (starting from age 50). Here, we extended these results by analyzing two additional measures of childhood misfortune, ACE and ACHE. We found ACHE is associated with narrowing SRH differences with aging in Southern and Eastern European welfare regimes. Other studies on CDA and SRH did not consider childhood predictors (Cullati et al., 2014; Mirowsky & Ross, 2008) and/or analyzed CDA patterns in stages earlier than old age

(Bauldry et al., 2012). A study with the same data and analysis outline but using frailty as the outcome measure, found similar patterns in the associations of childhood misfortune and adult-life SEC with the level of the outcome (Van Der Linden et al., 2019). However, in addition to the narrowing differences in the trajectories of the various ACHE categories, the study on frailty also found narrowing trajectories by CSC categories. Moreover, the article on frailty also found growing differences between low and high main occupational position in the Bismarckian welfare regime. This underlines the importance of considering various outcomes when studying the CDA theory (Van Der Linden et al., 2019). When looking at economic inequality in later life, existing research found that inequality within each cohort kept increasing with aging as well as between cohort inequalities, with higher economic inequality for younger cohorts (Crystal et al., 2017; Crystal & Waehrer, 1996). The longitudinal finding stating increasing inequality throughout the life course is contrary to our findings of narrowing health inequalities in old age. However, Crystal & Waehrer (1996) and Crystal et al. (2017) looked at economic rather than health inequality and used United States based data for their studies. Ferraro and Kelley-Moore (2003) have shown that obesity has long-lasting health consequences during adulthood. By employing a life-course reflexivity approach they found that these detrimental effects could be compensated through regular exercise. Although this study did not take into account potential macro-level influences on the associations, it showed the importance of considering experiences across the life course. In our study, we found that in Southern welfare regimes the detrimental effect of CSC could be compensated by adult-life SEC. Another study that looked at cross-national differences in the impact of childhood health and SEC on later-life health found a long lasting negative impact independent of adult-life SEC and behavioral factors and that this impact varies substantially across contexts, which is consistent with our study (S. A. Haas & Oi, 2018). However, this study did not look into health trajectories at older age.

The strengths of this study include a follow-up of 12 years with repeated measurements every 2 years, which allowed for an analysis of the SRH trajectories in different life-course events and socioeconomic circumstances

from age 50. In addition, the large sample size including respondents from different European countries, combined with comprehensive childhood misfortune indicators and adult-life SEC predictors allowed for a comparative analysis of the CDA framework on a macro-level across welfare regime. However, one limitation is the self-reported and retrospective data used for childhood misfortune and main occupational position, which may be subject to recall bias, common source bias, or social desirability. Nevertheless, previous research has shown adequate validity for recall measures of adverse experiences and SEC (Barboza Solís et al., 2015), and for childhood health (S. A. Haas & Bishop, 2010), especially as the models were adjusted with its predictors, such as socioeconomic resources (Vuolo et al., 2014). Second, as an inevitable characteristic of a longitudinal study, attrition may imply a selection bias in the remaining sample. By adjusting our models for attrition and conducting sensitivity analyzes excluding respondents who dropped out or died during follow-up, we accounted for this potential limitation. Third, as a subjective assessment of health in a cross-country study, SRH may be sensitive to the respondent's cultural context. However, previous research found that in a European context differences in reporting styles explained some part of the cross-country variations but did not eliminate them (Hardy et al., 2014). Fourth, due to data limitation and study design the countries included in the analyzes represent a selected sample and might bias the findings. Fifth, a robustness analysis using a continuous SRH outcome variable confirmed the above results. In addition, the continuous models revealed supplementary significant differences in SRH trajectories. We observed growing differences with aging between respondents with primary and tertiary education in Scandinavian welfare regimes only, which supports the CDA theory. However, these supplementary results can be explained by the fact that in the continuous case respondents move more easily between the response categories compared to the dichotomous case. Given that SRH is not a genuine linear variable with the same distance between the response categories, these results need to be looked at with caution. The binary SRH outcome gives a more clinical and

reliable assessment of the respondent's health by better dissociating good and poor health.

In conclusion, this study reveals the long-lasting consequences of childhood misfortune on health in old age and shows narrowing differences between ACHE categories over time in old age, which was driven by the effects in Southern and Eastern European welfare regimes. Furthermore, the present research underlines the importance of a life-course approach following the principle of life-course reflexivity, by considering adult-life SEC when examining the associations between childhood misfortune and health in old age. Similar to childhood misfortune, disadvantaged SEC in adult-life were associated with poorer health in old age. We observed narrowing differences over time in old age for the various categories of education, which was due to the effects in the Bismarckian welfare regime, and for main occupational position, which was due to the effects in the Scandinavian welfare regime.

Generally, we found that CDA processes before the age of 50 may explain the health differences in the studied categories up until that age. However, we did not find support for growing differences over time in old age (after 50) in the studied life-course characteristics as proposed by the CDA model but rather narrowing differences across these variables, which seemed to be specifically marked from 70 years on as Figure 1 suggests. The evidence for old-age trajectories in this study are in line with alternative hypotheses to the cumulative dis/advantage theory, such as the age-as-leveler hypothesis, stating that differences in old age decrease due to mortality selection, which leads to a more homogenous population in these age groups (S. M. Lynch, 2003). Another potential explanation for these findings may be that welfare regimes prevented CDA processes to continue their path in old age. However, future research is needed to confirm this explanation, as we did not test the "absence" of welfare regimes. This study underlines the importance to consider various analysis levels and life-course stages when examining CDA processes, as the individual life course on the micro-level seems to be influenced by social policies on the macro-level. Further research will be needed to carefully work out the causes for

the differences between welfare regimes in order to identify robust policy conclusions from these findings.

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Author contributions

S. Sieber, B. Cheval, B.W.A. van der Linden, and S. Cullati designed the analyses. S. Sieber, B. Cheval, D. Orsholits, and B.W.A. van der Linden analyzed the data. S. Sieber drafted the manuscript. All authors contributed to the final version of the manuscript.

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Conflict of Interest

None declared

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Supplemental Material

Content

Figure S1. Flow chart of participant inclusion

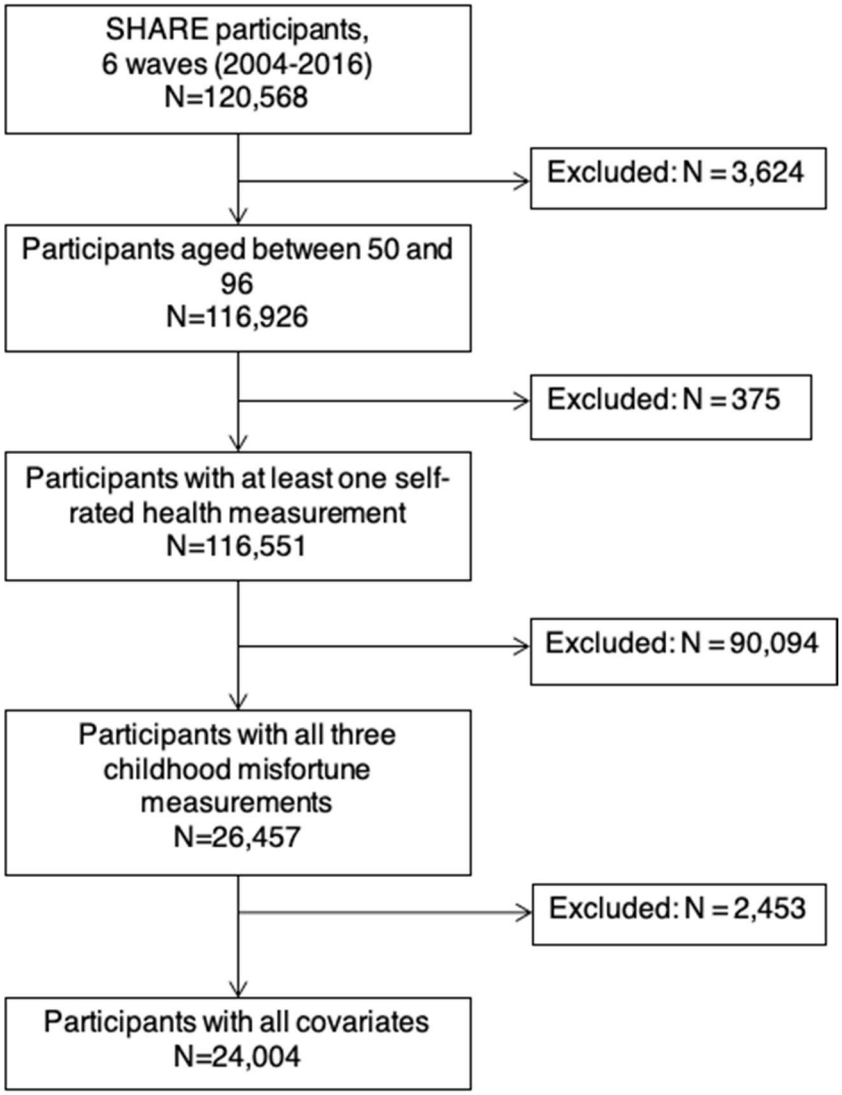

Table S1. Baseline sample characteristics by welfare regime

	Scandinavian		Bismarckian		Southern European		Eastern European	
	Good SRH N (%)	Poor SRH N (%)	Good SRH N (%)	Poor SRH N (%)	Good SRH N (%)	Poor SRH N (%)	Good SRH N (%)	Poor SRH N (%)
Total	3096 (85.4)	530 (14.6)	7657 (74.7)	2593 (25.3)	4583 (66.5)	2308 (33.5)	1603 (49.5)	1634 (50.5)
Age, mean (sd)	61.9 (8.8)	64.7 (10.1)	61.6 (8.9)	64.8 (9.8)	60.8 (8.6)	66.1 (9.3)	60.3 (8)	65.2 (9.5)
Sex								
Female	1668 (83.5)	329 (16.5)	4214 (73.8)	1496 (26.2)	2387 (61.7)	1482 (38.3)	907 (48.8)	952 (51.2)
Male	1428 (87.7)	201 (12.3)	3443 (75.8)	1097 (24.2)	2196 (72.7)	826 (27.3)	696 (50.5)	682 (49.5)
Birth cohort								
After 1945	1347 (87.4)	195 (12.6)	3535 (80)	882 (20)	2289 (78.4)	632 (21.6)	955 (60.3)	630 (39.7)
Between 1939 and 1945	798 (87.9)	110 (12.1)	1808 (76.1)	567 (23.9)	1045 (68)	492 (32)	362 (49.9)	363 (50.1)
Between 1929 and 1938	666 (83.8)	129 (16.2)	1670 (70)	717 (30)	962 (54.6)	800 (45.4)	228 (33.6)	450 (66.4)
Between 1919 and 1928	285 (74.8)	96 (25.2)	644 (60.1)	427 (39.9)	287 (42.8)	384 (57.2)	58 (23.3)	191 (76.7)
Attrition								
No dropout	2459 (87.4)	353 (12.6)	5482 (77.6)	1579 (22.4)	3492 (69.2)	1556 (30.8)	1150 (52.9)	1022 (47.1)
Dropped	407 (89.1)	50 (10.9)	1814 (71.1)	738 (28.9)	751 (68.6)	344 (31.4)	330 (54.1)	280 (45.9)
Deceased	230 (64.4)	127 (35.6)	361 (56.7)	276 (43.3)	340 (45.5)	408 (54.5)	123 (27)	332 (73)
ACE								
None	2464 (86.2)	393 (13.8)	6061 (76.1)	1900 (23.9)	3802 (69.1)	1702 (30.9)	1310 (50.7)	1273 (49.3)
At least one	632 (82.2)	137 (17.8)	1596 (69.7)	693 (30.3)	781 (56.3)	606 (43.7)	293 (44.8)	361 (55.2)
ACHE								
None	2170 (86.2)	348 (13.8)	5480 (75.5)	1774 (24.5)	3844 (67.3)	1868 (32.7)	1203 (49)	1254 (51)
At least one	926 (83.6)	182 (16.4)	2177 (72.7)	819 (27.3)	739 (62.7)	440 (37.3)	400 (51.3)	380 (48.7)
CSC								
Most disadvantaged	159 (73.3)	58 (26.7)	667 (62.8)	395 (37.2)	1326 (58.5)	940 (41.5)	340 (35.2)	626 (64.8)
Disadvantaged	426 (78.2)	119 (21.8)	1671 (70.3)	706 (29.7)	1556 (66)	803 (34)	326 (42.8)	435 (57.2)
Middle	1195 (85.5)	202 (14.5)	2712 (75.8)	866 (24.2)	1204 (74.6)	410 (25.4)	674 (60.3)	444 (39.7)
Advantaged	961 (88.9)	120 (11.1)	1921 (79.6)	492 (20.4)	417 (75)	139 (25)	237 (67.1)	116 (32.9)
Most advantaged	355 (92)	31 (8)	686 (83.7)	134 (16.3)	80 (83.3)	16 (16.7)	26 (66.7)	13 (33.3)
Education								
Primary	578 (80.2)	143 (19.8)	1166 (61.3)	735 (38.7)	2059 (55.6)	1647 (44.4)	305 (31.8)	655 (68.2)

Secondary	1405 (83.3)	281 (16.7)	4476 (75.4)	1457 (24.6)	1912 (76.9)	573 (23.1)	1115 (56)	877 (44)
Tertiary	1113 (91.3)	106 (8.7)	2015 (83.4)	401 (16.6)	612 (87.4)	88 (12.6)	183 (64.2)	102 (35.8)
Main occupational position								
High skill	1202 (92.5)	98 (7.5)	2212 (83.1)	449 (16.9)	621 (79)	165 (21)	404 (61.6)	252 (38.4)
Low skill	1876 (81.5)	425 (18.5)	5156 (72.5)	1954 (27.5)	3107 (66.6)	1557 (33.4)	1164 (47.1)	1309 (52.9)
Never worked	18 (72)	7 (28)	289 (60.3)	190 (39.7)	855 (59.3)	586 (40.7)	35 (32.4)	73 (67.6)
Satisfaction with household income								
Easily	2169 (87.6)	306 (12.4)	4069 (81.7)	914 (18.3)	787 (75.6)	254 (24.4)	269 (62.7)	160 (37.3)
Fairly easily	705 (82.6)	149 (17.4)	2490 (72.1)	962 (27.9)	1428 (73)	529 (27)	593 (55.3)	480 (44.7)
With some difficulty	186 (77.5)	54 (22.5)	862 (64.4)	477 (35.6)	1515 (63.4)	873 (36.6)	584 (47.2)	654 (52.8)
With great difficulty	36 (63.2)	21 (36.8)	236 (49.6)	240 (50.4)	853 (56.7)	652 (43.3)	157 (31.6)	340 (68.4)
Partnership status								
Alone	694 (78.2)	193 (21.8)	1883 (68.8)	854 (31.2)	848 (59)	589 (41)	406 (44.5)	507 (55.5)
In couple	2402 (87.7)	337 (12.3)	5774 (76.9)	1739 (23.1)	3735 (68.5)	1719 (31.5)	1197 (51.5)	1127 (48.5)
Unhealthy behavior index, mean (sd)	0.2 (0.2)	0.3 (0.3)	0.2 (0.2)	0.3 (0.3)	0.3 (0.3)	0.3 (0.3)	0.4 (0.3)	0.4 (0.3)

Note. SRH: Self-rated health, ACE: Adverse childhood experiences, ACHE: Adverse childhood health experiences, CSC: Childhood socioeconomic conditions.

Table S2. Fully adjusted associations (living with a partner and unhealthy behavior index) of childhood misfortune and adult-life socioeconomic circumstances with level and trajectories of poor self-rated health at old age for total and stratified sample by welfare regime.

	Total Sample N = 24004 M3a		Scandinavian N = 3626 M3b		Bismarckian N = 10250 M3b		Southern European N = 6891 M3b		Eastern European N = 3237 M3b	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Age (10-y period)	2.92 (2.55-3.36)	***	4.78 (3.10-7.36)	***	2.71 (2.14-3.44)	***	2.86 (2.17-3.77)	***	1.81 (1.23-2.67)	**
At least one ACE (ref. None)	1.61 (1.37-1.88)	***	1.61 (1.05-2.45)	*	1.42 (1.10-1.83)	**	1.66 (1.23-2.23)	**	1.48 (1.02-2.16)	*
At least one ACHE (ref. None)	1.83 (1.59-2.11)	***	1.49 (1.02-2.18)	*	1.66 (1.33-2.07)	***	2.06 (1.55-2.72)	***	1.53 (1.10-2.13)	*
CSC (ref. Most disadvantaged)										
Disadvantaged	0.78 (0.63-0.96)	*	0.86 (0.30-2.44)		0.72 (0.47-1.10)		1.04 (0.78-1.38)		1.04 (0.68-1.60)	
Middle	0.58 (0.47-0.71)	***	0.49 (0.18-1.33)		0.62 (0.41-0.95)	*	0.76 (0.55-1.05)		0.39 (0.26-0.59)	***
Advantaged	0.51 (0.40-0.65)	***	0.43 (0.16-1.19)		0.54 (0.35-0.84)	**	0.80 (0.50-1.26)		0.29 (0.17-0.50)	***
Most advantaged	0.39 (0.28-0.55)	***	0.30 (0.10-0.93)	*	0.39 (0.22-0.67)	**	1.17 (0.43-3.20)		0.66 (0.18-2.41)	
Education (ref. Primary)										
Secondary	0.67 (0.57-0.80)	***	1.23 (0.70-2.19)		0.60 (0.44-0.81)	**	0.48 (0.37-0.62)	***	0.48 (0.32-0.70)	***
Tertiary	0.35 (0.28-0.45)	***	0.98 (0.51-1.90)		0.39 (0.27-0.58)	***	0.16 (0.10-0.26)	***	0.38 (0.19-0.74)	**
Main Occupational Position (ref. High skill)										
low skill	1.56 (1.30-1.86)	***	3.49 (2.27-5.38)	***	1.66 (1.26-2.17)	***	0.90 (0.61-1.33)		1.61 (1.06-2.44)	*
never worked	0.98 (0.73-1.32)		3.46 (0.30-39.20)		2.41 (1.28-4.57)	**	0.58 (0.37-0.93)	*	1.09 (0.38-3.12)	
Financial strain (ref. Easily)										
Fairly easily	1.64 (1.40-1.93)	***	1.08 (0.70-1.65)		1.79 (1.41-2.27)	***	1.04 (0.73-1.49)		1.48 (0.92-2.38)	
With some difficulty	2.76 (2.31-3.30)	***	2.58 (1.25-5.30)	*	3.97 (2.91-5.43)	***	1.32 (0.93-1.88)		2.16 (1.35-3.46)	**
With great difficulty	5.35 (4.26-6.72)	***	5.44 (1.50-19.76)	*	19.72 (12.48-31.15)	***	1.94 (1.32-2.85)	**	5.37 (3.06-9.43)	***
Interactions										
Age x at least one ACE (ref. None)	0.98 (0.91-1.06)		0.92 (0.75-1.13)		1.07 (0.95-1.21)		0.98 (0.86-1.12)		0.86 (0.70-1.05)	
Age x at least one ACHE (ref. None)	0.86 (0.80-0.93)	***	0.99 (0.82-1.19)		0.93 (0.83-1.04)		0.82 (0.71-0.94)	**	0.80 (0.66-0.97)	*
Age x CSC (ref. Most disadvantaged)										
Age x Disadvantaged	1.00 (0.91-1.10)		0.98 (0.65-1.47)		1.08 (0.90-1.29)		0.95 (0.83-1.09)		0.89 (0.71-1.11)	
Age x Middle	1.00 (0.90-1.10)		1.08 (0.74-1.59)		1.01 (0.84-1.21)		0.95 (0.82-1.12)		1.11 (0.89-1.39)	
Age x Advantaged	0.98 (0.87-1.10)		0.98 (0.66-1.47)		1.03 (0.85-1.26)		0.95 (0.75-1.21)		1.10 (0.80-1.50)	

Age x Most advantaged	0.97 (0.82-1.15)		1.06 (0.66-1.70)		1.03 (0.80-1.33)		0.81 (0.49-1.33)		0.55 (0.26-1.18)	
Age x Education (ref. Primary)										
Age x Secondary	1.05 (0.97-1.13)		0.90 (0.71-1.15)		1.08 (0.94-1.24)		1.10 (0.96-1.26)		1.22 (1.00-1.49)	
Age x Tertiary	1.20 (1.06-1.35)	**	0.80 (0.59-1.07)		1.26 (1.04-1.52)	*	1.33 (1.03-1.73)	*	1.27 (0.87-1.84)	
Age x Main occupational position (ref. High skill)										
Age x Low skill	0.89 (0.81-0.98)	*	0.68 (0.56-0.84)	***	0.93 (0.81-1.07)		0.98 (0.79-1.20)		0.86 (0.68-1.09)	
Age x Never worked	1.08 (0.95-1.24)		0.61 (0.26-1.46)		0.88 (0.68-1.14)		1.10 (0.87-1.39)		1.03 (0.62-1.71)	
Age x Financial strain (ref. Easily)										
Age x Fairly easily	1.04 (0.96-1.13)		1.22 (1.00-1.49)	*	1.02 (0.91-1.14)		1.01 (0.85-1.21)		0.83 (0.65-1.07)	
Age x With some difficulty	1.04 (0.95-1.13)		1.03 (0.75-1.43)		0.91 (0.78-1.06)		1.11 (0.94-1.32)		0.85 (0.66-1.10)	
Age x With great difficulty	0.94 (0.84-1.06)		1.15 (0.62-2.12)		0.59 (0.46-0.75)	***	1.07 (0.89-1.29)		0.82 (0.59-1.12)	

Note. OR: Odds ratios, CI: Confidence interval, ACE: Adverse childhood experiences, ACHE: Adverse childhood health experiences, CSC: Childhood socioeconomic conditions. All models are adjusted for sex, birth cohort, attrition, living with a partner, and unhealthy behavior index. Age was centered at 50 y and divided by 10 so that the coefficients yielded the effects for a 10-year period.

