Socioeconomic Inequalities in Mortality Rates in Old Age in the World Health Organization Europe Region

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Socioeconomic adversity is among the foremost fundamental causes of human suffering, and this is no less true in old age. Recent reports on socioeconomic inequalities in mortality rate in old age suggest that a low socioeconomic position continues to increase the risk of death even among the oldest old. We aimed to examine the evidence for socioeconomic mortality rate inequalities in old age, including information about associations with various indicators of socioeconomic position and for various geographic locations within the World Health Organization Region for Europe. The articles included in this review leave no doubt that inequalities in mortality rate by socioeconomic position persist into the oldest ages for both men and women in all countries for which information is available, although the relative risk measures observed were rarely higher than 2.00. Still, the available evidence base is heavily biased geographically, inasmuch as it is based largely on national studies from Nordic and Western European countries and local studies from urban areas in Southern Europe. This bias will hamper the design of European-wide policies to reduce inequalities in mortality rate. We call for a continuous update of the empiric evidence on socioeconomic inequalities in mortality rate.

aged; Europe; mortality; social class; socioeconomic factors

Abbreviations: IHD, ischemic heart disease; OR, odds ratio; RII, relative index of inequality; RR, rate ratio; SEP, socioeconomic position; WHO, World Health Organization.

INTRODUCTION

Removing the persistent association of socioeconomic adversity with higher chances of ill health and death has been high on the agenda of European and other industrialized countries. Estimates suggest that inequality-related losses to health amount to more than 700,000 deaths per year and 33 million prevalent cases of ill health in the European Union as a whole. The universal existence of such socioeconomic inequalities in health is morally troubling. In older populations, too, socioeconomic adversity is associated with adverse outcomes, including frailty (1, 2), morbidity (3, 4), institutionalization (5, 6), and death, in the United States (7) and in other industrialized countries. In fact, as a predictor of death, socioeconomic position (SEP) performs as well as combined information on a multitude of physiologic risk factors, including body mass index, waist circumference, hip circumference, waist-to-hip ratio, systolic and diastolic blood pressures, leukocyte count, cholesterol level, serum C-reactive protein, postload insulin, bone mineral density, and more. SEP also outperforms information on specific genetic factors that are independently associated with death (8). In sum, socioeconomic adversity is among the foremost fundamental causes of human suffering.

In reports on socioeconomic inequalities in health in general, and certainly on inequalities in mortality rate, older populations have been relatively neglected. For instance, the latest European Union-funded Europe-wide research program drawing up the evidence of socioeconomic gaps in health and mortality rate has as yet published no estimates of the magnitude of socioeconomic inequalities in mortality rate in the older populations of these countries (9). Monitoring the magnitude of socioeconomic mortality rate inequalities in old age is becoming even more important because of population aging. Further increases in life expectancy will be gained to an increasing extent through reductions in old-age mortality rates. Large
injuries between socioeconomic groups in the mortality rate of older people in a country indicate that there should be considerable scope for further improvement of life expectancy by preventing earlier deaths in the lower-SEP groups and that national policies in these countries should be critically examined for their equity-value in the face of the existing evidence. Any well-informed effort to reduce socioeconomic inequalities in health should begin with monitoring the scope of the problem. In this review, we review the evidence on socioeconomic inequalities in mortality rates, a core indicator for public health. The purpose of this systematic review was to monitor the empiric evidence in countries that are part of the World Health Organization (WHO) Region for Europe, specifically within the past 2 decades. We aimed to examine the evidence for existing socioeconomic mortality rate inequalities in old age, including information about various indicators of SEP and from various geographic locations within the WHO Region for Europe.

METHODS

This report is based on part of a broader systematic review on inequalities in health that was conducted for The European Review on the Social Determinants of Health and the Health Divide: Report on the Task Group on Older People. The aim of that review was to describe the evidence base on inequalities in health, as well as in access to health care, according to age, gender, and SEP in the older European population. From this broader review, we extracted the papers that provided evidence of inequalities in old age, specifically in all-cause and cause-specific mortality rates, and between socioeconomic groups. This forms the content of the present systematic review.

The following procedure was used to identify studies. Articles were included in the review if they fulfilled the following criteria:

1) Geographic location: WHO Europe region
2) Population: people ≥65 years of age
3) Scope: studying health inequalities; reporting age, gender, socioeconomic, education, or ethnicity differences in health outcomes (mortality rate, disability, and subjective health)
4) Study design: empiric research
5) Type of publication: journal article
6) Date: 1995–2011 (June), study carried out after 1990
7) Language: any

Thus, this review was designed to cover the WHO European region countries, which represent a broader geographic and cultural area than the European Union region. Countries covered by the WHO European office that are not part of the EU-27 (Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, the Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, and the United Kingdom) are Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Croatia, Georgia, Iceland, Israel, Kazakhstan, Kyrgyzstan, Monaco, Montenegro, Norway, Republic of Moldova, Russian Federation, San Marino, Serbia, Switzerland, Tajikistan, the former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, and Uzbekistan.

