Factors in the differentiation of regional mortality in developed countries

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ABSTRACT
The aim of this article is to discuss factors that influence the distribution and differences in mortality between both regions and subpopulations in developed countries. The article provides an outline of basic theories that attempt to explain socioeconomic differences in mortality. A range of socioeconomic factors is analysed from both the micro-level and macro-level perspectives. Based on the study of the relevant literature, it was determined that more privileged groups enjoy better health and longer lives. A strong association between socioeconomic factors and total mortality and mortality by the cause of death was revealed at both the individual and aggregated levels. The relationship between socioeconomic variables and health status and mortality is explained via various mechanisms through which this association arises. Socioeconomic variables that act to influence health status and mortality have been shown to be strongly interrelated. These factors, in turn, impact the lifestyle and psychological state of individuals. Existing socioeconomic health and mortality determinants represent one of the main problems and challenges for the public health sectors in both more and less developed countries.

KEYWORDS
mortality; regional differentiation; economic factors; social factors; cultural factors

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1. Introduction

Significant changes occur in terms of the intensity and structure of mortality in developed countries as a result of political, economic, social and cultural changes, which leads to the question of how regional differences in mortality (or, in general, differences in mortality between subpopulations) are influenced by external economic, social, political or cultural factors. The basic premise of this approach concerns the consideration that differences in mortality between different subpopulations rather than being biologically determined are due to external factors.

The relationship between mortality, health status and external factors has been studied with respect to a number of populations and, in general, it can be stated that higher socioeconomic status (most often higher education and income levels) correlates with better health and a longevity (e.g. House 2002; Mackenbach et al. 2008; Smith et al. 1998b). These inequalities represent one of the main problems for the public health sector. Indeed, the World Health Organisation considers health equality to be a basic human right (WHO 2020: 1):

> The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.

Issues surrounding the socioeconomic determinants of health and mortality have also been addressed in various European Commission-initiated programmes (European Commission 2023), the aim of these programmes is to ensure the continuity of the relevant policies and the development of specific strategies aimed at positively influencing people's health. However, according to Marmot (2005), European countries address the various external health status and mortality factors only indirectly (sickness benefits, labour market policies, etc.). Moreover, it is the extent of the difference between the death rates of the most and least privileged groups in the population that offers potential sources of improvement concerning a nation's health status and life expectancy. However, differences in terms of mortality and health status cannot be explained only by the composition of the population and the various characteristics of its members, but also by the environment in which these individuals live.

The aim of this article, therefore, is to discuss the factors that influence the distribution of, and differences in, mortality between both regions and subpopulations in various developed countries.

The first part of the article focuses on the development of approaches to the study of the socioeconomic differentiation of mortality followed by a description of the basic theories that attempt to explain such differences. A range of socioeconomic factors are analysed from the micro-level (i.e. at the individual level) and the macro-level (i.e. aggregated individual variables or variables that do not have an individual equivalent) perspectives. The final chapter addresses the ecological fallacy and other potential issues connected to regional mortality factor studies. Although behavioural factors exert a significant influence on socioeconomic differences in mortality, determining an explanation of the mechanism by which these factors affect human health does not form the subject of this article.

2. The development of approaches to the study of the socioeconomic differentiation of mortality

Interest in the issue of differences in terms of the health and mortality of the population according to socioeconomic status has a long tradition. Even before the beginning of the 20th century, it was known that people from lower social class in society have a higher degree of intensity of mortality from most diseases (Bengtsson and Poppel 2011). The industrial revolution comprised the first stimulus for the investigation of the material aspects of living conditions and their impact on mortality. Social status was founded on income, position in the household and occupation indicators (Bengtsson and Poppel 2011). According to Hummer et al. (1998), the approach to the investigation of the differentiation of mortality in the second half of the 19th century and the first half of the 20th century was strictly demographic. The main objective of these studies was to document as accurately as possible the differences in the level of mortality within and between subpopulations, usually according to age, gender and race (or ethnicity). A smaller number of studies also included factors such as income, occupation and marital status. After World War II, life expectancy increased in many countries, and many scientists believed that social disparities in terms of mortality would converge (Bengtsson and Poppel 2011). However, global economic problems at the beginning of the 1970s severely diminished such optimism, and socioeconomic determinants of mortality once more became the subject of studies by demographers and epidemiologists. The key work in this respect comprised a study by Kitagawa and Hauser (1973), which examined the relationship between mortality, income and education in a sample of the US population. The approach to the study of mortality differentiation became significantly more comprehensive and was subsequently termed broader sociodemographic by Hummer et al. (1998). Mortality was no longer understood as a static phenomenon but, rather, as a long-term process influenced by many factors that exert positive or negative effects on the risk of death. Differences in mortality

are formed over the long term based on the entire life cycle of individuals and the development of society as a whole (Bengtsson and Poppel 2011). At the end of the 20th century, a transition to the individual longitudinal analysis approach occurred, which allowed for the deeper understanding of the formation of socioeconomic differences in mortality. Sociodemographic factors concerning mortality became understood as a reflection of so-called immediate determinants – i.e. behavioural, psychosocial, health and biological factors (Hummer et al. 1998; Dow and Rehkopf 2010).

3. The theory explaining socioeconomic differences in mortality

Throughout the development of the consideration of the relationship between socioeconomic factors and health alternatively mortality, the debate continued on the direction of the gradient between socioeconomic status and health (Smith 1999). The social causality hypothesis views higher morbidity rates as a consequence of poorer socioeconomic conditions (e.g. House 2002; Preston and Taubman 1994: 295–304). The simplest explanation for this causality is that healthcare is more easily available for people with higher socioeconomic status; moreover, higher socioeconomic status is associated with a more responsible approach to one's own health. For example, Cutler and Meara (2001) argue that more educated (and thus wealthier) people smoke less because they are well aware of the risks involved. Education has a stronger correlation to lower levels of smoking than does income. The opposing hypothesis assumes so-called selection, i.e. that poorer health is caused by lower socioeconomic status. A traditional example concerns the relationship between poor health and lower employment, as demonstrated by Bartley and Owen (1996) using the example of the United Kingdom. The selection hypothesis also considers the influence of socioeconomic conditions in childhood. Children from low-income households have a poorer health status, which subsequently impacts their income in adulthood (Case et al. 2002).