***p<.001, **p<.01, *p<.05

Methods

Welfare regimes

This study used the welfare regime classification as proposed by Eikemo et al. (2008), which expands Ferrera's typology with the Eastern European welfare regime (Esping-Andersen, 1990; Ferrera, 1996). Accordingly, the 13 countries in the final sample were classified into four welfare regimes: Scandinavian (Denmark, Sweden), Bismarckian (Austria, Belgium, France, Germany, the Netherlands, Switzerland), Southern European (Greece, Italy, Spain), and Eastern European (Czech Republic, Poland). See Supplemental Material for more information. Participants' welfare regime was measured at follow-up, as a proxy for an individual's life-course regime. To avoid misclassification, we compared participants' welfare regime at baseline with the last follow-up measure and found no participants who had changed. Additionally, we compared the welfare regime participants lived in at age 10 with their follow-up measure and found that less than 4% had a different welfare regime. Another article using a similar sample showed no impact on the results when controlling for childhood welfare regime (Sieber et al., 2019).

Measures

Outcome: Self-rated health

Participants were asked to rate their current general health on a 5-point Likert scale. The responses ranged from 1, "poor", to 5, "excellent" (Ware & Gandek, 1998). In line with a previous study (Sieber et al., 2019), we formed a binary outcome by grouping the categories "poor" and "fair" indicating poor SRH as opposed to "good", "very good" and "excellent" indicating good SRH.

Childhood misfortune

Adverse Childhood Experiences (ACE). We used a score combining a set of traumatic events (emotional, physical, or linked to household dysfunction) that occurred during childhood (from age 0 to 15) and that were outside a child's control (Felitti et al., 1998). We included the following indicators reflecting

specific ACE: parental death (father, mother, or both), parental mental illness, parental drinking abuse, child in care (living in a children's home or with a foster family), period of hunger, and property taken away. All indicators were binary apart from parental death. In the case where a participant lost both parents in childhood, we added 2 points to the ACE score. Following previous studies, we computed a score ranging from 0 to 7 by combining the 6 ACE indicators. Due to low numbers of respondents who reported two or more ACEs (less than 4%), we dichotomized the score by grouping those participants who did not experience ACE and those who experienced at least one ACE (Cheval, Chabert, Sieber, et al., 2019; Cheval, Orsholits, Sieber, et al., 2019). When participants did not answer all of the ACE items, the score was computed based on the non-missing information of the available items.

Adverse Childhood Health Experiences (ACHE) combined information on 5 indicators of childhood health problems up until the age of 15 (Cheval, Chabert, Sieber, et al., 2019; Cheval, Orsholits, Sieber, et al., 2019) into a binary variable; long hospitalization (hospitalization for a month or more), multiple hospitalizations (more than three times within a 12-month period), childhood illness (including polio, asthma, or meningitis/encephalitis), serious health conditions (including severe headaches, psychiatric problem, fractures, heart trouble, cancers), and physical injury that has led to permanent handicap, disability or limitation in daily life. Due to low numbers of respondents who reported two or more ACHEs (less than 6%), we computed a binary variable of participants with none versus one or more ACHE. When participants did not answer all ACHE items, the score was computed based on the non-missing information of the available items.

Childhood Socioeconomic Conditions (CSC) is a score derived from four binary indicators of adverse socioeconomic conditions, each reflecting specific conditions of participants at the age of 10 yr : 1) occupational position of the main breadwinner, 2) number of books in the home, 3) a measure of overcrowding, and 4) housing quality (Wahrendorf & Blane, 2015). Occupational position of the main breadwinner was constructed by reclassifying the 10 main occupational groups of the International Standard Classification of Occupations

(ISCO) according to their skill levels. The first and second skill level were grouped as “low” occupational position, and the third and fourth levels were classified as “high”. The number of books in the household indicated whether there was 0 – 10 vs 11+ books at home, with the former category indicating social disadvantage. The overcrowding measure was a combination of the number of people living in the household and the number of rooms (excluding kitchen, bathrooms, and hallways). More than one person per room living in the respective household indicated social disadvantage. Disadvantage related to the quality of the household was assessed through the absence of all of the following items: fixed bath, cold running water supply, hot running water supply, inside toilet, and central heating. The four binary indicators were combined to form a score consisting of a 5-level categorical variable ranging from “most disadvantaged”, “disadvantaged”, “middle”, “advantaged”, to “most advantaged”. Previous articles using the same score provide a more detailed description of the variable (Cheval, Boisgontier, et al., 2018; Cheval, Sieber, et al., 2018).

Adult-life Socioeconomic Conditions (SEC). We used three indicators of adult-life SEC representing different adult-life periods (Sieber et al., 2019). First, representing young adult life and according to the International Standard Classification of Education, we included participants’ highest educational attainment (primary, secondary, or tertiary education) during follow-up. Second, representing middle age, we coded main occupational position based on the skill classification of participant’s main job over the life course according to the International Standard Classification of Occupations (ISCO). ISCO’s 10 main occupational groups were reclassified according to their skill levels, whereby skill levels 1 and 2 were grouped into “low” and skill levels 3 and 4 were grouped into “high” main occupational position. Third, as an indicator for old-age SEC, we use financial strain based on the survey question “Is the household able to make ends meet?” Participants answered on a four-point scale ranging from 1 “easily” to 4 “with great difficulty”. Since financial strain was not measured in the third wave, as opposed to our outcome, and to keep as many observations as possible, we computed the mode over follow-up for each individual.

Covariates

Unhealthy behavior index. We computed an index combining four binary indicators of unfavorable health behaviors by taking the mean of 1) physical inactivity, 2) unhealthy eating, 3) smoking, and 4) alcohol consumption across waves for each participant. This resulted in a continuous variable ranging from 0, none of the 4 indicators, to 1, all of the 4 unhealthy behaviors (Sieber et al., 2019).

Living with a partner. We computed an indicator on whether a participant, independent of his/her marital status, was living with a partner during follow-up (by taking the mode); 0 was coded “mostly living alone” and 1 “mostly living with a partner” (Cullati et al., 2014; Sieber et al., 2019).

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The article in *Chapter 3* has shown that the cumulative dis/advantage theory does not hold in old age. According to the theory we expected widening self-rated health inequalities with increasing age. However, the results indicated no associations between childhood and adult-life socioeconomic circumstances, adverse (health) experiences in childhood and self-rated health trajectories in old age or converging trajectories between predictor categories. Both *Chapter 2 and 3* used the welfare regime approach to examine differences between clusters of countries. Yet, the limitations of this approach became apparent as it proved difficult to explain the differences found due to the large variance between the countries in the same cluster. To address this limitation, *Chapter 4* uses the expenditure approach, which allows for testing of differences between countries based on a specific indicator.

Chapter 4. Social protection expenditure on health in later life in 20 European countries: Spending more to reduce health inequalities (Article 3)

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Abstract

Background: This study aims to examine whether higher social protection expenditure reduces the negative association of life-course socioeconomic disadvantages with subjective health status and trajectories in later life.

Methods: We used SHARE data from participants living in 20 European countries aged 50 to 96. Seven waves allowed to examine the trajectories of health inequalities in later life. We used linear mixed-effects models stratified by sex to examine the association between life-course socioeconomic disadvantage and subjective (self-rated health, SRH) and objective (grip strength) health. Cross-level interactions between net social protection expenditure as percentage of gross domestic product and life-course socioeconomic disadvantage tested for the moderating effect of social expenditures on the association of disadvantage with SRH and grip strength in later life.

Findings: Higher social protection expenditure reduced socioeconomic health inequalities in both men and women for grip strength, and in women but not men for SRH. For SRH, health inequalities reduced with increasing age for both men and women, but higher social protection expenditure slowed down this reduction. For grip strength, we did not observe diminishing health inequalities with ageing for both men and women. In men's grip strength, the health-inequality-reducing effect of social protection expenditure decreased during the ageing process. Some separate expenditure functions were found to have inequality-widening effects in men's and women's SRH, which were either offset or overcompensated by the other functions.

Interpretation: Higher social spending reduces life-course socioeconomic inequalities in women's subjective health and in men's and women's objective health.

Research in context

Evidence before this study

An increasing body of literature has studied the impact of social protection policies on socioeconomic inequalities in late-life health and across the aging process. Cross-sectional evidence so far suggests that absolute educational inequalities in self-rated health (SRH) in the general population are smaller in countries with higher social protection expenditure. Furthermore, available evidence suggests that these inequality-reducing effects of social expenditure are stronger in women compared to men.

Added value of this study

This study extends existing knowledge by examining the role of social protection expenditure on life-course socioeconomic inequalities in indicators of subjective (SRH) and objective health (grip strength) simultaneously. In addition, we use a comprehensive measure for life-course socioeconomic disadvantage to capture the accumulation of disadvantage over the life course. Our findings suggest that higher social protection expenditure reduces the negative impact of life-course socioeconomic disadvantage on women's SRH, as well as on women's and men's grip strength at age 50. Furthermore, this study goes beyond cross-sectional data by examining how social protection expenditure affects the evolution of life-course socioeconomic inequalities across the ageing process. Results show that in SRH higher expenditure slowed down the age-related narrowing of socioeconomic inequalities. In grip strength, the positive effect of social protection expenditure decreased with ageing. Finally, the analysis of separate social protection functions indicated that some policies have an inequality-widening effect in subjective health, which is either offset or overcompensated when looking at total social protection expenditure.

Implications of all the available evidence

Generally, findings suggest that higher social spending reduces life-course socioeconomic inequalities. However, differences between men and women and the fact that some policies have inequality-widening effects in subjective health point to the need for careful analysis of social protection policies in relation to health inequalities.

Introduction

In the context of ageing European societies, it is crucial to understand people's health trajectories through later life and the factors that are associated with better or worse health during the ageing process. A large body of research has shown that socioeconomic disadvantage over the life course is associated with a wide range of adverse health outcomes in later life, including self-rated health and muscle strength (Cheval, Boisgontier, et al., 2018; Cheval, Chabert, Sieber, et al., 2019; Cheval, Orsholits, Sieber, et al., 2019; Hyde, Jakub, Melchior, Van Oort, et al., 2006; Sieber et al., 2019). Moreover, these health inequalities differ across countries and welfare regimes (de Breij et al., 2020; Sieber et al., 2019). These differences suggest that the impact of life-course socioeconomic circumstances on individuals' health can be influenced by macro-level factors (de Breij et al., 2020; Sieber et al., 2020). Since poor health in later life may have a significant economic and societal impact (Cristea et al., 2020), it is important to examine how macro-level factors are related to health inequalities and their pattern over the ageing process.

The expenditure approach uses information on the public spending on social protection and services at the national level to examine welfare state effort and generosity for between-country comparison (Dahl & van der Wel, 2013; de Breij et al., 2020; Reeves et al., 2014). Spending areas include sickness and health care, disability, old age, survivors, family and children, unemployment, housing, and social exclusion. Since the expenditure approach focuses on a specific characteristic of the welfare state, it enables analyzing how particular policies affect health inequalities. Thus, this approach is particularly useful when examining the potential mechanisms involved in macro-policy effects on health inequalities (Hillier-Brown et al., 2019; Lundberg, 2008).

As well as between-country factors, within-country factors also deserve consideration. Specifically, socioeconomic circumstances are thought to have an impact on health through both a material and a psychosocial pathway (Bartley, 2017). The material pathway is the mechanism through which absolute material living standards and resources (such as income and wealth) affect health. The psychosocial consequences evoked by socioeconomic

disadvantage, such as stress, stigmatization, feeling of loss of control, can have a negative impact on health. These within-country factors can interact with between-country factors. For instance, welfare systems are designed to build a safety net and provide resources to people in need or people who are not able to generate enough income on the labour market to provide for themselves (material pathway) (Bartley et al., 1997). As a consequence, people finding themselves in vulnerable situations can benefit from the welfare system in order to alleviate their difficult circumstances. Therefore, more generous welfare states in terms of social protection expenditure are believed to be better able to mitigate the negative impact of disadvantaged socioeconomic circumstances on health. Furthermore, the mere knowledge of an existing welfare system that people can revert to in case of need, can alleviate the stress related to the insecurity of potentially vulnerable situations (psychosocial pathway) (Sieber et al., 2020). Generous welfare systems have been shown to create a more beneficial psychosocial environment, even for those not in direct need of benefits (Bartley et al., 1997; Sieber et al., 2020). Moreover, in line with cumulative dis/advantage theory, not only the exposure but also the accumulation of exposure to sources of stress throughout the life course generates growing differences in later life (Dannefer, 2003). We hypothesize that more generous welfare systems are better able to break this vicious circle and prevent increasing socioeconomic health inequalities in later life.

Previous research has shown that higher social protection expenditure has a reducing effect on health inequalities and are associated to better health in the general population (Álvarez-Gálvez & Jaime-Castillo, 2018; Dahl & van der Wel, 2013). However, to our knowledge, existing studies have only looked cross-sectionally at health inequalities at a particular point in time. This study aims to examine whether higher social protection expenditure lowers the impact of life-course socioeconomic disadvantage on health levels and evolution across ageing. Our particular focus lies on the health inequalities that arise from disadvantaged socioeconomic circumstances and their evolution over the ageing process and how social protection expenditure on the country level influences these health inequalities across ageing. To achieve our goal of better

understanding this relationship, we make use of longitudinal data to look at the impact of social protection expenditure on the evolution of health inequalities over the ageing process. In this analysis we use self-rated health (SRH) and grip strength as indicators of individual health. These measures capture two different health domains, a subjective evaluation of one's general health for SRH, and an objective measure of participants' physical health for grip strength.

Methods

Data

This study used individual-level data from the cross-national and longitudinal Survey of Health, Ageing and Retirement in Europe (SHARE). The survey includes information on socioeconomic circumstances and health of individuals aged 50 and older in 27 European countries (A. Börsch-Supan et al., 2013). SHARE has collected seven waves of data between 2004 and 2017 (every two years). Waves 3 and 7 (for those who have not completed wave 3) include retrospective information on the life-course socioeconomic circumstances. To be included in our study, participants needed to be between 50 and 96 years old, have completed the retrospective module either in wave 3 or 7, and have provided at least one outcome observation over the seven survey waves. As a result, 20 countries were included in our analyses (Table S1, Supplementary Material).

Country-level data were obtained from Eurostat (the statistical office of the European Union) administered surveys and datasets. Data on social protection expenditure were derived from its ESSPROS framework (European System of integrated Social PROtection Statistics), which enables international comparison of national administrative data on social protection (European Union, 2019). The Real Gross Domestic Product (GDP) per capita data come from the National accounts database (Eurostat, 2020b). The unemployment rate data were obtained from the EU Labour Force Survey (Eurostat, 2020a).

Outcomes

Self-rated health

As a measure of subjective general health, respondents evaluated their own health on a five-point Likert scale ranging from 1 ‘poor’ to 5 ‘excellent’ by answering following question: “Would you say your health is…” (Ware & Gandek, 1998). SRH is a predictor of morbidity and mortality covering different health dimensions including physical and mental health (DeSalvo et al., 2006b). In the analyses, the scale was inversed such that higher scores indicated worse health.

Grip strength

As a measure of objective physical health, grip strength is a strong predictor of morbidity and mortality (Leong et al., 2015). In SHARE, grip strength was measured in kilograms twice on each hand with a handheld dynamometer (Smedley, S Dynamometer, TTM, Tokyo, 100 kg), alternating between the hands. For this study, we used the mean of the maximum values of both hands (Leong et al., 2015). Values corresponding to 0 were excluded. In the analyses, the scale was inverted such that higher values indicated weaker grip strength.

Main exposure

Life-course socioeconomic disadvantage is a score combining childhood and adulthood (young adulthood, middle age, later life) socioeconomic circumstances by giving each life-course period a weight of 2. For childhood, based on Wahrendorf & Blane’s measure (2015), we aggregated information on four binary indicators of socioeconomic disadvantage at age 10; occupational position of main breadwinner (high vs low skill), number of books in the household (11+ vs 10 or less), overcrowding (one or fewer persons per room vs more than one), and housing quality (presence of either vs absence of fixed bath, cold running water supply, hot running water supply, inside toilet, and central heating). For each indicator, 0 corresponds to an advantaged and 0.5 to a disadvantaged situation, amounting to a total possible score of two for childhood. For young adulthood, educational attainment was classified

according to the International Standard Classification of Education (ISCED) as “primary” (2), “secondary” (1), or “tertiary” (0). For middle age, occupational class of the respondent’s main occupation during work life was determined according to the International Standard Classification of Occupations as “never worked” (0), low skill (1), high skill (2). For later life, financial strain was measured through the mode of the available values of the ability to make ends meet over the follow up period. Those who made ends meet “with difficulty” or “great difficulty” were given a score of 2, those who made it “fairly easily” a score of 1, and those who made it “easily” a score of 0. This results in a score ranging from 0 to 8, where higher values indicate greater exposure to socioeconomic disadvantage throughout the life course. Supplemental Material provide more details on the construction of the score.

Net social protection expenditure

ESSPROS defines social benefits as transfers, in cash or in kind, by social protection schemes to households and individuals to relieve them of the burden of a defined set of risks or needs (European Union, 2019). These schemes are split into eight functions of social protection: sickness/health care, disability, old age, survivors, family/children, unemployment, housing, social exclusion not elsewhere classified. Net social protection expenditure is obtained by taking into account the average rates of taxes and social contributions paid by recipients of the schemes. In this study, we used net social protection expenditure as a percentage of GDP to measure welfare generosity. Since the net values were only available from 2007 on, we calculated the median of the percentages from 2007 to 2017 for each country. The analyses were performed for the total net social protection expenditure as well as for each function separately.

Covariates

At the individual level we included age, sex (woman, man), and birth cohort (1919–1928, 1929–1938, 1939–1945, and post-1945) in the models as known confounders of the association between life-course socioeconomic

circumstances and health (Sieber et al., 2020). In addition, models were adjusted for observations (number of waves participated to account for selection effects), partnership status (living with partner, alone), unhealthy behaviors (index combining physical inactivity, unhealthy eating, smoking, and alcohol consumption, ranging from 0 to 1, where 1 indicates unhealthy behavior across participated waves). These covariates are known to potentially influence the tested association (Sieber et al., 2020). Refer to supplemental material for more details on variable construction of partnership status and unhealthy behaviors.

As country-level confounders, we adjusted for the logged GDP per capita to remove the effect of between-country differences in wealth and the general unemployment rate (centered at the mean), since countries with higher unemployment rates tend to have higher social protection expenditure. To be consistent with net social protection expenditure, both country-level confounders represent the median for the 2007-2017 period.

Statistical analysis

The data were analyzed with linear mixed-effects models with observations (Level 1) nested within individuals (Level 2) nested within countries (Level 3). We adopted an accelerated longitudinal design by using age as the time basis (Cheval, Boisgontier, et al., 2018; Sieber et al., 2019, 2020). Thus, each participant contributed to a part of the outcome trajectories across the ageing process. The models included a random intercept and slope for linear age at the individual level as well as a random intercept and slope for the main exposure at the country level to account for cross-country differences in the effect of life-course socioeconomic disadvantage on health in later life. Age was centered at the beginning of the health trajectory (i.e., 50 years), which allowed to examine health inequalities at the youngest age of the sample's age range. In addition, age was divided by 10 to reduce multicollinearity and so that the coefficient yielded effects over a 10-year period. The models were stratified by sex as previous research has shown differential effects for women and men (Dahl & van der Wel, 2013; de Breij et al., 2020). For each outcome, model 1a tested the association between life-course socioeconomic disadvantage (centered at

the mean) and SRH/grip strength adjusted for all covariates except for partnership status and unhealthy behaviors. Cross-level interaction terms between life-course socioeconomic disadvantage and net social protection expenditure (centered at the mean) allowed to test for the moderating role of the macro-level variable on the health inequalities at age 50. A three-way interaction life-course disadvantage x net social protection expenditure x age examined the subsequent evolution of health inequalities. Model 1b was fully adjusted with partnership status and unhealthy behaviors. Our model can be written as (covariates not included in equation):

$$Y_{cti} = \beta_0 + \beta_1 Age_{cti} + \beta_2 SECdis_{ci} + \beta_3 SocProt_c + \beta_4 SECdis_{ci} * SocProt_c + \beta_5 Age_{cti} * SECdis_{ci} + \beta_6 Age_{cti} * SECdis_{ci} * SocProt_c + e_{cti}$$

Where Y_{tic} is the continuous health outcome (SRH or grip strength) for individual i at age t within country c. $SECdis$ = life-course socioeconomic disadvantage, $SocProt$ = net social protection expenditure, e_{cti} = level-1 residuals, β_3 = direct effect of net social protection expenditure on health for when *SECdis* and *Age* equal 0 (i.e. their centered values), β_4 = estimate of impact of net social protection expenditure by life-course socioeconomic disadvantage on health at age 50, β_5 = evolution of life-course socioeconomic health inequalities across ageing, β_6 = three-way interaction for moderating effect of net social protection expenditure on the evolution of health inequalities. In addition, for the random structure we have:

$$\beta_0 = \gamma_{000} + u_{0c} + u_c$$

$$\beta_1 = \gamma_{100} + u_{1ci}$$

$$\beta_2 = \gamma_{200} + u_{2c}$$

Where the intercept β_0 depends on a common intercept γ_{000} and two random terms u_{0ci} and u_c accounting for variation at the individual and country level, respectively. The slope for age β_1 depends on one random term accounting for

variation at the individual level. The estimate for the main exposure β_2 varies by country.

To decompose the effect of total net social protection expenditure and to explore specific policy effects, the same models were run for the eight separate social protection functions. For this purpose, each model included the eight functions plus the interactions with the main function of interest.

Sensitivity / robustness analyses

We ran the grip-strength models 1b by further adjusting them with the body mass index (BMI), as grip strength can depend on an individual's height and weight (data available upon request) (Leong et al., 2015). The main findings were not changed by this adjustment. Thus, to ensure maximum comparability between SRH and grip-strength analyses, we show the results without BMI adjustment.

In addition, we ran the analyses for total net social protection expenditure by excluding Luxembourg from the sample. Since a significant proportion of benefits in Luxembourg are paid to persons living outside the country, this might have an influence on the cross-level interactions (Dahl & van der Wel, 2013). Individual-level data from SHARE only considers people living in the country. Results from the sensitivity analyses revealed that the moderation of the association between life-course socioeconomic disadvantage and women's grip strength by social protection expenditure became statistically borderline insignificant (p=0·054), while the other findings were not changed.