Literature searches were undertaken in the following databases: Medline, Global Health, EMBase, Social Policy and Practice, Cinahl, Web of Science, and International Bibliography of the Social Sciences. Searches were saved in Endnote and merged to a combined file, and duplicate publications were deleted. Collaborators in the Task Group on Older People were asked to identify remaining publications that were not in the list. Screening was carried out in the first step on titles and abstracts and in a second step on full-text manuscripts. Full-text manuscripts were obtained for studies that appeared to meet the criteria or provided insufficient information to decide. These were checked according to the same inclusion criteria, and those that did not meet the criteria were excluded. EPPI-Reviewer software (EPPI-Centre at the Social Science Research Unit at the Institute of Education, University of London, United Kingdom) was used for screening, coding, and analyzing and for monitoring the progress of the review. The literature searches were carried out by authors C. A. T. and S. R. and screening and coding by C. A. T., E. G., and S. R. At all stages of the screening, a sample of studies (about 10%) was screened by 2 researchers. This was done to ensure consistency in the use of inclusion and exclusion criteria. In cases in which the screening decisions did not match, the principal investigator (E. G.) made the final allocation. Of the initial selection of 5,079 records on health inequalities and inequalities in access to health care that were obtained through literature searches, 175 articles were identified as relevant to the topic of health inequalities. Of these 175 manuscripts, authors M. H. and C. A. T. selected 25 articles that provided data on inequalities in mortality rate for the present review. M. H. checked the reference lists of these studies to identify further potential papers that were screened for inclusion with the same inclusion criteria as for the broader review on health inequalities. Again, studies that reported socioeconomic inequalities in mortality rate in people 50 years of age or older were included as long as they also reported on ages greater than 65 years. These searches yielded another 19 articles that were finally included in this review. Studies were included when they presented estimates of at least relative inequalities in mortality rate (rate ratios, odds ratios, relative index of inequality (RII), etc.) between lower and higher socioeconomic groups or estimates of absolute socioeconomic mortality rate differences or mortality rates stratified by levels of SEP. Estimates of inequalities were extracted for all-cause death and for several of the largest specific causes of death or cause-of-death groups when cause-specific data were presented. In this review, we report mostly estimates of relative inequalities in mortality rate because most papers that we identified relied primarily on statistically significant rate ratios or RIsIs to conclude whether there was evidence for socioeconomic inequalities in mortality rate. Besides the absolute public health impact of socioeconomic inequalities in mortality rate, which is better expressed by estimates of
the absolute gap in mortality rates, studies clearly aimed to establish evidence for an etiologic role of SEP in mortality rate, which is better reflected by relative measures of risk (10).

RESULTS

Of the selection of 44 empiric studies, 30 studies reported on inequalities in all-cause mortality rate and 21 reported on inequalities in cause-specific mortality rates. Most of these reports were from countries of the EU-27. We did not identify any empiric studies on socioeconomic mortality rate inequalities in old age for most countries that are included in the WHO European region but are outside of the EU-27, with the exception of Israel, Norway, and Switzerland. The selection of papers that present findings on all-cause mortality rate is given in Table 1. Those that present findings on cause-specific mortality rates are listed in Table 2. Several European overview studies included data from studies that were based on record-linkage data with information from a census conducted in 1990. These overview papers were retained in this review, and results from all countries from those overviews were extracted. We report below first on results by country or region and then consider variations by age and gender and the specific case of studies that considered inequalities in mortality rate related to heat waves.

Regions

United Kingdom. Overall, studies confirm that having a low SEP, regardless of how it is measured, proved detrimental to the survival of older men and women across different parts of Europe. Several studies situated within the United Kingdom have shown a higher mortality rate in lower socioeconomic groups. Studies from England and Wales showed that social class, educational level, and SEP evaluated on the basis of housing tenure or car ownership were associated with all-cause death in both men and women (11, 12) and that educational level was associated with several specific causes of death (ischemic heart disease (IHD) (13), cerebrovascular disease (14), and lung cancer (15)); however, no statistically significant educational inequalities in breast cancer were observed among women aged 50–69 years (women older than 69 years were not included in the study) (16). In Scotland specifically, area deprivation was associated with all-cause death (17) and with cardiovascular death (18, 19). O’Flaherty et al. (19) found 6-fold socioeconomic differentials between the coronary heart disease mortality rate in the most deprived quintile areas in Scotland and that in the least deprived quintile areas. For Northern Ireland, in a novel attempt in this field of research to measure accumulated wealth, Connolly et al. (20) examined the predictive value of an indicator based on a combination of housing tenure and house value on mortality rate. They observed that public sector renters had a higher mortality rate than owner occupiers and that there was a mortality rate gradient among homeowners that was based on the value of their houses (i.e., lower mortality rate among owners of higher-value homes). O’Reilly (21) reported that an ecologic measure of poverty based on income support ratios was strongly correlated with mortality rate at old ages in Northern Ireland.

Southern Europe. Reports from Southern Europe countries usually covered only large cities or regions, such as Barcelona (11, 13–16, 22–30), Madrid (11, 13–16, 24–26, 30, 31), Basque country (30), Rome (32, 33), Turin (11, 13–16, 24–26, 34), and Milan (35), although we also identified reports based on a national representative prospective epidemiologic study, the Italian Longitudinal Study on Aging (36, 37). For Barcelona and Madrid combined, Huisman et al. (11) confirmed the existence of small but consistent educational inequalities in all-cause mortality rate in the 1990s in men and women of different age groups: 60–69 years, 70–79 years, and 80–89 years (all rate ratios (RRs) < 1.4 but statistically significant). Martinez et al. (31) investigated educational inequalities in women from Madrid in the early 2000s and observed that educational inequalities in mortality rate persisted in the early 2000s in older women (≥65 years of age). Most of the gap in mortality rates between these older women from Madrid was due to educational inequalities in rates of death from cardiovascular and chronic lung disease, specifically. Other causes of death that were investigated in older men and women from Barcelona, Madrid, or the Basque country included IHD (13), cerebrovascular disease (14), lung cancer (15, 30), cirrhosis (29), breast cancer (16), suicide, and other injuries (23), including traffic-related injuries (23, 24). There was evidence for statistically significant relative inequalities in most of these causes of death, although several estimates indicated that educational inequalities in cause-specific mortality rates were reversed. This was the case for lung cancer in women aged 60–69 years in the Basque country (for education, RII = 0.16) and for women aged 60–69 years (for education, RII = 0.35) and 70–79 years (for education, RR = 0.63) in Barcelona (15, 30). Although estimates for Madrid also indicated that lung cancer inequalities were reversed in older men and women in the 1990s, these were not supported by statistical evidence (i.e., confidence intervals including 1.00) (15). Considerable inequalities were observed in Barcelona in men and women aged 75 years or older in rate of death from suicide (for educational level in men, RR = 3.34; for educational level in women, RR = 5.20; not significant). In Barcelona, women in this age group with lower educational levels were protected against traffic injury death (for no schooling versus secondary or more, RR = 0.47; for primary schooling versus secondary or more, RR = 0.37). Less educated men in this age group had a higher rate of death from traffic injury than the more educated men (for no schooling versus secondary or more, RR = 2.57) (23).