The relationship between socioeconomic variables and health status and mortality is explained by the various mechanisms via which this association arises. Skalická et al. (2009) divided health inequality theories into 5 closely related groups: the materialist, behavioural, psychosocial, biomedical and life course theories.

3.1 Materialist theories

Materialist theories view the main cause of socioeconomic differentiation in mortality as income and what that income allows. Higher incomes do not only mean that goods and services are more affordable, but they also offer the potential to avoid exposure to risk factors (polluted environment, inadequate housing, risky professions, etc.). At the macro level, materialist theories focus on the relationship between the public services available and the health of the population (Skalická et al. 2009).

Perhaps the most systematic model based on economics was described by Preston and Taubman (1994: 295–304). The model is based on the supposition that individuals make choices that help them to influence their health status. Death occurs when this state of health declines below a certain critical level. Although individuals are unable to directly decide the time of death, they can make decisions on investments (e.g. a healthy diet) and consumption (e.g. tobacco) that affect their health status. The authors also included education and occupation in the model. In general, those with higher education levels enjoy higher levels of income and are, therefore, able to invest more in their health (i.e. purchase healthier food, enjoy more free time and live in areas with better public services). Moreover, a person's occupation often influences their consumer goods taste preferences.

The neo-materialist theory is one of the other possible interpretations of health inequalities. This theory combines a lack of resources and exposure to risk factors with the unequal distribution of investments in a wide range of public and social infrastructure components. Unequal distribution is the result of historical, cultural and political-economic processes that both influenced the private resources of individuals and shaped the character of the public infrastructure, e.g. education, healthcare and transport services, environmental protection measures, the availability of high quality food, occupational health regulations, etc. (Lynch et al. 2000).

3.2 Behavioural theories

According to behavioural theories, socioeconomic differentiation concerning health and mortality is the result of the unequal distribution of unfavourable behaviour and lifestyles between socioeconomic groups. The influence of behavioural factors can only be examined in detail via the longitudinal analysis approach since such factors exhibit a long latent period before they begin to influence the onset of degenerative diseases and mortality; moreover, they may well change over time (Hummer et al. 1998).

The main principle behind so-called cultural-behavioural theories comprises the hypothesis that differences in lifestyle and unhealthy behaviour are the result of socioeconomic disadvantages and the higher degree of cultural acceptability of unfavourable behaviour by lower socioeconomic groups (Skalická et al. 2009). In addition, the social networks of persons with a higher status are characterised by the lower risk of exposure to passive smoking, enhanced support for behaviour that is associated with a healthy

lifestyle and better opportunities to be informed of the results of the latest health-related research. This is also one of the reasons for the persistence of socioeconomic inequalities despite ever-improving medical knowledge and opportunities, which are first taken advantage of by persons with higher socioeconomic status (Link and Phelan 1995).

3.3 Psychosocial theories

Psychosocial theories are based on the assumption that socioeconomic status affects the psyche of individuals, which subsequently exerts biological effects on the human organism. The socioeconomic gradient of morbidity and mortality can, thus, be explained by the uneven distribution of psychosocial risk factors, which may comprise the levels of social support and self-control and work-related demands, as well as susceptibility to hostility, anger and depression (Schneiderman 2004; Skalická et al. 2009). Preston and Taubman (2004: 295–304) consider the ability to avoid stressful situations to be one possible explanation for health-related socioeconomic differentiation. They opine that persons with a low level of education and/or low income are less able to avoid stressful and deprivation situations. Moreover, they emphasise the importance of multi-layered social relationships in terms of coping with psychologically-demanding situations. Furthermore, some studies (e.g. Tillmann et al. 2017) suggest that psychosocial factors are independent of each other, unlike many socioeconomic factors.

3.4 Biomedical theories

It is clear that biological mechanisms are involved in the association between socioeconomic status and mortality. The basic idea of the biomedical interpretation of socioeconomic inequalities in health and mortality concerns the unequal occurrence of biological risk factors between social groups (Skalická et al. 2009). According to House (2002), the biomedical paradigm gained popularity up until the 1960s and, currently, persists only in terms of the explanation of certain mortality risk factors, e.g. blood pressure, cholesterol and the functioning of the lungs. However, since one of the topics covered by biomedical theories comprises the relationship between genes and the environment, an approach that explains the socioeconomic differentiation of mortality as the unequal distribution of exposure to environmental risk factors in society could also be considered to be a biomedical factor.

Individuals with a lower socioeconomic status are more likely to be exposed to substances that exert adverse impacts on the human organism both at work and at home. Steenland et al. (2003) selected a range of harmful substances (dust, gases, fumes, smoke, arsenic, asbestos, cadmium, silicates, radiation, etc.) that are often detected in the work environments of manual workers, described their influence on various diseases and empirically proved their connection with the higher intensity of mortality experienced by lower social classes. Moreover, such persons are often also exposed to many of these substances in their place of residence.

Biomedical theories might also include theories that explain the difference in terms of mortality between races. At the turn of the 20th century, it was assumed that all the observed racial disparities relating to mortality were due to genetic differences between races (Williams et al. 2010). However, many studies (conducted mainly in the USA) have since proven that the main reason for such differences concerns primarily the persistent high degree of differentiation of socioeconomic status between races (e.g. Keil et al. 1992; Potter 1991).

3.5 Life course theory

The explanation of the socioeconomic gradient concerning health and mortality as a result of the accumulation of social, psychological and biological disadvantages during the lifespan is referred to as the life course theory (Skalická et al. 2009). This approach combines all the above theories, as well as social causality and selection. According to Osler et al. (2009), causal and selection mechanisms are interconnected throughout the life course and may apply in childhood as well as in adulthood.

Socioeconomic disparities relating to health apply at all ages. Children are influenced by the socioeconomic position of their parents as soon as they are born. Children born to women from lower social classes are more likely to be born with lower birth weights and birth defects as a result of the greater exposure of the foetus to risk factors such as smoking, physical inactivity and poor maternal diet (Osler et al. 2003).