Results

Tables S1-S4 show the baseline characteristics of the SRH (N = 55,457, 56·4% women) and grip strength (N = 54,759, 56·3% women) samples by country and sex. The highest SRH scores were reported in Denmark and Ireland for women (3·4) and in Denmark, Ireland, and Switzerland for men (3·4). The lowest scores were reported in Estonia and Poland (2·2) for women, and in Estonia (2·2) for men. The highest grip strength scores were reported in the Netherlands (26·2

kg) for women and Denmark (44·0 kg) for men, the lowest in Spain for both women and men (20·7 kg and 35·1 kg, respectively). Tables S5 and S6 show descriptive statistics for the country-level variables. The median over the 2007-2017 period of the total net social protection expenditure as percentage of GDP varied from 14·87% in Estonia to 29·96% in France, while the overall mean was 22·63%. Random intercept only models indicated that level-3 clustering (countries) accounted for 11·7% (women) and 11·3% (men) of the total variance in the SRH and 4·6% and 5·0% in the grip strength models.

Associations of life-course socioeconomic disadvantage with health at age 50 and moderation by social protection expenditure

For SRH (Model M1b, Table 1), the longer respondents experienced socioeconomic disadvantage over the life course, the worse was their reported health for both women and men (0·16, $p<0·0001$ for both). Results do not show a direct effect (at age 50 and the mean for life-course socioeconomic disadvantage) of net social protection expenditure on SRH for women and men (all $p>0·25$). The cross-level interaction between life-course socioeconomic disadvantage and social protection expenditure indicates that the detrimental health effects of life-course socioeconomic disadvantage were

Table 1 Associations of life-course socioeconomic disadvantage with poor self-rated health and the moderating effect of net social protection expenditure, stratified by sex

	Female				Male			
	M1a		M1b		M1a		M1b	
	Coef (95% CI)	P value	Coef·(95% CI)	P value	Coef (95% CI)	P value	Coef·(95% CI)	P value
Age	0·25 (0·24-0·26)	<0·0001	0·25 (0·24-0·26)	<0·0001	0·31 (0·30-0·33)	<0·0001	0·32 (0·31-0·33)	<0·0001
Birth cohort (ref. after 1945)								
between 1919 and 1928	-0·02 (-0·06-0·03)	0·50	-0·05 (-0·10--0·01)	0·02	-0·22 (-0·27--0·16)	<0·0001	-0·21 (-0·26--0·15)	<0·0001
between 1929 and 1938	0·03 (-0·00-0·06)	0·06	0·02 (-0·01-0·05)	0·12	-0·15 (-0·19--0·12)	<0·0001	-0·13 (-0·16--0·09)	<0·0001
between 1939 and 1945	-0·00 (-0·03-0·02)	0·87	0·01 (-0·01-0·03)	0·36	-0·10 (-0·13--0·07)	<0·0001	-0·09 (-0·11--0·06)	<0·0001
Observations	-0·02 (-0·03--0·02)	<0·0001	-0·01 (-0·02--0·01)	<0·0001	-0·02 (-0·03--0·02)	<0·0001	-0·01 (-0·02--0·01)	<0·0001
Life-course socioeconomic disadvantages	0·17 (0·16-0·18)	<0·0001	0·16 (0·15-0·17)	<0·0001	0·17 (0·15-0·19)	<0·0001	0·16 (0·14-0·17)	<0·0001
Net social protection expenditure	-0·01 (-0·04-0·02)	0·37	-0·01 (-0·04-0·02)	0·40	-0·02 (-0·05-0·01)	0·23	-0·02 (-0·05-0·01)	0·26
GDP per capita (log)	-0·33 (-0·52--0·15)	0·00	-0·32 (-0·51--0·14)	0·00	-0·32 (-0·50--0·14)	0·00	-0·31 (-0·49--0·13)	0·00
Unemployment rate	-0·02 (-0·04--0·00)	0·04	-0·03 (-0·05--0·00)	0·03	-0·04 (-0·06--0·02)	0·00	-0·04 (-0·06--0·02)	0·00
Living alone (ref. living with a partner)			0·01 (-0·01-0·02)	0·58			0·06 (0·03-0·08)	<0·0001
Unhealthy behaviors			0·64 (0·60-0·68)	<0·0001			0·52 (0·48-0·56)	<0·0001
Interactions								
LCSEC disadvantage x Social protection	-0·01 (-0·01--0·00)	0·01	-0·01 (-0·01--0·00)	0·01	-0·01 (-0·01--0·00)	0·02	-0·00 (-0·01-0·00)	0·06
LCSEC disadvantage x Age	-0·01 (-0·01--0·01)	<0·0001	-0·01 (-0·02--0·01)	<0·0001	-0·01 (-0·02--0·01)	<0·0001	-0·01 (-0·02--0·00)	<0·001
Social protection x Age	0·00 (0·00-0·01)	0·00	0·00 (0·00-0·01)	<0·001	0·01 (0·00-0·01)	<0·001	0·01 (0·00-0·01)	<0·001
LCSEC disadvantage x Social protection x Age	0·00 (0·00-0·00)	<0·0001	0·00 (0·00-0·00)	<0·0001	0·00 (0·00-0·00)	<0·001	0·00 (0·00-0·00)	<0·001

Note: SRH scale was inversed such that higher scores indicate worse health. LCSEC disadvantages = Life-course socioeconomic disadvantages, Social protection = Net social protection expenditure. Age was centered at 50 years and divided by 10 so that the coefficients yielded the effects for a 10-year period

reduced by higher expenditure at country level in women but not in men (-0·01, p=0·01 for women and -0·00, p=0·06 for men).

For grip strength (M1b, Table 2), the longer male and female respondents were exposed to socioeconomic disadvantage throughout the life course, the weaker was their grip strength at age 50 (0·39, p<0·0001 for women and 0·50, p<0·0001 for men). Results do not show a direct effect (at age 50 and the mean for life-course socioeconomic disadvantage) of net social protection expenditure on grip strength for both men and women (all p>0·39). However, the cross-level interaction indicates that higher social protection expenditure reduced the negative effects of life-course socioeconomic disadvantage on grip strength for both women and men (-0·02, p=0·03 and -0·07 p<0·01, respectively).

Associations of life-course socioeconomic disadvantage with evolution of later-life health and moderation by social protection expenditure

For SRH (M1b, Table 1), the interaction of life-course socioeconomic disadvantage with age indicates that the negative effects of life-course disadvantage on SRH found at age 50 decreased with ageing for both men and women (-0·01, p<0·001 for women and -0·01, p<0·0001 for men). The three-way interaction term (Figure 1), life-course socioeconomic disadvantage x social protection expenditure x age, reveals that higher country-level expenditure slowed down these decreasing effects in the ageing process in women and men (both 0·003, p<0·001).

For grip strength (M1b, Table 2), the effect of life-course socioeconomic disadvantage was not moderated by age in both women and men. However, the three-way interaction term indicates that (Figure 2), only for men, the reduction of the negative effects of life-course socioeconomic disadvantage on health by social protection expenditure became weaker with ageing (0·01, p=0·02 for men and 0·003, p=0·51 for women).

Table 2 Associations of life-course socioeconomic disadvantage with weak grip strength and the moderating effect of net social protection expenditure, stratified by sex

	Female				Male			
	M1a		M1b		M1a		M1b	
	Coef·(95% CI)	P value	Coef·(95% CI)	P value	Coef·(95% CI)	P value	Coef·(95% CI)	P value
Age	2·88 (2·82-2·95)	<0·0001	2·88 (2·82-2·95)	<0·0001	5·18 (5·08-5·29)	<0·0001	5·21 (5·10-5·31)	<0·0001
Birth cohort (ref· after 1945)								
between 1919 and 1928	1·41 (1·13-1·70)	<0·0001	1·25 (0·96-1·53)	<0·0001	2·09 (1·61-2·57)	<0·0001	2·10 (1·62-2·58)	<0·0001
between 1929 and 1938	0·75 (0·57-0·94)	<0·0001	0·72 (0·54-0·90)	<0·0001	0·74 (0·45-1·03)	<0·0001	0·92 (0·63-1·20)	<0·0001
between 1939 and 1945	0·23 (0·07-0·38)	0·00	0·26 (0·11-0·42)	0·0001	0·01 (-0·23-0·24)	0·96	0·12 (-0·12-0·35)	0·33
Observations	-0·32 (-0·36--0·28)	<0·0001	-0·27 (-0·30--0·23)	<0·0001	-0·44 (-0·50--0·38)	<0·0001	-0·37 (-0·44--0·31)	<0·0001
Life-course socioeconomic disadvantage	0·42 (0·35-0·49)	<0·0001	0·39 (0·31-0·46)	<0·0001	0·58 (0·44-0·72)	<0·0001	0·50 (0·36-0·63)	<0·0001
Net social protection expenditure	0·01 (-0·12-0·14)	0·89	0·01 (-0·12-0·14)	0·93	-0·08 (-0·29-0·12)	0·43	-0·09 (-0·30-0·11)	0·40
GDP per capita (log)	0·62 (-0·18-1·42)	0·15	0·72 (-0·06-1·50)	0·09	1·20 (-0·02-2·41)	0·07	1·39 (0·23-2·55)	0·03
Unemployment rate	0·16 (0·06-0·25)	0·01	0·15 (0·06-0·23)	0·01	0·30 (0·16-0·43)	0·00	0·31 (0·18-0·43)	<0·001
Living alone (ref· living with a partner)			0·17 (0·05-0·29)	0·01			1·24 (1·01-1·47)	<0·0001
Unhealthy behaviors			2·20 (1·96-2·44)	<0·0001			2·98 (2·61-3·34)	<0·0001
Interactions								
LCSEC disadvantage x Social protection	-0·02 (-0·04--0·00)	0·02	-0·02 (-0·04--0·00)	0·03	-0·07 (-0·11--0·03)	<0·001	-0·07 (-0·11--0·03)	0·00
LCSEC disadvantage x Age	0·00 (-0·02-0·03)	0·89	-0·00 (-0·03-0·02)	0·88	-0·01 (-0·05-0·04)	0·70	-0·00 (-0·05-0·04)	0·93
Social protection x Age	-0·01 (-0·02-0·00)	0·22	-0·01 (-0·02-0·01)	0·35	0·00 (-0·02-0·02)	0·85	0·00 (-0·02-0·03)	0·78
LCSEC disadvantage x Social protection x Age	0·00 (-0·01-0·01)	0·65	0·00 (-0·00-0·01)	0·51	0·01 (0·00-0·03)	0·02	0·01 (0·00-0·03)	0·02

Note: Grip strength scale was inverted such that higher scores indicate weaker grip strength. LCSEC disadvantage = Life-course socioeconomic disadvantage, Social protection = Net social protection expenditure. Age was centered at 50 years and divided by 10 so that the coefficients yielded the effects for a 10-year period

Table 3 Associations of life-course socioeconomic disadvantage with poor self-rated health and the moderating effect of separate functions of social protection expenditure, Models M1b

	Social protection function		LCSEC dis x Social prot		LCSEC dis x Age		Social prot x Age		LCSEC dis x Social prot x Age	
Women	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value
Sickness/Health Care	-0·05 (-0·17-0·07)	0·47	-0·00 (-0·01-0·01)	0·46	-0·01 (-0·02--0·01)	<0·0001	-0·00 (-0·01-0·00)	0·44	0·00 (-0·00-0·00)	0·82
Disability	0·02 (-0·22-0·26)	0·89	0·02 (0·00-0·04)	0·02	-0·01 (-0·02--0·01)	<0·0001	-0·02 (-0·03--0·00)	0·01	-0·00 (-0·01-0·00)	0·15
Old age	-0·05 (-0·12-0·01)	0·14	-0·01 (-0·02--0·01)	<0·001	-0·02 (-0·02--0·01)	<0·0001	0·02 (0·02-0·03)	<0·0001	0·01 (0·00-0·01)	<0·0001
Survivors	0·10 (-0·12-0·32)	0·41	-0·04 (-0·06--0·02)	<0·001	-0·02 (-0·02--0·01)	<0·0001	0·03 (0·02-0·04)	<0·0001	0·02 (0·01-0·02)	<0·0001
Family & Children	0·07 (-0·21-0·35)	0·62	0·04 (0·02-0·05)	<0·0001	-0·02 (-0·02--0·01)	<0·0001	-0·02 (-0·03--0·01)	<0·001	-0·01 (-0·02--0·01)	<0·0001
Unemployment	0·03 (-0·18-0·23)	0·79	-0·01 (-0·03-0·00)	0·13	-0·01 (-0·02--0·01)	<0·0001	-0·01 (-0·02-0·00)	0·05	0·00 (-0·00-0·01)	0·07
Housing	0·26 (-0·54-1·05)	0·54	0·04 (-0·01-0·10)	0·13	-0·01 (-0·02--0·01)	<0·0001	-0·07 (-0·10--0·03)	<0·0001	-0·01 (-0·03-0·00)	0·13
Social exclusion	0·12 (-0·43-0·67)	0·67	0·02 (-0·02-0·06)	0·32	-0·02 (-0·02--0·01)	<0·0001	-0·08 (-0·10--0·05)	<0·0001	-0·02 (-0·03--0·01)	0·00
Men										
Sickness/Health Care	0·01 (-0·10-0·13)	0·85	0·00 (-0·01-0·02)	0·50	-0·01 (-0·02--0·01)	<0·0001	-0·01 (-0·02--0·00)	0·02	0·00 (-0·00-0·01)	0·61
Disability	-0·07 (-0·30-0·15)	0·54	0·02 (0·00-0·04)	0·04	-0·01 (-0·02--0·01)	<0·0001	-0·01 (-0·03-0·00)	0·12	-0·01 (-0·01-0·00)	0·06
Old age	-0·08 (-0·15--0·02)	0·04	-0·02 (-0·03--0·01)	<0·001	-0·02 (-0·02--0·01)	<0·0001	0·04 (0·03-0·04)	<0·0001	0·01 (0·00-0·01)	<0·001
Survivors	0·14 (-0·08-0·36)	0·24	-0·04 (-0·07--0·02)	0·00	-0·02 (-0·02--0·01)	<0·0001	0·04 (0·03-0·05)	<0·0001	0·02 (0·01-0·03)	<0·0001
Family & Children	0·12 (-0·13-0·36)	0·38	0·04 (0·02-0·06)	<0·001	-0·02 (-0·02--0·01)	<0·0001	-0·04 (-0·05--0·03)	<0·0001	-0·01 (-0·02--0·01)	<0·0001
Unemployment	-0·03 (-0·23-0·17)	0·78	-0·03 (-0·05--0·01)	0·02	-0·01 (-0·02--0·01)	<0·0001	-0·02 (-0·03--0·01)	<0·001	0·01 (0·00-0·01)	0·01
Housing	0·11 (-0·62-0·84)	0·77	0·09 (0·03-0·16)	0·01	-0·01 (-0·02--0·01)	<0·0001	-0·07 (-0·11--0·03)	<0·001	-0·03 (-0·05--0·01)	0·01
Social exclusion	0·03 (-0·49-0·54)	0·92	0·06 (0·01-0·10)	0·03	-0·01 (-0·02--0·01)	<0·0001	-0·08 (-0·10--0·05)	<0·0001	-0·03 (-0·04--0·01)	<0·001

Note: SRH scale was inversed such that higher scores indicate worse health. LCSEC disadvantage = Life-course socioeconomic disadvantage, Social protection = Social protection function. All models are adjusted for the seven other social protection functions. Age was centered at 50 years and divided by 10 so that the coefficients yielded the effects for a 10-year period. Refer to Supplemental material for the not fully adjusted models M1a.

Exploratory results for separate net social protection expenditure functions

The models examining the effects of the separate net social protection expenditure functions offer a fine-grained picture of the results showed above. For SRH (Table 3), higher expenditure in old age policies was the only function that had a direct (at age 50 and the mean for life-course socioeconomic disadvantage) and beneficial effect on men's SRH (-0·08, p=0·04). The cross-level interactions indicate that higher expenditure in old age and survivors reduced the negative effects of life-course socioeconomic disadvantage at the beginning of the modelled SRH trajectories in women (-0·01, p<0·001 and 0.04, p<0·001, respectively). However, spending on disability and family and children schemes had the opposite effect of increasing the negative effects of life-course disadvantage (0·02, p=0·02 and 0·04, p<0·001, respectively). In men, results show a reduction of negative effects of life-course socioeconomic disadvantage on SRH by higher spending on old age (-0·02, p<0·001), survivors (-0·04, p<0.01), and unemployment (-0·03, p=0·02), while spending on disability (0·02, p=0·04), family and children (0·04, p<0·001), housing (0·09, p=0·01), and social exclusion (0·06, p=0·03) showed an increase of negative effects of life-course socioeconomic disadvantage on SRH. The three-way interactions are consistent with the results for the total net social protection expenditure. With increasing age, the moderation effects of the expenditure functions on the association of life-course socioeconomic disadvantage with SRH became weaker. Table S7 in Supplemental Material provides the models M1a.

Table 4 Associations of life-course socioeconomic disadvantage with weak grip strength and the moderating effect of separate functions of social protection expenditure, Models M1b

	Social protection function		LCSEC dis x Social prot		LCSEC dis x Age		Social prot x Age		LCSEC dis x Social prot x Age	
Women	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value
Sickness/Health Care	-0·56 (-0·96--0·17)	0·02	-0·06 (-0·12--0·00)	0·05	0·00 (-0·02-0·03)	0·73	0·03 (-0·01-0·07)	0·14	0·00 (-0·02-0·02)	0·96
Disability	0·27 (-0·52-1·06)	0·52	0·01 (-0·10-0·12)	0·91	-0·02 (-0·04-0·01)	0·27	-0·12 (-0·19--0·04)	0·00	-0·00 (-0·04-0·03)	0·97
Old age	0·09 (-0·14-0·31)	0·48	-0·03 (-0·08-0·01)	0·13	0·00 (-0·02-0·03)	0·79	-0·03 (-0·06--0·00)	0·03	0·01 (-0·01-0·02)	0·33
Survivors	0·36 (-0·37-1·10)	0·36	0·05 (-0·06-0·17)	0·37	-0·00 (-0·03-0·02)	0·85	0·03 (-0·04-0·10)	0·40	-0·01 (-0·05-0·02)	0·49
Family & Children	-0·83 (-1·70-0·04)	0·10	-0·05 (-0·15-0·05)	0·37	-0·00 (-0·03-0·03)	0·88	-0·02 (-0·09-0·04)	0·52	0·02 (-0·02-0·05)	0·35
Unemployment	0·64 (-0·04-1·32)	0·10	-0·05 (-0·15-0·05)	0·37	0·00 (-0·02-0·03)	0·93	0·02 (-0·04-0·07)	0·57	-0·01 (-0·04-0·02)	0·67
Housing	2·90 (0·33-5·47)	0·06	-0·23 (-0·55-0·08)	0·16	-0·01 (-0·04-0·02)	0·42	-0·26 (-0·46--0·06)	0·01	0·05 (-0·05-0·16)	0·31
Social exclusion	-0·93 (-2·67-0·81)	0·33	-0·15 (-0·37-0·07)	0·21	-0·01 (-0·03-0·02)	0·61	-0·11 (-0·25-0·03)	0·14	0·00 (-0·07-0·07)	0·99
Men										
Sickness/Health Care	-0·95 (-1·40--0·50)	0.00	-0·20 (-0·31--0·10)	<0·001	0·02 (-0·02-0·07)	0·29	0·11 (0·05-0·17)	<0·001	0·05 (0·01-0·08)	0·01
Disability	-0·61 (-1·50-0·28)	0·21	-0·36 (-0·57--0·16)	0·00	0·03 (-0·02-0·07)	0·27	0·23 (0·11-0·35)	<0·001	0·13 (0·07-0·19)	<0·0001
Old age	0·15 (-0·13-0·43)	0·33	-0·01 (-0·10-0·07)	0·77	0·02 (-0·02-0·07)	0·28	-0·10 (-0·15--0·06)	<0·0001	0·00 (-0·03-0·03)	0·91
Survivors	1·53 (0·65-2·41)	0·01	0·18 (-0·06-0·41)	0·15	0·05 (0·00-0·09)	0·04	-0·27 (-0·39--0·15)	<0·0001	-0·08 (-0·14--0·02)	0·02
Family & Children	-2·05 (-2·99--1·11)	0·00	-0·30 (-0·50--0·10)	0·01	0·06 (0·01-0·11)	0·01	0·30 (0·19-0·41)	<0·0001	0·14 (0·08-0·20)	<0·0001
Unemployment	0·57 (-0·21-1·35)	0·18	-0·15 (-0·34-0·04)	0·14	0·01 (-0·04-0·05)	0·78	0·01 (-0·08-0·11)	0·78	0·01 (-0·04-0·06)	0·77
Housing	1·91 (-0·94-4·77)	0·22	-1·05 (-1·67--0·43)	0·00	0·02 (-0·02-0·07)	0·33	0·49 (0·15-0·83)	0·00	0·36 (0·18-0·53)	<0·0001
Social exclusion	-3·00 (-4·89--1·12)	0·01	-0·83 (-1·25--0·41)	0·00	0·03 (-0·01-0·08)	0·15	0·53 (0·28-0·77)	<0·0001	0·25 (0·12-0·37)	<0·001

Note: Grip strength scale was inverted such that higher scores indicate weaker grip strength. LCSEC disadvantage = Life-course socioeconomic disadvantage, Social protection = Social protection function. All models are adjusted for the seven other social protection functions. Age was centered at 50 years and divided by 10 so that the coefficients yielded the effects for a 10-year period. Refer to Supplemental material for the not fully adjusted models M1a.

For grip strength (Table 4), higher expenditure in sickness/health care policies had a direct (at age 50 and the mean for life-course socioeconomic disadvantage) and beneficial effect on the outcome in women and men (-0·56, p=0·02, -0·95, p=0·00, respectively). Additionally, in men, spending on survivor schemes had a negative impact on grip strength (1·53, p=0·01), while expenditure in family and children (-2·05, p<0·01) and social exclusion (-3·00, p=0·01) had a positive effect. The cross-level interactions show a reduction of the negative effects of life-course socioeconomic disadvantage on grip strength at age 50 in men by the sickness/health care (-0·20, p<0·001), disability (-0·36, p=0·00), family and children (-0·30, p=0·01), housing (-1·05, p=0·00), and social exclusion (-0·83, p<0·01) functions. The three-way interactions indicate that these reduction effects became weaker with increasing age. Refer to Table S8 in Supplemental Material for models M1a.

