What was Killing Babies in Palma, Spain? Analysing Infant Mortality Patterns Using Individual-Level Cause of Death Data, 1836–1930

By Joana Maria Pujadas-Mora

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What was Killing Babies in Palma, Spain?

Analysing Infant Mortality Patterns Using Individual-Level Cause of Death Data, 1836–1930

Joana Maria Pujadas-Mora
Open University of Barcelona & Center for Demographic Studies

ABSTRACT

This paper explores infant mortality patterns to determine the epidemiological profile of the port city of Palma, Spain between 1836 and 1930 using individual-level cause of death and testing the newly constructed ICD10h coding system. Throughout the 19th century, infant mortality was well below 150 per 1,000 live births, possibly related to the practice of extended breastfeeding and frequent vaccination campaigns. However, between 1840 and 1860, as in other Spanish and European cities, the situation deteriorated. From the 1890s to 1930, the rate was almost always below 100. Post-neonatal mortality was higher than neonatal mortality, and the two rates began to fall at different times: the former in the 1870s and the latter in the 1920s. The main causes of neonatal mortality were congenital and birth disorders, while for post-neonatal mortality they were infectious diseases, mainly airborne, followed by waterborne and foodborne diseases. The decline in these rates was influenced by several factors, including improvements to public hygiene and nutrition and the quantity and quality of water sources. With regard to sex, a more pronounced female advantage was observed in post-neonatal mortality than in neonatal mortality. The seasonality of neonatal mortality in the 19th century was characterised by two peaks in autumn and winter, possibly related to the seasonality of births. In the 20th century, a summer peak was also observed. Post-neonatal mortality showed a sharp peak in summer, which receded and gave way to a winter peak by the late 1880s.

Keywords: Demographic transition, Mortality decline, ICD10h, SHiP project, Southern Europe

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1 INTRODUCTION

This paper explores infant mortality patterns to determine the epidemiological profile of the port city of Palma, Spain between 1836 and 1930 using a unique approach based on individual-level cause of death from cemetery burial and civil registers. It is linked to a special issue on the causes of infant mortality in European port cities during the 19th and 20th centuries, following a common analytical framework based on a descriptive approach for all contributions. The second aim of this article is to test the new European coding scheme for historical individual causes of death, known as ICD10h[1], developed within the SHiP+ network.

Life expectancy in the Balearic Islands between 1860 and 1930 was consistently among the highest in Spain, rising from 41.7 to 57.6 years. In the city of Palma, the capital of the Balearic Islands, life expectancy was 42.55 years in 1900, rising to 53.17 years in 1930 (Blanes Llorens, 1996; Dopico & Reher, 1998). In this context, studying the decline in infant mortality becomes crucial, as it has a significant impact on the improvement of life expectancy and serves as one of the most sensitive indicators of the economic and social development of populations (Masuy-Stroobant & Gourbin, 1995; Reidpath & Allotey, 2003; van der Veen, 2001). Indeed, previous studies have shown that infant mortality rates in Palma, Spain were among the lowest in the country, as evidenced by aggregate data from the vital statistics compiled by the Spanish National Statistics Institute (Arbelo Curbelo, 1962; Gómez Redondo, 1992; Pascua, 1934; Pérez Moreda et al., 2015). Against this background, it becomes imperative to delve into the specifics of the decline in infant mortality from an individual perspective, as this will make it possible to thoroughly examine the aetiology of the causes of death. Such an approach will make a significant contribution to the ongoing — albeit classic — discourse on the determinants of mortality decline, as exemplified by the contrasting views of Mckeown (1976) and Szreter (1988).[2]

The study of infant mortality using individual causes of death is regionally feasible in Europe thanks to the availability of comparable local sources dating back to the 19th century (Pozzi & Ramiro-Fariñas, 2015), as shown in the special issue to which this paper contributes. This allows comparisons over time and across regions, providing insights into the regional variability inherent in the global phenomenon of demographic transition. Indeed, in Spain there is an important tradition in this area of research using such data, often presented in doctoral theses. Notable among these works is Sanz Gimeno's (1997) analysis of rural municipalities in the province of Madrid. Similarly, Ramiro-Fariñas (1998) looked at rural parishes in the provinces of Cáceres and Toledo, Robles (2002) focused on a rural sample in Alicante, and Pujadas-Mora (2009) concentrated on infant mortality in the city of Palma. All of them used a standardised classification of diseases based on the original international classification of diseases by Bertillon and that proposed by Thomas McKeown (1976) in his book *The Modern Rise of Population*, adapted by Bernabeu Mestre and Pascual (1998). It is also worth mentioning Anaut's (1997) study on Pamplona, Pareja's (1998) research on Bilbao, Brel Cachón's (1998) examination of the Esla Valley (León and Zamora), Marín Paz's (2017) investigation of Vejar de la Frontera (Cádiz), and the recent research on Hellín, Albacete by Cañabate Cabezuelos (2021), among others focusing on specific smaller localities.

The article is structured as follows: The remainder of this section provides a historical background of the city of Palma and presents the data sources used (data on individual causes of death were collected from both burial and civil registers). The following sections describe the results of the study, focusing on estimates of infant mortality and its components, neonatal and post-neonatal mortality, as well as their epidemiological patterns and seasonality of death. The article ends with conclusions.

1.1 THE PORT CITY OF PALMA

The city of Palma grew from around 40,000 inhabitants in 1842 to more than 87,000 in 1930 (Figure 1). This growth was more pronounced in the 20th century than in the 19th, with annual growth rates of over 1%. However, it should be borne in mind that the city of Palma was walled until 1902, which meant that subsequent urban expansion took place outside the traditional city limits. In fact, in the second half of the 19th century, annual population growth rates in the suburbs exceeded 2% (Pujadas-Mora, 2009). As a result, the population of Palma represented between 25% and 30% of the total

1 For a thorough understanding of ICD10h, see Janssens (2021).

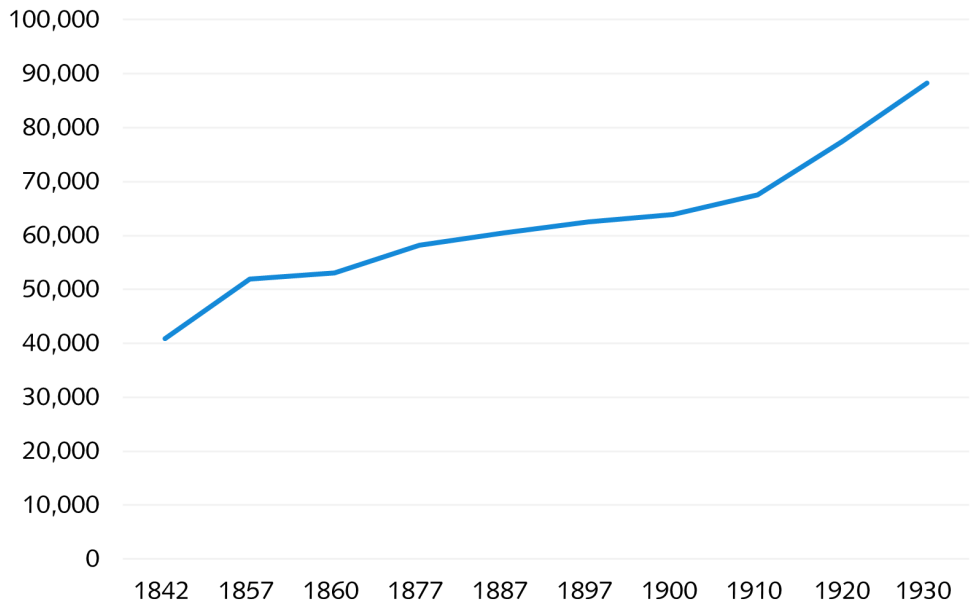
2 For a comprehensive overview of this debate, supplemented by recent contributions from other researchers, see Colgrove (2002) and Harris and Helgertz (2019).

population of the island of Mallorca, ranking it between the 10th and 12th largest Spanish capitals (out of the 50 existing capitals). Moreover, the island witnessed a significant transoceanic emigration to Cuba and the American countries of the Southern Cone, a cycle that did not end until 1930, with Palma serving as the starting point for this journey (Albertí Genovart, 2017; Buades Crespí, 2002).

