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Official Statistics

Mortality statistics

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Abstract: The creation of civil registries, together with the obligation to report information on the deceased from the death certificate, have enabled the monitoring of various population health indicators. Data from death certificates, as compiled and disseminated by central statistics offices, are used to estimate different measures, most classically infant mortality and life expectancy. However, in high-income countries, infant mortality is no longer considered an appropriate measure of population health due to its low magnitude. From the health system perspective, the adoption of the International Classification of Diseases and Causes of Death was a crucial milestone in population health statistics, shedding light on the diseases responsible for most deaths and the trends in causes of death over time. Morbidity statistics and public health surveillance systems have important objectives, but they do not allow adequate monitoring of the frequency of diseases and other health problems, nor can they quantify diseases' impact on population health. On the other hand, statistics on cause of death do provide this information thanks to the combination of two features: the exhaustiveness of the data they collect and the objective nature of the phenomenon they quantify.

Keywords: Civil registries, death certificate, central statistics offices, infant mortality, life expectancy, causes of death, public health surveillance

MSC: 62-03, 62B86, 62P10, 62Q05

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1 Introduction

The emergence of the State entailed tremendous political, economic, and administrative advances in human societies. From an administrative point of view, the obligation to record vital events —births, deaths, stillbirths, marriages, and divorces— was established in order to know at all times what was the situation in which its citizens were in terms of their vital and marital status. Most European countries created such systems over the 19th century, although in some, such as Sweden, they were introduced as early as the 18th century (Mackenbach, 2020).

Prior to the 19th century, information on these phenomena was often available from parish records of baptisms, burials, and marriages. The information contained in these registries has been used to estimate changes in the structure of the population, such as birth, death, and marriage rates. But its uneven implementation does not provide a comprehensive vision of the evolution of these phenomena during this period. And a sufficiently valid comparison of these estimates according to different sociodemographic characteristics of citizens is not possible either.

Since the creation of civil registries, central statistics offices of the countries have been in charge of managing the data obtained in these registries for their compilation and subsequent dissemination. This has made it possible to rigorously assess trends in births, deaths, and marriage rates and to assess variations in the magnitude of these rates according to sociodemographic and geographic characteristics. Data on deaths in the civil registries come from the death certificates, and it is this information that central statistics offices compile and disseminate for their mortality statistics.Estimates of total and cause-specific mortality rates require information on the number of deaths (numerator) and the population at risk (denominator). In unlinked mortality studies, the numerator and denominator come from different sources, so there may be a numerator/denominator bias when estimating mortality rates according to certain individual attributes. This bias does not occur in linked mortality studies, in which data from the census or general population surveys are linked to vital records, and in the case of death, to the date and cause of death. However, regulations to protect individuals' confidentiality greatly limit the use of linked and unlinked mortality statistics for scientific research, whether due to the regulations themselves or because of the restrictive interpretations thereof by some statistical offices not always sufficiently argued. On the other hand, some methodological developments by these offices are of enormous relevance, for example, the linkage between socioeconomic indicators and mortality by the National Statistics Institute of Spain, which enables the study of the relationship between socioeconomic factors and mortality and its variation over time.

2 Classical population health indicators

In high-income countries, information on deaths, compiled and disseminated for central statistics offices, has been used to document the enormous reduction in infant mortality rate and the rise in life expectancy over the 20th century. For example, it is known that the infant mortality rate in different Western European countries ranged from 80 to 210 deaths per 1,000 live births in 1990. By the end of the century, these rates had converged and dropped precipitously across the region, standing at 3 to 6 deaths per 1,000 live births. In Spain, infant mortality fell from 204 to 4 per 1,000 live births between 1900 and 2000 (Gómez, 1991; Viciana, 2003). This reduction, together with parallel advances in medical treatments and living conditions, led to a dramatic increase in life expectancy, from 35.7 years in 1900 to 79.3 years in 2000 (Goerlich and Pinilla, 2006). Similar trends were observed in surrounding countries with a similar socioeconomic situation (MSC 2005).

