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Avoidable Mortality: What it Means and How it is Measured

CHE Research Paper 63

Avoidable mortality: what it means and how it is measured

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June 2011

Background to series

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Abstract

We explore in this research paper the concept of avoidable mortality and how the way it is measured has evolved over time. Starting from an earlier review by Nolte and McKee (2004), we review the empirical studies which have been produced since then. Finally we appraise the empirical applications of the most recent literature. The concept of "avoidable mortality" refers, broadly speaking, to all those deaths that, given current medical knowledge and technology, could be avoided by the healthcare system through either prevention and/or treatment. It originates from the pioneering work by Rutstein, Berenberg et al. (1976) which introduced the notion of 'unnecessary untimely deaths' as a new way to measuring the quality of medical care.

The most recent empirical literature shows that the notion of avoidable mortality continues to be used to establish the extent to which people are dying from amenable conditions within and/or across countries and over time, and whether socio-economic status and ethnicity are related to mortality from amenable conditions. Most studies use data taken from national death registries, with only two which link the concept of avoidable mortality to routinely collected administrative data of healthcare provision, such as hospitals. A number of criticisms are raised, with probably the most remarkable being the lack of association found between avoidable mortality and healthcare inputs. No study has actually attempted to use the concept of avoidable mortality within the original aim envisaged by Rutstein, i.e. as a quality indicator of healthcare provision.

We recommend for future work in this area to focus on investigating the link between the provision of healthcare and the concept of avoidable mortality, with a particular emphasis on using routinely collected administrative data, such as hospital discharge data.

1. Introduction

The concept of "avoidable mortality" refers, broadly speaking, to all those deaths that, given current medical knowledge and technology, could be avoided by the healthcare system through either prevention and/or treatment. It originates from the pioneering work by Rutstein, Berenberg et al. (1976) which introduced the notion of 'unnecessary untimely deaths' as a new way to measuring the quality of medical care (healthcare). They proposed a list of 91 conditions – 'sentinel health events' – for which death should not occur if 'timely and effective' healthcare is provided. Any unnecessary disease, disability or unnecessary untimely deaths that occur for any 'sentinel health events' is included in a negative index to measure the (poor) quality of healthcare and should be further investigated (Rutstein, Berenberg et al. 1976).

A number of different lists of conditions[1] has since been produced and updated over time. Likewise, a considerable number of empirical studies have been implemented for various countries, socio-economic groups and time periods.

The goals of this paper are (1) to describe the concept of avoidable mortality and the evolution of the way it has been measured along with the most recent criticisms, (2) to review the empirical studies which have been produced since year 2004, updating the earlier review by Nolte and McKee (2004) and (3) to appraise the recent empirical applications.

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[1] Charlton, Hartley et al. 1983; Poikolainen and Eskola 1986; Mackenbach, Kunst et al. 1988; Mackenbach, Looman et al. 1988; Mackenbach, Looman et al. 1988; Poikolainen and Eskola 1988; Mackenbach 1991; Westerling 1992; Westerling 1993; Westerling 1996a; Westerling 1996b; Simonato, Ballard et al. 1998; Tobias and Jackson 2001; Nolte and McKee 2004; Page, Tobias et al. 2006

2. The concept of avoidable mortality

2.1 Health production process and avoidable mortality

Figure 1 describes the health production process and introduces the concept of avoidable mortality. Public Health programs and policies may have an impact on parental investments in health and education, but also may have an influence through the education of an individual, mass-media and environmental factors, as well as directly. All these factors along with the overall population health and individual health endowment at birth play a role in the formation of an individual's health beliefs, health behaviour and level of concern about health. Given these characteristics and the availability and costs of preventive and screening technology, an individual decides whether to engage in preventive behaviour and/or undergo screening and early diagnostics. Two outcomes are possible at this stage – either "good health" or contraction of a "disease". If the contracted disease is classified as "amenable to health policy", then a death from this condition is considered "avoidable" no matter whether the condition is "amenable to medical care" or not. Among the conditions which cannot be prevented through health policies are some which can be successfully treated ("amenable to medical care"). A death from one of such conditions is also considered "avoidable". Only a death from conditions which neither could be prevented nor treated is thought to be unavoidable and should not be viewed as reflective of the quality of a healthcare system.

2.2 The concept of 'avoidable mortality' and its evolution over time

The first studies that concerned themselves with the concept of the 'avoidability' of deaths date back to the early 20th century, when cases of maternal deaths were investigated as 'confidential enquiries' in the UK (MacFarlane 2004) and later in the USA, with the New York Academy of Medicine investigating maternal deaths in New York City. These investigations are believed to have played an important role in saving maternal lives (Holland 2009).

However, it was only in the 70s that a thorough investigation into the causes of deaths was carried out by a group of researchers based in the United States and led by Rutstein (1976). Experts from medicine, epidemiology, public health and related fields worked together to identify a number of conditions for which death or disability should not occur if timely and effective medical care is administered. The group suggested that any 'unnecessary disease or disability and unnecessary untimely death' that occurs in these conditions should serve as a warning signal, a "sentinel health event", of the poor quality of healthcare received. Three separate sets of conditions were identified. The first set included 91 conditions, which were identified as "clear-cut immediate use" indices of the quality of healthcare and have been referred to as "single-case indexes" (Carr, Szapiro et al. 1989). It was suggested that even one case of death within this list should be thoroughly investigated. The second set of conditions was identified as "limited use", for which a number of deaths (rather than a single event) should justify further investigation. These are also known as "indexes based on rates" (Carr, Szapiro et al. 1989). The third set included medico-social problems, which Rutstein and colleagues identified as the set demanding further work and clarification given that the medical knowledge of the time did not allow determining with certainty the contributions that healthcare could make in avoiding deaths from these conditions. Rutstein's original list was based on version 8 of the International Classification of Disease coding system.

Rutstein's original list of untimely disease, disability and death was revised in 1977 (Rutstein, Berenberg et al.) and 1980 (Rutstein, Berenberg et al.) to take into account advances in medical care as well as to incorporate changes made to the ICD codes (9th revision). The origin of the term avoidable mortality is due, however, to Charlton et al. (1983), who first introduced it in their study of regional variation in mortality in England and Wales. The concept was later broadened to include 'preventable causes' of deaths and the separate term 'amenable mortality' was introduced (Holland 1988; Simonato, Ballard et al. 1998; Tobias and Jackson 2001). Over time the words 'amenable', 'avoidable', and 'unnecessary causes of death' have been used interchangeably. However, more precise definitions have emerged, which distinguish between them (Nolte, Scholz et al. 2004; Wheller, Baker et al. 2007; Macinko and Elo 2009), although some authors still use the terms amenable and avoidable interchangeably (Kossarova, Holland et al. 2009). See Box 1 for a summary.
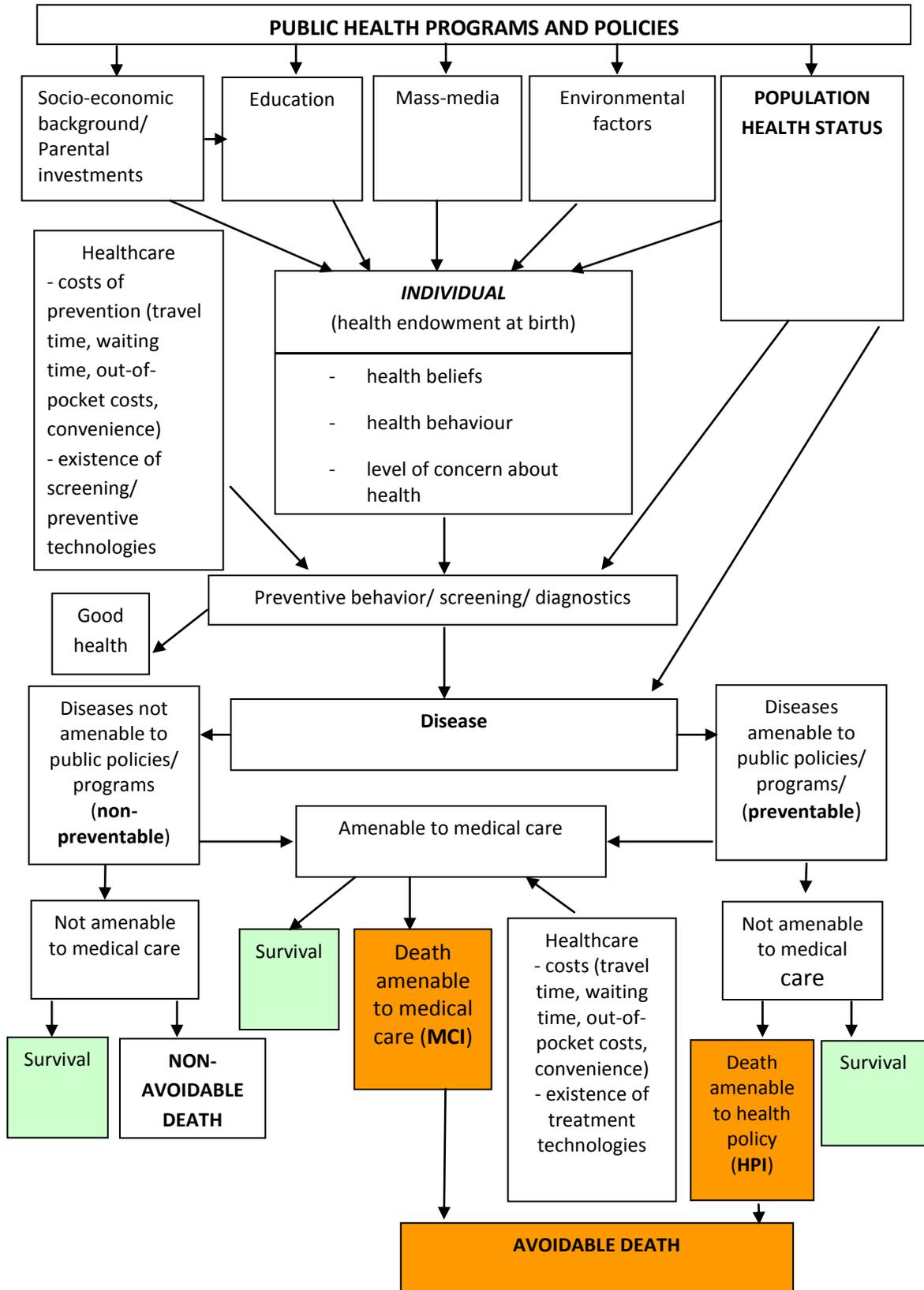
Figure 1. Individual and healthcare factors and avoidability of death

> **Box 1**
>
> **Avoidable mortality**: causes of deaths that are considered amenable to both medical intervention and health policy.
>
> **Treatable causes or medical care indicators (MCI)**: causes of deaths amenable to medical intervention only.
>
> **Preventable causes or health policy indicators (HPI)**: causes of death that are amenable to health policy only.

The concept of avoidable mortality refers, therefore, to all those deaths that, given current medical knowledge and technology, could be avoided by the healthcare system through either prevention and/or treatment. It follows clearly that the selection of conditions/diseases that are amenable to both healthcare treatment and prevention depends on the particular circumstances of any given country at any given point in time. Some of the deaths which are considered avoidable today in a developed country, half a century ago might well have been unavoidable (Dahl, Hofoss et al. 2007). Likewise, given the state of healthcare systems in the developing nations, many of the diseases for which the cure exists somewhere may be yet unavailable in this particular country. If the goal is to compare various countries and produce ranking of the healthcare systems using avoidable mortality as a measure of quality of service, this definition then might be problematic. The thing is that nowadays in the era of globalization and openness most technologies, especially health-related, are tradable. Therefore, what constrains less developed countries from using superior technologies is lack of resources or regulatory deficiencies not the technologies' availability (Tang, Petrie et al. 2009).