As the administrative capital of the region, Palma became an industrial city during the study period, attracting newcomers from other parts of the island, mainly in search of employment opportunities, until 1920 (Albertí Genovart, 2017). The Mallorcan economy was characterised by a system of manufacturing combined with agrarian work. However, this did not prevent the emergence in Palma of factories linked to commercial capital, such as the textile and shoe industries (Escartín, 2001; Manera Erbina, 2001). Traditional workshops continued to operate alongside an increasing specialisation in the manufacture of products for export, mechanisation and the introduction of new techniques. In 1847, the first steamer was installed in a cotton yarn factory in the city (Escartín, 2001).

In 1877 there were almost 1,000 workshops and factories in the city (Escartín, 2001). By 1887, it is known that 30.37% of Palma's working-age population was employed in the secondary sector, 39.38% in the primary sector and 30.35% in the tertiary sector. These figures hide the work of children and women and the fact that people often had more than one job, a characteristic of industrialisation in the Balearic Islands that was particularly pronounced in the city. These elements further reinforced the importance of the manufacturing and industrial sector (Escartín, 2001). The commercial significance of the city should also be highlighted. Its port was included in the first classification of ports in Spain in 1852, as one of only seven Spanish ports of general interest. This was mainly due to the importance of its trading activity, with infrastructure adapted to the increase in maritime traffic and steamships.[3] Indeed, the Mallorcan fleet grew from 353 ships in 1830 to 1,112 in 1884, including 12 steamers (Escartín, 2001). Furthermore, trade with America was resumed in 1833 and the first steam line to Barcelona was inaugurated. In 1875, the first railway line was built from Palma to Inca, in the centre of Mallorca, and in 1877 the line was extended to the port of Palma. In the decades that followed, various branches were gradually built that would eventually connect almost the entire island to the city of Palma (Brunet Estarelles, 1989).

Figure 1 *Population of Palma, 1842–1930*



Source: Pujadas-Mora (2009).

3 Important dredging work was carried out in 1870–1871. The creation of the Board of Works of the Port of Palma by royal decree in 1872 gave the port greater economic autonomy to improve its infrastructure (Salas-Vives & Pujada-Mora, 2020).

Despite Palma's specialisation in manufacturing and trade, a significant part of the population worked in agriculture, as mentioned above. A large share of the agricultural labour force worked in orchards, such as the Pla de Sant Jordi, and in various large farms traditionally owned by the nobility. In the 19th century, Palma continued to be the seat of the nobility, which, although in decline, still controlled many of the island's large estates. Palma's agricultural land was used for both irrigated and dry farming, mainly producing crops such as almonds, olives, cereals and grapevines. The tertiary sector, particularly domestic service, was also an important source of employment, alongside the commercial sector, as the previous discussion of commercial activity has shown.

As the provincial capital, Palma was home to all the civil, military and religious institutions of the province, such as the Civil Government and the Provincial Council, as well as the General Captaincy and various quarters. It also housed all the provincial charitable institutions, including a foundling hospital, which took in all abandoned children from birth to eight years old, not only from the city of Palma but from the whole island of Mallorca (Pujadas-Mora, 2009), a hospice and the so-called General Hospital. At the same time, the ecclesiastical seat and the main educational institutions were located in the city. For example, the Balearic Institute was founded in 1835 on the initiative of the Mallorcan Economic Society of Friends of the Country, one of the private development associations that were common in Spain from the second half of the 18th century (Moll, 1975).

1.2 DATA SOURCES

Due to the varying quality and coverage of the demographic sources, death data were used from the burial register (1836–1881) and the civil register (1882–1960), amounting to 14,917 deaths, and birth data were used from the parish register (1836–1881) and again from the civil register, comprising 135,388 live births. While data on deaths were collected individually and in detail, birth data were only summarized by sex, month, and year.

The cemetery register is hardly used as a source of data in demographic studies, especially in Spain, compared to the use of parish and civil registers. They have their origins in a series of public decrees issued at the end of the 18th century to locate cemeteries outside urban centres. Thus, the new rural (municipal) cemetery of Palma was inaugurated in 1821, and the register began that same year. Its first regulation stipulated the following:

> When the corpses are brought to the cemetery, those who bring the body must give a note to one of the priests in charge, stating the name of the deceased, his age, his parents, the parish in which he lived, the time and cause of death and, if he had made a will, the date and the name of the executor, and this note must be given to the pallbearers at the house of the deceased […] (Pujadas-Mora, 2009, p. 88)

This note was recorded in the burial books. The crucial aspect of these certificates for the purposes of this article was the inclusion of causes of death from the beginning of the register series, a practice that was not widespread in parish books before the Royal Decree of 1 December 1837 required their inclusion (Bernabeu Mestre, 1992). Between 1836 and 1881, only 6.5% of the total number of certificates did not indicate a cause of death, 90% of which related to deaths that occurred between 1848 and 1855. From the 1860s, the burial certificate had to include the name and surname of the physician who had treated the deceased, who was not recorded in the church books.

The successful introduction of the civil register in Spain did not take place until 1871, although there had been a number of previous attempts, such as in 1813, 1823 and 1835. The secularisation of the demographic register was one of the constant aspirations of Spanish liberalism in the 19th century (Muro, 1996). From the very beginning of civil registration, the certification of a death had to be accompanied by a medical certificate issued by a physician (Article 75 of the Civil Registry Law of 1870). However, its beginnings were complicated by both organisational and budgetary issues.

It is important to note the quality recording of causes of death in the burial books from the outset, as mentioned above, and the problems of general coverage observed in the early years of the civil register (Pujadas-Mora, 2009). Also, in the cemetery books, deaths within the first 24 hours of life were recorded together with all other deaths, unlike in the civil register death books. As a result, the latter register under-represented deaths occurring within the first 24 hours of life until 1975, due to a legal rather than biological criterion used to distinguish between "live birth" and "dead birth". To this effect, a death in the first 24 hours was considered a stillbirth and was recorded in a separate book,

the so-called abortion books, which had to be destroyed by law (Ramiro-Fariñas, 1998). Exceptionally, however, they were found for the city of Palma, which allowed both death and birth data to be corrected (Pujadas-Mora, 2009). Similar problems have also been observed in Italy (Breschi et al., 2012) and in England and Scotland until the first decades of the 20th century (Davis, 2009).

2 OVERVIEW OF INFANT MORTALITY

Throughout the 19th century, the infant mortality rate in Palma was usually below 150 per 1,000 live births, with a few exceptions. In 1847, 1853 and 1865 it was between 150 and 200 per 1,000 live births. In 1868 it was slightly over 200 (Figure 2). An outbreak of smallpox was reported in 1847, possibly one of the last major epidemics of the disease. Measles appeared in epidemic form in 1853 and again in 1868. The city experienced its only cholera epidemic in 1865, resulting in approximately 1,900 deaths across all age groups. However, the number of children dying from cholera was relatively low, although concentrated in the summer months. In the same year, deaths from pneumonia rose sharply. Palma was also hit by a yellow fever epidemic in 1870. Infant mortality soared to just over 200 deaths per 1,000 live births, but mainly from causes unrelated to yellow fever.

Mortality in the first year of life increased steadily between 1840 and 1860, rising by 20% over the two decades. This trend was also observed in other Spanish regions (Gurría & Lázaro, 1999; Ramiro-Fariñas, 1998; Robles González, 1998; Sanz, 1997), England (Woods et al., 1993), Sweden (Sundin, 1995) and Norway (Thorvaldsen, 2002). Some authors have suggested that this increase in mortality could be due to a change in the virulence of the prevalent diseases (Fridlizius, 1984), while others have blamed urbanisation, weather changes (Thorvaldsen, 2002) or even administrative failures (Szreter & Mooney, 1998). This worsening was observed in both urban and rural areas. Recently, Davenport (2020) has shown how scarlet fever should be considered as a contributing factor due to a change in its virulence. However, the incidence of this disease in Palma was very low.[4]

From the 1890s to 1930, the infant mortality rate was below 100 per 1,000 live births, except in 1895–1896, 1904, 1906–1907 and 1918–1921 when it was slightly higher (Figure 2). In 1895–1896 there was a measles epidemic, the lethality of which was unprecedented in the 19th century. The other peaks do not represent particular epidemics, but were years characterised by a certain concentration of respiratory diseases such as bronchitis. It should be noted that the influenza pandemic of 1918 did not hit the Balearic Islands until its second wave. In fact, it did not reach Palma until September 1918, when there was an increase in the number of cases of influenza in the infant population, in addition to an increase in other types of illness such as congenital weakness, athrepsia and gastroenteritis, as explained below. There was no discernible third wave.