Discussion

Our findings from this large European-wide study show that longer exposure to socioeconomic disadvantage throughout the life course was associated with worse SRH and grip strength at 50 years for both women and men. While the results suggest no direct association of social protection expenditure with these outcomes, as hypothesized, higher spending reduced the negative effects of socioeconomic disadvantage in women's subjective health (SRH) as well as in men and women's objective health (grip strength).

Furthermore, with increasing age the negative impact of socioeconomic disadvantage on SRH diminished for women and men. This finding corresponds to the 'age-as-leveler' hypothesis describing decreasing differences with ageing due to mortality selection, which has been supported by previous studies (Lynch, 2003; Sieber et al., 2020). The novelty of our study was to show that higher country-level expenditure on social protection slowed down this narrowing effect in subjective health (Figure 1). This result suggests that spending on social protection policies may slow down age selection and allow

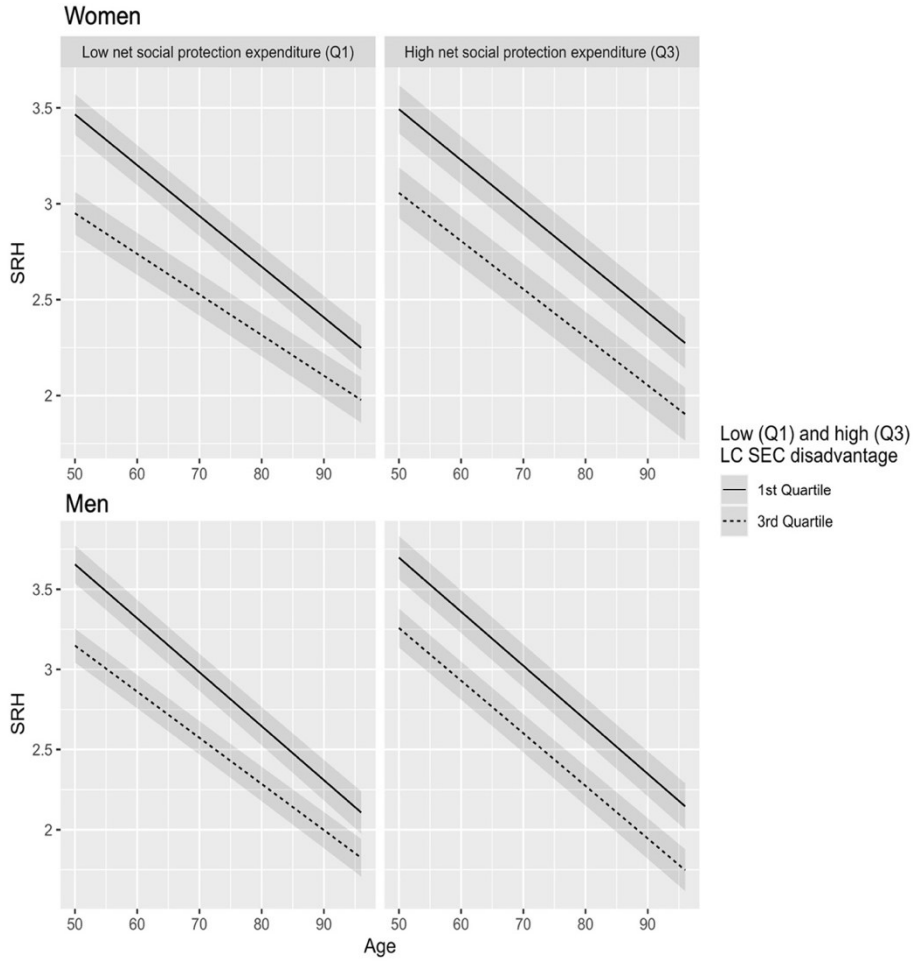

Figure 1 Marginal effects plot for predicted self-rated health by women and men. Notes: SRH = self-rated health [1;5], for a more intuitive reading of the figure, higher values on the SRH scale represent better health. Net social protection expenditure was dissociated into low and high by applying quartiles on the whole self-rated health sample: Q1 = 20·95%, Q3 = 25·85%. LC SEC disadvantage = Life-course socioeconomic disadvantage [0;8] was dissociated into low and high by applying quartiles on the sub-samples by women (Q1 = 2·50, Q3 = 5·50) and men (Q1 = 2·00, Q3 = 5·00).

individuals from lower socioeconomic strata to survive longer. For objective health, a similar narrowing of the socioeconomic inequalities over the ageing process was not found. While social protection expenditure had a positive moderating effect on grip-strength inequalities, this effect became weaker with ageing (Figure 2).

Looking at the separate functions of social expenditure reveals the differing influences of the various social protection policies on the association of socioeconomic disadvantage and later-life health. While spending in old age

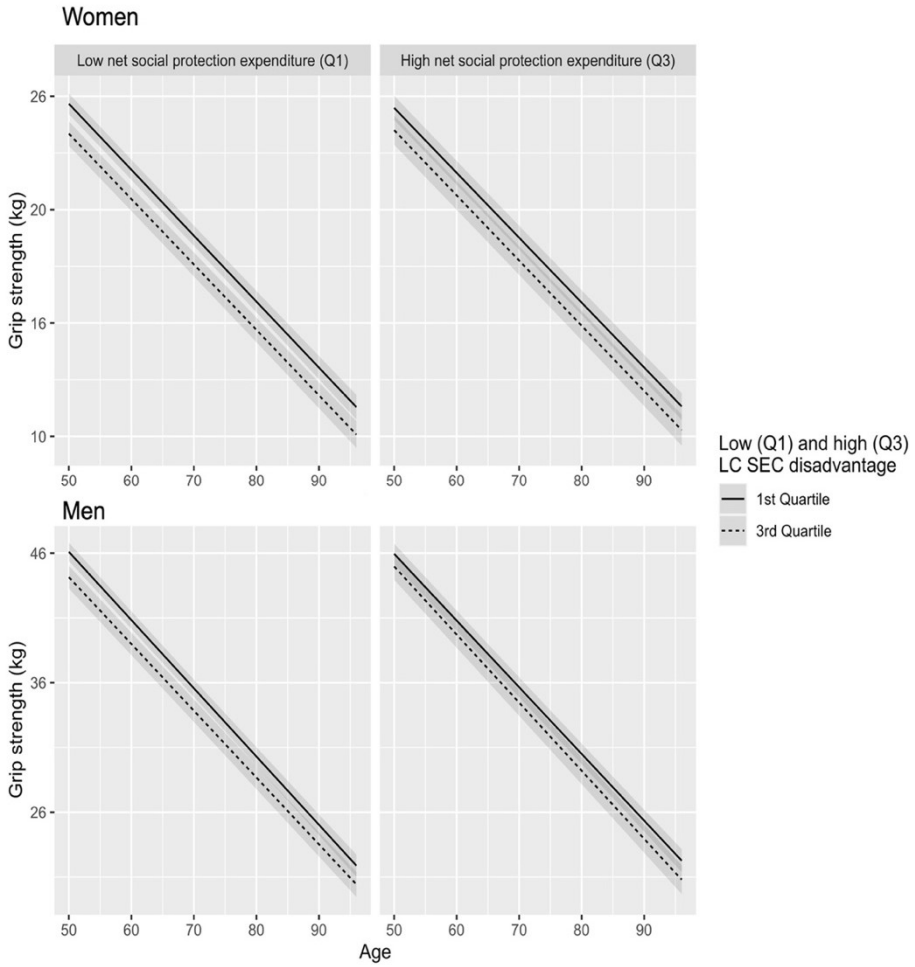

Figure 2 Marginal effects plot for predicted grip strength by women and men. Notes: For a more intuitive reading of the figure, higher values on the grip strength scale represent better health. Net social protection expenditure was dissociated into low and high by applying quartiles on the whole grip strength health sample: Q1 = 20·95%, Q3 = 25·85%. LC SEC disadvantage = Life-course socioeconomic disadvantage [0;8] was dissociated into low and high by applying quartiles on the sub-samples by women (Q1 = 2·50, Q3 = 5·50) and men (Q1 = 2·00, Q3 = 5·00).

and survivors policies had a protective effect by reducing socioeconomic inequalities in women's SRH at 50 years, disability and family and children schemes had the opposite, deteriorating, effect. However, the findings for total net social protection expenditure suggest that the former inequality reducing effects are stronger than the latter. In men, adding to the effects found in women, unemployment schemes play a positive role, too, while housing and social exclusion add to the negative effects. The findings for total net social protection expenditure suggest that positive and negative effects offset each other. The results for family and children policies are consistent with de Breij et

al.'s study (2020), where in countries with higher expenditure on family, educational differences in men's SRH were larger. Existing research suggests that individuals from lower socioeconomic strata more often rely on their parents for their children's care-taking duties instead of benefitting from childcare policies (de Breij et al., 2020; Wang & Marcotte, 2007). While individuals in our study's age range mostly do not have child care duties to fulfill, they may take care of their grandchildren. Consequently, better-off grandparents may benefit more from child care benefits. Furthermore, the inequality-widening properties of the disability and social exclusion schemes may be due to unintentional stigmatization effects that such policies can have on people's judgement of their own health (Buljevac et al., 2012). Consistently, these effects were not observed or had the opposing influence in the objectively measured grip strength outcome.

The separate functions showed no moderating effect on the life-course socioeconomic disadvantage and grip strength association in women at 50 years, whereas when taken together, higher total social protection expenditure reduced the negative impact of disadvantage on grip strength. In men, only old age, survivors, and unemployment showed no moderation on this association.

When discussing the results, we need to consider a potential impact of the Great Recession of 2009 on the results. Existing literature on the relationship between mortality and recessions revealed that this relationship is pro-cyclical, with mortality decreasing during economic recessions due to reductions in traffic accidents, liver and cardiovascular disease (Margerison-Zilko et al., 2016; Neumayer, 2004; Ruhm, 2016; Strumpf et al., 2017; Toffolutti & Suhrcke, 2014). This decrease in mortality comes despite the known negative effects of unemployment on SRH and mental health, and increased suicide rates (Margerison-Zilko et al., 2016; Martikainen & Valkonen, 1996; Morris et al., 1994). The detrimental health effects through unemployment are only partially important for our sample with a mean age of over 65 years for most of the countries (see Tables S1 – S4, Supplemental Material). Furthermore, EU countries responded to the crisis by increasing expenditure in social protection in order to account for increased unemployment and needs (further discussed

below), which has been shown to be a protective measure against the negative effects of a recession (Hone et al., 2019).

The social protection expenditure measure used in the stud reflects the median of the values between 2007 and 2017 to account for missing values and to avoid that extreme outliers in net social protection expenditure influence too much the results. Therefore, the impact of the Great Recession is not directly captured in the measure. A report by the European Commission on social protection expenditure and its financing in Europe came to the conclusion that the Great Recession had a significant impact on countries' social protection expenditure (Spasova & Ward, 2019). The report states that the increase in social protection expenditure as a share of GDP was concentrated in the period before 2010, with most of the increase occurring between 2008 and 2009 due to the crisis. The reason for this increase was not only the sharp decline in GDP fluctuation. Expenditure also went up in real terms, largely due to the growing number of unemployed and people in need of support (Spasova & Ward, 2019). After 2010, budgetary consolidation led to measures being undertaken to contain or reduce spending in virtually every country. As a consequence, social protection expenditure in 2016 was 1 percentage point of GDP less than in 2010 in the EU (Spasova & Ward, 2019).

These findings evidence that the Great Recession has had an impact on social protection expenditure but that this impact has been shared by virtually all EU countries in a similar way. This is also reflected by the fact that the report found three groups of countries in terms of their social protection expenditure relative to GDP which barely changed in composition over the period 2005-2016: 'high spenders', 'medium spenders', and 'low spenders' (Spasova & Ward, 2019).

By the above accounts it can be deducted that EU countries responded in a comparable way to the crisis and its aftermath. As a consequence, it is rather improbable that the Great Recession had a big impact on the results through the social protection expenditure measure. Furthermore, the models were adjusted for unemployment rates in order to capture some of the

expenditure increase due to the rising unemployment levels as a response to the crisis.

In comparison with previous literature, this study extends existing knowledge by not only looking at the protective or deteriorating role (moderation effects) of social protection expenditure on the association of life-course socioeconomic disadvantage and subjective and objective health in later life at age 50, but also by examining how the country-level policies influence this association over the ageing process. De Breij et al. found smaller absolute educational inequalities in SRH for both men and women in countries with higher total social protection expenditure, whereas our results suggests that this is only the case for women (de Breij et al., 2020). However, in de Breij's et al.'s study only post-retirement SHARE participants were included. Another cross-sectional study using the European Union Statistics on Income and Living Conditions (EU-SILC) database including a sample with a large age span of 25-80+ years found that higher social expenditures are associated with lower educational SRH inequalities among women and, to a lesser degree, among men (Dahl & van der Wel, 2013). These results were generally confirmed by a study using the repeated cross-sectional European Social Survey with a similar sample age range but that did not specifically look at sex differences (Álvarez-Gálvez & Jaime-Castillo, 2018).

This study comes with many strengths such as an approach considering subjective as well as objective health outcomes, a comprehensive measure of life-course socioeconomic disadvantage, and a large European sample including data allowing to look at health trajectories in later life. In addition, this study makes use of a precise indicator of welfare generosity (net social protection expenditure) to assess its interaction with an individual-level indicator of socioeconomic disadvantage on health in later life. However, there are some limitations worth mentioning. Information on childhood and middle age (main occupational position) is self-reported and obtained through a retrospective questionnaire, which may suffer from recall bias, common source bias, or social desirability. However, a previous study examining recall and contemporaneous measures of overcrowding has shown encouraging levels of consistency

between the two (Brown, 2014). Furthermore, SRH as a subjective outcome may be sensitive to the respondent's cultural context. Yet, existing research on the European context has shown that differences in reporting styles explained only some part of the cross-country variations (Hardy et al., 2014). Another limitation is related to the relatively small sample size at country level. It has been argued that the estimates of the country-level fixed effects may be biased when less than 25 countries are included in the analyses (Bryan & Jenkins, 2016). Therefore, caution is advisable when interpreting the β of the country-level effects. However, the Satterthwaite approximation used to calculate the F-tests in this study has been shown to produce acceptable Type 1 error rates in linear mixed-effects models even for smaller samples (Luke, 2017). In addition, social protection expenditure was included as a time-invariant predictor using its median over the 2007-2017 period as a proxy of a country's welfare system generosity. This is due to missing information before 2007. However, as can be deducted from Table S6 (Supplementary material), except for Ireland the percentage share of social protection expenditure of GDP did not vary considerably over this period. Furthermore, it is possible that our analyses are subject to omitted variable bias as there may be unmeasured variables on the individual and country level confounding the associations reported, such as personality traits, genetics, and environmental characteristics (Pingault et al., 2021; Präg et al., 2016). Finally, in spite of the longitudinal design, we cannot rule out that the results may be biased by reverse causation since some items included in the life-course socioeconomic disadvantage predictor (i.e. main occupational class and financial strain) were measured at the same time as the outcome.

This study makes a contribution to the literature examining how the generosity country-level policies affect individual-level life-course socioeconomic experiences and subjective and objective health in later life. In light of the current Covid-19 pandemic, research on this topic is crucial. As the virus is known to aggravate socioeconomic health inequalities by affecting vulnerable and socially disadvantaged people more frequently and severely, country-level

spending on social protection might be key to address these issues (Settersten et al., 2020).

By including a subjective as well as an objective measure of health and looking at their evolution over the ageing process, the findings add insights to existing literature. This study shows that socioeconomic disadvantage experienced over the life course is robustly associated with worse health outcomes in later life. In countries where expenditure on social protection was higher, differences in later-life grip strength could be reduced in both sexes, but only in women in subjective health. Furthermore, we suggest that higher social protection expenditure slowed down the mortality selection process observed in subjective health. A closer look at the separate functions of social protection expenditure revealed possibly unwanted inequality widening effects in subjective health which were not observed for objective health. This finding suggests policy makers should carefully examine social protection policies linked to disability or social exclusion as they may come with 'side effects' in terms of people's perceived health.

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Supplemental Material

Content

Definition of social protection functions

Definition of the separate social protection functions as per the manual and user guidelines of the European system of integrated social protection statistics – ESSPROS (2019 edition)[1].

Sickness/Health care

Income maintenance and support in cash in connection with physical or mental illness, excluding disability. Health care intended to maintain, restore or improve the health of the people protected irrespective of the origin of the disorder.

Disability

Income maintenance and support in cash or kind (except health care) in connection with the inability of physically or mentally disabled people to engage in economic and social activities.

Old age

Income maintenance and support in cash or kind (except health care) in connection with old age.

Survivors

Income maintenance and support in cash or kind in connection with the death of a family member.

Family/Children

Support in cash or kind (except health care) in connection with the costs of pregnancy, childbirth and adoption, bringing up children and caring for other family members.

Unemployment

Income maintenance and support in cash or kind in connection with unemployment.

Housing

Help towards the cost of housing.

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[1] https://ec.europa.eu/eurostat/documents/3859598/10295301/KS-GQ-19-014-EN-N.pdf/e7c8c019-944c-1c71-aee5-1ffc8ce45200 (Retrieved on 29 January 2021)

Social exclusion

Benefits in cash or kind (except health care) specifically intended to combat social exclusion where they are not covered by one of the other functions.

Life-course socioeconomic disadvantage

Life-course socioeconomic disadvantage is a score ranging from 0 to 8, with higher values indicating greater exposure to socioeconomic disadvantage throughout the life course. The score combines socioeconomic circumstances from different life stages; childhood, young adulthood, middle age, and old age. Each life stage is given a weight of 2 in the final score.

Childhood socioeconomic disadvantage was derived from four binary indicators of adverse socioeconomic conditions, each reflecting specific conditions of participants at the age of 10: 1) occupational position of the main breadwinner, 2) number of books in the household, 3) a measure of overcrowding, and 4) housing quality (Cheval, Boisgontier, et al., 2018; Cheval, Sieber, et al., 2018; Wahrendorf & Blane, 2015). Occupational position of the main breadwinner was constructed by reclassifying the 10 main occupational groups of the International Standard Classification of Occupations (ISCO) according to their skill levels. The first and second skill level were grouped as “low” occupational position, and the third and fourth levels were classified as “high”. The number of books in the household indicated whether there was 0 – 10 vs 11+ books at home, with the former category indicating social disadvantage. The overcrowding measure was a combination of the number of people living in the household and the number of rooms (excluding kitchen, bathrooms, and hallways). More than one person per room living in the respective household indicated social disadvantage. Disadvantage related to the quality of the household was assessed through the absence of all of the following items: fixed bath, cold running water supply, hot running water supply, inside toilet, and central heating. For each indicator, a socially advantaged situation was given a score of 0, while a socially disadvantaged situation was

given a score of 0.5. This results in a maximum score of disadvantage in childhood of 2.

Young adulthood socioeconomic disadvantage was derived from participants' highest educational attainment according to the International Standard Classification of Education. Tertiary, secondary, and primary education were given scores of 0, 1, and 2, respectively.

Middle age socioeconomic disadvantage was determined by the skill classification of the participant's main job over her/his life course according to the International Standard Classification of Occupations (ISCO). ISCO's 10 main occupational groups were reclassified according to their skill levels, whereby skill levels 1 and 2 were grouped into "low" and skill levels 3 and 4 were grouped into "high" main occupational position. Respondents with high skill main occupation, low skill, and those who never worked were given scores of 0, 1, and 2, respectively.

Old age socioeconomic disadvantage was determined by the survey question "Is the household able to make ends meet?" Participants answered on a four-point scale ranging from 1 "easily" to 4 "with great difficulty". We computed the mode over follow-up (variable was not measure in retrospective wave 3) for each individual in order to keep as many observations as possible. Answer categories "easily", "fairly easily", "with difficulty", and "with great difficulty" were given scores of 0, 0, 1, and 2, respectively.

As a result, the scores added up give us an exposure to disadvantage in the life course, where "0" means no exposition and "8" maximum exposition to socioeconomic disadvantages.

Unhealthy behaviors

We computed an index combining four binary indicators of unfavorable health behaviors by taking the mean of 1) physical inactivity, 2) unhealthy eating, 3) smoking, and 4) alcohol consumption across waves for each participant. This resulted in a continuous variable ranging from 0, none of the 4 indicators, to 1, all of the 4 unhealthy behaviors (Sieber et al., 2019).

Partnership status

We computed an indicator on whether a participant, independent of his/her marital status, was living with a partner during follow-up (by taking the mode); 0 was coded “mostly living alone” and 1 “mostly living with a partner” (Cullati et al., 2014; Sieber et al., 2019).