Rutstein et al. (1976) adopted the broadest definition of medical care, identifying 91 conditions leading to unnecessary untimely deaths. Charlton et al. (1983) narrowed the scope to medical interventions only, excluding conditions which depended mainly on prevention (e.g. lung cancer). They also set age limits for each condition, whilst excluding some conditions for which there were fewer than 200 deaths within the 5-year age groups in England and Wales. They identified 14 disease groups. The exclusion restrictions were justified by the fact that the authors analysed the conditions separately at the level of Area Health Authorities. Some later studies (Mackenbach, Looman et al. 1988; Schwartz, Kofie et al. 1990; Wood, Sallar et al. 1999) also used Charlton et al.'s list (1983) without questioning the inclusion criteria.

Poikolainen and Eskola (1986; 1988) also based their list of conditions on Rutstein's list but excluded one condition, which they thought to be outside the control of health services in Finland, and grouped the remaining ones into 70 'amenable' conditions and 20 'partly amenable' conditions.

Holland et al. (1988; 1991; 1997) in their compilation of the European Community Atlas of Avoidable Deaths adopted the concept of avoidable mortality using as a starting point the work by Charlton et al. (1983). They identified 17 disease groups, considered to be either preventable or treatable by healthcare services. They also introduced age limits (5 to 64) for most conditions with the exception of measles and respiratory disease (1-14), tetanus (0-64), cancer of cervix uteri and cirrhosis of liver (15-64), whooping cough (0-14), osteomyelitis (1-64), and maternal conditions (no age limit).

Westerling and others (Westerling 1992; Westerling 1993; Westerling, Gullberg et al. 1996) were the first to introduce explicit comparisons of preventable versus treatable conditions, whilst Simonato et al. (1998) started differentiating between mortality amenable to primary prevention, early detection and treatment, and mortality amenable to improved treatment and medical care. Tobias and Jackson (2001) broadened the list of conditions substantially by reviewing the literature on medical advances since 1980s. They also increased the age limit to 75, and assigned relative weights to primary, secondary and tertiary prevention. However, this latter approach has not been followed in subsequent studies. The most influential methodological studies involved either consultations with experts from various fields of medicine, a systematic review of the relevant literature to update the list according to the most recent medical advances (Nolte and McKee 2004) or both (Page, Tobias et al.

2006)[2]. Unfortunately, none of them provides a description of the methodology followed in the consultations and the criteria used to eventually reach an agreement in the event of differences in opinions. The only exception is the work by Page, Tobias et al. (2006) where the authors provide the rationale for including various causes into the list.

The variety of approaches to defining and identifying causes of death that are avoidable poses a number of challenges as patterns and trends of "avoidable mortality can be very sensitive to the use of different lists of causes of deaths (French and Jones 2006). The following table shows these differences by using the study by French and Jones (2006). The authors consider geographical trends in mortality over the period from 1981 to 1998 in Great Britain using both Charlton's et al.'s list (1983) and Holland's lists (1988). They find that both average trends and spatial patterns vary greatly between the two lists. Since the Holland's list is longer, it classifies a higher proportion of deaths as 'avoidable' – 22% compared to 3% following the Charlton's list. Table 1 summarizes the difference in the lists and major findings.

An entirely different approach to the measurement of avoidable mortality worth mentioning is the one adopted by a group of researchers from Australia (Tang, Chin et al. 2008; Petrie, Tang et al. 2009;Tang, Petrie et al. 2009). They consider the world population as a whole and identify for each age-gender group the country with the lowest risk of mortality in that particular age-gender group. This risk of mortality is then considered as the level of mortality that is unavoidable. In this way they construct an unavoidable risk profile for all age and gender groups for a hypothetical 'reference' country. The product of the population size in an age-gender group of a particular country and the risk of death from the reference distribution produces the number of unavoidable deaths in this country. Finally, the difference between the actual number of deaths and the number of calculated unavoidable deaths gives the number of deaths which could have been avoided in this country if it had as many resources and used them as effectively as the reference country (Tang, Petrie et al. 2009). However, this approach is subject to a number of limitations imposed by the availability of the data and strong underlying assumptions.

In summary, the way avoidable mortality is measured has undergone considerable changes over time, largely to reflect advances in medical knowledge and technology and to incorporate improvements in life expectancy, and across countries, mainly to adapt the list of amenable conditions to the characteristics of a specific country and/or to overcome data limitations.

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[2] See Table A1 in the Appendix with the list of conditions and their ICD-9 and ICD-10 codes considered avoidable from Nolte and McKee (2004) and Page, Tobias et al (2006)

Table 1: Differences in findings due to the use of different list as avoidable mortality

Findings	Charlton's list	Holland's list
Number of conditions	14 (Hypertensive disease, cancer of cervix uteri, pneumonia and bronchitis, tuberculosis, asthma, chronic rheumatic heart disease, acute respiratory disease, bacterial infections, Hodgkin's disease, abdominal hernias, acute and chronic cholecystitis, appendicitis, maternal deaths, iron deficiency anaemia, perinatal[3])	16 MCIs (tuberculosis, chronic rheumatic heart disease, abdominal hernias, cholelithiasis and cholecystitis, appendicitis, asthma, maternal deaths, cancer of cervix uteri, cervix and body uteri, hypertensive and cerebrovascular disease, respiratory disease, whooping cough, osteomyelitis, tetanus, measles, typhoid,) and 3 HPIs (cirrhosis of liver, cancer of trachea, bronchus and lung, motor vehicle accidents)
Criteria for the choice of the causes of death	• Conditions which are mainly preventable are excluded (e.g. lung cancer). • Age limits were set for each cause to increase the proportion of mortality potentially avoidable. • Out of the remaining conditions only those that had more than 200 deaths in an age group in England and Wales in these age groups were included.	• Charlton's 14 causes were used as a base, 3 health policy indicators were added. • Representatives from all the EC countries ranked the importance of diseases. • Selection of each cause was supported by the reference from medical literature identifying the corresponding effective intervention and existence of providers.
Ratio of avoidable mortality to total mortality	3%	22%
Average mortality over 1981-1998	Higher for women than for men	Higher for men than for women
Group with the highest prevalence of avoidable mortality	Men aged 15-24	Women aged 25-39
Overtime trend	Relatively small decline	Large decline
Degree of within district variation in the proportion of premature mortality considered avoidable	Significant	Significant but smaller than for Charlton's definition
Geographical distribution	Low SMRs in north of England and Scotland, high SMRs in South Wales and England with pockets of concentration of high SMRs in and close to London.	Follows north-south pattern (similar to the pattern of overall premature mortality) with a concentration around Glasgow and other districts in Western Scotland.
Within-district, between-ward geography	Similar	Similar
Gender difference in the degree of variance and geography	Substantial, with considerable more variance for men than for women.	Little

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[3] Excluded by French and Jones (2006).

3. Recent empirical research on 'avoidable mortality'

3.1 Later empirical studies

Although there is no unanimous view in the literature on the ways of defining and measuring avoidable mortality, the concept itself is quite useful as it offers a relatively simple way to evaluate the performance of the healthcare sector. In this context, empirical studies of avoidable/ amenable mortality provide useful information on differences in this health outcome along various dimensions.

Empirical studies on avoidable/amenable mortality have been thoroughly reviewed by Nolte and McKee (2004). An overview of more than 70 studies allowed the authors to generalise findings on the topic up to the year 2004. Most of these studies focus on high-income countries, with a few specifically addressing the situation in the former socialist countries. The studies which focus on geographical variation in avoidable mortality rates, usually find little association between avoidable mortality and quantity (quality) of healthcare services, but significant association with the socio-economic conditions in the region. The studies focusing on socio-demographic variation tend to find that socially disadvantaged/ vulnerable groups are at a higher risk of death from avoidable conditions. Finally, the studies devoted to the analysis of time trends mostly show a consistent decline in avoidable mortality over time, which is more pronounced than the decline in all-cause mortality.

This section revisits the review of empirical studies by Nolte and McKee (2004) and expands on it by analysing more recent empirical literature up until 2010.

The literature search from 2004 onwards identified 39 empirical studies of avoidable mortality. Following Nolte and McKee (2004) the recent studies were analysed using the same structured protocol: (1) study region, (2) time period under investigation, (3) aim of study and definition of avoidable mortality, (4) causes of death and age group(s) under study, (5) analytical design and (6) main results. This information is used to compile the annotated bibliography (similar to the one in Nolte and McKee (2004)) which can be found in the Appendix, Tables A2-A4. Studies are grouped according to their study focus. Within each summary table, papers are sorted in alphabetical order according to the country under the investigation, and the year of publication.

In contrast to the previous empirical literature, the studies from 2004 onwards are much more homogeneous in terms of the selection of causes of deaths and methodological approach. 11 out of the 34 studies are based on Nolte and McKee's (2004) list of 33 conditions amenable to medical care and Ischemic Heart Disease (most often analysed separately). Three further studies use the same list, but focus on a selection of causes. One study is based on an earlier version of Nolte and McKee's (Nolte, Scholz et al. 2002) list, which is 5 conditions shorter. Six studies use one or another variant of Holland's lists (1988; 1991; 1997), while six others are based on the work by Tobias and Jackson (2001) and Page, Tobias et al. (2006). There are also studies which analysed either one or a selected number of causes of avoidable mortality (Schwarz and Pamuk 2008; Schwierz and Wübker 2009).

Perhaps reflecting the influence of the Nolte and McKee (2004) study, the recent literature shows much less variation in the terminology used. Most studies used the term avoidable mortality to apply to mortality from conditions amenable to both health (medical) services and health policies. Usually these two sets of conditions have been analysed separately and have also been denoted as 'treatable' and 'preventable' or 'medical care indicators' and 'health policy indicators' respectively. Among the first group, Ischemic Heart Disease has usually been highlighted as one of the biggest killers and studied separately as not all cases of deaths from IHD can be considered amenable to medical care. The degree of avoidability of death from IHD is somewhere between 25% and 75% (Nolte and McKee 2004). In most studies, 50% of the deaths from IHD have been considered as amenable to medical care, whilst two did not apply this percentage (James, Manuel et al. 2006; Korda, Butler et al. 2007). In addition, some authors added HIV/AIDS as a cause amenable to health policies and analysed it separately (Stirbu, Kunst et al. 2006; Macinko and Elo 2009). A considerable number of studies focused only on mortality amenable to medical care and called them either 'amenable' mortality or 'medical care indicators' (Nolte, Scholz et al. 2004; Bautista, Alfonso et al. 2005; Grant, Munoz-Arroyo et al. 2006; Stirbu, Kunst et al. 2006; Tobias and Yeh 2007; Weisz, Gusmano et al. 2008; Tobias and Yeh 2009).

