The Weanling's Dilemma. Breastfeeding and Socioeconomic Status in 19th-Century Venice

By Renzo Derosas

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The Weanling's Dilemma

Breastfeeding and Socioeconomic Status in 19th-Century Venice

Renzo Derosas
Ca' Foscari University, Venice

ABSTRACT

Weaning is one of the most crucial steps in an infant's life. This study investigates how families of different socioeconomic conditions coped with weaning and its consequences for infant mortality, using individual-level longitudinal data drawn from the Venetian population register. As in previous studies, breastfeeding patterns are inferred from infant mortality features. However, the approach adopted differs in part from similar research, combining Cox proportional hazards and Aalen additive regression models. Aalen models allow coefficients to vary over time, showing discontinuities that can be interpreted as signs of the start of weaning. The Venetian case reveals a pronounced social gradient: the poorest mothers breastfed for no more than one month, whereas others continued for 6–8 months or longer. This disparity contributed substantially to socioeconomic inequalities in infant mortality.

Keywords: Breastfeeding, Infant mortality, Aalen's additive regression model, Cox proportional hazards regression model, 19th-Century Venice, Infant mortality seasonality

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1 INTRODUCTION

The "weanling's dilemma" refers to the choice to which infants are subjected, between loss of immunity and exposure to potentially contaminated food at weaning on the one hand, and malnutrition due to prolonged breastfeeding on the other. The term was coined by Gordon and colleagues (1963) to define the best feeding practices for children in poor countries, and was thereafter widely adopted in scholarly literature (Kendall et al., 2021). This study focuses on the weanling's dilemma in mid-19th-century Venice. In particular, it investigates the duration of exclusive breastfeeding and how it differed between social classes.

Contemporary guidelines from the World Health Organization (WHO, 2023) recommend six months of exclusive breastfeeding, followed by 18 months of complementary feeding. Nevertheless, fewer than half of infants under six months are currently breastfed. Breastfeeding rates are lowest in high-income countries (UNICEF & WHO, 2023), notwithstanding evidence linking formula feeding to a 49% increase in post-perinatal mortality (Ware et al., 2023) and to elevated risks of metabolic disorders across the life course (Munblit et al., 2020). However, it is in low- and middle-income countries, where 98% of infant deaths occur, that the consequences of suboptimal infant feeding are more severe (North et al., 2022). According to Victora and colleagues (2016), universal breastfeeding might annually avert 823,000 under-five deaths.

In the past, artificial feeding was even more harmful than it is today, as evidence from European countries in the late 19th and early 20th centuries suggests. According to Vögele and colleagues (2013), in Germany the death rate of bottle-fed infants was seven times higher than that of breastfed infants. In Paris, during summer time it was ten times higher (Rollet, 1997). In Düsseldorf, the mortality rate of bottle-fed infants from well-off families was twice as high as that of breastfed infants from poor families (Vögele, 2010), while among Bavarian working-class families breastfeeding reduced infant mortality by 75% (Brown & Guinnane, 2018). In Derbyshire, the post-neonatal mortality of hand-fed infants was 50% higher than that of breastfed infants (Reid, 2002).

Unfortunately, information on the rate and duration of breastfeeding in the past is rare, and only covers the early 20th century. Consequently, scholars of breastfeeding in earlier periods have to use indirect evidence to make inferences on feeding practices. This study aims to contribute to both these issues. From a substantive point of view, I ask whether in 19th-century Venice insufficient breastfeeding was pre-eminently a social problem, as contemporaries strongly denounced. From a methodological point of view, I suggest an approach that allows making inferences on the age at weaning. I use summer mortality as a litmus test of feeding practice, and show that summer hazards varied significantly by both age and social status. I argue that such variations are suggestive of the end of exclusive breastfeeding.

The study is organized as follows. In Section 2, I briefly review the historical literature on breastfeeding, focusing on the available sources and the methods used by scholars to infer information on feeding practices. Section 3 presents the historical context and the source material used for my analysis. In Section 4, I carry out a survival analysis of infant and child mortality, using Cox proportional hazards and Aalen's regression models. Results are discussed in Section 5. Finally, in Section 6 I draw some conclusions, stressing the relevance of early nutrition in mortality regimes, past and present.