The question remains, therefore, whether and how socioeconomic conditions and health in childhood influence a person's social position, health status and mortality in adulthood. Although many studies (e.g. Frankel et al. 1998; Pensola and Martikainen 2004; Smith et al. 1998a) have demonstrated the association between childhood socioeconomic status and adult mortality, this association is likely to be largely the result of the transfer of a person's social position from childhood to adulthood.

4. Socioeconomic factors that influence mortality

In terms of research into the differentiation of health status and mortality, the measurement of socioeconomic status is performed at both the individual and aggregate levels, the choice of which depends largely

on the sources and quality of the data available on the relevant socioeconomic variables. An individual's socioeconomic status can be understood as the internal characteristics and abilities of the individual. These micro-level factors are influenced by external processes that operate at the macro level. Both levels are equally important in terms of the study of regional mortality differentiation. Individual socioeconomic factors may be distributed differently between regions, and regional differences in mortality are determined, *inter alia*, by the composition of the population (Kibele et al. 2008). The individual socioeconomic variables that impact health status and mortality are strongly interconnected. The level of education attained logically affects one's future profession, income and economic activity. Together with family status, these factors affect the lifestyle (smoking, alcohol consumption, diet, BMI, etc.) and the psychological state of the individual (Fig. 1). For example, mortality rates for men over the age of 80 in Austria show a strong socioeconomic gradient. This gradient is already established during life, as it is linked first to education and then to income and social status in adulthood (Klotz et al. 2019).

4.1 Education

Education is considered to be a major socioeconomic factor in terms of the differentiation of health and mortality. A higher level of education is associated with the potential to attain a higher income and to be employed in a healthy environment, as well as enhanced accessibility to information and cognitive skills. According to van Oort et al. (2005), inequalities in mortality according to education are the result of both material and psychosocial factors that affect mortality through behavioural factors. The study of a sample of the Norwegian population (Skalická et al., 2009) suggested that psychosocial and behavioural factors are more important than material factors in terms of explaining differences in mortality according to education. However, the latter are of fundamental importance with respect to explaining income inequalities and mortality. Smoking comprises one of the key behavioural factors that are strongly associated with education. A higher prevalence of smoking among those with lower education levels was demonstrated by Smith et al. (1998a) and Winkleby et al. (1992). However, this association does not apply

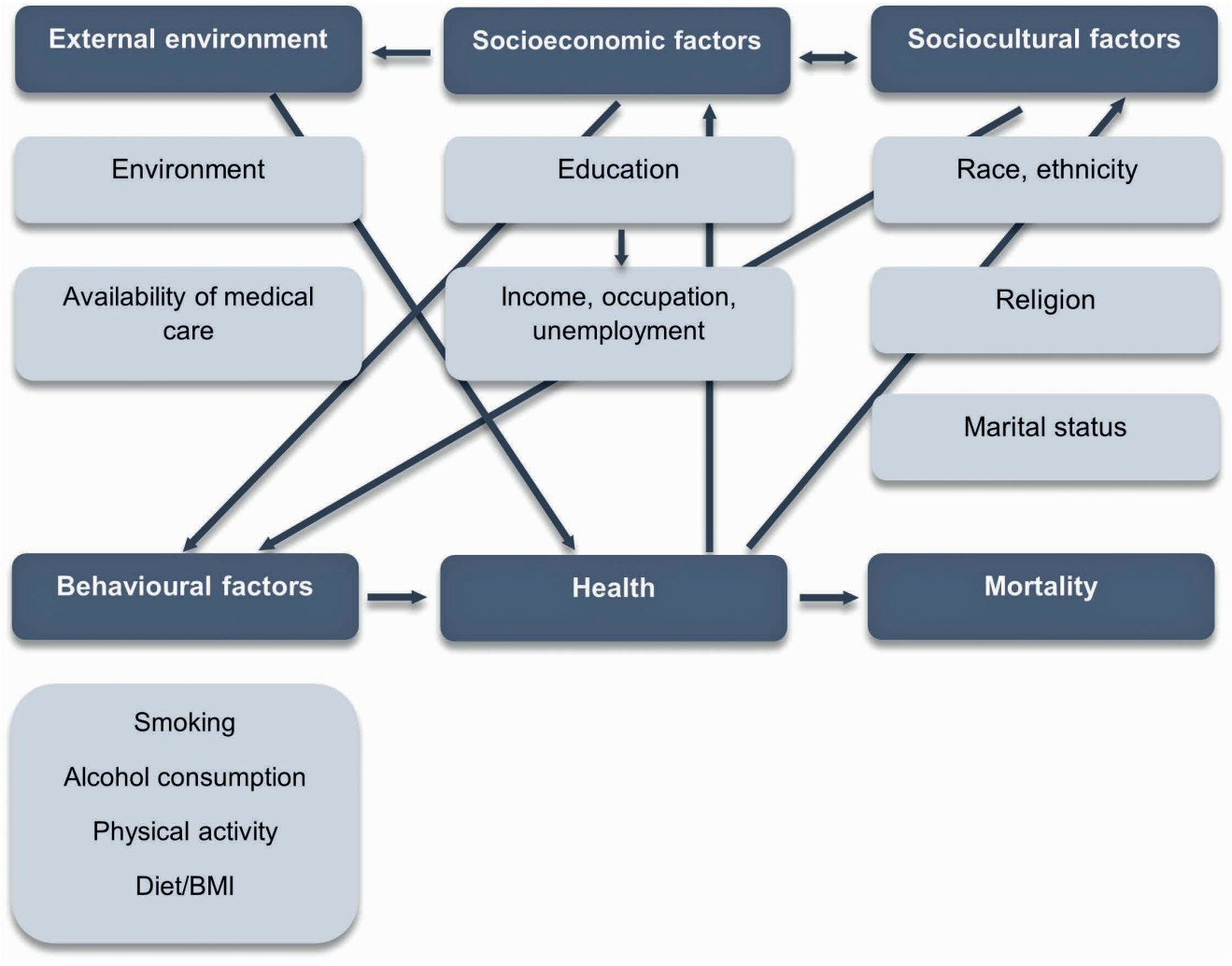

Fig. 1 Schematic representation of possible relationships between mortality factors.

universally. Mackenbach et al. (2008) observed a higher prevalence of smoking for groups of persons with higher education levels in southern European countries, whereas concerning other European regions, a higher proportion of smokers was associated with groups with lower education levels. The importance of behavioural factors was also confirmed by Mackenbach et al. (2015), who reported that differences in mortality by education are particularly evident in amenable mortality. At the same time, their study also found this trend is more significant in Central and Eastern Europe compared to other European countries.