The decline in mortality rates coincided with the rise of industrialisation and population growth, both propelled by a steady influx of migrants from other parts of the island. However, this was accompanied by an improvement in the provision of medical, health and childcare services. In fact, a municipal network of doctors had existed on the island since the mid-19th century, providing free medical care to the poor. Despite the limited treatment options available at the time, these doctors also acted as public health agents, spreading hygiene principles throughout the community. Furthermore, the earliest primary care centres, known as *casas de socorro*, were established in the city of Palma at the end of the 19th century. These centres would gradually gain importance and integrate various medical specialities as a sign of the progress of modern medicine (Pujadas-Mora & Salas-Vives, 2021). It is also worth noting that municipal doctors were responsible for administering smallpox vaccinations and revaccinations to schoolchildren. The development of this primary healthcare system was reinforced by a network of religious convents that served important social purposes, such as charity, the education of women and home healthcare (Gallego Caminero, 2009; Moll et al., 2014).

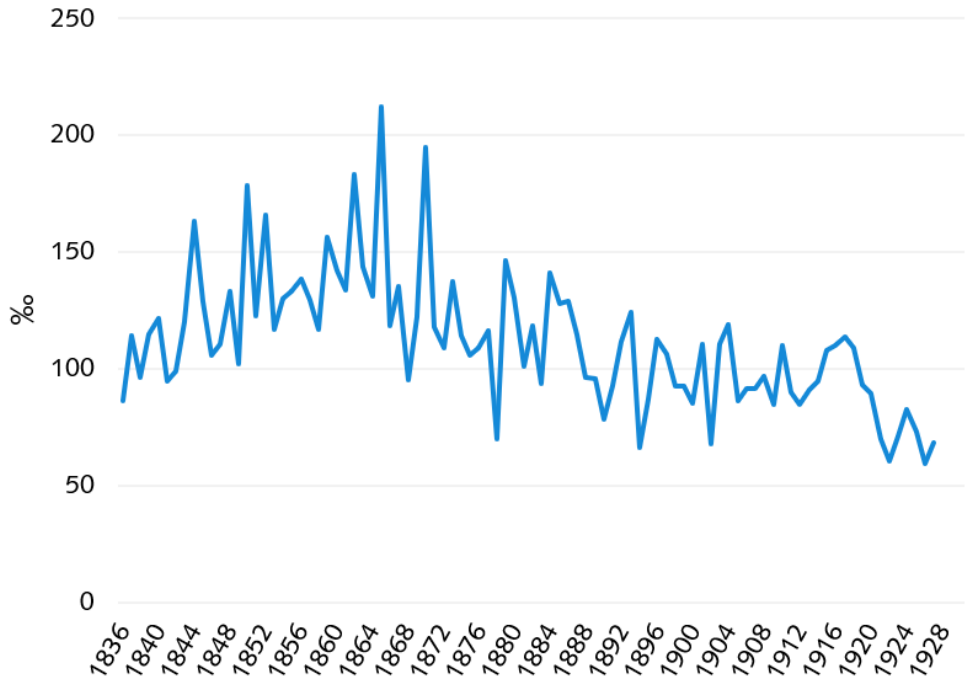
The establishment of childcare services in the city of Palma is particularly noteworthy. In January 1907, the Palma Milk Depot was inaugurated, offering a milk distribution service, medical check-ups and a school for mothers to promote and advise on breastfeeding. It was one of the first facilities of

4 During the study period, no neonatal deaths and only 29 post-neonatal deaths were reported as being due to scarlet fever in Palma.

its kind in Spain (Rodríguez Ocaña, 1987). The focus was on extended breastfeeding, as the Palma-based *Sociedad Protectora de la Infancia* (Society for the Protection of Children), founded in 1895, recommended breastfeeding for the first 18 months of life, while institutions such as the Foundling Hospital aimed for the first two years. Reflecting this stance, the medical community intensified its discourse on the necessity of breastfeeding, as articulated by Dr Josep Cerdá in *La Necesidad de la Lactancia Maternal* (1900). Cerdá highlighted the prevalence of wet nursing among the wealthy classes and contrasted it with the natural breastfeeding practised predominantly by the working classes. At the same time, he predicted that rural women would be healthier because of their active and labour-intensive lives, and that their milk would therefore be of better quality. Indeed, the Foundling Hospital consistently sought to place foundlings in rural communities for wet-nursing whenever their health allowed. Cerdá also reported having first-hand knowledge of advances in pasteurisation, which led him to affirm that mixed feeding was undoubtedly superior to wet and artificial feeding (Pujadas-Mora, 2009). In fact, many studies across Europe have shown that the practice and duration of breastfeeding are key to explaining the infant mortality rates and regional variations observed in the 19th century (Edvinsson et al., 2005; Fildes, 1992; Janssens & Pelzer, 2014; Kintner, 1988; Reid, 2002, 2017; Rollet, 1990; Thorvaldsen, 2008; van Poppel et al., 2005; Vögele, 2010; Walhout, 2010; Woods et al., 1988).[5] In addition, nurseries for working mothers were developed in the first decades of the 20th century. Although these were primarily private initiatives, they received considerable support from public authorities.

Contrary to the aforementioned factors that led to the decline in mortality, the Foundling Hospital, which served the entire island throughout the period analysed, contributed to an increase in neonatal mortality and, to a lesser extent, postneonatal mortality, especially from 1900 onwards. This rise can be attributed to the fact that the deaths of all abandoned children were registered in the institution, even if they were in foster care in the rural areas of the island (Revuelta, 2012). This could be crucial in explaining the so-called urban penalty (Ramiro Fariñas, 2007). Unlike the non-institutionalised population, mortality in the Foundling Hospital did not decrease, although the number of abandonments dropped significantly (Pujadas-Mora, 2009).

Figure 2 *Annual infant mortality rate in Palma, 1836–1930*



Source: Pujadas-Mora (2009).

5 For some authors, although breastfeeding was important in reducing mortality, other factors such as women's participation in the labour market may have been more determinant (Debuisson, 2001), even if breastfeeding was shortened (Wolleswinkel-van den Bosch et al., 2000).

Figure 3 *Quinquennial infant mortality rates by sex in Palma, 1836–1930*

Source: Pujadas-Mora (2009).

Regarding mortality by sex, there was a clear disadvantage for males in the first year of life (Figure 3). This means that males had an excess mortality throughout our study period, which was a common feature in 19th- and 20th-century Europe and was even observed in the 18th century (Barford et al., 2006; Gómez Redondo, 1992; Henry, 1989). The difference in mortality between the sexes remained more or less constant until 1921. This process would continue to the present day as a persistent feature, in contrast to older ages (Drevenstedt et al., 2008; Hill & Upchurch, 1995; Maiolo & Reid, 2020; Reid et al., 2016). Thus, the male disadvantage became more pronounced as mortality crises disappeared. That is, the lower the probability of dying in the first year of life, the greater the difference between the sexes. At the same time, the change in the epidemiological pattern with the Epidemiological Transition, i.e. the shift from infectious to non-infectious diseases, meant that a clear pre-eminence of perinatal causes developed among the very young. Thus, male vulnerability would increase with the change in disease pattern (Drevenstedt et al., 2008).

3 OVERVIEW OF NEONATAL AND POST-NEONATAL MORTALITY

Neonatal mortality showed a significant stabilisation between 1836 and 1890, with rates ranging from 25 to 30 deaths per 1,000 live births. However, its relative weight in the total number of infant deaths varied between 20% and 30%. A downward trend began in 1890 and accelerated in 1920, reaching values of 10 per 1,000 live births. In fact, this decline observed in the 20th century is a characteristic feature across Europe (Breschi et al., 2012; Raftakis, 2021; Ramiro-Fariñas, 1998; Reid & Garrett, 2012; Robles, 1998; Sanz, 1997). These relatively low neonatal mortality rates could suggest, as in the case of Sardinia, that post-birth mortality was under-recorded. However, neonatal mortality in Sardinia between 1866 and 1925 was only 6.1 deaths per 1,000 live births (Breschi et al., 2012), significantly lower than the rates observed in the Balearic capital. Furthermore, mortality within the first nine days of life accounted for an average of 56% of all deaths occurred in the first month between 1836 and 1899. This concentration indicates that the Palma register maintained a level of quality above expectations, comparable to the 40% proposed by Sanz (1997) for deaths in the first week of life in a rural sample from the province of Madrid.