With respect to the method used, 7 studies in our list were based on a cross-sectional analysis, 11 undertook a time trend analysis and 21 studies explored both cross-sectional and time dimensions of avoidable mortality (only two of which exploited the panel nature of the data). 18 studies analysed variation in avoidable/ amenable mortality by socio-demographic characteristics, among which some represent cross-sectional analysis while others study also the variation in time trends. Unlike the previous review, no study presented descriptive analysis at regional/country level at a point in time. Seven country/ regions studies covered considerable time periods. Five studies compared trends in different regions of the same country or across countries.

The list of reviewed studies mostly focused on high income countries (as before) with three evident clusters of 'avoidable' mortality research: UK (Grant, Munoz-Arroyo et al. 2006; Gubb 2007; Wheller, Baker et al. 2007), Australia and New Zealand (Korda and Butler 2006; Page, Tobias et al. 2006; Korda, Butler et al. 2007; Tobias and Yeh 2007; Li, Gray et al. 2009; Tobias and Yeh 2009), and Spain (Bautista, Alfonso et al. 2005; Gispert, Gervas et al. 2007; Gispert, Serra et al. 2008; Melchor, Nolasco et al. 2008; Nolasco, Melchor et al. 2009). 6 studies either focused or included in the analysis countries of Central and Eastern Europe (Logminiene, Nolte et al. 2004; Newey, Nolte et al. 2004; Nolte, Scholz et al. 2004; Treurniet, Boshuizen et al. 2004; Burcin 2009; Schwierz and Wübker 2009).

Regarding the time period, most studies covered the 1990s and the 2000s, but some authors have extended the analysis further in the past and included data from early 1980s (Nolte, Scholz et al. 2004; Treurniet, Boshuizen et al. 2004; Grant, Munoz-Arroyo et al. 2006; Page, Tobias et al. 2006; Macinko and Elo 2009; Tobias and Yeh 2009) and a few even from 1970s and late 1960s (James, Manuel et al. 2006; Korda and Butler 2006; James, Wilkins et al. 2007). As before, the major theme is documentation of the downward trends in avoidable mortality as measures of quality of healthcare systems and comparison of the relative performance of regions and/or countries in this regard. Compared to the previous literature, there is a sizeable growth in the analysis of socio-economic and demographic disparities in avoidable mortality (18 out of 39 studies reviewed here compared to 11 out of 70 reviewed in Nolte and McKee (2004)). The rest of the section will compare the findings from the previous literature to the most recent ones in more detail.

3.1.1 Geographical variation

Nolte and McKee (2004) reported how avoidable mortality differs geographically, with these variations usually explained in terms of healthcare inputs and socio-economic factors. The results show generally weak and inconsistent associations with healthcare inputs. However, socio-economic factors (e.g. education, unemployment, socio-economic status, income level) were found to be strongly associated with avoidable mortality.

The more recent literature on geographical variation in avoidable mortality mostly focuses on analysing and reporting time trends for various countries; provides ranking of countries with respect to avoidable mortality and/or change in avoidable mortality. The overall trend is that the rates of avoidable mortality have been declining much faster in the last decade of the 20th century and early years of the 21st century. Further, the rates of decline in mortality determined by Schwierz and Wubker (2009) confirm this finding in that they show that the increased use of intra-cardiac catheter facilities (an important diagnostic tool for IHD) is significantly related to decreases in avoidable mortality from IHD.

Several studies found France to have the lowest avoidable mortality rates, while UK and USA are among those with the highest avoidable mortality rates, although they have experienced a considerable decline in this indicator over the recent years. Countries which joined the EU in 2004 have shown considerable improvements with respect to treatable mortality since 2004, and this despite the significant deterioration in health at the start of the transition period. Furthermore, there is a difference observed in the time trends of mortality amenable to medical care and that amenable to health policies. Although the first indicator has been declining over time in all countries studied, mortality amenable to health policies has been declining at a considerably slower pace and in some countries has in fact been on the rise (Newey, Nolte et al. 2004).

A full summary of the studies that focus on geographical variations is presented in Table A2 in the Appendix.

3.1.2 Socio-demographic variation

As avoidable mortality constitutes deaths that should not occur in the presence of timely healthcare, socio-demographic/economic inequalities in this indicator can be interpreted as stemming from the differential access to healthcare services or differences in the quality of care received by various groups. These studies mostly concern countries with historical ethnic inequalities, but also those which have been experiencing a significant growth of migrant population.

Earlier studies of variation in avoidable mortality by race in the United States have shown a consistent significant difference between whites and non-whites. As Nolte and McKee (2004) summarised, in the 1980s the avoidable/ amenable mortality rates from selected causes were three to nine times higher for African-Americans than for white Americans (2.6 times higher for cervical cancer and 8.9 times higher for tuberculosis). The study by Macinko and Elo (2009), using the Nolte and McKee (2004) list of avoidable causes and covering the period from 1980 to 2005, confirmed this finding. So, in 1980 the ratio of black to white mortality amenable to medical care was 2.9 for men and 2.2 for women. This ratio remained stable up to the year 1998 showing a slight improvement for men only in 1999 (2.6) and 2005 (2.5).

Similarly the ethnicity gap was explored in New Zealand and Australia. Earlier literature found a decline in the ratio of the Maori to non-Maori amenable mortality ratio from 2.3-2.5 to 2 over the period 1968-1987 (Malcolm and Salmond 1993) returning back to 2.5 in 1996-97 (Tobias and Jackson 2001). The findings from the Atlas of Avoidable Deaths for Australia and New Zealand (Page, Tobias et al. 2006) indicate no change in Maori/Europeans (others) amenable mortality ratio up to the year 2001 and reports a worsening of the ratio for avoidable mortality (treatable and preventable) from 2.15 in 1986 to 2.73 in 2001. The same study considered the change in outcomes for Pacific compared to Europeans (others) over the same period. The ratio of Pacific/ Europeans (others) for amenable mortality increased from 1.61 in 1986 to 2.27 in 2001, for avoidable mortality from 1.4 to 2.1. Li et al. (2009) added to this literature by studying the Northern Territories and comparing the avoidable mortality among Aboriginal and Non-Aboriginal population there and with all Australian population. It turned out that among non-Aboriginal NT population avoidable mortality was close to being the same as the overall Australian avoidable mortality (the ratio ranges from 1 to 1.2 over the period from 1985 to 2004). At the same time the ratio of NT Aboriginal population avoidable mortality to that of Australian was consistently increasing over the period from 2.8 to 4.3 for males and from 3.1 to 4.9 for females. This increase was mostly due to the worsening of the differences in mortality amenable to health policies, while the difference in mortality amenable to medical care slightly improved over time.

Stirbu et al. (2006) documented a slightly higher risk in total avoidable mortality for the migrant population in the Netherlands (relative risk of 1.3) with relative risks greater than 3 for all infectious diseases and greater than 1.7 for several chronic conditions including asthma, diabetes and cerebrovascular disorders. Most of the ethnic difference was explained by demographic and socio-economic characteristics of the migrant population relative to the native Dutch.

The literature that provided evidence on inequalities in amenable/avoidable mortality by ethnicity and race was reinforced by the studies of socioeconomic variations in these measures, which support the earlier finding of a significant income gradient in amenable mortality. Two studies used individual level data to compare the likelihood of deaths from avoidable causes depending on socio-economic factors. Hjern, Vinnerljung et al. (2004) found that being a foster child or other welfare recipient increases the likelihood of deaths from suicide or from other avoidable cause even after controlling for the characteristics of the biological mothers. Bautista et al. (2005) in a matched case-control study at a Spanish hospital concluded that the only significant factor in determining the likelihood of death from avoidable causes is education. Individuals with low or middle level of education are at a much greater risk than those with higher levels of education (adjusted odds ratios are 3.6 and 2.8 respectively).

In the earlier literature differences in avoidable/ amenable mortality were also reported between blue and white collar workers, working and non-working population (Westerling, Gullberg et al. 1996).

To summarize, the most recent literature as well as the earlier studies, despite differences in the study design, region or the time period considered, find that there is a much greater risk of death from avoidable/ amenable causes for those who are considered disadvantaged because of either ethnicity or socio-economic status. Furthermore, no evidence is found for the narrowing of this gap.

Table A3 in the Appendix provides information on all studies investigating socio-demographic/ economic variation in avoidable/ amenable mortality.

3.1.3 Time trends

All studies of avoidable mortality generally show a significant decline in mortality from causes amenable to medical care and that this decline is much stronger than the decline in mortality from 'non amenable' causes. Wheller, Baker et al. (2007) for England and Wales estimated a 3.3-3.6% annual decline in amenable mortality for males and a 2.9-3.2% for females depending on the list of conditions used to measure amenable mortality over the period from 1993 to 2005. This is similar to the estimated annual decline of 3.6% over the period between 1970/74 and 1985/87 for the whole population and is somewhat higher than the 2.7% decline found for the period between 1955/59 and 1970/74 (Boys, Forster et al. 1991). In Australia the average annual decline was 3.5% for males and 3.9 % for females over the period from 1968 to 2001 (Korda and Butler 2006). Similarly, in South Korea the annual decline of 3.7% for mortality from treatable conditions and of 2.4% for mortality from preventable conditions was observed over the period from 1983 to 2004.

A summary of the literature on time trends in avoidable mortality can be found in Table A4 in the Appendix.

3.2 UK studies

Table 2 summarizes the findings from 7 studies of time trends in amenable mortality measures, however defined, for the United Kingdom. It includes studies that either directly estimated avoidable mortality rates as a percentage of all-cause mortality or that included figures that allowed us to calculate these percentage rates. The studies are from 2004 onwards for the UK or for England and Wales only. In order to compare with previous time periods, the results by Boys, Forster et al. (1991) and Nolte and McKee (2004) are also reported.

Four of the studies focus on very similar conditions considered amenable. These also analyse separately deaths from IHD (Newey, Nolte et al. 2004; Nolte and McKee 2004; Wheller, Baker et al. 2007; Nolte and McKee 2008). Three further studies provide comparable estimates with respect to mortality amenable to medical care from 1980 to 2003, whilst two other studies allow for the comparison of mortality amenable to both medical care and health policies (from 1990 to 2008). In 1980s, avoidable mortality from causes other than the IHD constituted about 20% of all-cause mortality for males and about 36% of that for females. In 2003, these numbers fell to 16% and 28% respectively. Mortality from causes amenable to health policies remained stable or even increased slightly over this time period. For example, Newey, Nolte et al. (2004) show that from 1990/91 to 2002/03 this changed from 13.5% to 13.9% for males and from 9.7% to 11.5% for females. If considered jointly, avoidable mortality (both medical care indicators and health policy indicators) over the period from 1990 to 2008 declined from about 30% for males and 41% for females to about 28% and 32% respectively. Further, avoidable mortality from IHD in 1980 represented 34% of all-cause mortality for males and 20% for females. However, this has changed dramatically over time with the latest estimates being 14.8% for males and 7.9% for females.

Overall, mortality from conditions amenable to healthcare and health policy has declined from 1955 to 2008. In every period studied, the decline in non-avoidable mortality was much smaller than the decline in avoidable mortality. The decline in mortality rate for IHD in 1970-87 was comparable to the decline in non-avoidable mortality. However, in the periods that follow (starting from the late 1980s) the decline in the avoidable mortality rate for IHD has been considerably greater than that for other avoidable causes. It is clear from these findings that avoidable mortality (as a percentage of all-cause mortality) over the last half of the 20th century and first 8 years of the 21st century has been declining by an average of 3% a year. At the same time non-avoidable mortality (as a percentage of all-cause mortality) has been declining on average by less than 1% a year. These estimates for the UK seem to suggest that the healthcare sector may have had a role in reducing all-cause mortality and avoidable mortality. The precise causal connection and the degree of this connection is, however, yet to be investigated and explained.