The level of education also exerts an impact on the take-up of preventive medical care and, thus, on the early recognition of the onset of diseases. More highly educated persons are more likely to undergo regular medical examinations (Sabates and Feinstein 2006). The association of education and access to healthcare is mediated by the higher levels of health awareness, responsibility, motivation, patience, communication access, social inclusion and self-esteem of more highly educated groups.

The individual-level differentiation of mortality by education has been documented in a large number of longitudinal studies. A US study (Rogot et al. 1992) revealed substantial differences in life expectancy at the age 25 between persons with the highest and lowest levels of education, whereas concerning a population of Finnish men (Pensola and Martikainen 2004), the risk of death decreased considerably from the lowest to the highest education levels with concern to all the observed causes of mortality. According to the results of a study by Mackenbach et al. (2008), who investigated socioeconomic inequalities and mortality intensity in 22 European countries, the most significant differences in mortality by education are evident in Czechia and Lithuania, and the smallest, yet significant, differences apply to Sweden and England. These differences were observed for all the monitored causes of death with the exception of breast neoplasms. The high differentiation of mortality according to education in Eastern European and the Baltic countries is the result of significantly higher inequality in terms of the rate of death from cardiovascular disease. Indeed, mortality from cardiovascular disease exhibits the strongest association with education (McFadden et al. 2008; Smith et al. 1998b). The relationship between education and mortality concerning neoplasms is, however, ambiguous. In France (Menvielle et al. 2005), inequalities in cancer mortality according to education were observed only for men (concerning primarily mortality from lung and oesophageal neoplasms). Mackenbach et al. (1999) even determined a higher intensity of mortality from neoplasms for women with higher education levels in Czechia and Hungary; the only exception concerned lung neoplasm mortality, which was higher for women with lower education levels. In addition, more highly educated women also exhibited a higher rate of mortality from breast neoplasms in some of the other countries studied. The results of this study also revealed that inequalities in the level of mortality according to education are greater for men than for women in terms of both total mortality and mortality from all the investigated causes of death. Other authors have arrived at the same conclusions (McFadden et al. 2008; Vescio et al. 2003).

The unequal distribution of the population according to education also plays an important role in terms of explaining regional differences in mortality. Kravdal (2010) offers several explanations for the impact of higher education levels on lower mortality at the regional scale, including the observation that higher levels of education are associated with higher incomes, which serve to increase regional tax revenues, which, in turn, can be used to construct and manage a denser network of health facilities or to create infrastructure that encourages physical activity. Further aspects related to higher proportions of more educated groups comprise the greater attractiveness of the respective region for qualified healthcare personnel and, primarily, the existence of social interaction networks via which knowledge, attitudes and behaviour associated with a positive attitude to one's health are transmitted within the region. The relationship between higher levels of education and a lower levels of mortality has been confirmed for men and women with respect to Japanese cities (Fukuda et al. 2004), US states (Muller 2002) and Hungarian districts (Kopp et al. 2006). A study of mortality differentiation concerning districts in Slovakia (Rosicova et al. 2009) revealed that the effect of education was statistically significant only for men.

4.2 Income

The income level reflects the financial opportunity to secure adequate housing, nutrition and medical care. However, it is less stable than education in terms of providing a measure of socioeconomic status since it changes considerably over the life cycle. Therefore, household income distribution (e.g. Nakaya and Dorling 2005), in some cases personal income (e.g. Kopp et al. 2006), is used in the literature to express the level of income. Many authors (Phelan et al. 2004; Preston and Taubman 1994: 295–304) have emphasised the primary importance of higher incomes with regard to averting premature death, which can be prevented via the use of quality medical care, more expensive health treatment options and the consumption of selected foods. One of the aspects concerning the influence of income on mortality, which is discussed primarily in the USA, comprises the lack of the availability of health insurance for persons with lower incomes (Cutler et al. 2006).

In most populations, those with higher incomes enjoy better health and longer lives. At the individual

level, this fact has been observed, for example, in studies conducted in the USA (Chetty et al. 2016), Norway (Skalická et al. 2009) and Japan (Liang et al. 2003). Krueger et al. (2003) attempted to describe the dependence of mortality on income sources and determined that a higher risk of death was associated with both lower income levels and fewer income sources. This relationship intensifies with age.

Studies that examine the regional differentiation of mortality usually consider the measure of income in terms of the average income of persons or households in the region. An average income has been negatively associated with mortality intensity for US counties (Blanchard et al. 2008) and microregions in Ontario, Canada (Finkelstein et al. 2003). Moreover, a study of districts in Hungary (Kopp et al. 2006) revealed a strong relationship between the average income and the level of mortality from cardiovascular disease. A study by Nakaya and Dorling (2005) further determined that the average income in both the UK and Japan correlated significantly with differences in mortality between NUTS2 regions in the UK and prefectures in Japan. This association was found to be weaker in Japan and was even reversed at age 75 and over (i.e. a higher average income was associated with higher mortality rates). Conversely, Kravdal (2007), who analysed differences in mortality between regions in Norway, concluded that there is no relationship between the average income and mortality.

As mentioned previously, both differences in absolute incomes and their relative distribution (income inequality) are important in terms of explaining mortality differentiation. A positive linear relationship between income inequality and the mortality intensity has been described for example by Muller (2002) and Kawachi et al. (1997) for US states. However, no statistically significant relationship between these variables was identified for US districts (Blanchard et al. 2008). Nevertheless, a strong correlation between income inequality and mortality intensity was determined for NUTS2 level regions in the United Kingdom (Nakaya and Dorling 2005).