Traditionally, infant mortality and life expectancy have been the classic indicators of population health status. However, in high-income countries, the low rates of infant mortality have reduced their usefulness as a sentinel indicator to reflect population health. On the other hand, life expectancy continues to be an ideal measure in that regard. Life expectancy at age x is the average number of years that a person of that age is expected to continue to live. This is a hypothetical measure since it does not measure the actual chances of survival. Its calculation is based on current mortality rates, which logically are subject to changes over time. Its fundamental advantage is that it can be used to compare different regions or countries and to observe their evolution over time, since it is not influenced by differences in the age structure of the populations being compared. In fact, the estimation of life expectancy has revealed the reversal of a key trend in Western Europe over the 20th century. People born in southern European countries in the late 19th and early 20th centuries could expect to live to around 40 years of age in Spain, Portugal, Italy, and Greece, lagging far behind their northwestern neighbors. However, the generation born in southern Europe the 1960s had a similar life expectancy as their northern peers, and by the 1980s life expectancy in southern European countries had surpassed that of some countries of higher latitudes (Mackenbach, 2020).

In the 21st century, life expectancy continues to be an ideal indicator for monitoring population health worldwide, since it reflects the impact that numerous health problems have on population mortality (WHO, 2022b). Figure 1 shows the evolution of life expectancy at birth in Spain from 2001 to 2020.

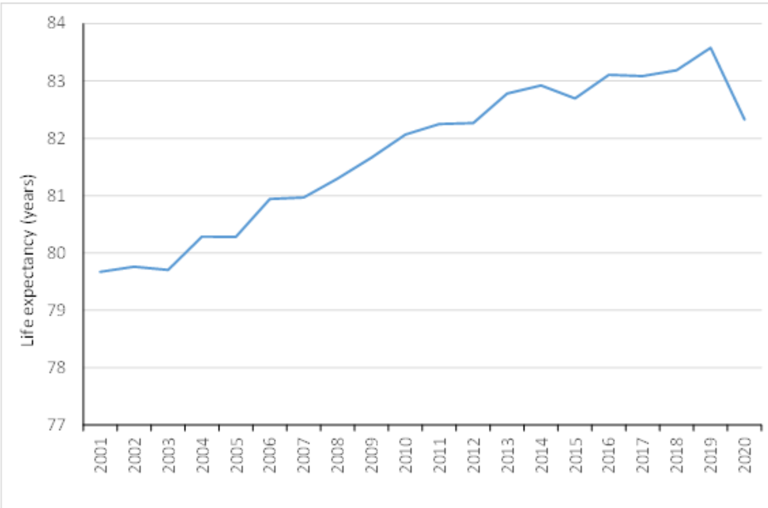

Figure 1: Life expectancy at birth. Spain, 2001-2020

Several years showed year-on-year decreases in life expectancy at birth, specifically 2003, 2005, 2015, and 2020, while this indicator hardly changed in 2007 and 2012. The increase in recorded deaths accounts for the decrease or maintenance of life expectancy each year compared to the previous one. The increase in deaths in the second half of 2003 was due to the heat wave that occurred that summer. In the rest of the years, except for 2020, the spikes in deaths were most likely the result of the increased intensity and/or duration of the influenza virus. The decrease in life expectancy from 2014 to 2015 —not only in Spain but also in most countries in the northern hemisphere— is notable (Ho and Hendi, 2018). In the 50 previous years, there had been no comparable reductions in life expectancy from one year to another; this decline is probably attributable to the combined effects of the two phenomena mentioned above: a particularly virulent flu season and a heat wave. As for

2020, the striking decline was due to the increase in deaths as a result of the COVID-19 pandemic.

The year-on-year changes in the number of deaths are also evident in the crude death rate, as shown in Figure 2. After all, life expectancy at birth can be considered a snapshot of the mortality of the population in a given period.