The 2 studies we identified that presented SEP inequalities in mortality rate in Italian nationally representative data, both from the Italian Longitudinal Study on Aging (36, 37), found no evidence for the existence of SEP inequalities in mortality rate in old age, either by education (36, 37) or by lifetime occupation (37). However, the results from that prospective epidemiologic study are clearly in contrast to statistically significant estimates for
education, housing tenure, and area SEP that were obtained from record-linkage studies from smaller geographic areas in Italy, including Turin and Rome, for all-cause death in men and women 60 years of age or older (11, 33). In Turin, the magnitude of inequalities in deaths from traffic injury were strikingly large in older people (aged ≥70 years) compared with younger age groups, although confidence intervals were wide and overlapped somewhat (24). The educational-level rate ratios of death from traffic injury in the population 70 years of age or older in Turin (men, RR = 3.42; women, RR = 2.21) clearly indicated that less educated older people are especially vulnerable in traffic in this urbanized area. For lung cancer, evidence indicated substantial educational inequalities in men aged 60–79 years (60–69 years, RII = 2.99; 70–79 years, RII = 2.05) but reversed educational inequalities in women (60–69 years, RII = 0.59; 70–79 years, RII = 0.79) (30).

The Nordic countries. Researchers from the Nordic countries have a relatively long history of reporting on socioeconomic inequalities in mortality rate. In these countries, the availability of a personal identity number makes it convenient to link death registry data and census records (38, 39). We identified multiple reports about inequalities in all-cause mortality rate in Finland measured with a broad range of SEP indicators: educational level (6, 11, 40); housing tenure (11, 40); occupational class (6, 40); household income (6, 41, 42); various other indicators of income, such as individual taxable income, household taxable income, and household disposable income (42); and area-level SEP (40). Without exception, these studies reported statistically significant associations of SEP with all-cause death in older men and women in various age groups (e.g., men and women aged 60–69 years, 70–79 years, or ≥85 years). Rate ratios were all between 1.00 and 2.00, indicating a consistent but modest association of SEP with risk of death regardless of the indicator of SEP that was investigated.

One study investigated the risk of death after a 5-year follow-up period in older Finnish men and women (≥65 years of age), stratified by "living with partner" status (living alone versus living with a partner) (35). In both groups, home ownership was the strongest predictor of death, independent of other SEP indicators such as educational level, occupational class, and household income (not owning a home versus home ownership: men living alone at baseline, odds ratio (OR) = 1.62; women living alone at baseline, OR = 1.47; men living with a partner, OR = 1.41; women living with a partner, OR = 1.55). Even so, educational level, occupational class, and household income also remained statistically significantly associated with risk of death independent of the other SEP indicators, although with smaller estimates.

Martikainen et al. (42) compared the association of several different measures of income with risk of death: individual taxable income, household taxable income, and household disposable income. Results indicated that the taxable income indicators were associated more strongly with death in older adults than was the disposable income indicator. The taxable income indicators demonstrated a more evident curvature in the association, meaning that mortality rate increases more rapidly at the lower ends of the absolute income distribution. These results remained after adjustment for other indicators of SEP: educational level, occupational class, and economic activity.

Socioeconomic inequalities in cause-specific mortality rate in old age in Finland were reported in relation to all cardiovascular disease (40), IHD (13), cerebrovascular disease (14), lung cancer (15, 30), and traffic-related injuries (24) in men but not in women and not in relation to breast cancer in women (16) or suicide (26).

Of the 4 papers we identified for Sweden, 3 covered not the total Swedish older population but specifically the population of Scania, the southernmost province of Sweden and one of the most densely populated (43–45). Articles about Sweden reported invariably statistically significant associations of SEP with all-cause mortality rate (43, 44), IHD (45), and lung cancer (30).

Data on Denmark were included in most papers covering older populations that arose from 2 European comparative projects: the Socioeconomic determinants of Healthy Ageing (SedHAna) project and the Eurotine project (11, 13–16, 24–26, 30). In contrast to the available data for other countries included in these studies, no reliable information could be obtained for Denmark on the educational level of the oldest old men and women (i.e., aged ≥70 years) in the period of the early and mid-1990s. Nevertheless, there was consistent evidence for the existence of socioeconomic mortality rate inequalities in Denmark as well, where statistically significant differences in all-cause mortality rate in the oldest ages were observed between house owners and renters (men aged 80–89 years, RR = 1.21; women aged 80–89 years, RR = 1.13). Educational level was associated with death from IHD (13) and lung cancer (15) in those aged 60–69 years and with death from cerebrovascular disease in those aged 60–74 years (14). The association of educational level with risk of death from suicide was reversed in Danish men and women aged ≥65 years (men and women combined, OR = 0.78), although this was not sufficiently supported by statistical evidence.

For Norway, too, we obtained most estimates from Europe-an comparative papers (11, 13–16, 24–26, 30), with the exception of a prospective epidemiologic study that was carried out in a sample of women 70 years of age or older in the Nord-Trøndelag county of Norway (46). The latter study provided statistically significant estimations of education inequalities in all-cause mortality rate (for <8 years of education compared with 8–11 years of education, RR = 1.21) and cardiovascular disease mortality rate (for <8 years education compared with 8–11 years of education, RR = 1.21) but not of occupational inequalities in these outcomes (for manual versus nonmanual labor for risk of all-cause death, RR = 1.10; for manual versus nonmanual labor for risk of cardiovascular disease death, RR = 1.21; not significant). The national data obtained from the census-linked death registry showed consistent educational-level and housing tenure-related inequalities in all-cause mortality rate (11) and educational-level inequalities in IHD (13) and lung cancer (15, 30) but showed no statistical evidence for educational inequalities in risk of death from breast cancer (for lowest versus highest education-level, RR = 1.40; 95% confidence interval: 1.00, 1.98) or...
Continental and Western Europe. Several countries from Western Europe and continental Europe were included in the European overview studies that we identified. Belgium, France, Austria, and Switzerland were included in all or most of these reports (11, 13–16, 24–26, 30) and in studies covering single countries (47, 48). Three prospective epidemiologic studies provided estimates for the Netherlands (37, 49, 50), of which 2 were based on the Longitudinal Aging Study Amsterdam (LASA) (37, 49). One record-linkage study examined inequalities in all-cause mortality rate in relation to occupation and pension income in men in Germany (51). Overall, the data from Belgium, France, Austria, and Switzerland showed evidence for inequalities in all-cause mortality rate in relation to education or housing tenure, with few exceptions. For most specific causes of death that were included in the overview studies, evidence indicated educational inequalities in risk of death from IHD, cerebrovascular disease, and lung cancer in older men (13–15, 30) and in risk of death from IHD in older women (13). Patterns of educational inequalities in lung cancer (15, 30) and breast cancer (16) mortality rates in women were less pronounced and most often not statistically significant in these countries, as was the case for inequalities in risk of death from traffic-related injury (24). The magnitude of educational inequalities in risk of death from suicide was relatively high in men and women from