4.3 Unemployment

The link between unemployment and mortality can be explained via several mechanisms (Bartley 1994; Iversen 1989). Unemployment can be understood as a psychosocial stress factor that threatens the identity, self-esteem and social networks of individuals. These factors then exert a negative impact on susceptibility to the development of somatic and mental diseases. The loss of an employment position also exerts direct negative effects on blood pressure and the secretion of stress hormones that affect the efficiency of bodily functions. A further negative impact of the loss of an employment position concerns lifestyle changes and the increased consumption of tobacco and/or alcohol. Long-term unemployment undoubtedly also affects an individual's financial situation and material security. However, the higher mortality rate of the unemployed can also be explained via a selective mechanism, i.e. that many people who become unemployed lost their jobs due to poor health. Stewart (2001) described and empirically proved that those with poorer health have both a greater risk of losing their jobs and a higher chance of remaining long-term unemployed. Manual workers are more at risk of job loss due to poor health than other groups in the workforce (Bartley and Owen 1996).

Empirical studies of the relationship between unemployment and mortality have usually been conducted with respect to persons of working age (approx. 20–64 years). Nylen et al. (2001) identified a strong positive association between the unemployment rate and the mortality rate in Sweden. After excluding those with long-term illnesses, the association between unemployment and the mortality level remained unchanged for men but increased for women. Based on a sample of the Finnish population, Martikainen (1990) reported that the effect of unemployment on the higher intensity of mortality increases with the duration of the period of unemployment. Moreover, he demonstrated the selection of the unemployed based on their age, education and marital status; however, selection was not found to be significant with respect to health status.

One of the aspects of the relationship between employment and mortality intensity comprises the effect of part-time work. According to Nylen et al. (2001) most women who work part-time do so in order to be able to take care of children and the home, while if a man works part-time it is often due to health problems. This assumption was confirmed in the above cited paper using a sample of the Swedish population. For women, no relationship was determined between part-time work and mortality intensity, while for men, part-time work was related to a higher mortality risk.

Van Lenthe et al. (2005) compared the importance of unemployment in terms of the regional differentiation of mortality for several micro-regions in Europe and the USA. For men, those who live in regions with the highest quartile of unemployment higher mortality risk than those who live in regions with the lowest quartile of unemployment. The most significant differences were observed in the Netherlands and Finland and the least in England. A weaker relationship between the level of unemployment and regional mortality differentiation was observed for women. The mortality risk of women living in the highest unemployment quartile was highest in the USA. A stronger positive correlation between the unemployment rate and the male mortality level was also observed for cities in Japan (Fukuda et al. 2004) and districts in Slovakia (Rosicova et al. 2009), as well as for the intensity of mortality from cardiovascular disease for districts in Hungary (Kopp et al. 2006). The impact of

unemployment on mortality from cardiovascular disease was also confirmed by Brenner (2016) among European Union countries.

4.4 Occupation

Occupation has also been studied as one of the principle factors in the differentiation of mortality. For example, based on data from the 19th century, Stocks (1938) observed both the higher mortality intensity of butchers compared to pub landlords in London and a higher mortality level in those English regions with higher proportions of persons working in industry than those with higher proportions of the population working in agriculture. Employment is associated with various workplace-related physical and psychosocial factors. Human health is negatively affected in the workplace by harmful substances, the risk of injury, psychological stress and shared risk behaviour (Johnson et al. 1999). A person's occupation is mainly associated with the education level attained and, according to Sundquist and Johansson (1997), the higher mortality intensity of manual workers can be largely explained by their lower education levels and the various related risk factors.

Most of the evidence for a relationship between mortality intensity and occupation originated in the United Kingdom. An increasing level of mortality from non-manual professionals to unskilled manual workers was observed by McFadden et al. (2008) and Smith et al. (1998b). According to Smith et al. (1998b) the same gradient also exists for men in terms of the intensity of mortality from diseases of the circulatory system, neoplasms and other causes of death. A study by McFadden et al. (2008) concluded that differences in the intensity of mortality by occupation are lower for women and statistically significant only with respect to mortality from cardiovascular causes, which can be partly attributed to smaller differences in the proportion of female smokers between occupational groups. Moreover, the smaller differences in terms of alcohol consumption between women of different social classes according to occupation was determined by Harrison and Gardiner (1999) as being one of the most important factors in the differentiation of mortality by occupation in the UK. In addition, in Finland, the significant impact was determined of higher alcohol consumption among manual workers on the higher mortality level thereof, even for women (in contrast to the United Kingdom) (Mäkelä et al. 1997). A Japanese study Hirokawa et al. (2006) revealed that agricultural and forestry workers of both sexes have a lower total mortality intensity and, particularly, mortality from cardiovascular causes, than other manual and non-manual workers. Such workers were shown to have, on average, a lower consumption of alcohol and unhealthy food, higher physical activity levels and a lower propensity to smoke. Although the relatively low level of mortality among persons working in agriculture has also been observed in the USA, it was no lower than for highly qualified professionals (Johnson et al. 1999). Similar conclusions were also drawn by Menvielle et al. (2005) in France with concern to mortality from neoplasms. This study determined that the most significant inequalities according to occupation concerned the occurrence of lung and oesophageal neoplasms in men, which is most likely due to the unequal distribution of alcohol and tobacco consumption between occupational groups.

At the regional level, the influence of occupation on mortality has been studied only rarely. The proportion of manual workers has been found to be the most significant factor in terms of the differences in mortality rates between microregions in the Helsinki metropolitan area (Martikainen et al. 2003). Higher proportions of manual workers in certain regions was reflected primarily in higher levels of mortality from cardiovascular disease and external causes of death. Moreover, living in regions with higher proportions of manual workers has been significantly associated with a higher mortality intensity in Australia (Turrell et al. 2007), England (Sloggett and Joshi 1994) and the Turin metropolitan area (Marinacci et al. 2004). A correlation between employment type and mortality rates has also been confirmed in Central Europe, specifically between regions in Poland (Rój and Jankowiak 2021).

4.5 Marital status

The available literature reports that marital status and the formation and dissolution of marriage exert a significant impact on both health status and mortality. This phenomenon can be explained by a combination of a range of selection and causal mechanisms (Kravdal 2007; Rogers 1995). According to the selection hypothesis, healthy people are more likely to marry, and unhealthy individuals are more likely to divorce. The criteria for choosing a marriage partner include not only income, physical appearance, psychological stability, etc. but also the avoidance of risk factors such as smoking or excessive alcohol consumption. The protective function of marriage hypothesis assumes that the lower level of mortality of married persons is the result of enhanced accessibility to social relationships, integration and social support. Marriage also leads to the creation of a clear social role and levels of responsibility that result in the avoidance of risks and the leading of a healthier lifestyle. According to the stress hypothesis, the higher mortality rate of divorced and widowed persons can be attributed to their higher exposure to mortality risk factors (smoking, higher alcohol consumption rates, higher blood pressure, higher BMI, etc.) following the end of the marriage. The relationship between marital status and mortality may also be related to income. A serious decrease in financial resources

following the dissolution of a marriage may lead to a deterioration in living conditions, overall lifestyle and the potential for access to quality health care.