Between 1836 and 1920, post-neonatal mortality accounted for an average of 75% of all child deaths. From 1921 to 1930, however, this percentage rose to around 85%. In fact, mortality in this age group increased throughout the mid-19th century, rising from 82 per 1,000 live births in 1836–1840 to a maximum of 116 and 114 in 1861–1865 and 1866–1870 respectively. This corresponds to the period

of deterioration in infant mortality mentioned earlier. There was then a downward trend until 1891–1895, when a period of stabilisation began that lasted until 1916–1920. However, there was a marked increase around the years of the influenza pandemic. This excess mortality was not entirely attributed to influenza. From this five-year period onwards, a clear downward trend was observed, reaching a threshold of 60 deaths per 1,000 live births.

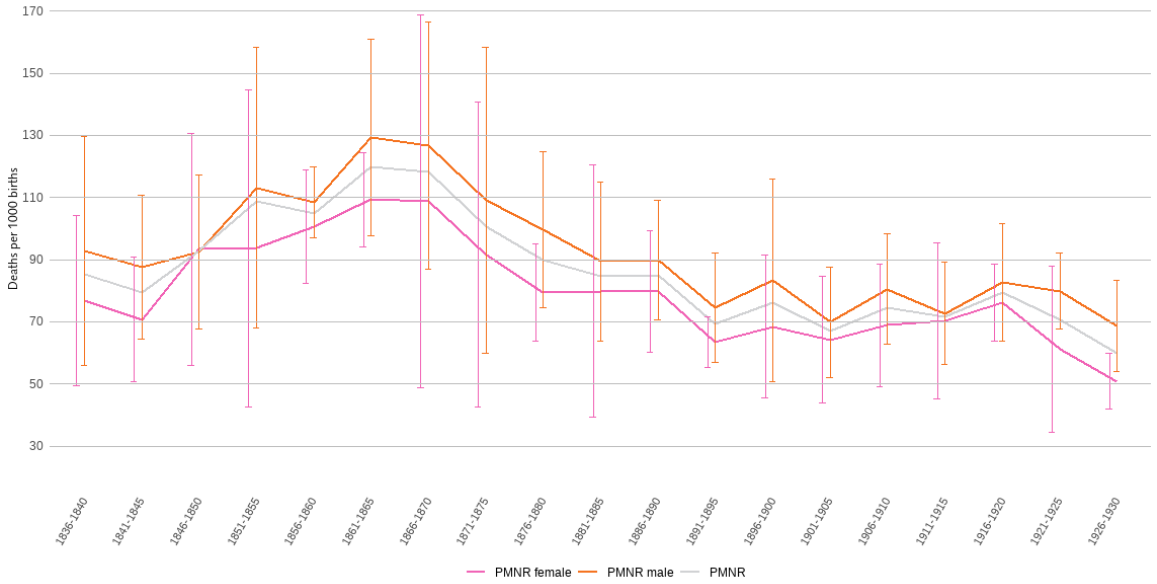
As regards sex differences in both neonatal and post-neonatal mortality, there was a more pronounced female advantage in the case of post-neonatal mortality (Figure 4). In the periods 1846–1850, 1851–1855, 1856–1860 and 1896–1900, neonatal mortality was about 1.5 times higher for males than for females. Some of these periods coincide with epidemics, such as smallpox in 1847 and measles in 1853 and 1896. In the case of 1847, there was a higher incidence of smallpox among males. From 1896, the sex gap in infant mortality became increasingly less pronounced. However, in the specific case of post-neonatal mortality, this gap did not seem to diminish, with the exception of the period 1901–1920, after which it returned to the values at the beginning of the series. The female mortality rate was thus only between 70% and 80% of the male value. In general, the advantage of women was evident in both neonatal and post-neonatal mortality, the latter being more pronounced.

Regarding the most prevalent causes of death, in the case of neonatal mortality, congenital and birth disorders accounted for a maximum of 15 deaths per 1,000 live births (Figure 5). Between 1851 and 1865 the rates fell, which was unusual as this was a time when neither pregnancy nor childbirth had been medicalised and certified midwives were not easily found. Exceptionally, in 1913 the City Council of Palma hired three midwives for poor families (Pujadas-Mora & Salas-Vives, 2021). The decline in the mortality rate due to congenital and birth disorders coincides with an increase in the number of death certificates with no cause from 1846, suggesting that in earlier periods bodies entering the cemetery were not always accompanied by properly completed burial notes. It is notable, however, that rather than relying on loosely defined terms based on lay declarations (from family members), the cemetery caretaker chose to be faithful to the limited information available. This practice may also explain the paucity of neonatal deaths attributed to water and foodborne diseases before 1861, after which their incidence increased.

This decrease could also be related to the noticeable but slight increase in the number of deaths attributed to weakness between 1861 and 1865 (to 4 deaths per 1,000 live births), which can be interpreted as a transfer of deaths from one category of disease to another. The category of weakness never again had such an important relative weight in the whole series of deaths analysed. Tangentially, convulsions had a slight presence between 1836 and 1845, but not throughout the whole period studied, which could also be interpreted as the reported case of weakness. Thus, there was no significant decrease in congenital and birth disorders until the 1920s. It is possible that all these variations, and those mentioned in the previous paragraph, depend more on the quality of diagnosis than on changes in the epidemiological pattern or in the determinants of mortality.

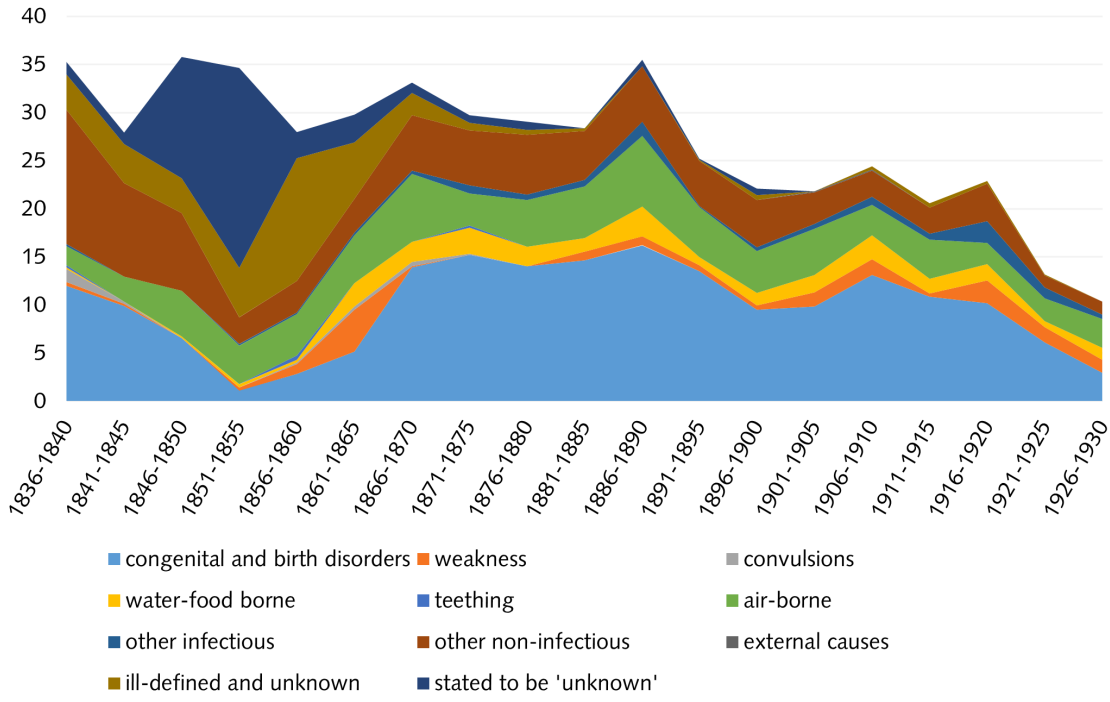
Airborne diseases were always present among the infectious causes of neonatal mortality. This mode of transmission was also the most common among infectious causes of death, with two peaks in the periods 1866–1870 and 1886–1890. These were related to the concentration of deaths from pneumonia in 1867 and bronchitis in 1890 in the winter months (Figure 5). However, these rates were less important than those for congenital and birth disorders. From 1900 onwards, there was a steady decline in airborne diseases, with a rate of 3 deaths per 1,000 live births. This trend was also observed for post-neonatal mortality, but at much higher levels (Figure 6). In fact, between 3 and 5 out of 10 children died from this cause, which included epidemic outbreaks of eruptive diseases such as measles and smallpox and respiratory diseases such as bronchitis and pneumonia. From 1906, there was a steady decline in post-neonatal mortality from airborne diseases to around 20 deaths per 1,000 live births. It should be noted that this type of disease characterised the epidemiological pattern of Spanish towns cities at that time (Sanz Gimeno & Ramiro Fariñas, 1997). These causes were related to living conditions, an issue that was also central to the medical discourse in Palma, along with personal hygiene (Pujadas-Mora, 2009).