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Table S1 Baseline characteristics of women in the self-rated health sample

					Birth cohort						
	N	Self-rated health[1]	Life-course SEC disadvantage[2]	Age	between 1919 and 1928	between 1929 and 1938	between 1939 and 1945	after 1945	Observations	Living alone	Unhealthy behavior[3]
Austria	1,733	3·0 (1·0)	3·5 (1·6)	67·0 (9·7)	96 (5·5%)	332 (19·2%)	420 (24·2%)	885 (51·1%)	4·2 (1·3)	733 (42·3%)	0·2 (0·2)
Belgium	2,699	3·0 (1·0)	3·4 (1·8)	65·4 (10·5)	217 (8%)	483 (17·9%)	455 (16·9%)	1,544 (57·2%)	4·4 (1·8)	938 (34·8%)	0·2 (0·2)
Croatia	971	2·6 (1·1)	5·0 (1·7)	65·3 (9·5)	17 (1·8%)	97 (10%)	180 (18·5%)	677 (69·7%)	2·0 (0·1)	282 (29%)	0·2 (0·2)
Czech Republic	2,535	2·7 (1·0)	3·9 (1·4)	66·3 (9·0)	95 (3·7%)	435 (17·2%)	583 (23%)	1,422 (56·1%)	3·9 (1·2)	1,025 (40·4%)	0·3 (0·2)
Denmark	1,610	3·4 (1·2)	2·4 (1·5)	64·9 (10·3)	120 (7·5%)	261 (16·2%)	292 (18·1%)	937 (58·2%)	4·5 (1·7)	506 (31·4%)	0·2 (0·2)
Estonia	2,086	2·2 (0·9)	3·9 (1·5)	66·9 (10·1)	68 (3·3%)	439 (21%)	423 (20·3%)	1,156 (55·4%)	3·6 (0·7)	923 (44·2%)	0·2 (0·2)
France	2,035	2·8 (1·0)	3·9 (1·9)	66·0 (10·7)	199 (9·8%)	396 (19·5%)	347 (17·1%)	1,093 (53·7%)	4·4 (1·6)	785 (38·6%)	0·2 (0·2)
Germany	2,113	2·8 (1·0)	3·1 (1·4)	64·6 (9·6)	104 (4·9%)	324 (15·3%)	410 (19·4%)	1,275 (60·3%)	3·8 (1·5)	557 (26·4%)	0·2 (0·2)
Greece	2,006	2·9 (1·0)	5·8 (1·6)	65·4 (10·1)	147 (7·3%)	409 (20·4%)	352 (17·5%)	1,098 (54·7%)	3·4 (1·2)	654 (32·6%)	0·3 (0·3)
Hungary	253	2·4 (1·0)	4·4 (1·2)	66·2 (8·7)	3 (1·2%)	37 (14·6%)	53 (20·9%)	160 (63·2%)	2·0 (0·1)	102 (40·3%)	0·3 (0·3)
Ireland	354	3·4 (1·2)	3·8 (1·8)	64·5 (9·1)	31 (8·8%)	64 (18·1%)	90 (25·4%)	169 (47·7%)	2·0 (0·2)	126 (35·6%)	0·3 (0·3)
Italy	2,635	2·7 (1·1)	5·3 (1·8)	65·2 (9·7)	124 (4·7%)	453 (17·2%)	534 (20·3%)	1,524 (57·8%)	4·2 (1·8)	581 (22%)	0·3 (0·2)
Luxembourg	456	2·9 (1·0)	3·1 (1·7)	63·7 (8·9)	6 (1·3%)	43 (9·4%)	56 (12·3%)	351 (77%)	2·6 (0·5)	114 (25%)	0·2 (0·2)
Netherlands	1,042	3·1 (1·0)	3·2 (1·5)	64·6 (9·1)	75 (7·2%)	199 (19·1%)	244 (23·4%)	524 (50·3%)	4·1 (1·0)	229 (22%)	0·2 (0·2)
Poland	1,125	2·2 (1·0)	5·4 (1·6)	64·6 (9·8)	77 (6·8%)	192 (17·1%)	175 (15·6%)	681 (60·5%)	3·9 (1·2)	319 (28·4%)	0·4 (0·3)
Portugal	194	2·3 (0·9)	5·9 (1·8)	64·7 (9·2)	4 (2·1%)	20 (10·3%)	39 (20·1%)	131 (67·5%)	2·8 (0·4)	40 (20·6%)	0·3 (0·2)
Slovenia	1,528	2·7 (1·0)	4·3 (1·7)	66·8 (9·7)	42 (2·7%)	260 (17%)	296 (19·4%)	930 (60·9%)	3·0 (0·9)	432 (28·3%)	0·1 (0·2)
Spain	2,678	2·6 (1·0)	5·1 (1·7)	67·5 (10·7)	238 (8·9%)	576 (21·5%)	497 (18·6%)	1,367 (51%)	4·0 (1·6)	628 (23·5%)	0·2 (0·2)
Sweden	1,899	3·3 (1·1)	2·7 (1·7)	67·6 (9·2)	128 (6·7%)	365 (19·2%)	519 (27·3%)	887 (46·7%)	4·3 (1·7)	512 (27%)	0·2 (0·2)
Switzerland	1,318	3·3 (1·0)	3·1 (1·4)	66·2 (10·0)	91 (6·9%)	243 (18·4%)	277 (21%)	707 (53·6%)	4·5 (1·4)	451 (34·2%)	0·1 (0·2)
Range		[1;5]	[0;8]	[50;96]					[1;7]		[0;1]

[1] higher values indicate better health, [2] higher values indicate more disadvantage, [3] higher values indicate more unhealthy behaviors

Note: SEC = Socioeconomic

Table S2 Baseline characteristics of men in the self-rated health sample

					Birth cohort						
	N	Self-rated health[1]	Life-course SEC disadvantage[2]	Age	between 1919 and 1928	between 1929 and 1938	between 1939 and 1945	after 1945	Observations	Living alone	Unhealthy behavior[3]
Austria	1,235	3·0 (1·0)	3·1 (1·5)	66·9 (9·2)	62 (5%)	212 (17·2%)	331 (26·8%)	630 (51%)	4·1 (1·2)	268 (21·7%)	0·3 (0·3)
Belgium	2,205	3·1 (1·0)	2·9 (1·7)	65·3 (10·0)	160 (7·3%)	390 (17·7%)	380 (17·2%)	1,275 (57·8%)	4·4 (1·8)	490 (22·2%)	0·3 (0·2)
Croatia	755	2·7 (1·2)	4·6 (1·5)	65·5 (8·4)	7 (0·9%)	69 (9·1%)	139 (18·4%)	540 (71·5%)	2·0 (0·1)	105 (13·9%)	0·3 (0·2)
Czech Republic	1,706	2·7 (1·0)	3·5 (1·4)	66·9 (8·9)	65 (3·8%)	305 (17·9%)	433 (25·4%)	903 (52·9%)	3·8 (1·2)	329 (19·3%)	0·4 (0·3)
Denmark	1,370	3·4 (1·2)	2·3 (1·4)	65·0 (9·6)	82 (6%)	216 (15·8%)	294 (21·5%)	778 (56·8%)	4·5 (1·7)	292 (21·3%)	0·3 (0·3)
Estonia	1,265	2·2 (0·9)	3·9 (1·4)	66·0 (9·9)	26 (2·1%)	240 (19%)	234 (18·5%)	765 (60·5%)	3·5 (0·8)	278 (22%)	0·3 (0·2)
France	1,452	2·9 (1·0)	3·5 (1·8)	65·5 (10·1)	111 (7·6%)	281 (19·4%)	249 (17·1%)	811 (55·9%)	4·5 (1·6)	320 (22%)	0·2 (0·2)
Germany	1,833	2·8 (1·0)	2·8 (1·4)	65·8 (9·1)	75 (4·1%)	338 (18·4%)	420 (22·9%)	1,000 (54·6%)	3·8 (1·5)	338 (18·4%)	0·3 (0·3)
Greece	1,507	3·2 (1·0)	5·0 (1·5)	66·8 (9·7)	109 (7·2%)	353 (23·4%)	313 (20·8%)	732 (48·6%)	3·6 (1·2)	202 (13·4%)	0·4 (0·3)
Hungary	176	2·4 (1·0)	4·5 (1·2)	66·0 (7·6)	3 (1·7%)	16 (9·1%)	46 (26·1%)	111 (63·1%)	2·0 (0·0)	30 (17%)	0·3 (0·3)
Ireland	268	3·4 (1·2)	3·5 (1·9)	65·0 (8·9)	20 (7·5%)	60 (22·4%)	61 (22·8%)	127 (47·4%)	2·0 (0·1)	59 (22%)	0·3 (0·3)
Italy	2,243	2·8 (1·1)	4·8 (1·6)	66·7 (9·3)	112 (5%)	460 (20·5%)	508 (22·6%)	1,163 (51·9%)	4·1 (1·7)	249 (11·1%)	0·3 (0·2)
Luxembourg	395	3·0 (1·0)	2·8 (1·7)	64·6 (8·5)	2 (0·5%)	33 (8·4%)	77 (19·5%)	283 (71·6%)	2·6 (0·5)	70 (17·7%)	0·2 (0·2)
Netherlands	871	3·1 (1·0)	2·8 (1·5)	65·3 (9·0)	69 (7·9%)	195 (22·4%)	217 (24·9%)	390 (44·8%)	4·0 (1·0)	114 (13·1%)	0·2 (0·2)
Poland	877	2·3 (0·9)	5·1 (1·5)	65·5 (9·4)	56 (6·4%)	171 (19·5%)	159 (18·1%)	491 (56%)	3·8 (1·2)	141 (16·1%)	0·4 (0·3)
Portugal	147	2·5 (1·0)	5·5 (1·6)	65·5 (8·1)	0 (0%)	17 (11·6%)	27 (18·4%)	103 (70·1%)	2·7 (0·5)	15 (10·2%)	0·3 (0·2)
Slovenia	1,075	2·7 (1·0)	4·2 (1·6)	66·8 (8·9)	18 (1·7%)	166 (15·4%)	228 (21·2%)	663 (61·7%)	3·0 (0·9)	126 (11·7%)	0·2 (0·2)
Spain	2,123	2·8 (1·0)	4·6 (1·7)	67·7 (9·8)	133 (6·3%)	455 (21·4%)	434 (20·4%)	1,101 (51·9%)	4·0 (1·5)	316 (14·9%)	0·3 (0·2)
Sweden	1,628	3·3 (1·1)	2·7 (1·6)	68·4 (9·1)	108 (6·6%)	356 (21·9%)	437 (26·8%)	727 (44·7%)	4·2 (1·6)	277 (17%)	0·2 (0·2)
Switzerland	1,086	3·4 (1·0)	2·6 (1·4)	66·8 (9·4)	58 (5·3%)	222 (20·4%)	265 (24·4%)	541 (49·8%)	4·5 (1·3)	241 (22·2%)	0·2 (0·2)
Range		[1;5]	[0;8]	[50;96]					[1;7]		[0;1]

[1] higher values indicate better health, [2] higher values indicate more disadvantage, [3] higher values indicate more unhealthy behaviors

Note: SEC = Socioeconomic

Table S3 Baseline characteristics of women in the grip strength sample

					Birth cohort						
	N	Grip Strength (kg)[1]	Life-course SEC disadvantage[2]	Age	between 1919 and 1928	between 1929 and 1938	between 1939 and 1945	after 1945	Observations	Living alone	Unhealthy behavior[3]
Austria	1,701	25·4 (6·7)	3·5 (1·6)	67·1 (9·5)	91 (5·3%)	327 (19·2%)	412 (24·2%)	871 (51·2%)	3·8 (1·4)	721 (42·4%)	0·2 (0·2)
Belgium	2,679	24·9 (6·8)	3·4 (1·8)	65·1 (10·5)	210 (7·8%)	480 (17·9%)	452 (16·9%)	1,537 (57·4%)	4·2 (1·8)	930 (34·7%)	0·2 (0·2)
Croatia	940	24·8 (6·9)	5·0 (1·7)	65·0 (9·2)	11 (1·2%)	87 (9·3%)	175 (18·6%)	667 (71%)	1·9 (0·3)	267 (28·4%)	0·2 (0·2)
Czech Republic	2,513	25·4 (6·4)	3·9 (1·4)	66·1 (8·9)	89 (3·5%)	424 (16·9%)	583 (23·2%)	1,417 (56·4%)	3·6 (1·3)	1,014 (40·4%)	0·3 (0·2)
Denmark	1,605	26·0 (6·5)	2·4 (1·5)	64·7 (10·2)	119 (7·4%)	260 (16·2%)	291 (18·1%)	935 (58·3%)	4·4 (1·7)	502 (31·3%)	0·2 (0·2)
Estonia	2,062	25·2 (7·0)	3·9 (1·5)	66·8 (10·1)	65 (3·2%)	435 (21·1%)	418 (20·3%)	1,144 (55·5%)	3·4 (0·9)	916 (44·4%)	0·2 (0·2)
France	2,009	23·8 (6·4)	3·9 (1·9)	66·0 (10·4)	193 (9·6%)	391 (19·5%)	345 (17·2%)	1,080 (53·8%)	4·1 (1·6)	772 (38·4%)	0·2 (0·2)
Germany	2,096	26·1 (6·4)	3·1 (1·4)	64·6 (9·5)	98 (4·7%)	322 (15·4%)	406 (19·4%)	1,270 (60·6%)	3·6 (1·6)	550 (26·2%)	0·2 (0·2)
Greece	1,928	23·6 (6·6)	5·7 (1·6)	64·9 (9·8)	128 (6·6%)	382 (19·8%)	340 (17·6%)	1,078 (55·9%)	3·1 (1·3)	615 (31·9%)	0·3 (0·3)
Hungary	246	22·5 (6·3)	4·4 (1·2)	66·1 (8·1)	1 (0·4%)	36 (14·6%)	52 (21·1%)	157 (63·8%)	1·9 (0·3)	100 (40·7%)	0·3 (0·3)
Ireland	348	23·0 (6·6)	3·8 (1·8)	64·8 (8·9)	28 (8%)	63 (18·1%)	89 (25·6%)	168 (48·3%)	1·7 (0·4)	123 (35·3%)	0·3 (0·3)
Italy	2,568	23·6 (6·8)	5·2 (1·8)	64·9 (9·4)	110 (4·3%)	438 (17·1%)	521 (20·3%)	1,499 (58·4%)	3·7 (1·8)	556 (21·7%)	0·2 (0·2)
Luxembourg	441	25·1 (6·4)	3·1 (1·7)	63·5 (8·8)	5 (1·1%)	41 (9·3%)	55 (12·5%)	340 (77·1%)	2·4 (0·7)	109 (24·7%)	0·2 (0·2)
Netherlands	1,036	26·2 (6·7)	3·2 (1·5)	64·5 (9·2)	74 (7·1%)	198 (19·1%)	244 (23·6%)	520 (50·2%)	4·0 (1·1)	227 (21·9%)	0·2 (0·2)
Poland	1,109	24·5 (7·0)	5·4 (1·6)	64·4 (9·6)	74 (6·7%)	184 (16·6%)	173 (15·6%)	678 (61·1%)	3·6 (1·3)	315 (28·4%)	0·4 (0·3)
Portugal	189	21·7 (6·4)	5·9 (1·8)	64·3 (8·9)	4 (2·1%)	17 (9%)	39 (20·6%)	129 (68·3%)	2·6 (0·6)	39 (20·6%)	0·3 (0·2)
Slovenia	1,506	25·3 (7·1)	4·3 (1·7)	66·7 (9·6)	38 (2·5%)	255 (16·9%)	294 (19·5%)	919 (61%)	2·8 (0·9)	420 (27·9%)	0·1 (0·2)
Spain	2,639	20·7 (6·7)	5·1 (1·7)	67·3 (10·4)	219 (8·3%)	567 (21·5%)	493 (18·7%)	1,360 (51·5%)	3·7 (1·6)	608 (23%)	0·2 (0·2)
Sweden	1,893	25·2 (6·5)	2·7 (1·7)	67·5 (9·2)	124 (6·6%)	364 (19·2%)	519 (27·4%)	886 (46·8%)	4·2 (1·7)	509 (26·9%)	0·2 (0·2)
Switzerland	1,315	25·3 (6·1)	3·1 (1·4)	66·1 (9·7)	91 (6·9%)	243 (18·5%)	275 (20·9%)	706 (53·7%)	4·3 (1·5)	451 (34·3%)	0·1 (0·2)
Range		[0.5 ;95.0]	[0;8]	[50;96]					[1;7]		[0;1]

[1] higher values indicate better grip strength, [2] higher values indicate more disadvantage, [3] higher values indicate more unhealthy behaviors
Note: SEC = Socioeconomic

Table S4 Baseline characteristics of men in the grip strength sample

Men					Birth cohort						
	N	Grip Strength (kg)[1]	Life-course SEC disadvantage[2]	Age	between 1919 and 1928	between 1929 and 1938	between 1939 and 1945	after 1945	Observations	Living alone	Unhealthy behavior[3]
Austria	1,203	41·3 (9·8)	3·1 (1·5)	66·9 (9·0)	59 (4·9%)	208 (17·3%)	326 (27·1%)	610 (50·7%)	3·8 (1·4)	261 (21·7%)	0·3 (0·2)
Belgium	2,199	41·6 (9·8)	2·9 (1·7)	65·3 (9·9)	160 (7·3%)	389 (17·7%)	380 (17·3%)	1,270 (57·8%)	4·2 (1·8)	488 (22·2%)	0·2 (0·2)
Croatia	738	41·6 (9·8)	4·6 (1·5)	65·4 (8·3)	6 (0·8%)	65 (8·8%)	135 (18·3%)	532 (72·1%)	1·9 (0·3)	100 (13·6%)	0·3 (0·2)
Czech Republic	1,691	40·9 (9·2)	3·5 (1·4)	66·9 (8·8)	63 (3·7%)	302 (17·9%)	431 (25·5%)	895 (52·9%)	3·6 (1·3)	325 (19·2%)	0·4 (0·3)
Denmark	1,367	44·0 (9·6)	2·3 (1·4)	65·0 (9·4)	82 (6%)	215 (15·7%)	294 (21·5%)	776 (56·8%)	4·5 (1·7)	291 (21·3%)	0·3 (0·3)
Estonia	1,229	41·9 (10·8)	3·9 (1·5)	66·0 (9·8)	26 (2·1%)	238 (19·4%)	228 (18·6%)	737 (60%)	3·2 (1·0)	273 (22·2%)	0·3 (0·2)
France	1,444	40·1 (9·4)	3·5 (1·8)	65·6 (9·6)	110 (7·6%)	278 (19·3%)	249 (17·2%)	807 (55·9%)	4·2 (1·6)	319 (22·1%)	0·2 (0·2)
Germany	1,822	42·4 (9·1)	2·8 (1·4)	65·7 (9·0)	74 (4·1%)	336 (18·4%)	418 (22·9%)	994 (54·6%)	3·7 (1·5)	336 (18·4%)	0·3 (0·3)
Greece	1,481	38·6 (10·4)	5·0 (1·5)	66·5 (9·5)	103 (7%)	344 (23·2%)	306 (20·7%)	728 (49·2%)	3·4 (1·3)	197 (13·3%)	0·3 (0·3)
Hungary	173	39·0 (9·9)	4·5 (1·2)	65·5 (7·8)	2 (1·2%)	15 (8·7%)	46 (26·6%)	110 (63·6%)	1·9 (0·3)	30 (17·3%)	0·3 (0·3)
Ireland	267	39·1 (9·2)	3·5 (1·9)	65·1 (8·9)	20 (7·5%)	59 (22·1%)	61 (22·8%)	127 (47·6%)	1·7 (0·4)	59 (22·1%)	0·3 (0·3)
Italy	2,191	38·5 (9·8)	4·8 (1·6)	66·4 (9·3)	103 (4·7%)	445 (20·3%)	499 (22·8%)	1,144 (52·2%)	3·8 (1·8)	240 (11%)	0·3 (0·2)
Luxembourg	389	41·5 (8·7)	2·8 (1·7)	64·4 (8·3)	2 (0·5%)	31 (8%)	77 (19·8%)	279 (71·7%)	2·5 (0·6)	70 (18%)	0·2 (0·2)
Netherlands	867	42·8 (9·3)	2·8 (1·5)	65·3 (8·9)	68 (7·8%)	194 (22·4%)	217 (25%)	388 (44·8%)	3·9 (1·1)	114 (13·1%)	0·2 (0·2)
Poland	865	39·6 (9·6)	5·1 (1·5)	65·2 (9·5)	54 (6·2%)	167 (19·3%)	158 (18·3%)	486 (56·2%)	3·6 (1·3)	138 (16%)	0·4 (0·3)
Portugal	144	35·9 (8·1)	5·5 (1·6)	65·4 (7·6)	0 (0%)	16 (11·1%)	27 (18·8%)	101 (70·1%)	2·5 (0·7)	15 (10·4%)	0·3 (0·2)
Slovenia	1,056	41·7 (10·2)	4·2 (1·6)	66·6 (8·7)	18 (1·7%)	158 (15%)	225 (21·3%)	655 (62%)	2·8 (1·0)	124 (11·7%)	0·2 (0·2)
Spain	2,098	35·1 (9·8)	4·6 (1·7)	67·4 (9·8)	131 (6·2%)	442 (21·1%)	432 (20·6%)	1,093 (52·1%)	3·7 (1·6)	313 (14·9%)	0·3 (0·2)
Sweden	1,626	42·2 (9·7)	2·7 (1·6)	68·3 (8·9)	108 (6·6%)	356 (21·9%)	436 (26·8%)	726 (44·6%)	4·1 (1·6)	276 (17%)	0·2 (0·2)
Switzerland	1,086	41·2 (9·3)	2·6 (1·4)	66·8 (9·2)	58 (5·3%)	222 (20·4%)	265 (24·4%)	541 (49·8%)	4·4 (1·4)	241 (22·2%)	0·2 (0·2)
Range		[0.5 ;95.0]	[0;8]	[50;96]					[1;7]		[0;1]

[1] higher values indicate better grip strength, [2] higher values indicate more disadvantage, [3] higher values indicate more unhealthy behaviors
Note: SEC = Socioeconomic