A comparison of differences in mortality according to marital status in 16 developed countries between 1940 and 1985 revealed that the mortality risk for unmarried persons was greater than for their married counterparts, with divorced persons affected by the highest mortality intensity rate in most cases. The differences were more significant for men than for women in all the countries studied (Hu and Goldman 1990). The same results were determined by a large number of longitudinal studies, e.g. in Sweden (Sundquist and Johansson 1997). In the USA, Rogers (1995) observed the highest mortality rate for unmarried persons; moreover, divorced and widowed persons were also observed to have a higher mortality rate than married persons. According to Murphy et al. (2007), who studied differences in the mortality level according to marital status in seven European countries, unmarried persons evince the highest intensity of mortality aged 40–59 years, whereas at older ages the mortality level is highest for divorced persons. Metsä-Simola and Martikainen (2013) found, based on a Finnish population sample, that the excess mortality of divorced men is highest immediately following divorce and decreases over time. This excess death rate was found to be lower for women than for men and to be evenly distributed over longer periods of time following divorce. Rogers et al. (2005) and Martikainen et al. (2005) emphasised the importance of the higher mortality intensity of unmarried persons from social pathology-related causes.

The usual measure of marital status and the formation and dissolution of marriage in terms of the study of the regional differentiation of mortality comprises the proportions of divorced, unmarried and widowed persons compared to those who are married (e.g. Kravdal 2007) or the intensity of the divorce rate (e.g. Popov 2009). In Norwegian municipalities, Kravdal (2007) determined that a higher proportion of divorced persons results in a higher mortality rate, while a higher proportion of single persons leads to a lower mortality rate for both men and women. Blomgren et al. (2004) identified the strong regional association of the proportion of divorced and single persons with alcohol-related mortality for a sample of the male population in Finland. According to a study of 89 Russian regions (Popov 2009), the change in the intensity of divorce in the period 1990–2003 was found to be one of the main determinants of mortality differentiation. The relationship between marital status (specifically divorce rate) and mortality has also been confirmed by Spijker (2014: 35–78). The negative effect of divorce is stronger for men than for women; and has also a larger effect in Eastern European countries compared to Western European countries. However, it is not significant for all causes of death.

4.6 Religion

Scientists agree on the positive effect of active religious participation on human health. The relationship between religion and mortality is reflected primarily via behavioural and psychosocial factors (Ellison and Levin 1998; Hummer et al. 1999; Musick et al. 2004). Part of the relationship between religious participation and mortality can be accounted for by health selection, i.e. many of those who do not attend religious meetings are unable to attend because of poor health (Hummer et al. 1999). Religious activity, particularly in the form of involvement in a religious community, may promote physical health via the regulation of health-related behaviour, particularly the lower consumption of alcohol, tobacco and addictive substances. However, less risky sexual behaviour and support for certain eating habits also comprise important factors. According to the empirical findings of Musick et al. (2004), behavioural factors are likely to explain 20% to 30% of the impact of the regular attendance of religious meetings on the lower intensity of mortality.

The enhanced social support network of religious communities also undoubtedly exerts a beneficial impact on health both formally and informally via an extensive network of social relationships with persons who share the same values, interests and activities. Other aspects concerning active religious participation comprise the enhancement of self-esteem and positive self-perception. The clearer and more complete value system that faith in God offers may also exert a beneficial effect on one's psychological resilience and health. Less evidence exists on the potential negative health effects of the social pressure within religious groups in terms of adhering to certain norms and behaviour. Breaking the rules may lead to the creation of strong feelings of guilt and shame. Moreover, many individuals may be negatively affected by remaining in unsatisfactory marriages due to the fear of societal condemnation should they decide to divorce (Ellison and Levin 1998; Oman et al. 2002).

Most studies that have addressed the relationship between religious participation and mortality in developed countries have focused only on those who follow the Christian and Jewish faiths (Powell et al. 2003). In addition, the lack of a unified definition of religious and spiritual activities presents a problem in terms of comparing different studies. In general, religious participation is most often measured as the frequency of attending church or praying.

Most of the evidence for a relationship between active religious participation and mortality originates in the USA, where religious activity is considered to be one of the main determinants of individual-level differences in mortality. According to Powell et al. (2003), this fact is based on the large proportion of the US population that believes in God and, primarily, the fact that the majority of the US population considers

religion to form a very important part of their lives. Dupre et al. (2006) observed a strong negative association between religious participation and mortality intensity for persons aged 65 years and older in North Carolina, USA. Their study revealed that those who did not attend religious gatherings had roughly twice the risk of mortality than those who attended services regularly. This risk was found to be slightly higher for women. Hummer et al. (1999) determined a considerable difference in the life expectancy at age 20 between men and women who do not participate in religious activities at all and those who participate more than once per week in the USA. According to Oman et al. (2002), who studied data from California, USA, the causes of death that have the strongest relationships to active religious participation comprise diseases of the circulatory system, diseases of the digestive tract and respiratory diseases. In Europe, a significant negative association between religious participation and mortality was demonstrated by la Cour et al. (2006) based on a sample of the elderly Danish population. However, this effect was found to be significant only for women. Moreover, they discovered no relationship between mortality and watching/listening to religious services on television or radio.