Figure 4 *Quinquennial neonatal mortality rate and post-neonatal mortality rate by sex in Palma, 1836–1930*



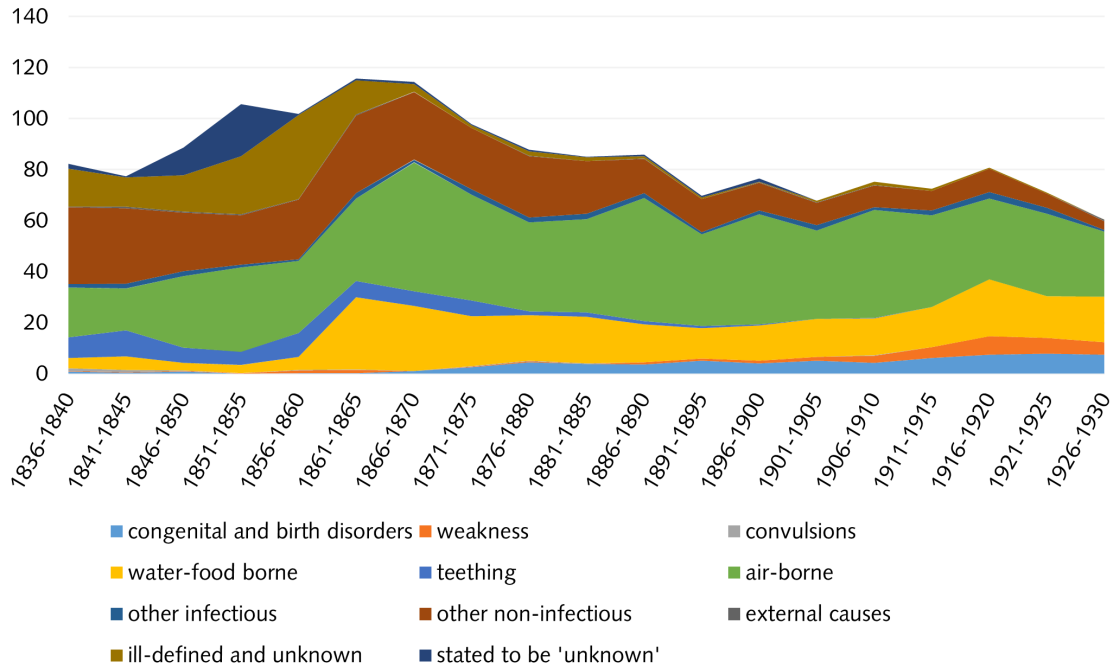
Source: Pujadas-Mora (2009).

Figure 5 *Quinquennial neonatal mortality rate by causal group in Palma, 1836–1930*



Source: Pujadas-Mora (2009).

Figure 6 *Quinquennial post-neonatal mortality rate by causal group in Palma, 1836–1930*



Source: Pujadas-Mora (2009).

There were major crises of smallpox in the late 1840s, mid-1850s, 1860s and 1870s, and in the late 1890s, but these were increasingly less severe. In fact, smallpox was the only disease that had a prophylactic vaccine since the 18th century. As a result, vaccination campaigns were organised by the Permanent Vaccination Commission of the Royal Academy of Medicine and Surgery, announced in the daily press from the 1830s and by the Balearic Institute of Direct Vaccination from 1886. Although vaccination was not mandatory, the continuous campaigns led by these institutions made it a widespread prophylactic practice with proven effects on mortality, as has been shown and verified in other parts of Europe (Ager et al., 2018; Bernoulli & Blower, 2004; Rutten, 2012; Sköld, 1996). Peak incidences of measles in post-neonatal mortality occurred in 1853, 1858–1859, 1868 and 1887. It is worth noting that convalescent serum was introduced in Palma in 1926, although it was already in use in other European countries and the United States.

Causes of death due to waterborne and foodborne diseases had a lower prevalence than airborne diseases in both neonatal and post-neonatal mortality (Figures 5 and 6). In fact, they did not show any particular prevalence until the 1860s, as a result of the cholera epidemic in the city of Palma in 1865, as mentioned above. From that decade onwards, their incidence was continuous but always low, never exceeding 3 deaths per 1,000 live births in the case of neonatal mortality. The absence of this type of cause in the first decades of this study could be related to the significant number of certificates with ill-defined and unknown causes between 1836 and 1870, corresponding to a maximum mortality of 12 deaths per 1,000 live births in 1856–1860, or under the heading "stated to be 'unknown'", corresponding to a mortality of 21 per 1,000 live births in 1851–1855. The disappearance of ill-defined and unknown causes reflects the progress made in describing causes of death more accurately, a result of the shift in the identification of disease from signs, symptoms and injuries to diagnosis based on infectious agents following the emergence of bacteriology. This shift underscores an improvement in the quality of cause of death recording that is particularly noticeable from the 1870s onwards.

Infectious diseases were more prevalent in post-neonatal mortality. The different weight of infectious diseases in the two age groups could be explained by the natural passive immunity that babies receive from their mothers and which is maintained during the first six months of life. In addition, part of this mortality can be explained by weaning and the consequent introduction of foods that would lead to greater susceptibility to infectious diseases, especially of a digestive nature (Victora et al., 1987). The improvement of clean water infrastructure leading to enhancements of both the quantity and quality of drinking water (Pujadas-Mora & Salas-Vives, 2021), played a crucial role in reducing deaths from waterborne and foodborne diseases. This decline is evident from the 1860s onwards, albeit with

some stagnation and occasional increases beginning in the late 19th century. This underscores the importance of the renovation of water transport channels and public water fountains, and conducting regular chemical analyses of drinking water. However, literature indicates that in other countries the implementation of water supply and wastewater systems at a later stage were key for those declines (Cutler & Miller, 2005; Ferrie & Troesken, 2008; Floris & Staub, 2019; Haines, 1995; Helgertz & Önnerfors, 2019; Kesztenbaum & Rosenthal, 2017; Macassa et al., 2006; Otaki et al., 2007). In the case of Palma, such infrastructure development was not fully realised until the late 1930s.

The prevalence of neonatal deaths from non-infectious diseases was similar to that for waterborne diseases, except for the period 1836–1850, when "spasm" was a common cause of death (Figure 5). This cause was relatively important until 1849, after which only occasional deaths were recorded, and no deaths at all from 1876. The prevalence of this cause has been documented in other Spanish Mediterranean regions, such as Alicante (Robles González, 2002). Some authors have suggested that this specific cause could be synonymous with "convulsions" (Bernabeu-Mestre et al, 2003). However, it should be noted that the Corachan medical dictionary (1936, published in fascicles from 1932) defines spasm as "an involuntary contraction of a muscle group, a muscle or an isolated bundle" (p. 224), whereas convulsion is described as "an involuntary movement of a muscle group or of the whole body due to the increased tonicity produced by certain nervous or toxic diseases" (p. 137). Spasms could also be synonymous with tetanus or should be understood as a symptom that accompanies death, probably due to an infectious disease, but not as a direct cause (Bernabeu Mestre et al., 1998).

In the case of post-neonatal mortality, non-infectious causes of death showed a steady decline from 1860, falling from 30 deaths per 1,000 live births to just 3 in 1930 (Figure 6). Again, spasm was among the leading causes of death, but only until 1848. Although some sporadic cases were reported from that year to 1871, this cause disappeared completely as a diagnostic term. Another cause of death that had some prominence between the late 1850s and early 1880s was "stroke", but it almost completely disappeared from the beginning of the 20th century. Also noteworthy is "hydrocephalus", which did not appear as a cause of death until the 1860s and disappeared as such after 1900. In some ways, hydrocephalus and stroke followed a similar trajectory, although the latter was always more commonly diagnosed. In fact, there was a certain relationship between the two diseases, especially when hydrocephalus appeared after birth and could be the result of head trauma, stroke, brain infection, etc.[6] Other diseases that also showed a certain concentration over time were "catarrh" (and variants), which did not appear until the mid-1870s.