Table 2: Changes in amenable mortality over time in the United Kingdom: summary of results from selected studies of 'avoidable' mortality

	Time period	Country	Causes amenable to medical care / health policy			IHD		All other causes	All causes
			No. causes (age)	% of all deaths	Change/year (%)	% of all deaths	Change/year (%)	Change/year (%)	Change/year (%)
Boys, Forster et al. 1991	1955-1987	ENG& WALES	22 (0-64)*	1985-87: 12.2	1955-70: -2.7 1970-87: -2.9	1985-7^: 42.9	1955-70: n.a 1970-87: -0.9	1955-70: n.a 1970-87: -0.9	1955-70: -0.7 1970-87: -1.3
Treurniet, Boshuizen, and Harteloh 2004	1980-1998	UK	19 (MCI+HPI) (0-64)	n.a	1980-89: -3.1 1989-98: -2.1	n.a	n.a	1980-89: -1.2 1989-98: -2.6	n.a
Newey, Nolte, et al. 2004	1990-2002	UK	33MCIs, 3HPIs,IHD (0-74)*	1990/91: 16.0/13.5 (m), 30.9/9.7 (f) 2002/03: 16.3/13.9(m), 27.7/11.5 (f)	m -2.0 f -2.4		m -3.8 f -3.9	m -0.8 f -0.5	m -2.1 f -1.8
Nolte and McKee 2004	1980,1990, 1998	UK	34 (MCI+HPI), IHD (0-74)*	1980: 19.6 (m) 35.9 (f) 1990: 15.9 (m) 30.8 (f) 1998: 17.4 (m) 29.9 (f)	1980-90: m -3.5 f -2.8 1990-98: m -1.3 f -2.1	1980: 33.7 (m) 20.1 (f) 1990: 31.4 (m) 19.7 (f) 1998: 25.6 (m) 15.1 (f)	1980-90: m -2.5 f -1.7 1990-98: m -4.1 f -4.2	1980-90: m -0.9 f -0.4 1990-98: m -1.4 f -0.6	1980-90: m -1.9 f -1.5 1990-98: m -2.2 f -1.8
Nolte and McKee 2008	1997/98 and 2002/03	UK	33 (MCI+HPI), IHD (0-74)	1997/98: 17.4 (m), 29.9 (f) 2002/03: 16.2 (m), 27.6 (f)	m -3.0 f -2.8	1997-98: 12.8 (m), 7.6 (f) 2002-03: 10.7 (m), 5.7 (f)	m -4.4 f -5.3	m -0.6 f 0.0	m -2.0 f -1.7
Wheller et al. 2007 (ONS web-site)§	1993-2008	ENG & WALES	35 (MCI+ HPI) (0-74)	1993: 36.0 (m), 41.6 (f) 2000: 33.4 (m), 38.3 (f) 2008: 27.7 (m), 32.2 (f)	m -3.4 f -3.1	1993: 23.1 (m), 15.2 (f) 2000: 19.1 (m), 11.6 (f) 2008: 14.8 (m), 7.9 (f)	m -3.9 f -4.1	m -1.1 f -0.6	m -2.6 f -2.2
Gubb 2007	1999-2005	ENG & WALES	12 (0-74)				-5.9		

* - age varies for some causes (see the bibliographic table below for the information on studies dated 2004-2008 and Nolte and McKee (2004) for earlier studies), ^ - 25-64 age limit for IHD, § - figures for England separately are not reported here for the lack of difference with England and Wales.

4. Some limitations of the empirical application of the concept of 'avoidable mortality'

Rutstein's seminal idea to use his list of conditions for which death could be avoided by timely and effective healthcare as indicators of the poor quality and effectiveness of healthcare, has over the years received a number of criticisms. In this section, we will briefly summarise some of these criticisms.

One of the most striking criticisms raised is the lack of a significant association found between avoidable mortality rates and healthcare inputs. The main argument posed is that healthcare inputs (e.g. number of doctors and nurses, expenditure, etc.) are not an ideal measure of healthcare as these merely reflect quantity and not the quality of healthcare.

Second, counts of deaths from amenable conditions are taken from death certificates compiled by medical doctors. Hence, some of the differences that we detect both at the country/regional level and over time may be due to dissimilarities in the death certification procedures and in diagnostic patterns (Nolte and McKee 2004). These limitations do not, however, undermine the concept of avoidable mortality itself but rather the use of these statistics as a source of data.

A further drawback of using death registries is that no mention is given to the incidence and severity of the diseases under investigation. In fact, no data on the incidence or severity of the disease seem to be reported in the studies on regional mortality. This poses a significant challenge to the interpretation of time trends and cross-regional differences in avoidable mortality as attributable to differences in healthcare quality. For example, an increase in the mortality rate due to tuberculosis/other disease in developed countries may be related to an increase in the incidence of the disease, for example due to immigration from countries with a high incidence of TB, and this certainly should not be attributed to a decline in the quality of healthcare. Further, the severity of a disease may be due to individuals' health-seeking behaviour, which may also vary by region and/or over time. Although this kind of behaviour may be affected by active health promoting policies, it is to a great extent outside the scope and control of healthcare providers. Despite these concerns, studies which do control for the incidence of a disease as measured from hospital discharge data (Carr, Szapiro et al. 1989; Treurniet, Looman et al. 1999) find a significant degree of variation in avoidable mortality, which is not explained by its incidence for the majority of conditions.

Another problem is posed by the introduction of somewhat arbitrary age limits. Rutstein's et al. list (1976) already contains some restrictions by age: e.g. only deaths occurring to people younger than 50 years from acute respiratory infections, influenza, pneumonia, and bronchitis are considered avoidable. Later studies imposed age limits on most conditions and these have been increasing over time. Unfortunately, these impositions and extensions of age limits seem to be poorly justified. Most studies do not provide any rationale for the age limits, while explanations of others could be questioned. For example, Charlton et al. (1983) set the age limits for each cause "to increase the proportion of mortality potentially avoidable", Holland (1986) – to improve "validity of mortality as an indicator of health service outcome". Nolte and McKee (2004) justify the setting of age limits for hypertension and stroke by referring to two large studies of systolic hypertension which summarized the existing evidence from clinical and epidemiological observational studies. However, this is provided only as an example and age limits for other conditions are simply chosen to "reflect increasing expectation of life" and to acknowledge the problem with the reliability of death certification at older ages. At the same time they confirm that the imposition of age limits should be an important issue in the debate on avoidable mortality that had not yet been properly addressed. A later study by Page et al. (2006) provides the following general arguments for further extending the age limit: (i) increase in overall life expectancy (now about 80 years in developed countries), (ii) better health at older age (probably relating to fewer comorbidities), and (iii) better coding "which allowed a single cause to be coded for most deaths" in spite of multiple comorbidities.

There is also concern with respect to the degree of 'avoidability' of deaths for certain diseases. There is a clear understanding in the literature that not 100% of deaths in the list of avoidable conditions are truly avoidable. However, the general consensus is that a substantial proportion of deaths should be avoided by medical intervention, prevention, or healthcare policies. However, there are some conditions for which the proportion of avoidable deaths is far from substantial (if we think of substantial in the range of 80-90%). For example, Poikolainen and Eskola (1988) developed a list of

'partly avoidable' conditions, without providing the reasons for such a classification. Tobias and Jackson (2001) used experts' opinions to assign weights for primary, secondary, and tertiary avoidable mortality, with primary being due to wider healthcare policies and prevention. The problem with these partial 'avoidability' weights is that often the authors do not provide the grounds for assigning them, referring at best to expert opinion. One of the conditions that poses most difficulties in this respect is Ischemic Heart Disease (IHD), given that medical knowledge in this area has been growing rapidly in recent years. Ideally one would like to have a systematic review of the medical literature, both experimental and epidemiological, on each of the avoidable mortality conditions so that an informed decision can be made on the appropriate degree of avoidability to assign to each condition. Nolte and McKee (2004) provide a review of the medical and epidemiological literature on the effectiveness of treatment for IHD and stroke, indicating for each the percentages of the effectiveness of various treatment. However, their review is far from being systematic. Based on the uncertainty surrounding the beneficial effects of healthcare on IHD, the authors choose to analyse it separately. Some later studies (e.g. Page, Tobias et al. (2006)) based their choices of the degree of avoidability on Nolte and McKee's conclusions, claiming that 50% of mortality due to IHD should be considered avoidable.

Finally, the list of avoidable conditions has been arbitrarily changed to adapt to particular contexts and over time. However, it seems that Nolte and McKee's review of 2004 and their proposed list has offered a consolidated platform for subsequent studies.

5. Conclusions and future work

This review of the literature has described the concept of avoidable mortality from its first inception to more recent days and summarised its empirical applications, following Nolte and McKee's extensive review of 2004, to which this review poses as an important update.

We found that the empirical applications of the notion of avoidable mortality have been widely used to establish the extent to which people are dying from amenable conditions within and/or across countries and over time, and whether socio-economic status and ethnicity are related to mortality from amenable conditions. Most studies have used data drawn from national death registries, with only two which to our knowledge have attempted to link the concept of avoidable mortality to routinely collected administrative data of healthcare provision, such as hospitals. A number of criticisms have been raised, with probably the most remarkable being the lack of association found between avoidable mortality and healthcare inputs. None have actually attempted to use the concept of avoidable mortality within the original aim envisaged by Rutstein, i.e. as a quality indicator of healthcare provision.

Future work in this area should focus on investigating the link between the provision of healthcare and the concept of avoidable mortality, with a particular emphasis on using routinely collected administrative data, such as hospital discharge data. These usually contain information on important medical (diagnosis and treatments) and demographic characteristics of the patients, as well as information of healthcare provision and resource use, and hospital characteristics. This type of analysis would allow a better understanding of the links between avoidable deaths (both within hospital and after a certain time from discharge) and the provision of healthcare. But perhaps most importantly it would allow us to understand whether the list of conditions of avoidable mortality is a good indicator of the quality of healthcare provision.