Table S5 Country-level variables

	Total net social protection expenditure[1]	Health / Sickness[1,2]	Disability[1,2]	Old age[1,2]	Survivors[1,2]	Family & Children[1,2]	Unemployment[1,2]	Housing[1,2]	Social exclusion[1,2]	Real GDP per capita in Euro[1]	Unemployment rate[1]
Austria	25·85	7·03	1·83	10·26	1·55	2·79	1·56	0·13	0·42	36135	5·30
Belgium	26·33	7·94	1·97	8·24	1·70	2·14	3·11	0·23	0·72	33490	7·80
Croatia	20·51	6·84	2·61	6·68	2·05	1·61	0·50	0·02	0·24	10565	13·10
Czech Republic	19·01	5·95	1·36	8·08	0·70	1·76	0·56	0·18	0·25	15125	6·10
Denmark	26·33	6·63	4·57	9·06	0·20	3·68	1·39	0·68	1·23	44650	6·40
Estonia	14·87	4·44	1·75	6·35	0·07	1·97	0·42	0·04	0·10	12535	7·40
France	29·96	8·94	2·00	11·43	1·62	2·45	1·80	0·82	0·93	31190	9·40
Germany	25·37	9·07	2·07	7·81	1·69	3·09	1·11	0·59	0·15	32760	5·40
Greece	24·06	5·76	1·54	12·23	2·24	1·00	1·14	0·03	0·06	19410	21·50
Hungary	20·95	5·06	1·56	8·70	1·25	2·46	0·52	0·39	0·12	10280	7·80
Ireland	20·24	7·66	1·06	5·23	0·49	2·05	2·48	0·52	0·26	39035	11·90
Italy	24·57	6·64	1·60	11·32	2·18	1·17	1·37	0·03	0·20	26760	10·70
Luxembourg	20·02	5·18	2·35	5·50	1·68	3·45	1·04	0·31	0·48	79250	5·10
Netherlands	22·41	8·84	1·64	7·56	0·77	1·09	0·90	0·36	1·18	38525	5·00
Poland	16·47	4·19	1·37	7·535	1·56	1·40	0·24	0·06	0·13	9625	9·00
Portugal	23·26	6·17	1·93	10·31	1·73	1·18	1·30	0·00	0·26	16715	11·20
Slovenia	23·17	7·40	1·54	9·555	1·53	1·78	0·64	0·02	0·65	17685	8·00
Spain	23·01	6·45	1·71	8·34	2·19	1·29	2·56	0·15	0·23	23090	19·90
Sweden	25·46	7·05	3·19	9·75	0·34	2·80	0·88	0·44	0·66	40445	7·80
Switzerland	20·73	6·95	1·94	8·13	1·02	1·28	0·69	0·26	0·52	56675	4·80
Mean (SD)	22·63 (3·52)	6·71 (1·35)	1·98 (0·75)	8·60 (1·87)	1·33 (0·67)	2·02 (0·80)	1·21 (0·76)	0·26 (0·24)	0·44 (0·34)	29697·25 (17144·59)	9·18 (4·51)

Notes: [1]Median over 2007-2017 period as % of GDP, [2]Sub-function of total net social protection expenditure, SD = standard deviation

Table S6 Total net social protection expenditure as % of GDP by country and year

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Median
Austria	23·56	24·00	25·98	25·98	25·21	25·44	25·79	25·91	25·96	26·36	NA	25·85
Belgium	23·35	24·57	26·61	25·86	26·56	26·33	26·73	26·69	26·50	25·78	25·08	26·33
Croatia	NA	17·93	20·07	20·40	20·29	20·84	20·62	21·13	21·17	20·69	20·25	20·51
Czech Republic	17·02	17·31	19·42	19·36	19·38	19·76	19·50	19·01	18·34	18·25	17·94	19·01
Denmark	23·77	23·78	26·89	26·86	26·43	26·24	26·42	26·55	26·06	25·20	NA	26·33
Estonia	11·67	14·49	18·08	17·03	15·17	14·57	14·36	14·39	15·59	16·04	NA	14·87
France	NA	NA	NA	29·38	29·20	29·65	29·96	30·21	30·09	30·19	NA	29·96
Germany	23·85	24·04	26·88	26·30	25·15	25·16	25·41	25·33	25·47	25·63	NA	25·37
Greece	19·51	21·10	22·83	24·15	24·96	25·66	24·29	24·06	24·43	24·03	23·20	24·06
Hungary	21·36	21·62	22·01	21·79	21·11	20·78	20·22	19·37	18·79	18·66	NA	20·95
Ireland	16·38	19·00	22·62	23·29	22·68	22·20	21·17	19·31	14·74	14·56	NA	20·24
Italy	NA	22·76	NA	24·50	24·06	24·57	25·08	25·18	25·12	24·79	24·56	24·57
Luxembourg	17·76	19·16	21·31	20·51	19·67	20·67	20·70	20·14	19·89	19·47	NA	20·02
Netherlands	19·55	19·66	21·71	22·14	22·39	23·14	22·80	22·73	22·44	22·43	NA	22·41
Poland	NA	NA	NA	16·77	15·89	16·01	16·47	16·22	16·69	17·71	NA	16·47
Portugal	21·10	21·66	23·82	23·58	22·98	23·84	24·20	23·47	23·05	22·01	NA	23·26
Slovenia	20·19	20·26	NA	23·58	23·75	24·07	23·98	23·17	23·04	22·60	NA	23·17
Spain	18·90	20·16	23·02	23·00	23·66	23·72	23·95	23·54	22·83	22·51	NA	23·01
Sweden	23·09	23·56	25·71	24·62	24·62	25·43	26·09	25·80	25·48	25·64	NA	25·46
Switzerland	19·18	18·82	20·47	20·14	20·14	20·73	21·27	21·25	21·76	22·17	22·40	20·73

Note: NA = Not available, Source: Eurostat

Table S7 Associations of life-course socioeconomic disadvantage with poor self-rated health and the moderating effect of separate functions of social protection expenditure, Models M1a

	Social protection function		LCSEC dis x Social prot		LCSEC dis x Age		Social prot x Age		LCSEC dis x Social prot x Age	
Women	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value
Sickness/Health Care	-0·05 (-0·17-0·06)	0·41	-0·00 (-0·01-0·01)	0·46	-0·01 (-0·01--0·01)	<0·0001	-0·00 (-0·01-0·00)	0·15	-0·00 (-0·00-0·00)	0·92
Disability	0·03 (-0·20-0·26)	0·83	0·02 (0·01-0·04)	0·01	-0·01 (-0·02--0·01)	<0·0001	-0·02 (-0·03--0·01)	0·00	-0·01 (-0·01-0·00)	0·05
Old age	-0·05 (-0·11-0·02)	0·19	-0·02 (-0·02--0·01)	<0·001	-0·02 (-0·02--0·01)	<0·0001	0·02 (0·02-0·03)	<0·0001	0·01 (0·00-0·01)	<0·0001
Survivors	0·08 (-0·13-0·29)	0·45	-0·05 (-0·07--0·03)	<0·001	-0·02 (-0·02--0·01)	<0·0001	0·03 (0·02-0·05)	<0·0001	0·02 (0·01-0·03)	<0·0001
Family & Children	0·07 (-0·20-0·33)	0·64	0·04 (0·03-0·06)	<0·0001	-0·01 (-0·02--0·01)	<0·0001	-0·02 (-0·03--0·01)	<0·0001	-0·01 (-0·02--0·01)	<0·0001
Unemployment	0·05 (-0·15-0·24)	0·64	-0·01 (-0·03-0·00)	0·12	-0·01 (-0·01--0·01)	<0·0001	-0·01 (-0·02-0·00)	0·08	0·00 (-0·00-0·01)	0·10
Housing	0·32 (-0·43-1·08)	0·42	0·05 (-0·00-0·11)	0·08	-0·01 (-0·02--0·01)	<0·0001	-0·08 (-0·11--0·05)	<0·0001	-0·02 (-0·03-0·00)	0·07
Social exclusion	0·07 (-0·45-0·59)	0·79	0·03 (-0·01-0·07)	0·22	-0·01 (-0·02--0·01)	<0·0001	-0·08 (-0·11--0·06)	<0·0001	-0·02 (-0·03--0·01)	<0·001
Men										
Sickness/Health Care	0·00 (-0·11-0·12)	0·94	0·00 (-0·01-0·01)	0·72	-0·01 (-0·02--0·01)	<0·0001	-0·01 (-0·02--0·00)	0·01	0·00 (-0·00-0·01)	0·54
Disability	-0·07 (-0·31-0·17)	0·58	0·02 (0·00-0·05)	0·03	-0·01 (-0·02--0·01)	<0·0001	-0·01 (-0·03-0·00)	0·11	-0·01 (-0·02--0·00)	0·03
Old age	-0·07 (-0·14--0·01)	0·06	-0·02 (-0·03--0·01)	<0·001	-0·02 (-0·02--0·01)	<0·0001	0·04 (0·03-0·04)	<0·0001	0·01 (0·00-0·01)	<0·001
Survivors	0·12 (-0·10-0·34)	0·31	-0·05 (-0·07--0·02)	<0·001	-0·02 (-0·02--0·01)	<0·0001	0·04 (0·03-0·05)	<0·0001	0·02 (0·02-0·03)	<0·0001
Family & Children	0·11 (-0·15-0·36)	0·43	0·04 (0·02-0·06)	<0·0001	-0·02 (-0·02--0·01)	<0·0001	-0·04 (-0·05--0·03)	<0·0001	-0·01 (-0·02--0·01)	<0·0001
Unemployment	-0·00 (-0·20-0·20)	0·99	-0·03 (-0·05--0·01)	0·01	-0·01 (-0·02--0·01)	<0·0001	-0·02 (-0·03--0·01)	<0·001	0·01 (0·00-0·01)	0·01
Housing	0·19 (-0·56-0·94)	0·63	0·09 (0·02-0·16)	0·01	-0·01 (-0·02--0·01)	<0·0001	-0·07 (-0·11--0·03)	<0·001	-0·03 (-0·05--0·01)	0·01
Social exclusion	-0·00 (-0·53-0·53)	0·99	0·06 (0·01-0·11)	0·02	-0·01 (-0·02--0·01)	<0·0001	-0·08 (-0·11--0·05)	<0·0001	-0·03 (-0·04--0·01)	<0·0001

Note: SRH scale was inversed such that higher scores indicate worse health. LCSEC disadvantage = Life-course socioeconomic disadvantage, Social protection = Social protection function. All models are adjusted for the seven other social protection functions. Age was centered at 50 years and divided by 10 so that the coefficients yielded the effects for a 10-year period

Table S8 Associations of life-course socioeconomic disadvantage with weak grip strength and the moderating effect of separate functions of social protection expenditure, Models M1a

	Social protection function		LCSEC dis x Social prot		LCSEC dis x Age		Social prot x Age		LCSEC dis x Social prot x Age	
Women	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value	Coef (95% CI)	P value
Sickness/Health Care	-0·60 (-0·97--0·24)	0·01	-0·06 (-0·12--0·00)	0·05	0·01 (-0·02-0·03)	0·59	0·02 (-0·02-0·06)	0·29	-0·00 (-0·02-0·02)	0·89
Disability	0·33 (-0·39-1·05)	0·40	0·02 (-0·09-0·13)	0·73	-0·01 (-0·04-0·01)	0·36	-0·13 (-0·20--0·06)	<0·001	-0·01 (-0·04-0·03)	0·75
Old age	0·09 (-0·12-0·30)	0·43	-0·04 (-0·08-0·00)	0·07	0·01 (-0·02-0·03)	0·55	-0·04 (-0·07--0·00)	0·02	0·01 (-0·01-0·02)	0·33
Survivors	0·33 (-0·34-0·99)	0·37	0·03 (-0·09-0·15)	0·66	-0·00 (-0·03-0·03)	0·99	0·04 (-0·03-0·11)	0·30	-0·01 (-0·05-0·03)	0·64
Family & Children	-0·83 (-1·63--0·04)	0·08	-0·03 (-0·13-0·08)	0·62	-0·00 (-0·03-0·03)	0·99	-0·03 (-0·10-0·03)	0·35	0·01 (-0·02-0·04)	0·50
Unemployment	0·70 (0·08-1·31)	0·06	-0·05 (-0·15-0·05)	0·34	0·01 (-0·02-0·03)	0·68	0·02 (-0·04-0·07)	0·58	-0·01 (-0·04-0·02)	0·57
Housing	3·46 (1·13-5·80)	0·02	-0·20 (-0·52-0·12)	0·23	-0·01 (-0·04-0·02)	0·51	-0·30 (-0·50--0·10)	0·00	0·04 (-0·06-0·15)	0·41
Social exclusion	-0·82 (-2·40-0·76)	0·34	-0·12 (-0·34-0·10)	0·30	-0·00 (-0·03-0·02)	0·75	-0·13 (-0·27-0·01)	0·08	-0·01 (-0·09-0·06)	0·74
Men										
Sickness/Health Care	-1·03 (-1·47--0·60)	<0·001	-0·21 (-0·32--0·10)	<0·001	0·02 (-0·03-0·06)	0·47	0·10 (0·04-0·17)	0·00	0·05 (0·02-0·09)	0·01
Disability	-0·52 (-1·38-0·34)	0·26	-0·34 (-0·55--0·13)	0·00	0·02 (-0·03-0·06)	0·43	0·22 (0·10-0·34)	<0·001	0·12 (0·06-0·18)	<0·0001
Old age	0·17 (-0·10-0·43)	0·25	-0·02 (-0·11-0·06)	0·63	0·02 (-0·03-0·06)	0·44	-0·10 (-0·15--0·05)	<0·0001	0·00 (-0·02-0·03)	0·91
Survivors	2·08 (1·59-2·56)	<0·0001	0·13 (-0·11-0·36)	0·31	0·04 (-0·01-0·09)	0·092	-0·26 (-0·38--0·14)	<0·0001	-0·07 (-0·14--0·01)	0·03
Family & Children	-2·08 (-2·99--1·17)	0·00	-0·28 (-0·48--0·08)	0·01	0·05 (0·00-0·10)	0·04	0·29 (0·18-0·40)	<0·0001	0·14 (0·08-0·19)	<0·0001
Unemployment	0·73 (-0·01-1·47)	0·08	-0·16 (-0·35-0·03)	0·11	0·00 (-0·04-0·04)	0·99	0·01 (-0·08-0·11)	0·78	0·00 (-0·05-0·06)	0·87
Housing	2·83 (0·09-5·58)	0·07	-1·03 (-1·65--0·40)	0·00	0·01 (-0·03-0·06)	0·536	0·45 (0·11-0·79)	0·01	0·35 (0·17-0·53)	<0·001
Social exclusion	-2·97 (-4·80--1·15)	0·01	-0·79 (-1·21--0·36)	0·00	0·03 (-0·02-0·07)	0·25	0·52 (0·27-0·76)	<0·0001	0·23 (0·11-0·36)	<0·001

Note: Grip strength scale was inverted such that higher scores indicate weaker grip strength. LCSEC disadvantage = Life-course socioeconomic disadvantage, Social protection = Social protection function. All models are adjusted for the seven other social protection functions. Age was centered at 50 years and divided by 10 so that the coefficients yielded the effects for a 10-year period

Chapter 5. General Discussion

The aim of this chapter is to discuss the main findings from the studies presented in Chapters 2, 3, and 4 in relation to the research questions introduced in section *1.5.2 Aims of this dissertation.* In addition, section *5.1 Main findings* puts the results into context by comparing the findings with previously published research. Section *5.2 Limitations and methodological considerations* then goes on to describe some potential limitations important to mention in order to offer a robust foundation for the interpretation of the results. The theoretical and policy implications are discussed in section 5.3. Finally, ideas and new angles for future research are presented in section 5.4, while section 5.5 offers some concluding remarks to this dissertation.

5.1 Main findings

The main findings are presented in the following sections according to the main research questions guiding this dissertation. First, we examine the findings related to the question whether childhood disadvantage is associated with health in old age (section 5.1.1). Second, we go a step further in the life course and synthesise the findings in relation to adult-life disadvantage and whether it can explain the association between childhood disadvantage and health in old age (section 5.1.2). Finally, results on the influence of the welfare state on these associations are consolidated in section 5.1.3.

5.1.1 Childhood disadvantage and health in old age

The first main research question focuses on the association between childhood disadvantage and health status and trajectories in old age. The aim was to analyse whether socioeconomic disadvantages and adverse experiences in childhood have a long-lasting impact on health and its evolution in old age. As the focus lied on both the association with the level and trajectories of health in old age, we separated the main findings into these two subcategories. With respect to this research question, the studies presented in Chapters 2 and 3 offer some insights related to this research question. The study presented in Chapter 4 does not treat childhood disadvantage as a separate exposure but

combines measures of socioeconomic disadvantage over the life course into one score. These results are discussed in section 5.1.2.

Levels of health

The study in Chapter 2 examined whether the associations between childhood and adult-life socioeconomic conditions and risk of poor self-rated health in old age were modified by welfare regimes. The statistical modelling of the analyses allows for the separate examination of the childhood socioeconomic conditions and health in old age association. Since we used a sequential approach with model 1 only including the childhood exposure as well as the confounders, we can use these results to address the research question. Age was centred at 73 years, which was the mid-point of the sample's age range (50 to 96 years). As a consequence, the associations of childhood socioeconomic conditions with self-rated health at old age report health status differences at the age of 73.

The results from this study revealed a persistent association of childhood socioeconomic conditions with self-rated health in old age. Independent from the welfare regime, socioeconomic disadvantage in childhood was associated with poor self-rated health, showing a social gradient with the lowest risk of poor self-rated health for the most advantaged and the highest risk for the most advantaged.

The study in Chapter 3 had a somewhat different approach to examine the relationship between childhood disadvantage and self-rated health in old age. While a similar sequential modelling strategy was chosen allowing for the separate examination of the childhood effects, age was centred at the beginning of the sample's age range, that is at 50 years. This yielded differences in self-rated health status by childhood disadvantage at the age of 50, which is the age of inclusion into SHARE and marks the beginning of the modelled self-rated health trajectories. Furthermore, together with socioeconomic conditions the study included two additional measures of childhood disadvantage, general and health-related adverse experiences.

The results were consistent with the findings from the Chapter 2 study, showing that the more disadvantaged the childhood socioeconomic conditions were, the higher were the odds of poor self-rated health. This finding was independent from adverse experiences, as socioeconomic conditions remained consistently associated with self-rated health showing the same gradient. Furthermore, respondents who reported adverse (health) experiences in childhood also showed higher odds of poor self-rated health compared to respondents who did not report adverse (health) experiences.

The above results indicate that childhood disadvantage has a long reach and is associated with inequalities in health status in old age. This finding is coherent with existing literature looking specifically at the relationship between childhood socioeconomic conditions and self-rated health in later life stages (Case & Paxson, 2011; Guimarães et al., 2014; Hagger-Johnson et al., 2011; S. Mckenzie & Carter, 2009). Moreover, the findings are in line with other LIFETRAIL studies with comparable research designs. These studies found evidence for inequalities in old age related to childhood disadvantage in various health outcomes, such as cognition (Aartsen et al., 2019), lung function (Cheval, Chabert, Orsholits, et al., 2019), physical activity (Cheval, Sieber, et al., 2018), disability (Landös et al., 2018), sleeping problems (van de Straat et al., 2020), frailty (Van der Linden et al., 2020), and depressive symptoms (von Arx et al., 2019). This consistency across outcomes suggests that the association between childhood disadvantage and health in old age is robust across different health domains, such as physical, mental, and cognitive health.

Health trajectories

Both studies presented in Chapters 2 and 3 did not only aim at examining differences in health status by childhood disadvantage, but did also analyse the evolution of these inequalities in self-rated health status across the ageing process. The goal was to study whether these health inequalities increased, decreased or remained stable over ageing. In terms of the statistical modelling of these trajectories, we used interaction terms between the childhood

exposures and the age variable which yielded the linear evolution of the childhood effects with increasing age.

Results in both studies did not reveal evidence for differing self-rated health trajectories in old age between different categories of childhood socioeconomic conditions. However, the study in Chapter 3 provided evidence that respondents who reported adverse health experiences in childhood showed a less steep decline in self-rated health compared to those who did not report adverse health experiences. This finding suggests that the health inequalities found at age 50 between the two categories became smaller with increasing age.

The above findings regarding the inexistent association of childhood socioeconomic conditions with self-rated health trajectories is in line with existing literature. A study from the LIFETRAIL project with a strong focus on analysing trajectories in various health outcomes used a design specifically adapted to capture the evolution over time rather than age (Cheval, Orsholits, Sieber, et al., 2019). While this study based its analyses on the same database, self-rated health was not included in the different health outcomes examined. Across measures related to physical (muscle strength, lung function), cognitive (delayed recall, verbal fluency), and emotional functioning (depressive symptoms), the study did not find strong and consistent evidence for an association between childhood socioeconomic conditions and health trajectories in old age. However, a study on cognitive health found faster declining cognitive functioning for people with more advantaged childhood socioeconomic conditions compared to people with less advantaged conditions (Aartsen et al., 2019).

With regards to the life-course models we expected that health inequalities by childhood socioeconomic conditions widen with increasing age. This is due to the accumulation model, particularly to the cumulative dis/advantage theory by Dale Dannefer suggesting a “systemic tendency for interindividual divergence in a given characteristic (e.g., money, health, or status) with the passage of time’’ (Dannefer, 2003, p. S327). However, we did not find evidence for growing differences between more or less

socioeconomically disadvantaged respondents in childhood in old age. Yet, given the robust inequalities in self-rated health status, it is possible that accumulation patterns occur over the life course before the inclusion in the survey, that is age 50, leading to the observed inequalities in old age.

5.1.2 Adult-life socioeconomic conditions and health in old age

From a life-course perspective it is crucial to not only examine the influence childhood exposure has on health in old age, but also to look at the role that adult-life socioeconomic conditions (education, main occupational position, satisfaction with household income) play in this association (Dannefer, 2018). According to the life-course models, adverse effects of childhood disadvantage on health in old age can be influenced in three different ways by adult-life socioeconomic exposures (Kuh & Ben-Shlomo, 2004). First, the adverse effects may be compensated by more advantageous socioeconomic exposures in adult life, which would be evidence for the pathway model. Second, the childhood effects may not be compensated by adult-life exposure (or only partially) which would support the sensitive or critical period model, indicating that childhood may be a critical period in human development affecting future health outcomes. Third, the adverse effects of childhood disadvantage on health may cluster together with adult-life socioeconomic disadvantage and have a cumulative effect on health. Clustering happens when exposures all relate to an individual's or family's socioeconomic position in society (Kuh & Ben-Shlomo, 2004). This may be evidence for the accumulation model. The three models are not mutually exclusive and may simultaneously offer a valid explanation for the observed associations (Kuh & Ben-Shlomo, 2004).

Similarly as in the previous section, we assess the main findings in relation to the influence of adult-life exposures from the studies presented in Chapters 2, 3, and 4 according to the life-course models they may or may not support. Again, a distinction is made between results related to the level and the trajectories of health in old age.