Teething does not appear as a particular cause of death between birth and the first month of life. Only six children of this age were recorded as dying from this cause — all before 1872. In the case of post-neonatal mortality, there was some prevalence between 1836 and 1875, falling from 8–10 to 1 death per 1,000 live births (Figure 6). As Perdiguero (1993) masterfully explains, the term "teething" was used throughout the 19th century by both mothers and doctors as a synonym for disease, a consequence of knowledge assimilation from the late 18th and early 19th centuries. The disappearance of this term has been linked to the abrupt increase in causes such as diarrhoea, enteritis and athrepsia (Bernabeu et al., 2003; Sanz & Ramiro Fariñas, 2002).

In the case of neonatal mortality, we find a certain sex gap in mortality attributed to certain causal groups as ill-defined and unknown (standardised residual = -1.9) and other non-infectious diseases (s.r. = -1.1). In this sense, the male sex had a much higher number of attributed causes in these two groups than would be expected from the total number of deaths. In the case of post-neonatal mortality, females had more cases of other infectious deaths than males (s.r. = 1.9).

4 SEASONALITY OF NEONATAL AND POST-NEONATAL MORTALITY

The seasonality of neonatal mortality between 1836 and 1895 shows two important peaks from January to April and from September to December, of which January–February and November–December stand out (Figure 7). In fact, mortality between January and February was 60% higher than would be expected if mortality were evenly distributed throughout the year. This pattern was also observed in Italy (Breschi et al., 2000) and Greece (Raftakis, 2021). Between November and December, mortality was at least

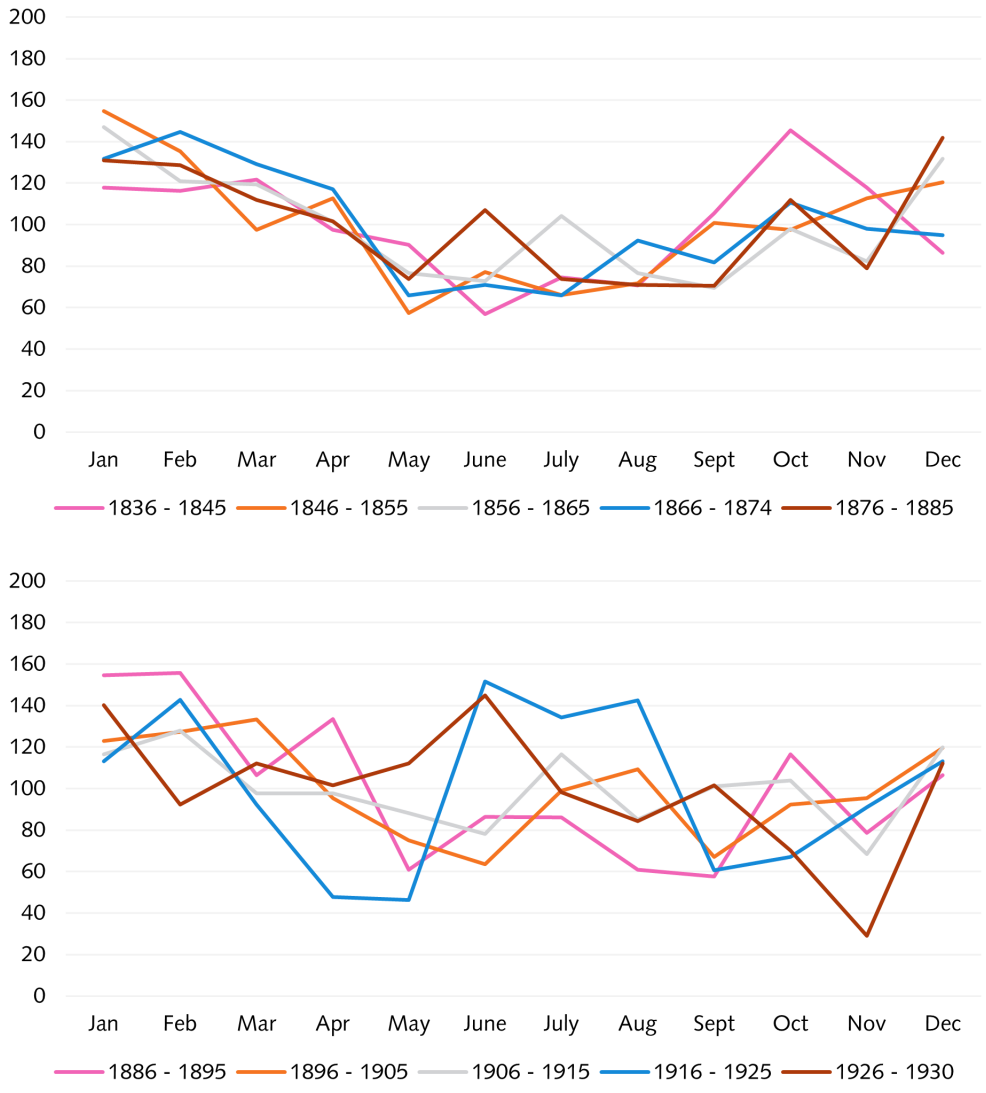
6 For more on hydrocephalus, see https://medlineplus.gov/spanish/hydrocephalus.html.

40% higher than average, whereas between May and August, the distribution of deaths was fairly balanced, showing about 20% less intensity than an even distribution of deaths over the rest of the year. This winter peak could be related to the seasonality of births as shown by Reher and Sanz Gimeno (2006) in their study of the city of Aranjuez, Madrid. From 1896 onwards, there was a change in the seasonal pattern that foreshadowed the emergence of another peak in the summer months, specifically between the months of July and August, alongside the continuing peaks in winter and autumn.

Between 1836 and 1885, the seasonal pattern of post-neonatal mortality was characterised by a sharp summer peak. In some periods, the summer months were as much as 80% and 60% higher than the average for the whole year (Figure 8). Another lower peak was observed in winter in the period 1886–1895, as in the case of neonatal mortality. In some periods this meant an increase of 60% in the monthly distribution of deaths, accompanied by some attenuation of the summer peak.

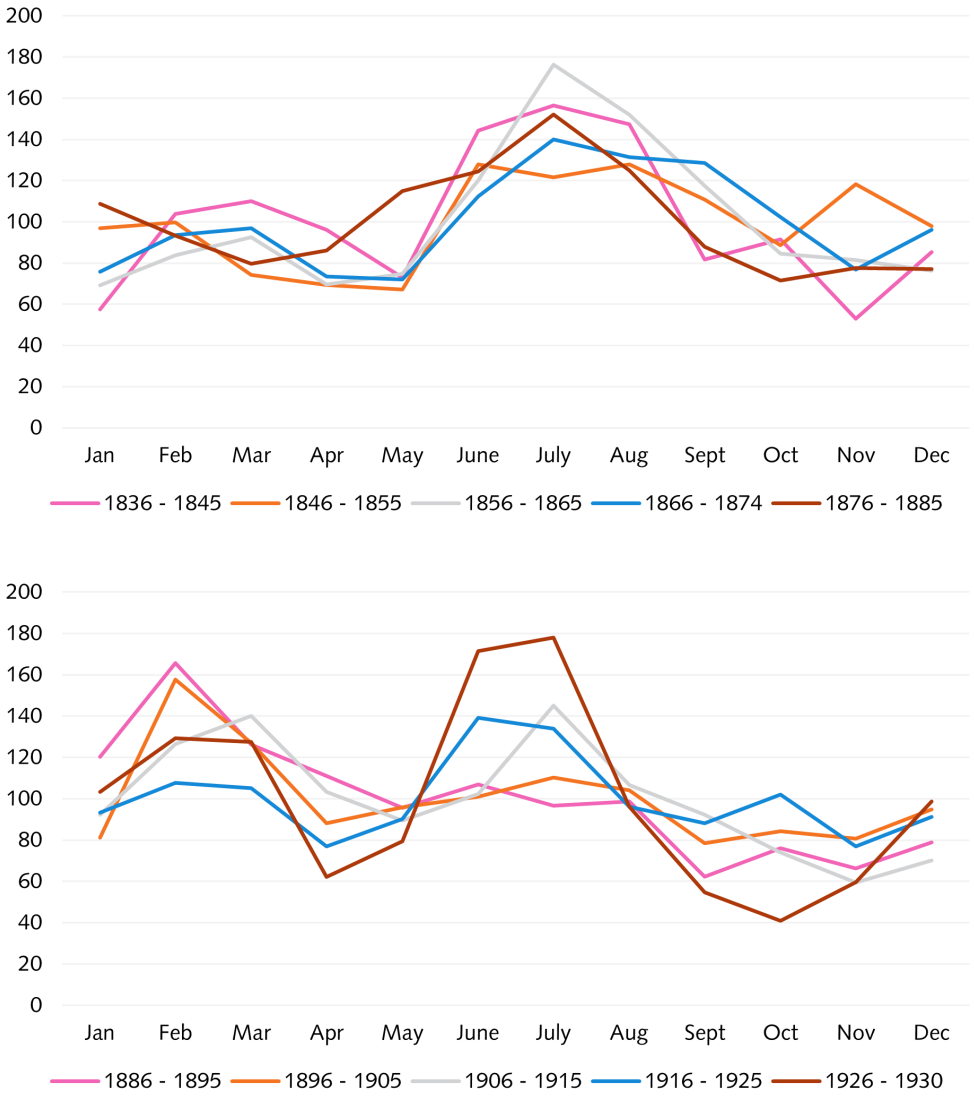
The seasonality trends described so far must be understood as the product of the causes of death. It has been noted that there is some divergence in the peaks and troughs of neonatal and post-neonatal mortality during the 19th century. However, there are many more similarities in the years analysed in the 20th century, and this is determined by the dominant cause of death groups and their evolution over time. The fact that infectious diseases were the main cause of post-neonatal mortality reinforces the seasonal pattern, as described below.