Appendix

Table A1: Causes of death considered amenable to healthcare and prevention

Causes amenable to healthcare (avoidable, treatable)	Nolte and McKee (2004)			Page et al. (2006)		
	Age Limits	ICD-9 codes	ICD-10 codes	Age limits	ICD-9 codes	ICD-10 codes
Infectious diseases						
Intestinal infections (other than typhoid, diphtheria)	0-14	001-009	A00-A09			
Other infections (diphtheria, tetanus, poliomyelitis)	0-74	032, 037, 045	A36, A35, A80			
Whooping cough	0-14	033	A37			
Septicaemia	0-74	038	A40-A41			
Measles	1-14	055	B05			
Selected invasive bacterial and protozoal				0-74	034-036, 038, 084, 320, 481, 482, 485, 681, 682	A38-A41, A46, A48.1, B50-B54, G00, G03, J02.0, J13-J15, J18, L03
Hepatitis				0-74	070	B15-B19
HIV/AIDS				0-74	070	B20-B24
Tuberculosis	0-74	010-018, 137	A15-A19, B90	0-74	010-018, 137	A15-A19, B90
Influenza	0-74	487	J10-J11	0-74	487	J10
Pneumonia (only viral in PT)	0-74	480-486	J12-J18	0-74	480	J12, J17.1, J21
Neoplasms						
Colon and rectum	0-74(‡)	153-154	C18-C21	0-74	153-154	C18-C21
Melanoma of skin				0-74	172	C43
Skin (nonmelanotic)	0-74(‡)	173	C44	0-74	173	C44
Breast	0-74	174	C50	0-74	174	C50
Cervix uteri	0-74	180	C53	0-74	180	C53
Vervix uteri and body of the uterus	0-44	179, 182	C54, C55	0-74	179, 182	C54, C55
Testis	0-74(‡)	186	C62			
Hodgkin's disease	0-74(‡)	201	C81	0-74	201	C81
Leukaemia (only lymphoid in PT)	0-44	204-208	C91-C95	0-74	204.0, 204.1	C91.0, C91.1
Thyroid				0-74	193	C73
Lip, oral cavity and pharynx				0-74	140-149	C00-C14
Oesophagus				0-74	150	C15
Stomach				0-74	151	C16

Causes amenable to healthcare (avoidable, treatable)	Nolte and McKee (2004)			Page et al. (2006)		
	Age Limits	ICD-9 codes	ICD-10 codes	Age limits	ICD-9 codes	ICD-10 codes
Liver				0-74	155	C22
Lung				0-74	162	C33, C34
Bladder				0-74	188	C67
Benign				0-74	210-229	D10-D26
Nutritional, endocrine and metabolic conditions						
Diseases of the thyroid	0-74	240-246	E00-E07	0-74	240-246	E00-E07
Diabetes mellitus	0-49	250	E10-E14	0-74(§)	250	E10-E14
Neurological disorders						
Epilepsy	0-74	345	G40-G41	0-74	345	G40-G41
Circulatory diseases						
Rheumatic heart disease (Only Chronic in NM)	0-44(‡)	393-398	I05-I09	0-74	390-398	I01-I09
Hypertensive disease	0-74	401-405	I10-I13, I15	0-74	402	I11
Ischaemic heart disease	0-74($)	410-414	I20-I25	0-74(§)	410-414	I20-I25
Cerebrovascular disease	0-74	430-438	I60-I69	0-74(§)	430-438	I60-I69
Aortic aneurysm				0-74	441	I71
All respiratory diseases (excluding pneumonia /influenza)	1-14	460-479, 488-519	J00-J09, J20-J99			
Digestive disorders						
Peptic ulcer	0-74	531-533	K25-K27	0-74	531-534	K25-K28
Appendicitis	0-74	540-543	K35-K38	0-74	540-543	K35-K38
Abdominal hernia	0-74	550-553	K40-K46	0-74	550-553	K40-K46
Cholelithiasis (& cholecystitis)	0-74	574-575.1	K80-K81	0-74	574-575.1	K80-K83, K85, K86, K91.5
Chronic liver diseases (excluding alcohol related)				0-74	571.4-571.9	K73, K74
Genitourinary disorders						
Nephritis and nephrosis	0-74	580-589	N00-N07, N17-N19, N25-N27	0-74	403, 580-589, 591	I12, I13, N00-N09, N17-N19
Obstructive uropathy				0-74	592, 593.7, 594, 598, 599.6	N13, N20, N21, N35, N99.1
Benign prostatic hyperplasia	0-74	600	N40			
Maternal and infant causes						
Maternal deaths	all ages	630-676	O00-O99			

Causes amenable to healthcare (avoidable, treatable)	Nolte and McKee (2004)			Page et al. (2006)		
	Age Limits	ICD-9 codes	ICD-10 codes	Age limits	ICD-9 codes	ICD-10 codes
Birth defects				0-74	237.70, 740-760	H31.1, P00, P04, Q00-Q99
Congenital cardiovascular anomalies	0-74	745-747	Q20-Q28			
Perinatal deaths all causes excluding stillbirths	all ages	760-779	P00-P96, A33, A34	0-74	764-779	P03, P05-P95
Respiratory diseases						
DVT with pulmonary embolism				0-74	415.1, 451.1	I26, I80.2
COPD				45-74	490-492, 496	J40-J44
Asthma				0-44	493	J45, J46
Misadventures to patients during surgical and medical care	all ages(‡)	E870-E876, E878-E879	Y60-Y69, Y83-Y84			
Drug use disorders						
Alcohol related disease				0-74	291, 303, 305.0, 425.5, 535.3, 571.0-571.3	F10, I42.6, K29.2, K70
Illicit drug use disorders				0-74	292, 304, 305.2-305.9	F11-F16, F18, F19
Unintentional injuries						
Road traffic injuries				0-74	E810-E819	V01-V04, V06, V09-V80, V87, V89, V99
Falls				0-74	E880-E886, E888	W00-W19
Fires and burns				0-74	E890-E899	X00-X09
Accidental poisoning				0-74	E850-E869	X40-X49
Drownings				0-74	E910	W65-W74
Intentional injuries						
Suicide and self-inflicted injuries				0-74	E950-E959, E980-E989	X60-X84, Y87.0, Y10-Y34
Violence				0-74	E960-E969	X85-Y09, Y87.1

(‡) condition not included as 'amenable condition' in Denmark, Finland and Sweden (Nolte and McKee, 2004)
(§) condition considered 50% amenable in Page et al. ($) Analysed separately in Nolte and McKee (2004)

Table A2: Empirical studies of avoidable mortality – analyses of geographical variation (cross-sectional and longitudinal) (2004 onwards)

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Nolte & McKee (2008)	USA, 14 western European countries, Canada, Australia, New Zealand and Japan	1997-98 and 2002-03	Rank countries by amenable mortality and estimate the overtime change focusing on the USA. 'Avoidable mortality': conditions amenable to healthcare with only half of the mortality from IHD considered amenable (treated separately).	Basis: Nolte and McKee (2004) - 33 conditions plus IHD treated separately - Age limit 0-74 (diabetes mellitus under 50, intestinal infection, whooping cough, measles, childhood respiratory disease under 15, leukemia under 44)	<u>Cross-sectional and time trend</u> Age standardized death rates by sex at the country level, ranking of countries.	By 2002-03 amenable mortality had fallen in all countries with the decline averaged at 17 percent for males and 14 percent for females over the period from 1997-98. The decline in amenable mortality constituted more than 10 percent for all countries except the US (4 % for males and 5% for females), Sweden (8% for females), and Denmark (9% for females).
Nolte, Scholz, & McKee (2004)	Lithuania, Hungary, Romania, West Germany (for comparison)	1980-1997	Examine the contribution of healthcare into life expectancy in Central and Eastern Europe and compare the levels and trends to West Germany. 'Avoidable' mortality: conditions amenable to secondary prevention or medical treatment.	Basis: Nolte et al. (2002) - 28 conditions with IHD treated separately - Age limit 0-74 (diabetes under 50)	<u>Cross-sectional and time trend</u> Decomposition of differences in life expectancy due to deaths from avoidable conditions following Andreev (1982), Arriaga (1984) and Pressat (1985).	In the 1980s, falling infant mortality from amenable conditions made a substantial contribution to improvements in temporary life expectancy in all countries. At older ages, falling amenable mortality contributed about 40% among those aged over 40 in Germany and, to a lesser extent, in Hungary, while causing a loss of life expectancy in Romania. In the 1990s, improvements in infant mortality continued to make substantial contributions to life expectancy in Lithuania and Hungary but had little impact in either Germany or Romania. Among adults, improvements in amenable mortality continued to benefit Hungarians and west Germans. In Lithuania, up to two-thirds of the gain in temporary life expectancy were attributable to falling mortality from ischaemic heart disease, whereas medical care otherwise seems to have had a negative impact. Romanian men and women experienced increases in amenable mortality that contributed up to a half of the overall loss of life expectancy.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Treurniet, Boshuizen, & Harteloh (2004)	15 EU countries, the Czech Republic and Hungary	1980-1997	Analyse international variations of trends in 'avoidable mortality'. 'Avoidable' mortality: causes amenable to both medical care interventions and national health policies.	Basis: Holland's list (1988, 1993) - 19 causes - Age limit 0-64	<u>Cross-sectional and time trend</u> Age and sex directly standardized mortality rates (using European standard population) are studied employing a multilevel (random slope) model to estimate both a general Europe-wide trend and individual differences in trends among countries in AM.	Avoidable mortality declined (1980–1997) in all the countries except Hungary. The difference between the trends in avoidable and non-avoidable mortality was small (-2.4% compared to -1.5% per year. The largest trend variations between countries are attributable to causes mainly or partly amenable to prevention. For five of the 19 causes of death the international variations decreased over time. Various countries show trends that deviate significantly from the mean trend.
Newey, Nolte, et al. (2004)	25 EU member states, Bulgaria and Romania	1990-2002	Examine the trends in treatable and preventable mortality in 25 EU member states and 2 candidate countries between 1990 and 2002. 'Avoidable' mortality: treatable mortality, preventable mortality and IHD.	Basis: Nolte and McKee (2004) - 33 treatable conditions, 3 preventable and IHD - Age limit 0-74 (intestinal infections, whooping cough 0-14, measles, respiratory disease (excl. pneumonia and influenza) 1-14, uterine cancer, leukemia 0-44, diabetes 0-49, maternal, perinatal deaths, misadventures to patients during surgical and medical care – All)	<u>Cross-sectional and time trend</u> Age standardized avoidable mortality rates by gender are compared between 1990/91 and 2000/01/02 for 25 EU member states, Bulgaria and Romania. Time trends for 7 countries (Hungary, Poland, Slovenia, Romania, Sweden and Portugal) are examined over the period 1990-2002.	This analysis demonstrated a clear east-west divide in avoidable mortality in the early 1990s for both men and women. The findings suggest that both Romania and Bulgaria, scheduled to join the European Union in 2007, have a considerable way to go to achieve the health outcomes seen in their neighbouring EU countries (e.g. avoidable mortality in Romania and Hungary compared to Sweden in 1990/91 was 4 times higher for men and 3 times higher for women, while all-cause mortality was only about double the rates). In contrast, most countries that have joined the European Union in 2004 have made considerable progress in modernizing their health systems as reflected by the improvements in health outcomes, i.e. treatable mortality.