Räsänen et al. (1996) compared differences in mortality between Lutherans and Orthodox believers in Eastern Finland in the form of a longitudinal study. Even after adjusting for other socioeconomic variables, the total mortality intensity of Orthodox believers was strongly higher than that of Lutherans. A lower mortality rate for Protestants than for Catholics was determined by O'Reilly and Rosato (2008) in Northern Ireland. With respect to Christian churches, the avoidance of risk-taking behaviour is considered to be more characteristic of Protestants than Catholics, a factor that has been proven in several studies on regional differences. Holt et al. (2006) found that US states with a high proportion of Catholics have higher rates of alcohol consumption than predominantly Protestant states. Blanchard et al. (2008) studied the association of mortality differentiation for US states and the proportion of Catholics and Protestants. A higher proportion of Catholics correlated to a higher intensity of mortality from social pathology-related causes. Mackenbach et al. (1991) revealed that the excess mortality in the southern part of the Netherlands is strongly associated with a higher proportion of Roman Catholics. The higher proportion of Catholics was linked to both the higher intensity of total mortality and, significantly, a markedly higher level of mortality from lung cancer and other diseases directly related to smoking.

4.7 Race

Race in relation to differences in mortality has been studied to date primarily in the USA. Sometimes race is even used as an indicator of socioeconomic status due to its high correlation with education, income, occupation and unemployment. The higher mortality rate of African Americans compared to white Americans has been reported by many authors (Dupre et al. 2006; Keil et al. 1992; Potter 1991; Rogers et al. 1996). This difference decreases with age; however, according to the results of a study in North Carolina by Dupre et al. (2006), at around the age of 80, i.e. the highest age group, this trend is reversed and African Americans have a lower risk of mortality than white Americans. The authors offer two possible explanations for this phenomenon – the underestimation of the real intensity of mortality among African Americans in the highest age groups and the selective survival of the hardiest individuals in the African American subpopulation, which exhibits a higher mortality intensity for younger age groups. According to all the most recent studies on this theme, the higher mortality intensity of African Americans is attributed primarily to their lower socioeconomic status. Keil et al. (1992) showed via a longitudinal study that when education and occupation are considered, differences in mortality between African Americans and white Americans are no longer significant. A further observed trend in the USA concerns the lower mortality rate of Asians. According to Rogers et al. (1996), this is the consequence of their lower alcohol and tobacco consumption, healthier diet and higher socioeconomic status. Dwyer-Lindgren et al. (2017) concluded at the US county level that race is one of the causes of large and growing disparities in mortality rates. Consistent with studies at the individual level, the factor of race was confirmed to be closely associated with other socioeconomic and behavioural factors.

4.8 Migration, nationality and ethnicity

Mortality among immigrants and ethnic groups is influenced by a wide range of interacting social and cultural factors, as well as genetic differences and selective migration (Kibele et al. 2008). The health status of individual ethnic and immigrant groups differs from the population of the destination country due to differing behavioural, psychosocial and material characteristics, which may change with the length of stay in the destination country and with differing experiences of migration. In Europe, there is the evidence of immigrants being healthier and having lower mortality rates than the population of the destination country (e.g. Razum et al. 1998; Uitenbroek and Verhoeff 2002). This phenomenon can be explained by selective migration, i.e. most migrants decide to emigrate only if they enjoy good health. In addition, migrants often have to undergo mandatory medical examinations prior to migration. According to Uitenbroek and Verhoeff (2002), the selection of migrants is based on health status, as well as psychological resistance, ambition and motivation, which are thought to exert a positive impact on health at later ages. Razum et al. (1998) cites the return of immigrants to their

country of origin in case of serious illness as one of the potential reasons for the lower mortality rate of immigrants in Germany.

Studies of regional differences between districts in the Netherlands (Mackenbach et al. 1989) and between regions in Russia (Popov 2009) revealed only a weak relationship between the level of mortality and the proportion of immigrants.

4.9 Urbanisation

The relationship between urbanisation and mortality is reflected via a range of socioeconomic, behavioural, psychosocial and other factors. Urban environments offer more opportunities for employment, education and social contact, as well as enhanced access to health and social services. Conversely, living in cities in the developed world is also associated with higher psychological stress levels, an unhealthy lifestyle, air pollution, noise and higher crime rates. One of the most important aspects of the connection between urbanisation and the intensity of mortality concerns the differing composition of the population in cities and in the countryside. Concerning European countries, it has been shown that the populations of the most urbanised regions are younger and have higher education and income levels, higher proportions of atheists and single persons and higher divorce rates. Declining industrial regions, however, may be affected by the accumulation of economic and social unrest in urban areas (Mackenbach et al. 1991; van Hooijdonk et al. 2008).

The problem with comparing empirical studies concerns the various definitions of urban and rural regions. Some authors define urban regions based on land use (e.g. O'Reilly et al. 2007) and others via the population density (e.g. van Hooijdonk et al. 2008). The most frequently employed criterion for determining the degree of urbanisation consists of the proportion of the population that lives in cities above a certain population size. According to most studies concerning Western Europe, overall mortality increases with the degree of urbanisation; however, this gradient differs according to both the causes of death and age. Van Hooijdonk et al. (2008) in the Netherlands and O'Reilly et al. (2007) in Northern Ireland discovered slightly lower levels of total mortality in urban regions; however, the mortality of children and young people and those in the oldest age categories was found to be lower in rural regions. Both studies determined that the strongest relationship relates to living in urban regions and mortality from respiratory diseases and lung neoplasms. In addition to these two causes of death, Law and Morris (1998) also observed the higher intensity of mortality from diseases of the circulatory system in urban areas of England and Wales. These findings thus support the assumption that urban environments are associated with poorer air quality and the higher prevalence of smoking.

4.10 Availability of medical care

The development of medical care has undoubtedly contributed significantly to improving the health of the population and extending life expectancy. It is reasonable, therefore, to expect the significant influence of the availability of, and resources provided by, healthcare systems in terms of decreasing mortality intensity, especially with respect to conditions that can usually be treated by rapid medical intervention (e.g. heart attacks). However, studies on regional differences conducted in Western European countries in the second half of the 20th century failed to agree on a uniform and clear association between differences in healthcare provision and mortality levels (Mackenbach et al. 1990). According to several studies, the explanation for this inconsistent and unexpected relationship can be explained by the conscious and unconscious satisfaction of the demand for doctors according to the respective health problem in various countries. The hypothesis that the system responds to demand was proposed, for example, by Fukuda et al. (2004) based on the positive relationship between mortality intensity and the density of primary medical care facilities determined for cities in Japan. Mackenbach et al. (1990) believe that the absence of a clear association between medical care and mortality may be due to the fact that the indicators applied (i.e. most frequently the number of doctors or hospital beds per inhabitant) do not accurately reflect the quality and efficiency of the medical care provided. The availability of health services as an independent influence on the reduction of mortality has, however, been confirmed in the USA, unlike in several European countries. The negative association between the number of primary health care physicians per capita and the mortality rate was determined with respect to US states and to differences between US counties in the eastern and northern states of the country (Ricketts and Holmes 2007).