### Table 1. Key Studies on Socioeconomic Inequalities in All-Cause Mortality in Old Age in the World Health Organization European Region

<table>
<thead>
<tr>
<th>First Author, Year (Reference No.)</th>
<th>Countries/Regions</th>
<th>Period</th>
<th>Age Range, years</th>
<th>Study Design</th>
<th>Indicators of SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penninx, 1997 (49)</td>
<td>The Netherlands</td>
<td>1992/93–1995</td>
<td>55–84</td>
<td>PES</td>
<td>Education in years</td>
</tr>
<tr>
<td>Van Rossum, 2000 (60)</td>
<td>The Netherlands</td>
<td>1989/93–1996</td>
<td>≥55</td>
<td>PES, national representative</td>
<td>Educational level, occupational class, household income</td>
</tr>
<tr>
<td>Martikainen, 2001 (41)</td>
<td>Finland</td>
<td>1991–1996</td>
<td>≥65</td>
<td>RLS</td>
<td>Household income, social class (manual vs. nonmanual labor)</td>
</tr>
<tr>
<td>O’Reilly, 2002 (21)</td>
<td>Ireland</td>
<td>1990–1998</td>
<td>≥75</td>
<td>RLS</td>
<td>Area-level SEP, income support</td>
</tr>
<tr>
<td>Bopp, 2003 (47)</td>
<td>Switzerland</td>
<td>1990–1997</td>
<td>65–74, ≥75</td>
<td>RLS, covering the population in German-speaking Switzerland</td>
<td>Educational level</td>
</tr>
<tr>
<td>Martikainen, 2003 (40)</td>
<td>Helsinki area (Finland)</td>
<td>1991–1995</td>
<td>≥65</td>
<td>RLS</td>
<td>Area-level SEP, educational level, occupational level, housing tenure</td>
</tr>
<tr>
<td>Merlo, 2003 (43)</td>
<td>Scania (Sweden)</td>
<td>1999</td>
<td>≥65</td>
<td>RLS, men only</td>
<td>Personal income</td>
</tr>
<tr>
<td>Huisman, 2004 (11)</td>
<td>Finland, Norway, Denmark, England/Wales, Belgium, France, Switzerland, Austria, Turin (Italy), Barcelona (Spain), Madrid (Spain)</td>
<td>Between 1990 and 1997</td>
<td>60–69, 70–79, 80–89</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level, housing tenure</td>
</tr>
<tr>
<td>Huisman, 2005 (25)</td>
<td>Finland, Norway, England/Wales, Belgium, Austria, Switzerland, Turin (Italy), Barcelona and Madrid (Spain)</td>
<td>Between 1991 and 1997</td>
<td>60–74, ≥75</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level</td>
</tr>
<tr>
<td>Kalediene, 2005 (53)</td>
<td>Lithuania</td>
<td>2001</td>
<td>60–64, 65–69, ≥70</td>
<td>Unlinked cross-sectional study</td>
<td>Educational level</td>
</tr>
<tr>
<td>Noale, 2005 (37)</td>
<td>Finland, Israel, Italy, The Netherlands, Spain, Sweden</td>
<td>Between 1987 and 1997</td>
<td>65–89</td>
<td>PES</td>
<td>Educational level, lifetime occupation</td>
</tr>
</tbody>
</table>

Table continues
Belgium and Austria (lowest versus highest educational level: Belgium, OR = 2.64; Austria, OR = 2.23) (26).

The prospective epidemiologic studies from the Netherlands provided little or no evidence for SEP inequalities in mortality rate in old age (37, 49, 50). In the study of Van Rossum et al. (50), covering men and women 55 years of age or older, this might be due partly to lack of statistical power, because point estimates of associations of specific SEP indicators with death ranged between 1.2 and 2.0 (rate ratio). Shkolnikov et al. (51) demonstrated that occupational and pension income inequalities in all-cause mortality rate persisted in Germany among the oldest old men.

**Eastern Europe and the Baltic countries.** We identified a few studies that included data from Eastern European or Baltic countries. Leinsalu et al. (52) reported relatively large educational inequalities in all-cause mortality rate in older men and women from Estonia during the 1990s (lowest versus highest educational level: men aged 55–69 years, RR = 2.26; men aged ≥70 years, RR = 1.60; women aged 55–69 years, RR = 2.20; women aged ≥70 years, RR = 1.57). Kalediene and Petrauskiene (53) provided evidence for educational inequalities in men and women aged 65 years or older in Lithuania in 2001. Van der Heyden et al. (30) included data from several Eastern European countries