Author(s)	Country/region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Weisz, Gusmano et al. (2008)	France, England and Wales and USA (Paris, Inner London and Manhattan)	1988-1990 and 1998-2000	Compare the three rich countries of the OECD in avoidable mortality and their largest cities. 'Avoidable' mortality: premature deaths amenable to medical interventions.	Basis: Nolte and McKee (2004) - 22 conditions (without IHD and with 50% of IHD deaths) - Age limit 1-75 years, childhood infections are excluded	<u>Cross-sectional and time trend</u> Age and gender standardized mortality rates. Regression controlling for the income levels for the period 1998-2000.	France has the lowest mortality rates in both periods (1.38 and 1.19 per 1000 population respectively). The US exhibits higher overall mortality rates, but similar AM rates compared to England and Wales (when excluding the IHD deaths). Rates of AM are lowest in Paris and highest in London. Avoidable mortality rates are higher in poor neighbourhoods of all three cities; only in Manhattan is there a correlation between the percentage of deaths that are avoidable and an income related variable.
Page, Tobias, et al. (2006)	Australia and New Zealand	1981-2001	Study the time trend of avoidable and amenable mortality in Australian and New Zealand regions and overall. 'Avoidable' mortality: amenable causes (causes whose case fatality could be substantially reduced by currently available healthcare technologies; preventable causes (causes whose case fatality could be reduced by preventing the condition from occurring in the first place).	Basis: Tobias and Jackson (2001) updated and revised - 27 amenable conditions (diabetes, IHD and cerebrovascular disease – 50%) and 21 preventable conditions - Age limit 0-74 (asthma 0-44, chronic obstructive pulmonary disease 45-74)	<u>Cross-sectional and time trend</u> Age standardized mortality rates by cause are analysed for both males and females. The associations between avoidable mortality and socio-economic status, ethnicity in different regions are described.	Almost three quarters of all deaths at ages 0 to 74 years in Australia and New Zealand for the period 1997 to 2001 were considered to be avoidable: 71.5% in Australia and 74.4% in New Zealand. In Australia, 40.2% of these avoidable deaths are considered to be amenable to healthcare. In New Zealand, the proportion is higher, at 43.2%. Total mortality at 0 to 74 years accounted for 41.5% of deaths at all ages in Australia, and 43.7% in New Zealand. There was also a clear socioeconomic gradient in rates for all causes of avoidable mortality and for most conditions examined. The Indigenous/Maori rate of deaths from avoidable causes was much higher than the rate for the European/non-Indigenous population.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
James, Manuel, et al. (2006)	Canada	1975-1999	Examine mortality trends from avoidable causes in Canada. 'Avoidable' mortality: conditions amenable to medical care or public health.	Basis: Holland (1997) - 13 conditions amenable to medical treatment plus IHD analysed separately, and 3 health policy indicators - Age range 5-64 (IHD, hypertension, cerebrovascular disease, and lung cancer 35-64, breast cancer 25-64, cervical and uterine cancer and Hodgkin's disease 15-64, ulcers 25-64, maternal mortality 0-64)	<u>Cross-sectional and time trend</u> National and regional (5 regions) age-standardized mortality rates using the direct method with Canada 1991 as the reference population.	From 1975-1979 to 1995-1999, the decrease in avoidable mortality (46.9%) was more pronounced compared to mortality from other causes (24.9%). There were persistent regional avoidable mortality differences with consistently lower avoidable mortality in Ontario and British Columbia compared to the Atlantic, Quebec and Prairies regions, with no difference in mortality from other causes. Injuries, IHD and lung cancer strongly influenced the overall avoidable mortality trends.
Schwierz & Wubker (2009)	East and West Germany	1996-2004	Identify selected factors influencing the decrease in the number of avoidable deaths from IHD in West and East Germany.	- IHD - Age limit 1-64	<u>Panel</u> Age standardize mortality rate by the expected mortality for age groups, fixed effect with the panel data.	Increasing number of intracardiac catheter facilities (an important diagnostic tool for IHD) significantly account for decreases in avoidable mortality from IHD.
Sundmacher, L. (forthcoming in 2011)	Germany	2000-2004	Identify areas in Germany burdened by exceptionally high rates of amenable cancer mortality and investigate the marginal contribution of healthcare on amenable cancer using counties as the unit of analysis. 'Amenable' to medical care types of cancer.	Basis: Nolte and McKee (2003), Ward et al. (2006) - 10 conditions (only selected malignant neoplasm types) - Age limit 0-75	<u>Panel</u> Age standardized death rates as dependant variables in the Poisson regression model with fixed effects and robust standard errors.	Amenable cancer mortality rates differ significantly among small areas of Germany showing a clear north-south gradient in men and less in women (higher rates in the north). The regression results suggest that the quantity of healthcare, measured by the number of physicians and the number of beds in all hospitals, is not significantly associated with amenable cancer mortality. However, the differences in socio-economic and environmental factors do explain differences in amenable cancer mortality rates.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Bares, Gispert, et al. (2005) (in Spanish)	Spain (Catalonia)	1986-2001	Analyse time trends and geographical variation in avoidable mortality by health areas in Catalonia. 'Avoidable' causes: those amenable to medical care and those responsive to health policy (preventable).	Basis: Department of Health of Catalonia - 18 conditions - Age limit 5-64 (uterine cancer 15-64, cardio rheumatic disease 5-44, respiratory disease 1-14, asthma 5-44, hypertensive and cerebrovascular diseases 35-64, complications related to pregnancy and delivery, motor accidents – all ages, cholera and tetanus 0-64, whooping cough 0-14, osteomyelitis 1-64, cirrhosis 15-74, ADS 20-49)	<u>Cross-sectional and time trend</u> Age standardized mortality rates, Poisson regression to estimate time trends.	The mean annual change for avoidable causes was -2.43% (95% CI, -2.60 to -2.26), higher than the -1.57% (95% CI, -1.61 to -1.52) change for general mortality. The rates were higher for preventable causes than for treatable causes, although mortality decreased in both groups. The health area of Segre was notable for its significantly higher mortality from both treatable and preventable causes in both periods. Four health areas showed a significant increase in mortality from preventable causes but none showed an increase in mortality from treatable causes.
Duarte, Benach, et al. (2009) (in Spanish)	Spain	1990-2001	Describe the geographical distribution of avoidable and non-avoidable mortality in small areas in Spain by sex. 'Avoidable' causes: those amenable to medical care (including IHD) and those responsive to health policy (preventable).	Basis: Gispert et al. (2006) - 27 conditions - Age limit 0-74 (uterine cancer 15-74, asthma 5-49, maternal mortality and adverse events during medical treatment or surgery – all ages, IHD 35-74, leukaemia 0-14, diabetes 0-49)	<u>Cross-sectional and time trend</u> Empirical Bayesian model-based estimates of age-adjusted relative risk were displayed in small-area maps for each group of causes of death by sex.	There is a heterogeneous geographical distribution of avoidable mortality for both sexes. Areas with greater mortality are located in the south and northwest of Spain. Especially for hypertension, cerebrovascular disease and ischaemic heart disease in men there is a clear aggregation of deaths in these areas. Geographical distribution of non avoidable mortality in both sexes is similar to that described for these three causes.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Melchor, Nolasco, et al. (2008) (in Spanish)	Spain (Valencia)	1990-2004	Analyse time trends and the geographical distribution of avoidable mortality in the autonomous community of Valencia and its health departments by sex in the periods 1990-1994, 1995-1999, and 2000-2004. 'Avoidable' mortality: conditions amenable to medical care and preventable.	Basis: Holland (1991) - 17 treatable conditions and 4 preventable conditions - Age limit 5-64 (uterine cancer 15-64, cardio rheumatic disease and asthma 5-44, respiratory diseases 1-14, hypertension and cerebrovascular disease 35-64, maternal deaths, measles – All, cholera and tetanus 0-64, whooping cough 0-14, osteomyelitis 1-64, cirrhosis 15-74, accidents – All, AIDS 20-24)	<u>Cross-sectional and time trend</u> Age standardized mortality rates by sex are analysed over time and across the Valencia region.	The total number of avoidable deaths was 38,061 (7.1% of overall deaths). Men accounted for 76.2% and women for 23.8%. By groups, 82.4% were preventable and 17.6% were treatable. Preventable deaths represented 86.5% of deaths in men and 69.4% of those in women. Avoidable mortality in Valencia significantly decreased in both sexes, this decrease being more marked in the group of treatable deaths and in men. Mortality from lung cancer in women significantly increased. Between 2000 and 2004, none of the health departments showed a significant excess of treatable mortality.
Gubb (2007)	UK (England and Wales)	1999-2005	Analyse time trends in the 'biggest' killers in the UK (cancer and circulatory diseases) and compare the country position among other European countries. 'Avoidable mortality': mortality from conditions which are either amenable to treatment and medical care and/or amenable to secondary prevention through early detection.	Basis: Nolte and McKee (2004): - 12 conditions (circulatory disease and cancer) analysed separately - Age limit 0-74 ('malignant neoplasm of cervix uteri and body of the uterus' and 'leukaemia', where an age-limit of 44)	<u>Cross-sectional and time trend</u> Age standardized mortality rates.	The major finding is that the rate of avoidable mortality from the two 'major killers' (cancer and circulatory diseases) has fallen over time at an increasing rate with the only exception for cancer between 1999 and 2005. The decrease in avoidable mortality for England and Wales was higher than the average for 11 European countries at similar level of development, but Austria that started at a similar position has performed much better. However, despite greater improvements AM still remains very high in England and Wales compared to other European countries.

Table A3: Empirical studies of avoidable mortality – analyses of variation by socio-demographic factors (2004 onwards)

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Hayen, Lincoln, et al. (2004)	Australia (New South Wales)	1980-2000	Study the changes in inequalities by socio-economic groups in potentially avoidable mortality over time. 'Primary avoidable mortality': deaths from conditions which are preventable through change in individual behaviour or through health policies.	Basis: Tobias and Jackson (2001) - 3 (lung cancer, road traffic injury, IHD) - Age limit 0-74	<u>Cross-sectional and time trend</u> Age standardized mortality rates for local government areas, Poisson regression to assess changes in deaths rates by SES group after adjusting for age.	Rates of Primary Avoidable Mortality have decreased steeply for the three SES groups (20% lowest, 60% middle, and 20% highest), with the rates decreasing by 51% in males and 44% in females between 1980 and 2000. The relative gap between the highest and the lowest SES group and between the highest and the middle SES group increased for both males and females. The results are similar for all three conditions analysed separately.
Korda, Butler et al. (2007)	Australia	1986, 1991, 1997, 2002	Investigate the distribution of the benefits of healthcare across the SES distribution through the comparison of declines in avoidable and non-avoidable mortality. 'Avoidable' mortality: causes amenable to medical care, causes mainly responsive to health policy, and IHD.	Basis: Nolte and McKee (2004) - 34 conditions (Medical Care Indicators) plus IHD treated separately, plus 3 Health Policy Indicators - Age limit 0-74	<u>Cross-sectional and time trend</u> Pooled cross-section time trend analysis using the aggregated area data with two models: negative binomial and quasi-Poisson with SES, year and their interaction separately for avoidable and non-avoidable mortality. The first model is used to identify differences in time trend for the Relative Index Inequality (= the ratio of the rate of mortality that is predicted for the lower end of the socioeconomic continuum to the rate of mortality for the higher end). The second – for the Slope Index of Inequality (=absolute difference in standardized mortality ratios predicted for the lower and higher ends of socioeconomic continuum).	The annual percentage decline in avoidable mortality at the higher end of the socioeconomic continuum was larger than that at the lower end, with relative inequality increasing between 1986 and 2002, greater than that in non-avoidable mortality. In absolute terms, avoidable deaths fell annually by 7.4 and 8.4 deaths per 100 000 at the higher and lower end of the spectrum, respectively, with absolute inequality decreasing between 1986 (SII = 97.8) and 2002 (SII = 81.5).