At the level of larger regional units, access to health care can also be measured by healthcare expenditures. This perspective was used, for example by Gavurova et al. (2020), in a study focusing on socioeconomic differences in mortality rates in the European Union. However, healthcare expenditures did not have a significant effect on explaining differences in mortality.

4.11 The environment

The environment influences all individuals regardless of their personal characteristics. A wide variety of harmful substances are able to enter the human body both with oxygen from the air and through the digestive system through contaminated water or food. Exposure routes and the health risks of the most frequently occurring pollutants are listed in the WHO air quality guidelines (Sivertsen 2006: 31–60). The occurrence of oxides of nitrogen and sulphur is

mainly associated with the burning of fossil fuels in the industrial sector, heating systems and motor vehicle emissions. These chemical compounds exert primarily an effect on the respiratory system. However, they may also have an impact on cardiovascular diseases or neoplasms via biological processes. The main substances that pollute the air in cities and industrial areas are oxides of sulphur and particulate matter, which contain a complex mixture of organic and inorganic substances of different sizes. Heavy metals also make up a dangerous component of such particles. Of the oxides of nitrogen, nitrogen dioxide, anthropogenically produced via transport-related combustion processes, exerts the greatest effect on the human body. However, since nitrogen dioxide is associated with the emissions of other substances, it is difficult to detect its independent effect (Sivertsen 2006: 31–60).

However, according to the results of several longitudinal studies conducted in Europe (e.g. Hoek et al. 2002) and the USA (e.g. Dockery et al. 1993), it is possible to conclude that pollutants that are concentrated in the external environment have a weaker effect on mortality than do the harmful substances inhaled through smoking. According to these studies, following adjustment for individual characteristics, air pollution exerts an impact on mortality from cardiopulmonary causes and lung neoplasms only. The short-term effect of particulate matter (PM_{10}) emissions on mortality has been studied in detail in 90 US cities (Samet et al. 2000) and 29 European cities (Katsouyanni et al. 2001). In the USA, a 10 $\mu g/m^3$ increase in PM_{10} concentrations was associated with a higher next-day mortality. A stronger relationship was observed for cardiopulmonary causes of death. The results varied widely concerning European cities. The greater impact of an increase in PM_{10} concentrations by 10 $\mu g/m^3$ was observed in the cities studied in southern Europe, on the other hand, for example in Germany, the relationship between daily PM_{10} emissions and mortality was observed to be negative. A similar analysis was also performed by Peters et al. (2000) in North Bohemian districts of Czechia and districts in Bavaria that border Czechia based on data from 1982–1994. While in Czechia the dependence of next-day mortality on the emission of pollutants was determined, the relationship between these variables was not found to be significant in Bavaria. The concentration of particulate matter exerted the greatest impact on next-day mortality, whereas the concentration of oxides of sulphur had the greatest effect on two-day mortality.

5. Ecological fallacy

Since no individual data is usually available for studies of regional mortality differences in defined territorial units, the unit of analysis adopted comprises data on groups of individuals. The danger associated with interpreting the results of such analysis concerns the so-called ecological fallacy, which results from the aggregated nature of the data. The ecological fallacy arises if the connections observed at the regional population level are applied to its constituent members (Diez 2002).

The distinction between individual and aggregate (ecological) level relationships was first described in the early 1950s by the American sociologist Robinson (1950), who investigated the relationship between race and illiteracy. Although the correlation coefficient of the proportion of African Americans and illiteracy in US states was found to be positive, this association was observed to be the opposite at the individual level. A further example of the ecological fallacy is provided by Diez (2002). In several countries worldwide, an increasing level of mortality from traffic accidents has been determined with increasing income per capita. However, this relationship is misleading since, according to studies conducted in various countries based on individual data, the death rate from traffic accidents is higher for persons on lower incomes.

However, the differences in the relationships found at the individual and ecological levels do not necessarily result from aggregation, but also from methodological errors and the poor selection of variables. Other variables and the interactions between them may exert a substantial impact on the explanation of the respective associations. Moreover, the relationships determined at the aggregate level should not be interpreted as causal, but as the connection between two variables. According to Lancaster and Green (2002), in general, in order to minimise bias in the results, it is sufficient to standardise the data and include other factors in the model that are potentially responsible for the variability of the explained variable. According to their study on the influence of socioeconomic conditions on differences in health status, the risk of ecological error is reduced when a different population structure is taken into account at the aggregate level. Schwartz (1994) emphasises the validity of ecological studies in terms of assessing the impacts of the differentiation of the external environment (economic, cultural and social) on human behaviour and health. Moreover, it is not necessarily the case that individual-level models are better defined than aggregate-level models. Indeed, the grouping process itself may serve to cleanse the data of errors that arise from biased responses provided in individual studies. Thus, ecological studies cannot be considered to be mere substitutes for individual studies due simply to the absence of data.

6. Conclusion

The existence of significant socioeconomic and sociodemographic differences in mortality observed and described in detail for many countries worldwide

demonstrates how extremely dependent health status and subsequent mortality are on external factors. Based on the study of the literature, it was determined that more privileged groups enjoy better health and longer lives. A strong association was revealed between socioeconomic factors and mortality at both the individual and the aggregate levels. However, the question remains as to which mechanisms such external factors are linked directly to human health. Most often, the existence of a relationship between socioeconomic or sociodemographic factors and mortality can be explained with the help of materialist theories (the main cause of the socioeconomic differentiation of mortality lies in income and what the income allows), psychosocial theories (socioeconomic status affects the psyche of individuals which, in turn, exerts biological impacts on the human organism), biomedical theories (the uneven occurrence of biological risk factors between social groups), the life course theory (the accumulation of social, psychological and biological advantages and disadvantages during the lifespan) and, above all, behavioural theories (the unequal distribution of unfavourable behaviour and lifestyles between socioeconomic groups).

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