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**Table 1.** Continued

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<thead>
<tr>
<th>First Author, Year (Reference No.)</th>
<th>Countries/Regions</th>
<th>Period</th>
<th>Age Range, years</th>
<th>Study Design</th>
<th>Indicators of SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cesaroni, 2006 (33)</td>
<td>Rome (Italy)</td>
<td>1990–2001</td>
<td>60–74</td>
<td>RLS</td>
<td>Area-level SEP</td>
</tr>
<tr>
<td>Shkolnikov, 2007 (51)</td>
<td>Germany</td>
<td>2003</td>
<td>≥65</td>
<td>RLS, men included in the German Public Pension System</td>
<td>Pension entitlements, occupational class, health insurance</td>
</tr>
<tr>
<td>Martikainen, 2008 (6)</td>
<td>Finland</td>
<td>1997–2002</td>
<td>≥65</td>
<td>RLS: 40% random sample of Finnish population ≥65 years of age</td>
<td>Educational level, occupational class, household income, home ownership</td>
</tr>
<tr>
<td>Martikainen, 2009 (42)</td>
<td>Finland</td>
<td>1998–2004</td>
<td>≥65</td>
<td>RLS: 11% sample of population plus oversampling among deceased</td>
<td>Individual taxable income, household taxable income, household disposable income</td>
</tr>
<tr>
<td>Martinez, 2009 (31)</td>
<td>Madrid (Spain)</td>
<td>2001–2003</td>
<td>≥65</td>
<td>RLS: women only</td>
<td>Educational level</td>
</tr>
<tr>
<td>Rey, 2009 (60)</td>
<td>France</td>
<td>2003</td>
<td>≥56</td>
<td>National death registry, ecologic</td>
<td>Area-level SEP</td>
</tr>
<tr>
<td>Connolly, 2010 (20)</td>
<td>Northern Ireland</td>
<td>2001–2006</td>
<td>≥65</td>
<td>RLS</td>
<td>Housing tenure and house value</td>
</tr>
<tr>
<td>Grundy, 2010 (12)</td>
<td>England and Wales</td>
<td>1991–2001</td>
<td>60–79</td>
<td>RLS: 1% sample of English/Welsh population</td>
<td>Educational level, occupational class, housing tenure, access to car</td>
</tr>
</tbody>
</table>

Abbreviations: PES, prospective epidemiologic study; RLS, record-linkage study; SEP, socioeconomic position.

*a Study provides information on the contribution of specific causes of death to overall inequalities in mortality rate but provides no specific indications (rate ratios or hazard ratios) of relative inequalities in causes themselves.
in their overview of lung cancer death inequalities: Slovenia, Hungary, the Czech Republic, Poland, Lithuania, and Estonia. Educational level inequalities in death from lung cancer in men were relatively large in these countries as compared with other countries, especially in Hungary, the Czech Republic, and Poland. In women, lung cancer inequalities in these countries were either not statistically significant or reversed, with higher-educated women showing

<table>
<thead>
<tr>
<th>First Author, Year (Reference No.)</th>
<th>Countries/Regions</th>
<th>Period</th>
<th>Age Range, years</th>
<th>Study Design</th>
<th>Indicators of SEP</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fernandez, 1999 (22)</td>
<td>Barcelona (Spain)</td>
<td>1992–1995</td>
<td>≥65</td>
<td>RLS</td>
<td>Educational level</td>
<td>Cancer</td>
</tr>
<tr>
<td>Martikainen, 2003 (40)</td>
<td>Helsinki area (Finland)</td>
<td>1991–1995</td>
<td>≥65</td>
<td>RLS</td>
<td>Area-level SEP</td>
<td>Lung cancer, other cancer, circulatory causes, other diseases, accidents and violence, alcohol-related causes</td>
</tr>
<tr>
<td>Avendano, 2004 (14)</td>
<td>Finland, Norway, Belgium, Austria, Switzerland, Turin (Italy), Barcelona and Madrid (Spain)</td>
<td>Between 1991 and 1997</td>
<td>60–74, ≥75</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level</td>
<td>Cerebrovascular disease</td>
</tr>
<tr>
<td>Mackenbach, 2004 (15)</td>
<td>Finland, Norway, England/Wales, Belgium, Austria, Switzerland, Turin (Italy), Barcelona and Madrid (Spain)</td>
<td>Between 1991 and 1997</td>
<td>60–69, 70–79, 80–89</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level</td>
<td>Lung cancer</td>
</tr>
<tr>
<td>Borrell, 2005 (24)</td>
<td>Finland, Norway, Belgium, Austria, Switzerland, Turin (Italy), Barcelona and Madrid (Spain)</td>
<td>Between 1990 and 1997</td>
<td>50–69, ≥70</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level</td>
<td>Transportation injury</td>
</tr>
<tr>
<td>Huisman, 2005 (25)</td>
<td>Finland, Norway, England/Wales, Belgium, Austria, Switzerland, Turin (Italy), Barcelona and Madrid (Spain)</td>
<td>Between 1991 and 1997</td>
<td>60–74, ≥75</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level</td>
<td>Ischemic heart disease, cerebrovascular disease, other cardiovascular causes, lung cancer, other cancer, chronic obstructive pulmonary disease, pneumonia, external causes, other causes</td>
</tr>
<tr>
<td>Lorant, 2005 (26)</td>
<td>Finland, Norway, Belgium, Austria, Switzerland, Turin (Italy), Barcelona and Madrid (Spain)</td>
<td>Between 1990 and 1997</td>
<td>≥65</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level</td>
<td>Suicide</td>
</tr>
</tbody>
</table>
higher rates of death from lung cancer (in Slovenia, Hungary, Czech Republic, and Poland in women aged 70–79 years). All of the data from these 3 papers were based on unlinked cross-sectional studies, with the exception of data from Slovenia in the study by Van der Heyden et al. (30).

Israel. In the 1990s and 2000s, several reports were published on socioeconomic mortality rate inequalities in old age in Israel, which were based on the Israel Longitudinal Mortality Studies I and II (54–59). We identified one of these (59) that adhered to the guidelines for inclusion in the present review. Jaffe et al. (59) reported educational inequalities in risk of all-cause death and death from cardiovascular disease in Israeli men and women aged 65–89 years (0–8 years versus ≥13 years of education:

<table>
<thead>
<tr>
<th>First Author, Year (Reference No.)</th>
<th>Countries/Regions</th>
<th>Period</th>
<th>Age Range, years</th>
<th>Study Design</th>
<th>Indicators of SEP</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avendano, 2006 (13)</td>
<td>Finland, Norway, Denmark, England/Wales, Belgium, Austria, Switzerland, Turin (Italy), Barcelona and Madrid (Spain)</td>
<td>Between 1991 and 1997</td>
<td>≥60</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level</td>
<td>Ischemic heart disease</td>
</tr>
<tr>
<td>Chaix, 2007 (45)</td>
<td>Scania (Sweden)</td>
<td>1996–2003</td>
<td>65–79</td>
<td>RLS</td>
<td>Educational level, 20-year averaged personal income, occupational class 25 years before retirement, area-level SEP</td>
<td>Ischemic heart disease</td>
</tr>
<tr>
<td>Strand, 2007 (16)</td>
<td>Finland, Norway, Denmark, England and Wales, Belgium, France, Switzerland, Austria, Turin (Italy), Barcelona (Spain), Madrid (Spain)</td>
<td>Between 1990 and 1997</td>
<td>50–69</td>
<td>RLS; national, regional, and urban census-linked death registries</td>
<td>Educational level</td>
<td>Breast cancer</td>
</tr>
<tr>
<td>Antunes, 2008 (28)</td>
<td>Barcelona (Spain)</td>
<td>1995–2003</td>
<td>≥65</td>
<td>RLS</td>
<td>Area-level SEP, ecologic</td>
<td>Lung cancer</td>
</tr>
<tr>
<td>Martinez, 2009 (31)</td>
<td>Madrid (Spain)</td>
<td>2001–2003</td>
<td>≥65</td>
<td>RLS; women only</td>
<td>Educational level</td>
<td>All causes, AIDS, cancer, diabetes, cardiovascular diseases, respiratory diseases, digestive diseases, external causes, other</td>
</tr>
<tr>
<td>Rostad, 2009 (46)</td>
<td>Nord-Trøndelag (Norway)</td>
<td>1995–2004</td>
<td>≥70</td>
<td>RLS; women only</td>
<td>Educational level, occupational class</td>
<td>All causes, cardiovascular diseases</td>
</tr>
<tr>
<td>Van der Heyden, 2009 (30)</td>
<td>Finland, Sweden, Norway, Denmark, Belgium, Switzerland, Turin (Italy), Basque Country, Barcelona (Spain), Madrid (Spain), Slovenia, Hungary, Czech Republic, Poland, Lithuania, Estonia</td>
<td>Between 1990 and 2003</td>
<td>60–69, 70–79</td>
<td>RLS and unlinked cross-sectional study</td>
<td>Educational level</td>
<td>Lung cancer</td>
</tr>
</tbody>
</table>

Abbreviations: AIDS, acquired immunodeficiency syndrome; RLS, record-linkage study; SEP, socioeconomic position.

a Reports on inequalities in all-cause mortality rate as well but only for ages 40–89 years combined.

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Inequalities in the oldest ages

Age gradients in the magnitude of mortality rate inequalities likely reflect several mechanisms that do not all have to do with age effects. Absolute differences in mortality rates are usually largest in the oldest old, at least when all-cause death is considered, just because the mortality rate is so high in this group. By the same token, relative inequalities, if they are expressed in rate ratio measures, are almost per definition small in the oldest old, because mortality rates are so high. Sometimes health selection is offered as a potential explanation for smaller relative inequalities in older ages, but this explanation makes less sense for mortality rate inequalities if the age groups that are compared are those less than 65 years of age versus those 65 years of age or older, simply because the mortality rate before age 65 years is so low. Nevertheless, studies that presented estimations of the magnitude of (relative) inequalities in all-cause mortality rate in the oldest ages (≥80 years) showed that inequalities generally persisted into very old age. In a study of German men, Shkolnikov et al. (51) reported persisting inequalities in men aged 80 years or older according to occupation and pension earnings (for manual versus salaried employment, RR = 1.20; for second pension earnings quintile versus highest earnings quintile, RR = 1.27). An overview of educational inequalities in 80- to 89-year-olds is presented for several countries in Figure 1A (men) and 1B (women). These figures present the magnitude of relative inequalities in risk of all-cause death and death from lung cancer in the early 1990s, reported by Huisman et al. and Mackenbach et al. (11, 15). Clearly, these figures demonstrate that relative educational inequalities in all-cause death were generally small in this age group but were remarkably persistent, in that they were statistically significant in all countries with the exception of women in England/Wales. Rate ratios for lung cancer were more variable, more often were not statistically significantly different from 1.00, and more often indicated that the rate of death from lung cancer was higher in higher-educated women.

Differences between men and women in mortality rate inequalities

We did not find evidence that relative inequalities in overall mortality rate are mainly larger in men or larger in women. For instance, a European overview of mortality rate inequalities in old age by educational level and housing tenure observed that the magnitude of inequalities was on some occasions larger in women and on some occasions larger in men, depending on the country at hand, the age group, and the socioeconomic indicator examined (11). In addition, Martikainen et al. (6) demonstrated that estimates of inequalities according to several indicators of SEP in Finland seemed larger in men among those who were single, whereas they were often larger in women among those living with a partner (although we could not examine overlaps between confidence intervals because these were not reported in the study).

Differences between men and women in the pattern of relative inequalities in mortality rate depend on which specific causes of death are examined. Relative inequalities in rate of death from IHD were slightly larger in older women (≥60 years, RR = 1.36; 95% confidence interval: 1.33, 1.38) than older men (RR = 1.22; 95% confidence interval: 1.21, 1.24) in the combined 10 Western European populations in the study of Avendano et al. (13), but the north-south gradient in IHD mortality rate inequalities was smaller in women, as were variations between populations in the magnitude of inequalities. For lung cancer, the point estimates tended to be larger in older men (≥60 years) than in older women in these Western European populations, especially in the oldest old (Figure 1). However, these men-women differences are tied to the smoking epidemic, and in younger generations in a few countries—England/Wales and Norway—relative inequalities in lung cancer mortality rate were already larger in women than in men (15, 30). Relative stroke mortality rate inequalities in these populations were of similar size in men and women (men, RR = 1.27; women, RR = 1.29) (14). Striking differences were observed in the contribution of inequalities in specific causes of death to inequalities in overall mortality rate between men and women. Avendano et al. (14) observed that reducing educational inequalities in stroke would lead to an average reduction of the educational differences in life expectancy of 7% among men (from 3.22 to 2.98 years) and of 14% among women (from 2.18 to 1.87 years) in 10 European populations. Huisman et al. (25) estimated that the contribution of all cardiovascular disease to educational inequalities in overall mortality rate in men 75 years of age or older amounted to 41.6%, but in women the estimated contribution was as high as 62.6%. Rosvall et al. (44) also observed that cardiovascular disease contributed more to mortality rate inequalities in women than in men in the population of Scania, Sweden.