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Piers, Carson, et al. (2007)	Australia (Victoria)	1979-2000	Describe trends in avoidable mortality in Victoria by sex, degree of socio-economic disadvantage and remoteness among local government areas (LGAs).	Basis: Tobias and Jackson (2001) - 56 conditions (partitioned into primary, secondary, and tertiary prevention) - Age limit 0-74	<u>Cross-sectional and time-trend</u> Age standardized mortality rates by sex, tests of the differences in time trends using OLS regression methods for the logarithms of age standardized mortality rates (in log form).	Total avoidable mortality rates declined significantly in both males and females between 1979 and 2001, but were significantly higher in males compared with females and in rural compared with metropolitan LGAs. Total avoidable mortality rates in the least disadvantaged quintile were significantly lower than those in the most disadvantaged quintile over the entire five-year period in males and in three years in females. Total avoidable mortality rates were highest in remote LGAs and lowest in highly accessible LGAs.
Li, Gray et al. (2009)	Australia (Northern Territories)	1985-2004	Analyse the rates of avoidable and non-avoidable mortality in Aboriginals and non-Aboriginal residents compared to the all-Australian magnitudes. 'Avoidable' conditions are divided into conditions amenable to medical care, conditions responsive to population-based health policies, and IHD.	Basis: Korda and Butler 2006 (NM 2004) - 34 conditions (Medical Care Indicators) plus IHD treated separately, plus 3 Health Policy Indicators - Age limit 0-74	<u>Time trend</u> Age standardized mortality rates by sex and Aboriginality, NT and Australia (Poisson regression)	Over the period from 1985 to 2004 the avoidable mortality rates fell by 18.9% in Northern Territories Aboriginal peoples, by 61% in Northern Territories Non-Aboriginal peoples, and 59% in Australians overall. Aboriginal people continue to experience higher avoidable mortality and the difference tends to increase over time. Most of the decline in avoidable mortality for aboriginal people occurred for conditions amenable to medical care.
Schwarz & Pamuk (2008)	Austria	1981 and 1991	Identify which causes of death contributed most to the increase in educational inequality in mortality over the decade from 1981 to 1991 in Austria.	Basis: Blakely et al (2005) - Colorectal cancer, lung cancer, IHD, cerebrovascular disease, diabetes, respiratory disease, injury, suicide - Age limit 30-74	<u>Cross-sectional and time trend</u> Estimation of the slope index of inequality (SII) and relative index of inequality (RII) for overall mortality and by cause.	Among men, increasing education-related disparity in deaths from ischemic heart disease was the major contributor to the change in disparity in overall mortality. Without this increase, mortality disparity would have declined. In women, increasing education-related disparity in deaths from ischemic heart disease also contributed most to the slight increase in absolute inequality in overall mortality, but diabetes and colorectal cancer also contributed significantly. In relative terms, there were striking increases in disparity for deaths from colorectal cancer and digestive diseases among men, and for diabetes deaths among women.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
James, Wilkins, et al. (2007)	Canada	1971, 1986, 1991, 1996	Examine the income related differences in avoidable mortality over a 25 year period after the establishment of universal insurance for doctors and hospital services in Canada (metropolitan neighborhoods). 'Avoidable' mortality: conditions amenable to medical care and health policies.	Basis: previous literature - 41 condition amenable to medical care plus IHD analysed separately, plus 6 conditions amenable to health policies. - Age limit 0-74 (IHD, hypertension and cerebrovascular disease 35-74, intestinal infection, whooping cough, leukemia 0-14, measles and acute respiratory infections 1-14, breast cancer 25-74, cervical and uterine cancer 15-74, diabetes and asthma 0-49).	Time trend Changes in age-standardized expected years of life lost (SEYLL) from causes amenable to medical care and health policies between the 1st and 5th income quintiles over the 25 year period.	Differences between the richest and poorest quintiles in age-standardised expected years of life lost amenable to medical care decreased 60% in men and 78% in women; those amenable to public health increased 0.7% in men and 20% in women; those lost from ischaemic heart disease decreased 58% in men and 38% in women, and from other causes decreased 15% in men and 9% in women. Changes for deaths amenable to medical care were significantly larger than those for deaths amenable to public health or other causes for both men and women.
Stirbu et al. (2006)	Netherlands	1995-2000	Investigate the association between avoidable mortality and ethnic origin and analyse the role of socio-economic and demographic factors in the association and the influence of the duration of residence in the Netherlands on the risk of death from 'avoidable' conditions. 'Avoidable" mortality: treatable conditions.	Basis: Tobias and Jackson (2001) - 24 conditions plus HIV/AIDS and suicides - Age limit 0-74, childhood infections are excluded	Cross-sectional Poisson regression with age-standardized mortality rates to estimate relative risk by ethnicity (with and without controls for socio-economic and demographic characteristics).	Found slightly elevated risk in total 'avoidable' mortality for migrant populations. Higher risks of death among migrants were observed from almost all infectious diseases and several chronic conditions including asthma, diabetes and cerebrovascular disorders. Migrant women experienced a higher risk of death from maternity-related conditions. Surinamese and Antillean/Aruban population had a higher mortality risk, while Turkish and Moroccans experienced a lower risk of death from all 'avoidable' conditions compared to native Dutch. Control for demographic and socioeconomic factors explained a substantial part of ethnic differences in 'avoidable' mortality.

Author(s)	Country/region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Tobias & Yeh (2007)	New Zealand	2000-2002	Quantify the contribution of healthcare to ethnic and socio-economic inequalities in health in New Zealand. 'Amenable': treatable mortality	Basis: Page et al. (2006) - 27 conditions - Age limit 0-74 (asthma 0-44)	<u>Cross-sectional and time trend</u> Age standardized mortality rates by sex from amenable causes is compared to the same measure from all causes and serves as a measure of the contribution of health system to the population health. Similar procedure is performed for different ethnic groups to arrive at a measure of health inequality. Afterwards, both approaches are combined to find the contribution of healthcare to changes in health inequality.	Amenable causes of death account for 27%, 34%, 33% and 44% of the total mortality disparity for Maori males, Maori females, Pacific males and Pacific females, respectively.
Tobias & Yeh (2009)	New Zealand	1981-2004	Estimate the contribution of healthcare to health gain, and to ethnic and socio-economic health inequalities. 'Amenable': treatable mortality	Basis: Page et al. (2006) - 28 conditions - Age limit 1-74 (asthma 0-44)	<u>Cross-sectional and time-trend</u> Time difference in age standardized mortality rates by sex from amenable causes is compared to the same measure from all causes and serves as a measure of the contribution of health system to the population health. Similar procedure is performed for different ethnic groups to arrive at a measure of health inequality. Afterwards, both approaches are combined to find the contribution of healthcare to changes in health inequality.	Approximately one third of the fall in mortality over the last quarter of the 20th century is accounted for by the fall in amenable mortality (implies only treatable causes) for the population as a whole, for all income groups and ethnic groups, except for Pacific people (no decline in amenable mortality)

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Strand & Tverdal (2004)	Norway (Oppland, Sogn og Fjordane, and Finnmark counties)	1974-78, 2000	Investigate the degree to which smoking, physical activity, marital status, BMI, blood pressure, and cholesterol explain the association between educational level and ischaemic heart disease (IHD) mortality and other forms of cardiovascular mortality, with main focus on IHD mortality	- IHD - Age limit 35-49 years old in 1974-78	<u>Cross-section</u> Estimation of relative risk (RR) using Cox regression with adjustments for various IHD related risk factors	IHD mortality risk was higher for people with low education compared with people with high education. Further, people with low education had also more adverse risk factors. Adjustment for smoking, physical activity, marital status, BMI, blood pressure, and cholesterol reduced the relative risks from 1.44 to 1.03 for men and from 1.91 to 1.24 for women.
Dahl, Hofoss, et al. (2007)	Norway	1994-1999	Analyse socio-economic inequalities in avoidable deaths. 'Avoidable' conditions are divided into conditions amenable to medical care, conditions responsive to population-based health policies, and IHD	Basis: Korda and Butler (2006) (NM 2004), only conditions applicable to adults 25 and older - 29 conditions (Medical Care Indicators) plus IHD treated separately, plus 3 Health Policy Indicators - Age limit 25-67 years	<u>Cross-sectional</u> Age-standardized mortality rates, multiple logistic regression analysis controlling for age, marital status, immigrant status, disability pension, unemployment, and equivalised household income.	Adjusted for sociodemographic and socioeconomic factors, education forms a marked and independent gradient in overall and non-avoidable mortality. With respect to the gradient in avoidable mortality it is the same as in the overall moratlity for women and is somewhat larger for men. Analysis by categories of avoidable mortality reveals for men the steepest gradient in mortality from preventable causes and for women from IHD. The gradient in mortality from treatable causes is even flatter than from non-avoidable causes.
Hem, Naes, et al. (2007)	Norway	1990-2001	Investigate if there are educational inequalities in causes of death considered amenable to healthcare in Norway and compare this with non-amenable causes. Avoidable mortality: deaths amenable to healthcare	Basis: Nolte and McKee(2004) - 33 conditions (plus IHD) - Age limit 25-49 and 50-74	<u>Cross-sectional</u> Cox hazard model to estimate the association between education and mortality adjusting for age separately for men and women.	Educational differences in amenable mortality from causes of death amenable to healthcare are significant in both age groups and sexes. This was seen both when including and excluding IHD. The effect sizes were comparable for amenable and non-amenable causes in both age groups and sexes, indicating that the healthcare system has no impact on the differences in avoidable mortality.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Strand & Kunst (2007)	Norway	1970, 1990, 1990-2000	Describe the association between childhood socio-economic position measures (parents; education, occupation, and income) and mortality, for both genders, and assess to what extent this association is mediated by adult socio-economic position.	- IHD, breast cancer - Age limit 25-45	Cross-sectional Estimation of relative risk (RR) using Cox regression with adjustments for adult socio-economic factors.	Childhood socio-economic position has a strong association with mortality from IHD, but not from breast cancer. There is a significant mediation effect for both men and women of the adult socio-economic position with respect to the childhood socio-economic position gradient.
Bautista, Alfonso, et al. (2005)	Spain	1998-2000	Study the associations between avoidable mortality and socio-economic factors in a matched case-control study. 'Avoidable' mortality: deaths from causes amenable to medical care.	Basis: Holland (1988) - 18 medical care indicators - Age limit 5-64 (uterine cancer 15-64, all respiratory disease 1-14, hypertension and cerebrovascular disease 35-64, whooping cough 0-14, tetanus 0-64, osteomyelitis and periostitis 1-64, maternal – All, perinatal - < 1 week)	Cross-sectional Conditional logistic regression for matched cases. The match is based on medical care indicators and age from hospital discharge data.	82 cases of death from avoidable causes were compared to 300 controls matched on medical care indicators and age. The variables that showed a statistically significant association with in-hospital avoidable mortality were number of diagnoses (the greater the number, the higher the risk), length of stay (patients staying seven or more days presented a lower risk), and education. Those patients with low and middle educational levels showed a greater risk of avoidable mortality (adjusted odds ratio 3.57 and 2.82 respectively) than those patients with higher levels of education.
Nolasco, Melchor, et al. (2009)	Spain (Alicante, Castellon, Valencia)	1996-2003	Describe the inequalities observed in preventable avoidable mortality (from selected causes) with respect to socio-economic status in small urban areas and analyse the changes in these inequalities over time. 'Avoidable' mortality: preventable avoidable mortality.	Basis: Nolte and McKee (2004): - 4 conditions: malignant tumor of the trachea, bronchus and lung, cirrhosis and other chronic disease of the liver, motor vehicle accidents and AIDS; - Age limit 0-74	Cross-sectional and time trend Age-standardized mortality rate using the European population as a standard by sex and Census Tract. Poisson regression to estimate the relative risk of death by socio-economic status, controlling for age and time trend. Each cause of death is analysed separately.	The analysis reveals inverse relationship between socio-economic status and risk of death from the four specified preventable avoidable causes for men but not for women. In terms of specific causes, AIDS shows the greatest differences in mortality between the lowest and highest SES groups.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Hjern, Vinnerljung, & Lindblad (2004)	Sweden	1991-2000	Compare rates of avoidable mortality in adolescence among child welfare recipients and inter-country adoptees with the general population. 'Avoidable' mortality: selected causes of death amenable to medical care interventions and health policies.	Basis: Rutstein et al. (1976) and Charlton et al. (1986) - 6 medical care indicators and 4 health policy indicators - Age limit: Adolescence (13-27)	Cross-sectional Multivariate analyses with Cox regressions of proportional hazards of time to event with the outcomes defined as avoidable mortality.	Intercountry adoptees had a high sex and age adjusted relative risk for suicide death only in comparison with the general population, while foster children and adolescents who had received other kinds of child welfare interventions had high sex and age adjusted relative risk for suicide death, as well as for other avoidable deaths. The relative risk of avoidable deaths for foster children and other child welfare recipients decreased considerably when compared with youth brought up in homes with similar psychosocial characteristics as their original home.
Grant, Munoz-Arroyo, et al. (2006)	UK (Scotland)	1981-2004	Study the time-trends and regional differences in avoidable mortality across Scottish regions. 'Avoidable' mortality: deaths amenable to medical care.	Basis: Nolte and McKee (2004) - 33 treatable conditions and IHD - Age limit 0-74 (intestinal infectious disease, whooping cough 0-14, respiratory disease (excl. pneumonia and influenza) 1-14, uterine cancer, leukemia 0-44, diabetes 0-50, misadventures to patients during surgical and medical care, maternal deaths – All)	Cross-sectional and time trend Regional differences in age standardized mortality rates, comparison of overall Scottish time trend in avoidable mortality to selected EU countries.	Age and sex standardized amenable mortality rate for the period 1981 to 2004 show considerable variation across Scotland. Descriptive analysis points to the existence of a gradient between deprivation and avoidable mortality. More deprived areas observe higher avoidable mortality. A comparison between Scotland and selected countries in the European Union shows that compared to the UK, France, Italy, Portugal, Austria and Spain, Scotland had higher avoidable mortality rates over the period 1980-1998 for both males and females. However, the difference has decline over time.
Macinko & Elo (2009)	USA	1980-2005	Analyse black-white differences in avoidable mortality and their development over time. 'Avoidable mortality' in four categories: conditions (1) amenable to medical care, (2) sensitive to public health policies, (3) IHD, (4) HIV/AIDS.	Basis: Nolte and McKee (2004) - 34 conditions (Medical Care Indicators) plus IHD treated separately plus HIV/AIDS, plus 3 Health Policy Indicators - Age limit 0-64, since black male life expectancy in 1980 was 64 years.	Time trends Age standardized mortality rates by sex and race and cause of death, negative binomial regression model to estimate relative mortality risk for black people versus white people.	In 2005, medical care amenable mortality was the largest source of absolute black-white mortality difference, contributing 30% of the difference in all-cause mortality among men and 42% among women. Avoidable mortality from causes sensitive to public health policies contributed 20% of the difference for men and 4% for women. Although absolute black-white disparities for most conditions diminished over time, relative disparities as measured by rate ratios changed little, except for HIV/AIDS for which relative risks increased substantially for both black men and women.