Levels of health

In both studies presented in Chapters 2 and 3, childhood socioeconomic disadvantage and adverse (health) experiences remained associated with self-rated health in old age after adjustment with adult-life socioeconomic conditions. This finding suggests that childhood represents a sensitive period, in which exposures have a long-lasting effect on health in old age that cannot be fully compensated by better conditions in later life periods. This finding is consistent with other LIFETRAIL studies showing a similar long reach of childhood disadvantage on old-age health (Aartsen et al., 2019; Cheval, Chabert, Orsholits, et al., 2019; Cheval, Sieber, et al., 2018; Van der Linden et al., 2020; von Arx et al., 2019). Furthermore, it has been shown that this pattern is especially true for women, having the fewest opportunities to compensate for a bad start into life in terms of muscle strength and disability (Cheval, Boisgontier, et al., 2018; Landös et al., 2018). According to the definition of the sensitive and critical period model (Bartley, 2017; Kuh & Ben-Shlomo, 2004), we consider this finding to rather support the sensitive than the critical period model. The definition states that if a certain exposure only has an impact on the individual during a specific period it is considered a critical period for further development. Since socioeconomic conditions in adult-life were also shown to be associated with health in old age, it seems more appropriate to consider childhood a sensitive period.

While the associations between childhood disadvantage and health in old age were not fully explained by adult-life exposures, these associations were, however, partly explained by socioeconomic conditions in later life periods. The study in Chapter 2 showed that the effect of childhood socioeconomic conditions on self-rated health in old age was attenuated by 23% (Eastern European welfare regime) to up to 53% (Southern European welfare regime) depending on the welfare regime. In addition, the study revealed that satisfaction with household income was the most important mediator among the three adult-life socioeconomic exposures, showing the strongest attenuation effects. Similarly, results from Chapter 3 indicated an attenuation of the effects of childhood socioeconomic conditions on self-rated health in old age by adult-life exposures.

When the models were adjusted for adult-life socioeconomic conditions, the childhood effects decreased by up to 64% compared to the unadjusted models including only childhood variables. An analysis of separate adult-life exposures was not possible in this study as the statistical approach was slightly different by adding the adult-life variables simultaneously instead of separately. These findings support the pathway model, as part of the association between childhood disadvantage seems to go through adult-life socioeconomic conditions, indicating a pathway from childhood through adult-life to health in old age (Kuh & Ben-Shlomo, 2004). These findings are in line with other studies which found evidence for a socioeconomic pathway from childhood to adult life in self-rated and functional health (Haas, 2008; Link et al., 2017).

The study presented in Chapter 4 offers insights into the potential accumulation effects leading to the health inequalities observed in old age. Using a different approach in the operationalisation of life-course socioeconomic conditions, the study combined the exposures from different stages in people's life course (from childhood to young adult life to middle age to old age) into a single score. Through this construction, the score represents accumulative life-course disadvantage going from the most advantaged position to the least advantaged position (socioeconomic disadvantage in all life-course stages). The results indicated that the more men and women experienced socioeconomic disadvantage throughout their life course, the worse was their subjective and objective health at age 50. This finding provides evidence for the accumulation model of health inequalities, as the amount of socioeconomic disadvantage experienced in the life course seems to play a role, with worse health for every added socioeconomic disadvantage (Dannefer, 2003; Kuh & Ben-Shlomo, 2004). Another study examining accumulation of socioeconomic disadvantage over the life course with a comparable score reported analogous results for coronary heart disease, poor mental and physical functioning, and minor psychiatric disorder (Singh-Manoux et al., 2004). In addition, the same accumulation patterns were also found for all-cause mortality, functional limitation, and overall health-related burden (Turrell et al., 2007).

Health trajectories

The study presented in Chapter 3 offers insights into how separate adult-life socioeconomic factors are associated with self-rated health trajectories in old age. The results indicated narrowing self-rated health trajectories between primary and tertiary education over the ageing process, as well as between high and low skill main occupations. These results hint at socioeconomic health inequalities becoming smaller with growing age for these indicators. For inequalities in satisfaction with household income, no changing patterns over the ageing process were observed. A systematic review of the factors associated with self-rated health trajectories found strong and consistent associations for income, education, and occupation status (Cullati et al., 2014). The observed associations indicated a less steep decline in self-rated health for more advantaged categories, which contradicts the findings from the studies presented in this dissertation. However, the systematic review also stated that this finding held specifically true for studies in which self-rated health was assessed at two points in time only to describe trajectories. For studies describing the self-rated health trajectories with more than two measurement occasions, which is closer to our methodological approach, this finding was more ambiguous.

The study in Chapter 4 examined the evolution of subjective and objective health inequalities in the life-course socioeconomic disadvantage score at age 50 with increasing age. For both men and women, the differences in self-rated health found at 50 years decreased over the ageing process and became smaller with increasing age. However, the inequalities in the grip-strength measure did not change with increasing age for both men and women, which indicates differing patterns between subjective and objective health.

The findings from both chapters do not support the cumulative dis/advantage model, which suggests interindividual divergence in socioeconomic characteristics with the passage of time (Dannefer, 2003). The results rather indicate either stable or decreasing health inequalities with increasing age in the second half of life. However, as mentioned above, the robust health inequalities evidenced at age 50 could be an indication for

cumulative dis/advantage processes happening before the age of inclusion to the studies, leading to these differences. With respect to the decreasing self-rated health inequalities with increasing age, the observed patterns are in line with the alternative 'age-as-leveller' hypothesis, which states that differences in old age decrease due to mortality selection (Lynch, 2003). Thus, mortality selection in old age causes that only the most robust individuals in each socioeconomic group are able survive with increasing age, resulting in a more homogenous population in these age groups (O'Rand, 2009). Interestingly, the findings of this dissertation indicate that this is only the case for inequalities in subjective health assessment, while inequalities in objective health remained stable with increasing age. This suggests that subjective health assessments become more homogenous over the ageing process while this does not seem to be the case for objective health.

5.1.3 The welfare state and life-course health inequalities

One of the main research questions of this dissertation is to examine how the welfare state influences the associations between childhood disadvantage and adult-life socioeconomic conditions with health in old age. In the two previous sections, the findings were analysed at the individual level only, independent of influences on the country level. The three studies covered in Chapters 2, 3, and 4 all included approaches to account for the impact the welfare state might have on the individual-level associations. While Chapters 2 and 3 drew on the regime approach, Chapter 4 made use of the expenditure approach to address this research question. Hence, the different methodological approaches offer insights to distinctive welfare state characteristics.

Levels of health

With regard to the influence of the welfare regime on the association between life-course disadvantage and health in old age, Chapters 2 and 3 follow a similar approach allowing for the analysis of the effects on the separate socioeconomic factors over the life course. However, the findings in relation to the association between childhood socioeconomic conditions and self-rated health in old age

are somewhat different between the two chapters. On the one hand, the study in Chapter 2 found that childhood socioeconomic conditions were consistently associated with health status in old age across welfare regimes, showing a gradient with worsening health for more disadvantaged individuals compared to the most advantaged individuals. This finding indicates that the welfare regime did not differentially modify the effect from childhood on old-age self-rated health. On the other hand, the study in Chapter 3 revealed differing associations between childhood socioeconomic conditions and self-rated health at age 50. In the Southern European welfare regime, this association was fully explained by the adult-life socioeconomic conditions, which is evidence for the pathway life-course model. In the other welfare regimes, childhood socioeconomic conditions remained associated with the addition of adult-life factors, although in the Scandinavian regime childhood health inequalities were largely reduced. This is an indication for childhood being a sensitive period in the development of future health in these welfare regimes. There are two main differences between the studies potentially explaining the disparities in the findings. First, the Chapter 2 study did not adjust for additional childhood disadvantages, such as adverse (health) experiences. Thus, it is possible that the association between childhood socioeconomic conditions and health in old age was stronger in this study compared to the Chapter 3 study, where parts of the childhood socioeconomic effects may have been explained by the other childhood disadvantage factors. A recently published systematic review confirmed the clear relationship between childhood socioeconomic conditions and adverse experiences in childhood (Walsh et al., 2019). Second, differences in the level of self-rated health were not measured at the same age in the two studies. While in Chapter 2 health inequalities were observed at 73 years (midpoint of the sample's age range), in Chapter 3 they were observed at 50 years (minimum age of inclusion in SHARE). However, the interactions with age in both studies indicated that the childhood associations did not change with increasing age, which suggests that ageing has a limited impact on health inequalities related to childhood socioeconomic conditions.

A recent study using cross-sectional data has found that among individuals who experienced childhood economic stress the probability of poor self-rated health in adult life was higher in the Southern and Eastern welfare regime relative to the Scandinavian regime (Widding-Havneraas & Pedersen, 2020). These results are not supported by the findings of Chapters 2 and 3. While Chapter 2 did not show major differences in the association of childhood socioeconomic conditions with health in old age, Chapter 3 found that the negative effects of childhood disadvantage could be compensated by adult-life socioeconomic conditions in adult life in the Southern (fully) and Scandinavian (to a large extent) welfare regime. However, Widding-Havneraas & Pedersen did not adjust for adverse (health) experience in childhood, used cross-sectional data, and the mean age of their examined sample ranged between 48 and 53 years across welfare regimes, which is considerably younger compared to the studies in this dissertation. The age difference between the studies is important to note, as there may be cohort effects explaining the discrepancy in the findings. People from a specific age cohort may not have experienced the welfare regime they have spent their life course in the same way as people from another age cohort. This is due to the rapid changes in welfare regimes during the second half of the 20st century (Hemerijck, 2013; Mackenbach, 2019). Thus, people from different age cohorts experienced these changes at different life stages which may have a diverse impact on socioeconomic conditions and health.

The study in Chapter 4 followed a different approach both in terms of the life-course socioeconomic disadvantage measure and the indicator for welfare state generosity. The score measuring socioeconomic conditions throughout the life course represented an indicator of accumulation of disadvantage as opposed to the separate factors used in the previous studies. This allowed for a more direct investigation of the accumulation model over the life course. Furthermore, the welfare state was characterised by the percentage of expenditure in social protection in relation to the country's gross domestic product. This indicator allowed to use an objective measure of welfare state generosity and avoided the clustering of countries into welfare regimes. The

results indicated that higher expenditure in social protection expenditure reduced the health inequalities in self-rated health at age 50 for women but not for men. Previous studies specifically looking at educational inequalities in self-rated health, generally confirm that the effect of social protection expenditure is stronger in women than in men (Dahl & van der Wel, 2013; de Breij et al., 2020). As a contrast, for life-course socioeconomic inequalities in grip strength, men and women living in more generous countries showed less health inequalities compared to less generous countries. Furthermore, when comparing the results for subjective and objective health in relation to specific social protection policies, the findings hint at a possible stigmatisation effect, since expenditure in disability and social exclusion policies were shown to increase inequalities in subjective health but not in objective health (Buljevac et al., 2012).

Health trajectories

In terms of health trajectories as per categories of the different life-course socioeconomic factors, the study in Chapter 2 did not find any evidence for changing health inequalities with increasing age. This is partly in line with the study in Chapter 3, which did not find differing health trajectories by childhood socioeconomic condition categories. However, the latter study included indicators of adverse (health) experiences as additional markers of childhood disadvantage in addition to socioeconomic circumstances. The findings show that individuals who reported adverse health experiences in childhood had slower decreasing self-rated health trajectories compared to those who did not report adverse health experiences in the Southern and Eastern European welfare regime, while they remained stable in the other regimes. That is, the health inequalities found at age 50 between the two groups of people decreased with ageing which is in line with the age-as-leveller hypothesis and may be generated by health selection bias (Lynch, 2003; O'Rand, 2009). For self-rated health trajectories in adult-life socioeconomic factors, Chapter 3 revealed similar narrowing trajectories with ageing for education and satisfaction in household income in the Bismarckian welfare regime. In addition, findings evidenced decreasing health inequalities between main occupational categories with

increasing age in the Scandinavian welfare regime. These findings indicate that there are different ageing patterns involved across welfare regimes. While in some welfare regimes the socioeconomic health inequalities do not seem to change with ageing (Southern and Eastern European welfare regime), decreasing health inequalities were observed in others (Scandinavian and Bismarckian welfare regime).

The above findings evidence differences between welfare regimes, but since the regime clusters represent a general grouping of countries, it is challenging to carve out the actual drivers behind these disparities (Hillier-Brown et al., 2019). The study in Chapter 4 takes a more specific approach by focusing on a particular marker of welfare generosity, which is the expenditure in social protection. For subjective self-rated health, the study showed that health inequalities at age 50 due to life-course socioeconomic disadvantage decreased with increasing age, hinting at a potential mortality selection process driving this pattern (Lynch, 2003; O'Rand, 2009). Interestingly, higher welfare generosity seemed to slow down this process. This may be interpreted as higher social protection expenditure slowing down mortality selection by providing welfare provisions to the most vulnerable and frail and thereby allowing them to survive longer. For objective physical health (grip strength), a similar narrowing pattern of socioeconomic health inequalities with increasing age was not observed. However, the inequality reducing effect of higher social protection expenditure became weaker with increasing age.

Reflections on the evolution of welfare states and the life course

The welfare state and the individual life courses are inextricably intertwined (Mayer & Schoepflin, 1989; Yerkes et al., 2012). Following the 'Life Course Cube' in Bernardi et al. (2019), individual life courses are three-dimensional with interdependencies shared between time, life domains (e.g. work, family, education) and different levels (inner-individual, individual action, and supra-individual with societal systems). As a consequence, individual life courses are not only shaped by welfare states but also by their changing characteristics across time and history. For instance, the welfare state influences both the

timing of life course events, such as the age at which people marry, have children, or retire, as well as the duration of life-course events, such as training and education (Yerkes et al., 2012). Since welfare states adjust to address the changing social risks in society (Yerkes, 2011; Yerkes et al., 2012) as well as to external historical shocks (e.g. The Great Depression, collapse of the Soviet Union, The Great Recession, war), the time dimension is crucial when welfare states and life courses are analyzed. In fact, the relationship between the life course and welfare state policies and regulations is not static and subject to constant change (Yerkes et al., 2012).

The above becomes apparent when a country like Germany is looked at more closely. When the Soviet Union collapsed in 1990, the two German states were united. As a consequence, East Germans had the right to immediately participate in the various systems of the Federal Republic's welfare state (West Germany) (Hauser, 1995; Pfaller, 1997). This caused the expenditure of these systems to increase drastically, which was financed in part by an increase in public debts and in part by higher taxes (Pfaller, 1997). The particular case of Germany reveals that people surveyed in SHARE have not necessarily lived through the same historical experiences even if they come from the same country.

Given that the welfare typologies used in Chapters 2 and 3 are rather static and do not necessarily account for cross-country changes over time, it has to be noted that the results do not reveal the impact of specific policy variations on individual life courses and health across time. Similarly, the expenditure measure in Chapter 4 captures the median welfare generosity over the 2007-2017 period. Therefore, it does not account for the variation in expenditure over this time period.

5.2 Limitations and methodological considerations

In this section the limitations and methodological considerations in the studies described in Chapters 2, 3, and 4 are discussed. Since every study comes with a set of limitations, it is important to lay them out in order to provide information

on the context in which the results have been obtained. Moreover, a thorough discussion of the limitations gives an idea about the extent to which the results are robust to certain influences that might be affecting the findings. Some of the limitations presented below are specific to the type of survey data used, others are due to the measurements and approaches chosen in the studies.

5.2.1 Sample selection bias

Population based surveys such as SHARE are all affected by sample selection bias. Selection bias occurs when nonresponse to the survey does not happen at random and follows a certain observed or unobserved pattern, thereby compromising the representativeness of the included survey sample in relation to the studied general population (Rothman et al., 2012c). This type of bias poses serious threats to the generalisability of the obtained results, particularly if policy implications are deducted from them (Börsch-Supan et al., 2013).

Selection bias can have different sources and arise at distinctive stages of the data collection process. One of the sources of selection bias is unit nonresponse at the moment of survey data collection. When respondents included in the survey share different sociodemographic or other unobserved characteristics than the general population of theoretically eligible individuals for the study, it is possible that the findings based on the included sample may not be generalisable to the whole population originally under scrutiny (Rothman et al., 2012c). This is the case when participation to the survey is dependent on either the exposure or outcome investigated in a study. For instance, existing studies have shown that healthier and socioeconomically better off individuals tend to reveal higher participation rates in surveys (Gray et al., 1996; Lipps, 2007). Therefore, SHARE applies appropriate sampling procedures and calibrated design weights in order to account for bias due to nonresponse and ensure satisfying sample representativeness (Börsch-Supan & Krieger, 2013). Moreover, studies on people who refused to participate in the SHARE survey revealed little evidence of nonresponse bias related to health status, occupational status or household composition (Börsch-Supan et al., 2013; Börsch-Supan & Krieger, 2013).

Due to the design of SHARE, sample selection bias can also occur as a result of differential survival in the studied population (Glymour et al., 2008; Rothman et al., 2012d). Since SHARE samples people at the age of 50 or above at baseline, information on people who have never reached that age is not included in the survey. It is possible that the people who died before a potential inclusion in the survey shared similar sociodemographic or other unobserved characteristics and, thus, their absence may bias the findings deducted from the selective sample (Rothman et al., 2012d). Considering that people from lower socioeconomic groups show greater probabilities to die earlier compared to people from higher strata, the characteristics associated to the former might be ultimately underrepresented in the study sample (Glymour et al., 2008; van der Linden et al., 2018). Moreover, the survivors from the lower socioeconomic groups who do reach the required age for study participation are thought of being especially 'robust' due to unobserved genetic, social, or behavioural characteristics and to even show similar or better health outcomes than their counterparts in higher socioeconomic groups (Glymour et al., 2008). This can lead to diminishing differences between the socioeconomic groups over the ageing process. In the articles presented in Chapters 2 to 4 we cannot control for survival bias up to the age of 50. The results related to the differences in health status between socioeconomic groups may be affected by this bias. We would expect this bias to reduce differences in health status due to the robustness of the surviving individuals in lower socioeconomic groups. However, in all three articles the findings show clear and robust differences between levels of socioeconomic disadvantage across health outcomes, indicating only limited influence of the survivor bias. Yet, when looking at the evolution of health over the ageing process, we cannot exclude that differential survival might be driving our results as narrowing health trajectories with increasing age are a recurrent finding.

Another source of sample selection bias is attrition, which is an issue shared by virtually all longitudinal surveys. Attrition results in missing data by participants who die (an important factor in surveys focusing on older people) or drop out for other reasons during follow-up waves (i.e. unwillingness to

participate again, loss of contact due to moving etc.) (Hill, 2004). This missing data may be problematic when attrition does not happen at random, thereby influencing the analyses. That is, if people dropping out from longitudinal surveys share common characteristics (e.g. age, sex, health status or other unobserved characteristics) distinguishing them from the participants remaining in the study, these underlying characteristics may have an important impact on the results (Hill, 2004). Studies have suggested that people who leave surveys tend to be in worse health compared to those who stay, which leads to the remaining sample showing better health outcomes than the general population (Gray et al., 1996; Lipps, 2007). A somewhat related type of attrition bias arises when using the SHARELIFE module within the SHARE survey. SHARELIFE data was collected only in wave 3 and then in wave 7 for those who did not participate before. Since not all included participants in SHARE provided information on this special retrospective module, this results in a selected sample within the general SHARE sample when using life-course data in the analyses. However, SHARE has conducted analyses regarding SHARELIFE retention rates and came to the conclusion that while retention rates differed across countries, they managed to interview a large proportion of eligible cases for SHARELIFE data collection without consistent attrition patterns across gender and age groups (Blom & Schröder, 2011).

As a panel study, SHARE has adopted different strategies to address attrition. Through refreshment samples introducing new participants in certain countries, SHARE aims to limit attrition bias and keep representativeness of the sample at a high level (Börsch-Supan et al., 2013). In addition, SHARE subgroup analyses of response behaviour by sex and age have revealed only small differences in the patterns of panel retention (Blom & Schröder, 2011; Börsch-Supan & Krieger, 2013).

In addition to these adjustments and analyses by the survey provider, we addressed attrition through two measures in our studies. First, we included participants in our analyses who had only one outcome measure. This strategy to limit attrition bias had the goal to include the largest amount of participants possible and allowed individuals who provided only one outcome measure to

contribute to the results. The accelerated longitudinal design used to analyse the data in all three articles permitted for this inclusion of individuals who did not repeatedly participate in the survey. Second, to control for this bias, we included a variable capturing attrition in our models. This variable distinguished between respondents who stayed in the survey, those who dropped out (as indicated by not having participated in the last two waves), and those who died over the follow up. Although this statistical adjustment cannot solve the problem of attrition bias, other studies have shown that the influence of this bias on associations between health and socioeconomic position are negligible (Carter et al., 2012; Contoyannis et al., 2004; Powers & Loxton, 2010). Furthermore, we carried out sensitivity analyses in the different articles by excluding participants who died or dropped out, which revealed no differences in comparison to the original results including the whole sample.

5.2.2 Recall bias

The SHARE survey offers great opportunities to analyse people's life-course trajectories through its SHARELIFE module. With the help of a life history calendar, respondents are questioned about their life course before inclusion in the survey (Börsch-Supan et al., 2013). While this method of data collection comes with the advantage of including retrospective information, it may suffer from recall bias. As opposed to prospectively collected information, where data is collected in relative chronological proximity of the events, certain information obtained by a retrospective questionnaire might come from a long time ago. Naturally, this data might be affected by imprecise recall of the timing or the inaccuracy of its magnitude and importance (Rubin, 1996; Schröder, 2011). In addition, individual characteristics, the type of data collected, and the period of recall can all influence the accuracy of retrospective data (Rubin & Baddeley, 1989; Schröder, 2011; Sudman & Bradburn, 1973).

An important part of the research presented in Chapters 2, 3, and 4 bases its analyses on the SHARELIFE module. The information on childhood socioeconomic conditions, adverse childhood (health) experiences, and main occupational position all comes from this retrospective module included in the

SHARE survey. Similarly, educational achievements may date back many years too. As such, our findings may potentially suffer from recall bias due to the long periods between certain exposures and the time of data collection. The team involved in the construction of SHARE has run additional analyses to test the reliability of the retrospective data included in SHARELIFE (Garrouste & Paccagnella, 2011). The main results from these analyses reveal generally strong consistency of the SHARELIFE data with independent data at the time of occurrence of the event. Overall, they found less than 10% of errors in recalling the events. This finding is in line with another study assessing recall of early-life circumstances, demonstrating that 50-year-olds were typically able to recall these aspects of their childhood with reasonable accuracy (Brown, 2014).