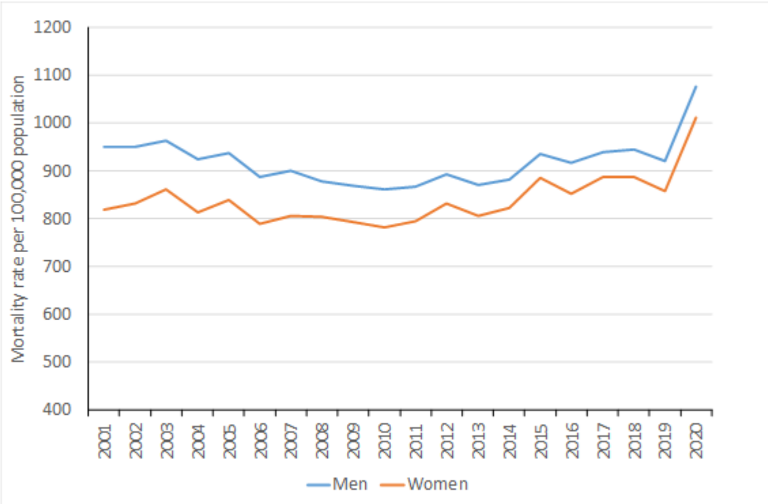

Figure 2: Crude death rate per 100,000 population. Spain, 2001-2020

3 International Classification of Diseases and Causes of Death

From a public health perspective, standardized recording of the cause of death in the civil registry was a milestone, providing valuable insight on the diseases responsible for the most deaths. A second great achievement was the establishment of an international classification of causes of death, which provided standard criteria for central statistics offices to use in the collection, processing, and classification of information, and for the presentation of death statistics.

The need for a common system to classify causes of death was recognized at the first International Statistical Congress, held in Brussels in 1853. The Congress asked William Farr and Marc d'Espine to prepare a standard classification of causes of death applicable to all countries. At the next Congress, in Paris in 1855, Farr and d'Espine presented two separate lists based on very different principles; the Congress adopted a version representing a compromise between the two. In successive years, that list was revised according to Farr's criteria, although it never gained universal acceptance. The first International List of Causes of Death would have to wait until Jacques Bertillon's proposal was approved by the International Institute of Statistics in 1893. This classification adopted Farr's criteria for distinguishing systemic diseases from those with a precise anatomical location. In 1899, the International Statistical Institute agreed to revise the list every 10 years in order to reflect advances in medical science and statistical procedures. Numerous revisions were undertaken throughout the 20th century. The most recent, known as the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10), was released in 1999. Since the sixth revision in 1948, when the World Health Organization (WHO, 2022a) took over its development, the Classification has also contained a list of causes of morbidity (Alderson 1988, WHO, 2022a).

The list of causes of morbidity has given rise to various classifications in different medical specialties and areas of the health system. Possibly the best known and most used is the International Classification of Diseases, Ninth Revision, Clinical Modification, which was published in the USA to classify diagnoses and reasons for health care contacts. It is a classification of both diseases and procedures, used to code clinical information derived from health care, mainly in hospitals and other specialized medical care settings.

Mortality statistics remain the most suitable indicator for monitoring trends in the burden of disease over time and from one place to another. However, this is not, nor can it be, the objective of the morbidity statistics derived from health services data. These statistics reflect the burden of disease that the health system has to deal with at any given time, but this information is not suitable for reflecting the trend in the frequency of diseases. This important distinction can be explained by the increase in healthcare resources, the growing size of the population covered by all types of healthcare insurance, improvements in diagnosis, and new indications for care. Moreover, some patients suffering from a disease may not use any health services, while others could be registered several times in the information systems of different health services. Likewise, patients could present to different health centers whose information systems are not interconnected. These circumstances, inherent to the health system of any country, make it impossible to ascertain whether the variations observed in morbidity reflect changes in the frequency of disease or only variations in the use of health services. Morbidity statistics have similar limitations in terms of their aptness for estimating geographic variations in disease frequency.