Table A4: Empirical studies of avoidable mortality – analyses of changes over time (2004 onwards)

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Korda & Butler (2006)	Australia	1968-2001	Investigate the time trend in avoidable mortality on Australia over the period 1968-2001 and compare the country to other 10 EU countries. 'Avoidable' mortality: causes amenable to medical care; causes mainly responsive to health policy, and IHD.	Basis: Nolte and McKee (2004) - 34 conditions (Medical Care Indicators) plus IHD treated separately, plus 3 Health Policy Indicators - Age limit 0-74	Time-trend Age standardized mortality rates by sex, comparison to 10 EU countries from NM (2004) and ranking.	Total avoidable death rates fell by 68% in females and 72% in males. The corresponding non-avoidable death rates fell by 35 and 33%. The annual declines were 3.47% in males and 3.89% in females in avoidable mortality rates and 1.09% and 0.95% respectively for non-avoidable mortality. In females, declines in death rates from causes amenable to medical care contributed 54% to the decline in avoidable mortality rates, ischaemic heart disease contributed 45% per cent, and causes responsive to health policy intervention contributed one per cent. In males, the corresponding contributions were 32%, 57% and 11% respectively. These rates, and the declines between 1980 and 1998, were comparable with selected European countries, with Australia's ranking improving over the period.
Burcin (2009)	Czech Republic	1990–2006	Evaluate the contributions of avoidable mortality categories in different age groups to the change in temporary life expectancy (ages 0-74) between 1990 and 2006. 'Avoidable' mortality: causes both treatable and preventable, and IHD.	Basis: Nolte and McKee (2004) and Newey et al. (2004) - 33 treatable conditions, 3 preventable and IHD - Age limit 0-74 (intestinal infectious disease, pertussis, measles 0-14, respiratory disease (excl. pneumonia and influenza) 1-14, uterine cancer, leukemia 0-44, diabetes 0-49)	Time-trend Age and sex standardized mortality rates are used to decompose temporary life expectancy changes over the period.	Observed decline in avoidable mortality among males in the Czech Republic was almost 40% and among females almost 38%, whilst the decrease in unavoidable mortality was 21% and 24%, respectively. The observed decline in avoidable mortality contributed significantly (among males 75% and among females 68%) to the total increase in average life expectancy expressed as temporary life expectancy between the ages of 0 and 75.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Luran, Lopes et al (2009)(in Spanish)	Colombia	1985-2004	Assess trends in avoidable mortality of preschool children in Colombia	Basis: Taucher (1979) - 46 conditions - Age limit <1 year, 1-4 years	<u>Time trend</u> Calculation of percentages of mortality due to avoidable conditions'.	In children aged less than one, the avoidable mortality accounted for more than 50% of recorded deaths. In children aged 1 to 4 - 40% of recorded deaths-deaths due mainly to respiratory diseases. Over the 20-year period, the avoidable mortality rate decreased by 34% in children aged less than one, and by 23% in children 1-4
Logminiene, Nolte et al. (2004)	Lithuania	1991-1999 compared to 1970-1990	Compare trends in 'avoidable mortality' (separately preventable and treatable) over two periods of time. 'Avoidable' mortality: causes of death amenable to healthcare ('treatable') and causes of death amenable to broader health policy ('preventable').	Basis: Holland (1997) - 14 conditions: 11 treatable and 3 preventable - Ages 5-64 for comparability; cervical cancer 15-64, rheumatic heart disease and asthma 5-44, respiratory disease 1-14, hypertens./cerebrovasc. 35-64, maternal deaths all years, liver cirrhosis 15-64.	<u>Time trend</u> Age standardized death rates using European Standard Population, graphical analysis of AM as a whole and by particular causes.	Avoidable mortality declined as a proportion of total mortality in Lithuania during 1991-1999 compared with 1970-1990 in spite of some initial rise in death rates from treatable and preventable causes in early 90s. In 1970-1990, avoidable causes of death accounted for 26.3% of all deaths. By 1991-1999 this figure had decreased slightly to 24.6%. At the same time, age-standardised death rates from avoidable causes increased by 8%. Avoidable mortality among men was considerably higher than for women in both periods. Increases were registered for death rates from tuberculosis, cervical cancer and liver cirrhosis and, immediately after the independence, also from hypertensive and cerebrovascular diseases and, among men, from lung cancer. This has, however, declined with time. Deaths from chronic rheumatic heart disease, asthma and other respiratory diseases, appendicitis, abdominal hernia, cholelithiasis and maternal mortality declined continuously over time.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Nante et al. (2005)	Italy (Liguria region)	1990-1992 and 1996-1998	Analyse life expectancy at birth and avoidable mortality in the region and compare it to the rest of Italy. ‘Avoidable mortality’ from selected causes of death which could be avoided “with primary prevention”, “with early diagnosis and intervention”, “with adequate diagnostic and therapeutic (hospital) services”, “with health services”.	Basis: Prometeo (2001) study - 4 conditions (MCI) plus 4 (Primary Prevention), analysed separately - Age limit 5-69 years	Time trend Age standardized mortality rates by sex and cause of death.	Compared to the rest of Italy, the Liguria region has generally low rates of avoidable mortality with the exception of AIDS (province of Genoa) and uterus cancer (province of Imperia).
Gispert, Serra, et al. (2008)	Spain	1987-2001	Evaluate the impact of avoidable mortality on changes in life expectancy at birth. ‘Avoidable’ mortality: deaths from causes amenable to health services and health policies.	Basis: Gispert et al. (2006) - 27 conditions avoidable by health service interventions plus 6 health policy indicators; - Age rage 0-74 (cervical and uterine cancer 15-74, asthma 5-49, IHD 35-74, diabetes 0-49, leukemia 0-14, alcoholic live disease 15-74, maternal mortality, perinatal conditions, adverse effects during surgical and medical procedures. AIDS/HIV, traffic accidents, suicide, homicide – all ages)	Time trend Decomposition of changes in life expectancy using the method developed by Arriaga (1984).	Life expectancy increased in all ages and both sexes primarily due to reductions in mortality amenable to health policy interventions. The highest improvement in LE was due to non-avoidable causes, but avoidable mortality through health service interventions showed improvements in LE in those younger than 1 year and in those aged 45-75 years.

Author(s)	Country/ region	Time period	Topic/aim of study	Number of causes	Design/method	Results
Chung, Song, et al. (2008)	South Korea	1983-2004	Evaluate the achievement of healthcare services by observing the time trend of avoidable death between 1983 and 2004. 'Avoidable' mortality: deaths amenable to medical care, secondary prevention and primary prevention (health policy indicators).	Basis: Holland (1993) 32 conditions (Medical Care Indicators and Health Policy Indicators) Age limit 1-64, maternal deaths 15-64	<u>Time trend</u> Age standardized mortality rates by age groups and sex.	The avoidable mortality rate (per 100,000 persons) decreased from 225 to 84 in men and from 122 to 41 in women. Accordingly, the proportion of avoidable deaths among all classifiable deaths was reduced by 8.1% in men and 6.4% in women. However, mortality rates from some preventable causes such as IHD and malignant neoplasms of lung, breast, cervix, and colorectum have been on the rise. Mortality preventable by appropriate medical care showed the greatest reduction (by 77.8%), while mortality preventable by primary prevention showed the least reduction (by 50%).
Wheller et al. (2007)	UK (England and Wales)	1993-2005	To analyse recent trends in avoidable mortality using lists of avoidable causes by NM (2004) and Page, Tobias et al (2006) and discuss options for the development of the National statistics of avoidable mortality. 'Avoidable mortality': causes of deaths which can be avoided through healthcare interventions (NM 2004), same plus conditions sensitive to public health policies (Page, Tobias et al. 2006).	Basis: - Nolte and McKee 2004 (34 conditions) - Page et al. 2006 (28 amenable to healthcare plus 22 preventable) - Age limit 0- 74	<u>Time trend</u> Directly age-standardized mortality rates, standardized years of life lost due to avoidable causes.	Levels of avoidable mortality between 1993 and 2005 decreased by 43-46% for males and 38-41% for females depending on the list of conditions used. Mortality from preventable causes decreased by 18% for males and 8% for females (Page et. al list). Mortality from all causes not considered avoidable decreased by 9-14% and 5-8% for males and females respectively.

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