Inequalities in mortality rate during heat waves

We identified 3 studies that reported on the impact of heat exposure on inequalities in mortality rate to investigate whether deprived populations were more vulnerable to heat waves. Results were mixed. Two studies were conducted in the context of the 2003 heat wave: one in France (60) and one in Barcelona (27). The study in Barcelona did not find evidence of excess vulnerability of lower-SEP groups based on educational level, whereas the study in France reported that in the areas of densely populated Paris with the most extreme heat exposure, the excess mortality rate was twice as high in the most deprived cantons than in the least deprived. Ishigami et al. (35) did not find evidence for any excess vulnerability to heat-related death in the lower-SEP groups in older people from 3 large European cities: London, Milan, and Budapest.
DISCUSSION

This review of SEP inequalities in mortality rate in older populations within the WHO Region for Europe showed that the evidence on the persistence of these inequalities into old age is accumulating. The results leave no doubt that SEP inequalities in all-cause mortality rate in men as well as women persist into the oldest ages, in all countries for which information is available. Although the relative risk measures observed were rarely higher than 2.00, even such moderately sized rate ratios imply that substantial absolute mortality rate gaps exist between socioeconomic groups in old age. Although there were often differences in the exact magnitude between SEP indicators, we did not observe any specific SEP indicator that was consistently not related to all-cause mortality rate, even after adjustment for alternative indicators of SEP.

The present review provided further evidence for the universality of SEP-mortality inequalities, which constitute one of the most pervasive associations uncovered in social epidemiology. At the same time, we identified glaring gaps in the available knowledge base for several Western European countries, Eastern European countries, and countries within the WHO Region for Europe but outside the EU-27. We chose to structure the description of results separately for countries/regions because it remains important to demonstrate explicitly the crucial differences in the available evidence base on this issue between them. Within the WHO Europe region, there is an immense geographic area for which evidence on the existence and magnitude of inequalities remains absent. Needless to say, such absence of evidence severely hampers targeted health-policy action.

For this review, we relied on reports from the scientific literature. Consequently, we could have missed more reports in the so-called gray literature (e.g., reports from national statistical periodicals). This limitation should be acknowledged and could mean that we have identified gaps in the existing evidence base where there are in fact none. However, we think that this is unlikely, and it is even less likely that any existing gray literature could challenge our main conclusion.

The age range of 65 years or older was chosen pragmatically because it usually is used in studies to distinguish “old age,” largely because in many countries 65 marks the age of eligibility for retirement pensions. At the same time, it overlaps with the life phase during which many men and women begin encountering health problems such as chronic disease. Future studies might consider alternative cutoffs for distinguishing older populations that would be based on different characteristics or on criteria such as average years of life remaining.

Several European countries have a long history of providing access to record-linkage data, which enables the monitoring of socioeconomic inequalities in mortality rate. Most notable are the Scandinavian countries, where the availability of a personal identity number makes it convenient to link death registry and census records (38). Even for people at older ages, the Nordic countries have population registers that have been evaluated as highly accurate (61). Such data have no issues with external validity because they usually cover the whole population without potential for nonresponse or missing data, and they provide large sample sizes that allow the detection of associations between SEP and mortality rate even if effect sizes are small. The invaluable contributions of data infrastructures to public health and epidemiologic science cannot be stressed enough—especially those in the Nordic countries, but also those in Israel, the United Kingdom, Belgium, and Switzerland and more local sources such as Barcelona and Madrid.

Overviews of mortality rate inequalities have been provided by several European Union-funded projects and have been carried out by a research group at the Department of Public Health of the Erasmus University Medical Center in...
Rotterdam (The Netherlands) that has built an invaluable expertise on the subject and a core network of researchers and data representatives who strive for continuous disclosure of the latest information on mortality rate inequalities in Europe. The group acquires data from multiple countries and regions, puts much effort into harmonizing the data, and publishes overviews of mortality rate inequalities within Europe. These efforts provide a unique infrastructure for monitoring mortality rate inequalities in Europe, and recently, data on mortality rates from several Eastern European and Baltic countries were included in these overviews for the first time. So far, analyses on these data have been limited to younger age groups or to specific causes of death. Some of the outcomes on lung cancer were on older populations, and these have been included in the present review (30). However, a general overview of mortality rate inequalities specifically in older populations has not yet been published from those data, although such an overview could be published in the near future. This means that the most recent information on mortality rate inequalities in old age was not yet available to us for this review. Most of the studies that we identified covered periods in the 1980s and 1990s, with some studies covering the early 2000s. These studies still provided crucial information for public health policy and helped us identify "sore spots" of inequalities within the European fabric, but it is essential that information on mortality rate inequalities in old age is updated regularly once new census-linked registry data become available, inasmuch as patterns of inequalities sometimes can develop considerably within the time span of just a few years. For example, lung cancer inequalities in Southern European women were positive (i.e., higher lung cancer mortality rates in the higher educated) in the 1990s (15), and it was concluded that lung cancer inequalities unfavorable to lower-educated women might still be avoided. These reversed educational gradients in lung cancer still reflected the differential increase in smoking in women in the 1960s (e.g., in Spain), with higher uptake among the higher educated as cigarette smoking became a symbol of progress and freedom (62). More recent data, however, suggest that the reversal to negative associations has already set in (30).

Despite the fact that most of the data from record-linkage studies are limited in the number of explanatory factors they are able to include, these studies can yield important clues about the etiology of socioeconomic inequalities in mortality rate, especially those that address cause-specific mortality rate inequalities. Several studies highlight this potential. In an innovative research design, Martikainen et al. (63) (not included as part of the present review) investigated educational differences in the rate of death from lung cancer in a cohort of Finnish men who all had a long history of tobacco use. They observed that the mortality rate differences between educational-level groups were modest. Because lung cancer deaths are highly concentrated in regular and heavy smokers, Martikainen et al. concluded that lung cancer mortality rate inequalities as they have been observed for the whole Finnish population likely reflect educational differences in heavy smoking. Herttua et al. (64) (not included in the present review) examined the impact of alcohol price cuts that occurred in Finland in 2004 by comparing alcohol-related mortality rates in 2001–2003 with alcohol-related mortality rates in 2004–2005, after the introduction of the price cuts. The study was not included in this review because it did not present any data on SEP inequalities in alcohol-related mortality rate for older people specifically. However, Herttua et al. did show that absolute increases in alcohol-related deaths were largest in the lower socioeconomic groups in younger adults aged 30–59 years, which clearly demonstrates the relevance of these mortality rate data for evaluating public health effects of national policy. Finally, Huisman et al. (25) rank-ordered the specific causes of death that were found to contribute most to educational inequalities in all-cause mortality rate. In Western European older men (≥75 years), these were cardiovascular diseases (accounting for 42% of the educational gap in all-cause mortality rate) and cancer (15%) but also chronic obstructive pulmonary disease (16%). In women, these were mostly cardiovascular diseases (accounting for 63% of the educational gap in all-cause mortality rate), with IHD accounting for 20% and cerebrovascular disease for 19%.