These imprecisions do not exist in death statistics, because a person dies only once. In addition to the objective nature of the phenomenon, the exhaustive nature of vital statistics makes mortality indicators very useful for monitoring diseases and other health problems and for establishing public health priorities. It is true that morbidity statistics from population-based disease registries enable an adequate comparison of the incidence —new cases— of diseases. But various limitations related to the clinical characteristics and diagnostic criteria for different pathologies, together with the inefficiencies inherent to these registries, mean that relatively few population-based disease registries exist.

4 Main causes of death

The available data on cause of death have revealed important changes in the percentage of deaths attributable to specific diseases. In high-income countries, the proportion of deaths from infectious diseases —tuberculosis, intestinal infectious diseases, influenza, and pneumonia— declined in the first half of the 20th century, while deaths from cardiovascular diseases and accidents rose. During the second half of the century, the contribution of these causes to total mortality decreased, while cancer deaths increased. Recent decades have also seen a rise in deaths from mental and neurological diseases, namely Alzheimer's disease and Parkinson's disease. However, since mortality statistics cannot reflect the burden of diseases and health problems that are not lethal, mental illnesses impose a much larger burden to the population than that reflected in these statistics.

Adequate estimation of mortality from cause of death requires high-quality information on this variable in death certificates. This quality has gradually improved. The quality of information on cause of death in national mortality registries has gradually improved. In Spain, for example, through the better inclusion of judicial and forensic information in cases where professionals from these fields are involved. This was not always the case: into the 1980s and 1990s, specific registries of mortality from AIDS or from acute reactions to drugs were necessary to adequately monitor the impact of these problems on population health (De la Fuente et al., 1995; Brugal et al., 1999). Another indicator of the quality of mortality statistics by cause of death is through the proportion of deaths that cannot be assigned to a specific cause of death. In Spain, the figure is around 2.

Currently, the leading causes of death in in high-income countries are cancer, heart disease and cerebrovascular disease. These three causes of death represent half of the deaths, as can be seen in Table 1 referring to Spain. The exception was the year 2020, since deaths from COVID-19 represented the third leading cause of death.

Cause of death	**Codes**	**2017**	**2018**	**2019**	**2020**
All causes		424,523	427,721	418,703	493,776
Malignant neoplasms (cancer)	C00-C97	109,073	108,526	108,867	108,533
Diseases of heart (heart disease)	I00-I09,I11, I13, I20-I51	85,143	83,744	80,444	82,309
COVID-19	U07.1, U07.2	..	..	..	74,839
Cerebrovascular diseases (stroke)	I60-I69	26,937	26,420	25,712	25,817
Alzheimer disease	G30	15,201	14,929	14,634	15,571
Chronic lower respiratory diseases	J40-J47	15,486	14,607	13,808	12,734
Influenza and pneumonia	J10-J18	11,397	12,267	10,843	11,676
Accidents (unintentional injuries)	V01-X59,Y85-Y86	11,502	11,530	11,827	11,297
Diabetes mellitus	E10-E14	9,773	9,921	9,644	9,662
Nephritis, nephrotic syndrome and nephrosis	N00-N07, N17-N19, N25-N27	6,757	7,269	7,369	7,517
Hypertensive disease	I10, I12, I15	4,787	4,998	4,912	6,239
Parkinson disease	G20-G21	4,656	4,583	4,615	5,008
Chronic liver disease and cirrhosis	K70, K73-K74	4,236	4,001	4,021	3,976
Suicide	X60-X84+Y87.0	3,680	3,541	3,673	3,941
Septicemia	A40-A41	3,800	3,040	2,885	2,745

Table 1: Number of deaths for the 15 leading causes of death for the total population. Spain, 2017-2020. (Cause of death and codes based on International Classification of Diseases, 10th Revision)

Many criteria are considered in the development of the ICD, for instance disease etiology, anatomical location, and clinical manifestations. Some diseases, including several infectious diseases, are even encompassed under other groups because one criterion is prioritized over another. Therefore, there is no single way of presenting the information. Table 1 shows the method used by the US National Center for Health Statistics and by the Spanish Ministry of Health to determine the main causes of death. But other institutions and central statistics offices use other techniques. For example, based on the large groups of the ICD, diseases of the circulatory system constitute the main cause of death in Spain. This statement is correct, but so is the more granular information in Table

1. Thus, when presenting such statistics, it is important to report the ICD codes used to group the selected causes of death.