5.2.3 Causality

When carrying out observational studies, causality in the observed associations cannot be fully ensured by design. While certain adjustments and statistical corrections can be made to increase the probability to be observing causal relationships, a degree of uncertainty in this respect cannot be avoided. Consequently, no single observational study can prove or disprove causality in the examined relationships (Pickett & Wilkinson, 2015). To assess whether an exposure-outcome relationship is causal, a body of evidence needs to be considered (Pickett & Wilkinson, 2015). The first widely discussed criteria for the evaluation of causality were proposed by English epidemiologist Sir Austin Bradford Hill in 1965 based on the earlier Surgeon General's Report of 1964 (Hill, 1965). His nine widely-used criteria have been further refined and include temporality, consideration of alternative explanations, biological plausibility, consistency, coherence, strength of association, specificity, dose response relationship, and cessation of exposure (Celentano & Szklo, 2018). Although the use of these criteria has been criticised, they are considered to offer a useful tool for a critical review of causality (Bhopal, 2016; Pickett & Wilkinson, 2015; Rothman et al., 2012b).

The temporality criterion is probably one of the most important ones when it comes to assessing causality, stating that the exposure must precede

the outcome (Pickett & Wilkinson, 2015). Longitudinal data are a great tool to ensure that the temporality criterion is met. Applying the temporality criterion to our studies, we can assert that the associations between childhood socioeconomic conditions and adverse childhood (health) experiences with health in old age follow a clear temporal distinction between exposure and outcome. In terms of adult-life socioeconomic conditions the same goes for education and main occupational position, which are both set before the measurement of the outcome. However, with respect to satisfaction with household income, we cannot guarantee that the temporality criterion is met as this variable was measured at the same time as the outcome during follow up (Van Der Linden, 2019). Thus, reverse causation between health in old age and satisfaction with household income (health causes income to decrease) is possible. Considering the higher-level exposures such as welfare regime or net social protection expenditure it is challenging to speak about temporality. 'Experiencing' a welfare state and its social policies is continuous and happens over the whole life course as long as an individual lives in it. Hence, a clear temporal distinction between the exposure to the welfare state and the health outcome is probably impossible to ensure, unless the focus lies on the impact of specific policies and policy changes, which can, for instance, be examined through intervention studies or 'natural policy experiments'.

Considering alternative explanations is of great importance when analysing the importance of the findings. There might be one or more other factors that could be confounding the observed associations (Celentano & Szklo, 2018). A confounding factor is (1) associated with both the exposure and the outcome, and (2) not influenced by neither the exposure nor the outcome (Rothman et al., 2012a). In our studies, we adjusted our models for a set of identified confounders, such as age, gender, and birth cohort. However, SHARE does not provide information on all potential confounders of the life-course socioeconomic conditions and health in old age association. For instance, a range of events in old age not included in the survey as well as genetics could be confounding the observed findings (Van Der Linden, 2019). Furthermore, with regard to the welfare-state findings, we cannot exclude confounding factors

as the welfare concept is very broad and in some cases lacks of specificity. For instance, it could be argued that the observed findings are not related to welfare state but are caused by cultural differences between the countries (Pickett & Wilkinson, 2015).

The biological plausibility criterion posits that the association should fit with existing biological knowledge (Celentano & Szklo, 2018). As discussed in section *1.2.3 Explanatory models of health inequalities*, researchers have suggested biological explanations for the observed association between life-course socioeconomic conditions and health in old age as well as the influence of the welfare state on it. For instance, the psychosocial model states that the experience of relative disadvantage causes stress which can become chronic. This chronic stress can impair memory, increase the risk of depression, lower immune response, elevate blood pressure and risk of cardiovascular disease, and affect hormonal systems (Pickett & Wilkinson, 2015). Hence, the observed associations in our studies have a plausible biological foundation.

The consistency criterion states that the associations should have been replicated in different methodological, geographical, and time settings. As outlined in the discussion of our main findings (section 5.1 ‘Main findings’), the comparison of our studies with other research demonstrates that this is partly the case. Most of the research on life-course socioeconomic condition and health in old and the welfare state’s influence has been carried out in rich and developed countries, neglecting other geographical contexts (Pickett & Wilkinson, 2015). This is partly due to data availability issues. Similarly, the coherence criterion states that the associations should have been supported by other scientific knowledge. Comparing our main findings with other research provides support for our results but in some cases ambiguous and contradictory findings are reported too (section 5.1 ‘Main findings’).

Furthermore, the stronger an association is, the less likely it is that there is some alternative unknown explanation (Celentano & Szklo, 2018). An assessment of the strength of the association between childhood socioeconomic conditions and health in old age was not part of our research focus. Yet, given that this association is present in all of our studies and remains

after adjustment with adult-life socioeconomic conditions and other covariates, we assume that the association is rather strong and robust. The strength of the influence of the welfare state on the socioeconomic conditions and health associations is more ambiguous. While the welfare regime approach in Chapters 2 and 3 make an evaluation of the strength of the association very difficult due to stratification, the net social protection expenditure effects in Chapter 4 were rather small in comparison to other variables. Thus, we cannot exclude that there is some alternative unknown explanation.

The specificity criterion states that there is a high probability that an exposure is causally linked to some outcomes more than to others (Celentano & Szklo, 2018). This criterion is regarded as irrelevant and outmoded in a modern epidemiology context (Pickett & Wilkinson, 2015). It used to be relevant when the research focus was on infectious diseases which could only be caused by exposure to a specific pathogen (Pickett & Wilkinson, 2015). However, in modern social epidemiology many outcomes share causes and most health and social problems have multiple, interacting causes (Pickett & Wilkinson, 2015). This is reflected in our studies where we find robust associations across different health outcomes.

The dose response relationship refers to the mechanism that an increased exposure is related to increased outcomes (Celentano & Szklo, 2018). This criterion is supported by two observations in terms of socioeconomic conditions. First, when focusing on childhood socioeconomic conditions, we observe a clear and robust gradient in the association with health in old age, which indicates a dose response relationship. Second, when combining childhood and adult life to a score of life-course socioeconomic conditions (Chapter 4), a clear dose response relationship can be observed. The longer the exposure to disadvantaged socioeconomic conditions throughout the life course, the worse are the health outcomes in old age. Considering the influence of the welfare state, we observe a hint to a dose response relationship when focusing on welfare generosity as indicated by net social protection expenditure as percentage of the GDP (Chapter 4). The more the countries are generous, the bigger the effect on the life-course socioeconomic condition and health in old

age association. However, it has to be noted that the linearity of the relationship between social protection expenditure and health is assumed and applied in the models without being tested. It is possible that the true relationship is in fact non-linear. Similar to the dose response relationship, cessation of exposure posits that if the exposure changes (positively or negatively), the incidence of the outcome will rise or fall (Celentano & Szklo, 2018). However, a real cessation of exposure can hardly be observed in our studies, only changes in exposure can. As discussed for the dose response relationship criterion, changes in the exposure seem to be related to changes in the outcomes too. Statistical approaches using counterfactual inference methods may be appropriate tools if applicable to address this causality criterion (Höfler, 2005; Naimi & Kaufman, 2015).

In conclusion, this section provides a discussion on the plausibility of causality in our studies. While there is strong support for assuming that the observed associations follow a causal pathway, we cannot fully exclude the possibility of reverse causation.

5.3 Theoretical and policy implications

This section's aim is to go back to the main findings and relate them to the theoretical framework laid down in Chapter 1. Some references to the theoretical models have already been made in section *5.1 Main findings*. Furthermore, a few recommendations for policies derived from the main findings are discussed. The objective is not to propose concluded policy projects since the results from observational studies need to be analysed with caution and do not provide deterministic insights readily fit for policy decisions. Yet, some conclusions can be put in a context allowing for suitable propositions.

The main findings provide support for all of the life-course models discussed in Chapter 1. However, the extent to which the evidence supports each model differs. Generally, the main findings from Chapters 2 and 3 consistently support the sensitive period model for childhood disadvantage effects on self-rated health in old age. Childhood socioeconomic conditions and adverse (health) experiences were robustly associated with old-age health

status after adjustment with adult-life socioeconomic conditions. This evidence showing that detrimental effects from childhood disadvantage cannot be fully compensated by more favourable later-life socioeconomic exposures underlines the importance of the childhood period for developmental processes. From a policy perspective, this evidence confirms that tackling unfavourable conditions and experiences early in life is crucial for a fair healthy-ageing prospect for everyone in the population (Van Der Linden, 2019). Yet, it has to be noted that the findings in Chapter 3 revealed that childhood socioeconomic conditions were fully explained by adult-life socioeconomic factors in the Southern European welfare regime when controlling for adverse (health) experiences in childhood and to a large extent (although not fully) in the Scandinavian regime as well. This is evidence for the pathway life-course model in these welfare regimes, suggesting that the childhood effects follow a pathway through adult-life socioeconomic conditions to health in old age. Interestingly, this observation applies to two very distinct welfare regimes. While the Southern European welfare regime is characterised by rather rudimentary welfare arrangements which is compensated by extensive family support, the Scandinavian regime is distinguished by a universal welfare system providing support to all citizens (Esping-Andersen, 1990; Ferrera, 1996; Mackenbach, 2019). Hence, with respect to the Scandinavian welfare regime it is plausible to suggest that its universalist welfare policies offer an environment favourable to social mobility, such that the vicious circle from childhood socioeconomic disadvantage to later life periods can be broken (Campos-Matos & Kawachi, 2015). For the Southern European welfare regime, a possible explanation may be the expansion of welfare benefits which mainly occurred during the studied cohort's adult life (Ferrera, 1996). These observations hint at the importance of stable welfare arrangements which offer the people the possibilities to be socially mobile and compensate for a bad start in life, thereby limiting the detrimental long-term impact of disadvantaged socioeconomic conditions in childhood. However, additional research is needed to carve out the specific drivers behind these findings (see section 5.4).

Although the socioeconomic conditions in adult-life were not shown to be able to fully compensate the detrimental childhood effects in the other welfare regimes, the findings indicated a partial attenuation of this unfavourable impact on health in old age. This suggests that while childhood does have a long reaching arm into old age, there is still some scope to act in later life stages in order to achieve better health outcomes. The results in Chapter 2 indicated that satisfaction with household income may be the most important (while not the only one) socioeconomic factor in adult-life in the pathway between childhood and health in old age. From a policy perspective two lessons may be taken from this. First, as seen above, adult-life socioeconomic exposure is important from a social mobility angle in order to mitigate the detrimental impact of unfavourable exposure earlier in life (Campos-Matos & Kawachi, 2015). Second, household income in old age seems to be a crucial factor in people's life course. Therefore, contexts offering people favourable conditions including welfare safety nets in case of need as well as support to be socially mobile throughout the life course may be beneficial for people's healthy-ageing opportunities.

In terms of the accumulation model, the findings differed depending on the life-course phase. As Chapter 3 has shown, the results did not support the accumulation model in old age. The examined self-rated health trajectories between categories of different life-course socioeconomic conditions did not, as hypothesised, widen with increasing age. The theory posits that interindividual inequalities grow bigger with the passage of time (Dannefer, 2003). In our research this was not the case for old age health trajectories. Rather the socioeconomic health inequalities remained stable or diminished with increasing age, which supports the alternative 'age-as-leveller' hypothesis (Lynch, 2003). Through mortality selection only the most robust individuals in each socioeconomic category survive with ageing, which results in a more homogeneous population in these age groups (O'Rand, 2009). While we did not find evidence for the cumulative dis/advantage theory in old age, the findings did support the theory in the first half of life. The robust and consistent findings of health inequalities at age 50 showing a social gradient may be the result of accumulation patterns up to that age. Furthermore, the research design of the

study in Chapter 4 allowed to specifically look at the accumulation of socioeconomic disadvantage throughout the life course. The results clearly show a graded pattern with people who experienced longer disadvantage in their lives showing worse subjective and objective health outcomes. From a policy perspective, Chapter 4 also offers insights into how these detrimental consequences of the accumulation effects may be mitigated. The findings indicate that the more generous welfare states with greater spending in social protection policies reduce subjective and objective health inequalities in old age. However, for subjective health this inequality-reducing effect appears to be stronger for women than for men. Furthermore, the Chapter 4 study offers indications that certain social protection policies may be examined carefully in terms of health inequalities, as it seems that policies linked to disability and social exclusion may show undesired detrimental effects on people's subjective health through potential stigmatisation patterns (Buljevac et al., 2012).

5.4 Future research

The main findings of this dissertation provide some answers to the research questions formulated in Chapter 1. Nevertheless, some of the results raise new questions or expose shortcomings, both in terms of data and research design, which introduce limitations that do not allow to fully address the desired research questions. This section picks up a number of these points and discusses them in the context of opportunities for future research. Five stepping stones for future research projects are presented. First, the use of objective health indicators including blood biomarkers in comparative research. Second, more longitudinal studies examining health trajectories in old age in a comparative context. Third, comparative research with a smaller and more focused number of countries. Fourth, qualitative studies across countries could add depth to the existing quantitative findings. Finally, the existing research would benefit from an extension to low- and middle-income countries.

As Chapter 4 has demonstrated, differences between measures of health exist and do not always lead to the same conclusions depending on what they measure. A large body of morbidity-related comparative research uses self-

reported health measures such as self-rated health. While individuals are likely to evaluate their own health status differently even when they have the same objective condition (Jürges, 2007), self-reported health data are of great value in themselves as they may be telling something that objective data cannot tell (Doiron et al., 2015; Jylhä, 2009). However, self-reported data on both past and current health conditions depend on recognising those symptoms, having access to medical care and being diagnosed, and being able to recall the diagnoses (see section 5.2.2 Recall bias) (Börsch-Supan et al., 2020). Therefore, it is crucial to consider objective information on health in comparative research on health inequalities in order to carve out specific differences between individuals and countries. SHARE includes a range of objectively measured health data, such as grip strength, peak expiratory flow, walking speed, and chair stand as indicators of physical health and the Euro-D scale, word recall and delayed recall tests for mental and cognitive health (Börsch-Supan et al., 2020). These measures offer a great opportunity for further investigation of health inequalities in a cross-national context. Furthermore, the proliferation of bio-medical data in ageing surveys is generating additional possibilities to examine a range of conditions and diseases. For instance, the collection of blood biomarkers allows to capture health aspects (yet) unknown to the survey participants (Börsch-Supan et al., 2020). These data include cardiovascular, metabolic, and inflammatory biomarkers and have been shown to predict morbidity and mortality (Gruenewald et al., 2006; Ridker, 2007). With greater availability of these data across ageing surveys, this offers an opportunity to assess the influence the welfare state and its characteristics have on these biomarkers. Specifically, the indicators for inflammation may be crucial to explore the psychosocial pathway of health inequalities in different welfare contexts, which is linked to stressful experiences due to unfavourable and unsupportive welfare provisions. SHARE has collected blood biomarkers in a number of countries and is working on the publication of these data (Börsch-Supan et al., 2020). In combination with already available and comparable data in similar surveys, such as HRS (United States) and ELSA (England), this allows for interesting comparative research across contexts.

One of the main goals of this dissertation was to examine health trajectories in old age and compare them between welfare contexts. To date, research analysing longitudinal data in a cross-country perspective is scarce. However, as the studies in this dissertation have shown, health trajectories may differ between countries and welfare systems. The existing literature examines the association between socioeconomic position and health trajectories between countries (Sacker et al., 2007, 2011; Stolz et al., 2017), but studies including older cohorts with a robust life-course approach are rather rare. Future research may make further use of the longitudinal data available to find determinants of differing ageing trajectories between contexts.

While it is important to examine a breadth of countries, it comes with a potential drawback of losing some depth which could be important in understanding the impact of policies (Ólafsdóttir & Beckfield, 2020). A focus on a smaller set of relatively similar countries is likely to yield new insights. For instance, it could reveal the reasons for the variations in health and health inequalities within the diverse liberal welfare regime (Ólafsdóttir & Beckfield, 2020). Furthermore, comparisons across two strategically selected countries that share many similarities but differ in important factors would provide new insights into understanding the context that creates and sustains health inequalities (Ólafsdóttir & Beckfield, 2020). A few studies following this kind of approach are worth noting. Firstly, two related articles that have been recently published focus on the comparison of Switzerland and Belgium in cervical cancer screening (De Prez et al., 2020; Jolidon et al., 2020). Another article focuses on selected countries considered as representative of their welfare regime type to examine the evolution of social participation in Europe (Lakomý, 2021).

Qualitative research is one type of research not present in the body of existing healthy-ageing literature in cross-country studies. The quantitative results related to health inequalities in different welfare contexts are sometimes ambiguous and inconclusive, which may be attributed to substantial theoretical and methodological differences between studies (Bergqvist et al., 2013). As demonstrated in this dissertation, there are several ways of analysing welfare

states and health inequalities in comparative health research. For instance, in Chapter 3 we found similar associations between childhood socioeconomic conditions and self-rated health in old age in two diverse welfare regimes (Southern European and Scandinavian). The specific drivers behind this finding are difficult to identify due to the general welfare typology applied in the analyses. Well-designed qualitative studies across societies could shed some light on the processes and mechanisms driving health inequalities over the life course in different contexts (Ólafsdóttir & Beckfield, 2020).

Most of the life-course and comparative research has been carried out in high-income countries such as in Europe and North America. However, populations in low- and middle-income countries are ageing rapidly and, consequently, the burden of disease is shifting from infectious to non-communicable diseases (Tollman et al., 2016). Projections forecast that the share of the population aged 60 years or older will rise to 13.1% by 2030 and to 19.2% by 2050 across South America, Asia, and sub-Saharan Africa (Tollman et al., 2016). Analogous to the developments in high-income countries, this expansion of older people in the populations will come with an increase in chronic diseases. Thus, it is essential to incorporate a life-course approach in order to capture the aetiological pathways of these diseases. Furthermore, from a comparative perspective, the examination of life-course patterns in low- and middle-income countries may offer interesting insights when comparing them to high-income countries. One of the reasons for the lack of studies in low- and middle-income countries is the scarcity of suitable data in these contexts. Yet, over the past years many ageing studies using the US-based Health and Retirement Study (HRS) as an example have been started in low- and middle-income countries (Sonnega et al., 2014; Tollman et al., 2016). Among them are surveys from Brazil (ELSI-Brasil), China (CHARLS), India (LASI), Mexico (MHAS), Costa Rica (CRELES), Malaysia (MARS), and South Africa (HAALSI). Since these studies use the same framework, they are comparable to other ageing studies such as SHARE. Efforts to harmonise the data from these different ageing surveys and to render them as comparable as possible are

synthesised on the Gateway to Global Aging Data[2], which is a powerful tool to obtain comparable data across contexts.

5.5 Concluding remarks

This dissertation aimed at shedding some light on the question of life-course health inequalities in old age and their evolution across ageing and how the welfare state and its policies influence these relationships. Three main research questions guided the analyses in the empirical chapters 2, 3, and 4. First, we examined whether childhood socioeconomic conditions and adverse (health) experiences were associated with health status and trajectories in old age. Second, we were interested in the role that adult-life socioeconomic conditions played in the associations between childhood disadvantages and health in old age. Finally, we investigated whether there were differences between welfare arrangements in the life-course associations with health status and trajectories in old age. With the use of a large population based European database across multiple countries the studies included in this dissertation addressed these research questions in various ways. The retrospective information included in the SHARE database enabled the analyses of socioeconomic conditions throughout the life course. Furthermore, the longitudinal characteristic of the data allowed for the investigation of health trajectories across ageing, which is a rather scarce feature of existing studies in comparative research.

The findings indicated that childhood socioeconomic disadvantages and adverse experiences were associated with lower self-rated health levels but not with trajectories in old age. In addition, people who reported adverse health experiences in childhood had a worse self-rated health status in old age but with increasing age their health status decreased less quickly compared to those who did not report adverse health experiences. With the addition of adult-life socioeconomic conditions, differences between welfare regimes became apparent. While in the Bismarckian and Eastern European welfare regime the detrimental effects of childhood disadvantages on self-rated health in old age

[2] https://g2aging.org/

could only partly be compensated by adult-life socioeconomic conditions, we found evidence for more social mobility in the Scandinavian and Southern welfare regime, where these negative effects could be largely offset. In terms of self-rated health trajectories, the inequalities between adult-life socioeconomic categories remained stable or reduced with increasing age, which supports the 'age-as-leveller' hypothesis (Lynch, 2003). Furthermore, we found evidence that the accumulation of socioeconomic disadvantages over the life course lead to lower levels of both subjective (self-rated health) and objective (grip strength) health in old age. While for subjective health the inequalities between levels of socioeconomic disadvantage reduced over ageing, they remained stable for objective health. Higher welfare generosity decreased the inequalities between levels of socioeconomic disadvantage in women but not in men for subjective health, and in both for objective health. Furthermore, higher social protection expenditure slowed down the inequality-reducing effect of age in subjective health. This indicates that social protection expenditure may reduce mortality selection processes by keeping individuals in worse health alive over a longer period of time.

These findings are evidence for all three life-course models. The robust association of childhood disadvantage with health in old age without being compensated by adult-life factors supports the sensitive period model. The model states that childhood consists of a sensitive period for human development and future health. Furthermore, the partial explanation of the childhood effects by adult-life socioeconomic conditions supports the pathway model, indicating that parts of the detrimental childhood disadvantages effects go through adult-life factors to old-age health. Finally, the findings supported the accumulation model in the first half of people's life but not in old age. Cumulative disadvantage processes may explain the robust socioeconomic health inequalities we found at the beginning of people's health trajectories. However, we did not find evidence for further increasing inequalities across ageing in the second half of life.

In conclusion, this dissertation evidences the long reach of childhood socioeconomic conditions and experiences to health in old age, while also

showing that some of the unfavourable outcomes can be addressed throughout the life course. Furthermore, more generous welfare arrangements were shown to have an advantageous impact on socioeconomic health inequalities in old age. However, some of the findings related to differences between welfare regimes are inconclusive and need further investigation to carve out the specific drivers behind them.

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