Several of the studies that we identified on the basis of prospective epidemiologic data did not find evidence for inequalities. It could still be that studies using data from prospective epidemiologic studies that report null findings are published less often than the ones that report statistically significant inequalities in mortality rate, which would lead to publication bias. Even if this is the case, we believe that the studies based on record-linkage data are of superior study design for estimating the existence and magnitude of inequalities. These usually cover entire populations and have no issues with external validity, and the conclusion from available record-linkage data is that the existence of SEP inequalities in mortality rate in old age in the WHO Europe region is widespread.

Nevertheless, more studies are needed that use data from prospective epidemiologic studies. These studies have their own shortcomings for estimating inequalities in mortality rate, but they have the crucial advantage that they usually include information on potential explanatory factors that are not available from record-linkage studies. They also are usually more flexible in gathering information about multiple indicators of SEP at the same time, which is indispensable for estimating overlapping as well as indicator-specific contributions to mortality risks. Efforts like the Integrative Analysis of Longitudinal Studies of Aging (IALSA) (65), which incorporates data from more than 30 longitudinal aging studies from around the world, could overcome some of the obstacles to scientific inference that are presented by the lack of power in analyses on just a few hundred or few thousand respondents by facilitating the pooling of data and immediate replication of findings. Ultimately, the challenge is to find explanations for why the SEP inequalities in mortality rate exist. Moreover, one of the fundamental open scientific questions in this research area is whether the inequalities seen at older ages are simply a continuance of health trajectories already manifest at younger ages or whether additional factors operating at older ages increase or perpetuate the social gradients. Answering this question will also require investment in data analysis from life-course prospective epidemiologic studies.
because these allow, in principle, the tracking of life-course trajectories of inequalities. In addition, prospective epidemiologic studies could enable a more thorough examination of what constitutes low SEP in old age. Crucial questions are how specific SEP indicators relate to poverty and poor health, which indicators of SEP best reflect the social position of older people, and which indicators are related most strongly to risk of death and why. These are questions not likely to be resolved by relying on record-linkage data alone.

There has been rather little debate or controversy surrounding this field of research, even though the implications of some of it might be far reaching in terms of understanding the performance of welfare policies. However, 3 scholars in this field recently entered into a debate that addressed most of the issues at the core of this type of research. Interestingly, in a discussion of the results published by Hoffmann (66), which compared the magnitude of mortality rate inequalities between Denmark and the United States, Avendano and Galama (67) and Hoffmann (68) themselves were in complete disagreement as to what the results indicated about the relative magnitude of inequalities in both countries. Whereas Hoffmann concluded that mortality rate inequalities were larger in Denmark than in the United States, despite what might be expected given generous Danish welfare policies, Avendano and Galama concluded that the magnitude of inequalities was remarkably similar between the 2 countries. This difference of opinion illustrates the difficulties of comparing the magnitude of mortality rate inequalities between countries when study designs are different (e.g., record-linkage studies versus unlinked cross-sectional studies or prospective epidemiologic studies), when indicators of SEP are different (e.g., taxable versus disposable income, income versus education, occupation, housing tenure, etc.), and when different parts of the socioeconomic gradient are compared (e.g., the lowest deciles of income as opposed to income tertiles). More researchers should be willing to enter into such debates, helping one another in developing a set of generally agreed-upon guidelines for presenting data, administering various measures of effect, and including multiple indicators of SEP when possible.

For instance, rather little theoretical work has been put into justifying the outcome measures that usually are used in this research: mortality rate ratios and mortality rate differences. Although most national comparative studies usually have reported the RII, which expresses the magnitude of inequality across the whole socioeconomic gradient and not just between specific socioeconomic groups and which therefore could lead to fewer problems when comparing the magnitude of inequalities between countries and between socioeconomic indicators. The absolute version of the RII, the slope index of inequality, was not being used routinely until only recently. Indeed, very different considerations underlie the reporting and interpretation of relative and absolute inequalities, especially when time trends or differences between countries are considered (69). The fundamental normative decisions about what kind of considerations should be made in judging when health is distributed unequally have been described by Harper et al. (69). In this review, we focused primarily on relative inequalities in mortality rate, which implies, according to Harper et al., that we endorse a very strict egalitarian position that “what matters is equality itself, independent of other considerations” (69, p. 9). We are not of the opinion that studies should always base their conclusions primarily on relative inequalities, especially when the study’s purpose is to compare countries or examine time trends. Comparing countries or examining time trends was outside the scope of the present review, however, and we decided that describing the evidence base in terms of relative inequalities would fulfill the review’s main aim.

Finally, we call for a continuous update of the empiric infrastructure on socioeconomic inequalities in mortality rate, which could help researchers strive toward what might be a general theory of socioeconomic inequalities in aging. However, only if data on mortality rate inequalities are coupled with data on morbidity and disability inequalities can such a theory be established. Currently, increases in life expectancy at birth can be attributed to decreases in mortality rate in old age (70), but there is no consensus about the consequences of increased life expectancy for patterns of morbidity and disability in old age. There is no framework for explaining geographic variations in the socioeconomic mortality or morbidity differences or for explaining variations over time. This implies that researchers are in a poor position to provide solid expectations about future developments in socioeconomic inequalities in aging. This might not be surprising, because a “general theory on population aging” (71) is still emerging. Researchers who aim to elucidate socioeconomic inequalities in aging would do well to link their efforts to research that contributes to constructing such a theory. To be able to do so, estimating inequalities in measures more comprehensive than mortality rate alone, like health expectancy measures, is crucial.

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