Figure 7 *Seasonality of neonatal deaths by decade in Palma, 1836–1930*



Source: Pujadas-Mora (2009).

Figure 8 *Seasonality of post-neonatal deaths by decade in Palma, 1836–1930*

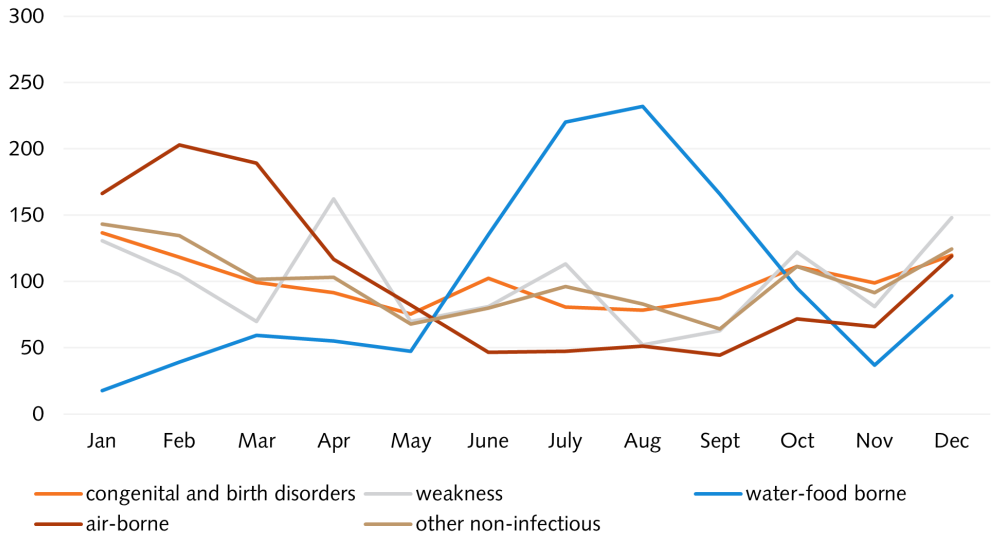


Source: Pujadas-Mora (2009).

In the case of neonatal mortality, deaths due to congenital and birth disorders were 40% higher in January than the average for all months. This was particularly marked for congenital weakness or "being viable" (*ser viable* in Spanish) (Figure 9), a pattern also reported in other southern localities (Breschi et al., 2009) and in England (Reid, 2001). The "weakness" group shows a different peak during the year, whether in winter, summer or autumn, which could be somewhat erratic due to the low number of cases. For airborne and waterborne diseases, the same monthly pattern is observed for post-neonatal mortality. Waterborne and foodborne diseases show a slightly higher seasonality than airborne diseases, but this is not the case for post-neonatal mortality. The peaks for infectious deaths were slightly lower for neonatal mortality than for post-neonatal mortality. The most common specific causes of infectious diseases in neonatal mortality are the same as those observed in post-neonatal mortality. Contrary to what was observed for post-neonatal mortality, there is a 40% increase in non-infectious causes of death such as "spasm" in January.[7]

7 Among the five main groups of causes of neonatal mortality, the groups "ill-defined and unknown" and "stated to be 'unknown'" stand out, with peaks in winter accounting for up to 50% of the increase in mortality.

Figure 9 *Seasonality of neonatal death for causal group in Palma, 1836–1930*



Source: Pujadas-Mora (2009).

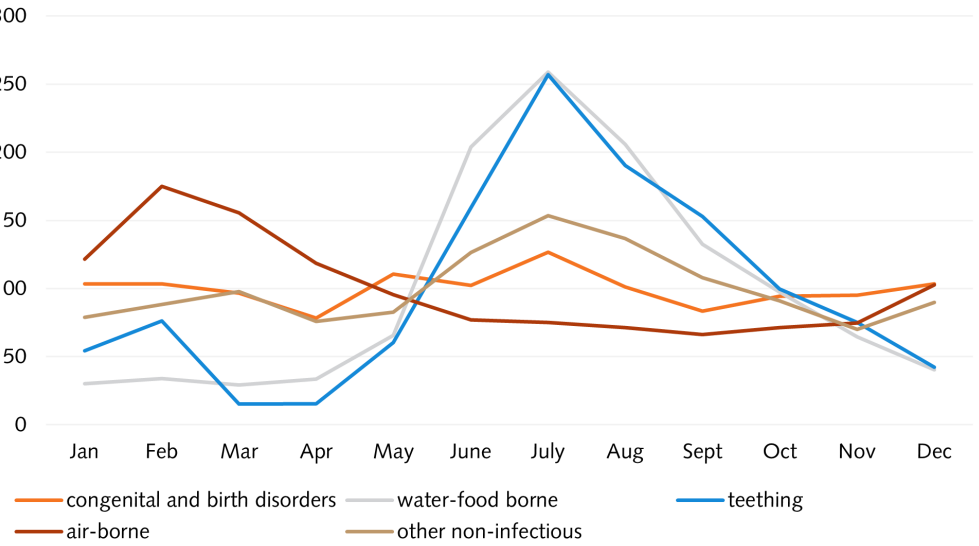
Focusing on the top five causal groups of post-neonatal mortality, mortality from congenital and birth disorders does not show a clearly defined seasonal pattern, with a small 20% peak in August, mainly due to the specific causes of congenital weakness and eclampsia (Figure 10). Airborne and waterborne/foodborne diseases show a much more pronounced seasonal pattern, with greater intensity in the latter case than in the former. Airborne diseases peaked in the winter months (February and March), when mortality from bronchopneumonia, bronchitis, pneumonia, measles and smallpox was between 50% and 70% higher. The peak for waterborne/foodborne diseases was even more intense. Between June and August, mortality from causes such as enteritis, enterocolitis and gastroenteritis could be as much as 150% higher than the annual average. This seasonal pattern and its intensity are fully consistent with that of the teething group, a phenomenon that had already been observed in other Spanish localities (Bernabeu et al., 2003; Robles, 2002; Sanz & Ramiro Fariñas, 2002). Non-infectious causes of death had a higher incidence in summer, with 40% peaks in July, due to stroke, spasm, hydrocephalus or rickets. Ill-defined and unknown causes of death show a significant peak in July, concentrating 60% of deaths.