The cause of death tabulated is the underlying cause of death. In accordance with WHO recommendations, medical death certificates include three causes of death: the immediate cause (the disease or condition that directly led to death), the intermediate cause of that disease or condition, and finally, the initial or basic cause (the disease or injury that initiated the aforementioned events that led to death). This last cause is the one used to disseminate information on causes of death, monitor the main diseases and health problems, and conduct research. However, on occasion, some countries' central statistics offices and some research groups disseminate information on the number of deaths according to multiple causes in order to consider various combinations of causes appearing on medical death certificates.

These calculations show that certain causes appear on the death certificates of many deceased people, even though they are not the basic cause of death. The utility of this information, however, is unknown. It can confound conclusions about mortality patterns by cause of death. A physician can include in the death certificate certain intermediate and immediate causes, but another physician can include other different intermediate and immediate causes. Furthermore, from a statistical point of view it makes no sense. If, instead of including the three causes of death mentioned above, numerous other causes could be included in the medical death certificate, the presence of some causes would increase even more than in the combination of multiple causes. The only way for an analysis of multiple causes of death to be logically rigorous would be to include all the causes of death from the ICD in a death certificate, and for the physician certifying the death to explicitly indicate whether each one was or not relevant to the case at hand —something completely crazy.

5 Public health surveillance

One objective of public health surveillance is the early detection of epidemic outbreaks for purposes of disease control. This endeavor requires a continuous collection of health data for analysis and interpretation, but not exhaustive information on each and every disease case (de Mateo and Regidor, 2003). Indeed, not all sick people use health services. Furthermore, the collection criteria may change to increase the validity of the measurement of the phenomenon under surveillance, as information emerges around the transmissibility of the infectious agent, its clinical manifestations, and the prognosis of the patients. Therefore, the real impact of an epidemic outbreak on the mortality of the population does not necessarily correspond to the deaths from cases that have been detected.

In most epidemic outbreaks, numerous media sources and large swaths of the scientific community criticize the mortality figures produced by public health surveillance systems. These criticisms were highly publicized during the COVID-19 pandemic. Most likely, such judgments are due to the poor understanding of this public health practice, together with the anxiety generated by epidemic situations. A very rough estimate of the impact of epidemic outbreaks on mortality is made using the daily mortality monitoring systems of public health surveillance institutions, or through weekly death statistics from central statistics offices. The true estimate can only be made much later, when the mortality statistics by cause of death have been consolidated, since these statistics are the ones that offer exhaustive data on deaths.

Notably, before the end of 2021, Spain was one of a very few countries worldwide that had exhaustive information on cause-specific mortality from 2020, when the first two waves of the COVID-19 pandemic occurred. This achievement was only possible due to the diligent efforts of the National Statistics Institute and the regional statistics agencies and death registries to expedite the compilation and dissemination of the cause-specific death statistics for 2020.

6 Conclusions

Mortality statistics remain the most suitable indicator for monitoring trends in the burden of disease over time and from one place to another. Information on deaths, compiled and disseminated for central statistics offices from the civil registries, has been used to document the enormous reduction in infant mortality rate and the rise in life expectancy. Likewise, from a public health perspective, standardized recording of the cause of death in the civil registry was a milestone, providing valuable insight on the diseases responsible for the most deaths. A second great achievement was the establishment of an international classification of causes of death.

The tabulation on basic cause of death is used monitor the main diseases and health problems, and conduct research. Sometimes, some countries' central statistics offices and some research groups disseminate information on the number of deaths according to multiple causes in order to consider various combinations of causes appearing on death certificates. The utility of this information, however, is unknown and it can confound conclusions about mortality patterns by cause of death.

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