Seasonal mortality was estimated as early as the 19th century in the hygienic studies carried out to assess the health of the population of the city of Palma. The low mortality rate in Palma was explained by the favourable weather conditions, especially the mild winters (Pujadas-Mora, 2012).[8] These studies were the forerunners of those that would later confirm the existence of significant climatic variations in the second half of the 19th century, which would go some way towards explaining the deterioration in mortality. In Spain, a cooling trend was observed in the 1860s, 1870s and 1880s. The decrease in mean temperature was particularly harsh and steady in this last decade (Carreras & Tafunelll, 2006). In fact, 1885 and 1886 were exceptionally cold and rainy. We should also mention the cold wave of 1890–1891, which affected not only Spain but the whole of Europe. The minimum temperature in Palma in the winter of 1890–1891 was -3.2 degrees Celsius (Font Tullot, 1988; Núñez Mora, 2020). After that decade, the trend reversed. It should be noted that the summers of the 1890s had very high maximum temperatures of over 30 degrees Celsius. However, contrary to what has been observed in northern Europe (Huck, 1994; Woods et al., 1993), this did not seem to have an effect on infant mortality in the city of Palma.

The seasonal pattern of mortality has also been linked to breastfeeding and weaning practices (Davenport, 2019; Knodel, 1983). Indeed, supplementation of breastfeeding with often inadequate food is associated with increased mortality because infants no longer receive passive immunity from their mothers and are consequently exposed to new foci of infection (Huck, 1997; Katzenberg et al., 1996; Woods et al., 1993). This would partly explain the summer peak in mortality from waterborne diseases.

8 The studies carried out in the second half of the 19th century by the Balearic physicians Fajarnés and Mayol on the relationship between weather and mortality can be clearly compared with the work by Guy and Cantab entitled "An attempt to determine the influence of the season and weather on sickness and mortality", published in 1843 in the *Journal of the Statistical Society of London*, one of the leading publications on the study of seasonality in the 19th century (Rau, 2007).

Figure 10 *Seasonality of post-neonatal death for causal group in Palma, 1836–1930*



Source: Pujadas-Mora (2009).

5 CONCLUSIONS

Infant mortality rates in Palma, as in the Balearic Islands as a whole, were notably lower than in other Spanish urban centres, underscoring the early onset of the demographic transition in the region. Scholars have discussed the concept of "regional variation in infant mortality" in Spain (Gómez Redondo, 1992), proposing the existence of two distinct transition models: a more advanced model observed in the northern provinces of the Iberian Peninsula, Catalonia and the Balearic Islands, contrasting with a delayed transition in the inland provinces and the Andalusian coast (Arbelo Curbelo, 1962; Bujosa et al., 2000; Cabré, 1999; Gómez Redondo, 1992; Muñoz Pradas, 2005; Nicolau Nos, 1991; Pascua, 1934). Moreover, infant mortality in Palma was lower than in other European port cities such as Bordeaux, Cardiff, Dublin, Hamburg-Altona, Trieste, Liverpool and Amsterdam (Cattaruzza, 1999; Dickson, 1989; Gehrmann, 1994; Guillaume, 1969; Janssens & Riswick, 2023; Lawton & Lee, 2002; Lee, 1998; Lewis, 1980). Notably, cities such as Bremen had mean values comparable to Palma (Lee & Marschalck, 2002), while districts in Antwerp and Malmo had even lower rates for certain decades (Donrovich et al., 2018; Fridlizius, 2002).

The triumph in the fight against infant mortality was the decline in post-neonatal mortality. While this rate began to fall between 1871 and 1875, neonatal mortality did not fall significantly until 1921. In this sense, the most important causes of post-neonatal mortality were those transmitted through the air, such as measles, smallpox and respiratory diseases (bronchitis and pneumonia), followed by those transmitted through water and food. This disparity underscores the critical importance of initiatives such as the promotion of breastfeeding, recurrent smallpox vaccination campaigns, the establishment of a robust primary healthcare network and targeted care for children, and improvements in the quantity and quality of drinking water, as discussed earlier. These public efforts were informed by a robust hygienic medical discourse that emphasised the imperative of preserving the health of the population. This discourse not only advocated public intervention, but also stressed the importance of personal hygiene, promoting measures such as ventilation and domestic hygiene, which inevitably played a role in reducing mortality from airborne diseases (Mackenbach, 1996). The argument for ventilation also played a role in the decision to demolish the city walls in 1902. Furthermore, with regard to the decline in measles cases, improved nutrition and reduced virulence were likely contributing factors, as specific therapeutics for measles were not available in Palma until the 1920s (Shanks et al., 2015). In terms of nutrition, the average height of Balearic recruits — an indicator of overall nutritional status — has been consistently among the highest in Spain since the late 19th century. Indeed, they have consistently been among the tallest Spaniards since the early 20th century (Martínez-Carrión & María-Dolores, 2017; Martínez-Carrión et al., 2016; Quiroga, 2001). However, this decline in mortality coincided with

the city's industrialisation, making Palma one of the most important industrial centres in Spain after Catalonia, the Basque Country and Asturias (Molina de Dios, 2003), while also experiencing a steady influx of migrants, especially from other parts of the island. According to Manera Erbina (2006), the economic expansion of the Balearic Islands, characterised by low labour costs, fostered relatively high-quality development, with better environmental conditions and better food than many industrial cities on the mainland.

The observed progress in reducing post-neonatal mortality since the 1860s stands in stark contrast to the persistent lack of decline in neonatal mortality, prevailing of congenital and birth disorders until the 1920s. This disparity can be attributed to the delayed emergence of neonatology, which only began to flourish in the latter half of the 20th century (Philip, 2005). Among non-infectious diseases, spasms had some significance in both neonatal and post-neonatal mortality until the late 1840s, but convulsions did not. However, deaths from teething were only noticeable in post-neonatal mortality, and then only until 1875, when diarrhoea and enteritis showed an increase. In the 1840s and 1850s there was also a significant number of death certificates with no cause of death and with ill-defined and unknown causes, a problem that most affected neonatal mortality, probably because diagnoses were more complicated in this age group. Nevertheless, this lack of precision diminished from the beginning of the 20th century with the use of qualifiers and the disuse of terms such as inflammation or irritation. This coincided with the transition from miasmatical to bacteriological theories. These findings pave the way for further research into how causes of death are constructed through their wording as a result of the circulation of knowledge. This places the doctor responsible for certifying causes of death at the centre of this process.

With regard to differences by sex, the female advantage was more pronounced for post-neonatal than for neonatal mortality. As regards the seasonality of neonatal mortality, in the 19th century it was characterised by two peaks in winter and autumn. Throughout the 20th century, a summer peak was also observed, accompanied by a decrease in the autumn peak. The winter peak may be related to the seasonality of births. Post-neonatal mortality was marked by a sharp summer peak, which receded from 1886 in favour of a winter peak due to the importance of airborne and waterborne/foodborne causes of death, which have a more pronounced seasonal pattern in the case of post-neonatal mortality. The causes of non-infectious diseases also have different seasonal peaks for neonatal and post-neonatal mortality, the former in January and the latter in July, although the individual causes would be the same with a different balance.

As stated in the objectives, this article serves as a test of the new ICD10h coding system. This system not only enables a comprehensive representation of the epidemiological patterns in the city of Palma, but also facilitates comparisons over time and space, allowing the study of both past and present trends. Notably, the classification criteria of ICD10h are based on the aetiology of diseases rather than purely anatomical considerations, which distinguishes it from previous classifications. This shift allows a deeper understanding of the determinants of mortality reduction. Furthermore, this study has highlighted the importance of analysing the specific trends of certain diseases that are prevalent in both neonatal and post-neonatal mortality, such as eclampsia, athrepsia, spasms and fevers, whose prevalence diminished over the course of the 19th century. As noted throughout the article, it should be carefully considered whether, in the case of Palma, athrepsia is synonymous with foodborne and waterborne infectious diseases, and spasms with convulsions. Another important epidemiological feature that could be considered, not only for this case study but also for other Mediterranean populations, would be the distinction between vector-borne infectious diseases. This would allow the evolution of diseases such as malaria and yellow fever to be identified. Malaria did eventually become endemic in the Mediterranean (Majori, 2012) and was not officially eradicated in Spain until 1963 (Bueno Marí & Jiménez Peydró, 2008). As for yellow fever, a higher incidence was observed in Mediterranean port cities from the 19th century onwards, as a result of the intensification of Atlantic colonial trade since the 18th century and its links with the increasingly urbanised and dynamic Mediterranean coast. This meant that the disease was no longer confined to the Andalusian coast, the gateway to Latin America in Spain, but also spread to the Valencian Community, Catalonia and, consequently, Mallorca. It should be noted, however, that the term yellow fever was not observed as a cause of death among infants in Palma during the epidemic that struck the city in 1870.

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