2 HISTORY OF BREASTFEEDING: SOURCES AND METHODS

The literature on the history of infant feeding is extremely rich, spanning from the prehistoric past to classical antiquity and early modern times (see e.g. Cocozza et al., 2025; Fildes, 1986; Fulminante, 2015; Matthews Grieco, 1991; Obladen, 2014; Rebay-Salisbury, 2017; Wickes, 1953). Scholars reconstructed the evolutionary, biological, historical, cultural, and socioeconomic contexts of feeding habits, highlighting the stunning variety of the methods employed, the differences between geographical areas, cultures, and social conditions, and their evolution over time. However, these studies mostly rely on qualitative evidence. A notable exception is bioarchaeologists and osteoarchaeologists, who obtain information on breastfeeding and weaning behaviour from the isotope analysis of skeletal remains (Jay, 2013). Interestingly, this approach was successfully applied also to early-modern populations (see e.g. Herring et al., 1998; Moggi-Cecchi et al., 1994; Newman & Goland, 2017; Nitsch et al., 2011).

For instance, Waters-Rist and colleagues (2022) found that, against expectations, in a protestant, dairy farming Dutch community in the 19th-century breastfeeding was either absent or very short.

The earliest statistics on breastfeeding were published in the late 19th century, when governments and social reformers, driven by concerns over high infant mortality, promoted surveys on infant rearing conditions. Aggregate statistics at the district level were produced for Germany (Kintner, 1985), England (Fildes, 1998), Sweden (Brändström et al., 2002), Iceland (Guttormsson & Garðarsdóttir, 2002), and France (Rollet, 1990). Such materials have been widely studied (see e.g. Kintner, 1988a, 1988b; Knodel & van de Walle, 1967; Woods et al., 1988, 1989). However, the analysis of aggregate data suffers from several limitations, and poses the risk of ecological fallacy (Shih et al., 2023). On the other hand, historical sources with information on the rate and duration of breastfeeding at the micro level, like those used by Woodbury (1925) for his study in eight American cities, Fildes (1992) for London, Reid (2002, 2017) for Derbyshire, and Guttormsson and Garðarsdóttir (2002) for Iceland, are unique of their kind, and all concern the early 20th century.

In the absence of direct evidence on breastfeeding, researchers carried out demographic analyses from which to infer the infant feeding habits prevailing in a population or social group. Given the effect of lactation on postpartum amenorrhea, some studies used birth intervals as proxies of breastfeeding habits (Davenport, 2019; Jaadla et al., 2020; Janssens & Pelzer, 2014; Newton, 2011; Pebley et al., 1991). Other scholars focused on infant mortality patterns that could suggest the absence or the inadequacy of breastfeeding. For instance, Knodel and Kintner (1977) argued that deviations of the age pattern of infant mortality from the standard linear biometric model reveal the deficiency or early termination of breastfeeding. Similarly, summer mortality peaks and the burden of deaths from diarrhoea and gastrointestinal diseases have been considered as suggestive of poor or unfit feeding practice (see e.g. Cheney, 1984; Huck, 1997; Mühlichen & Doblhammer, 2025; Murkens et al., 2023; Thornton & Olson, 2011; van den Boomen & Ekamper, 2015; van Poppel et al., 2002, 2018; Walhout, 2010).

Both the "birth-interval approach" and the "mortality approach" allow comparisons between groups or populations. Differences in breastfeeding related to socioeconomic status and religious affiliation have been given special attention.

Contemporary reformers typically addressed the poorest strata of population, attributing low rates of breastfeeding to ignorance and material deprivation and prompting interventions like maternal education and welfare programs (Brown & Guinnane, 2018; Fildes, 1992, 1998; Kintner, 1985; Vögele et al., 2013). However, the social gradient in breastfeeding was far from linear. As a rule, mothers in the upper class were less likely to breastfeed. In London, the attitude of the elites towards maternal breastfeeding began to change in the late 18th century, significantly contributing to child survival (Davenport, 2019; Trumbach, 2013). Breastfeeding was instead more common among the families of day labourers, whose newborns had surprisingly low mortality rates (Jaadla et al., 2020). Still in the early 20th century, breastfeeding was more widespread in the poorest boroughs in London, though it was early terminated or integrated with solid food (Fildes, 1992).

The impact of culture, namely religious culture, on infant feeding is a particularly controversial topic. There is a widespread agreement that breastfeeding, infant care, and infant wellbeing largely depended on religious affiliation: Jews always enjoyed the most favourable conditions, far outpacing Protestants and Catholics (see e.g. Connor, 2017; Gráda, 2006; Preston et al., 1994; Thornton & Olson, 2011; van Poppel et al., 2002). Thorvaldsen (2008) suggested that Europe has been long divided into two broad areas: in northern Protestant Europe, breastfeeding was widely practiced, while in southern Catholic countries recourse to wet-nurses and artificial feeding was common. However, when moving from such a broad picture to more detailed analyses, things become problematic. For instance, in a forthcoming paper I show that among Venetian Jews breastfeeding was neither as widespread nor as protracted as one would expect (Derosas, forthcoming).

Dutch historians lively discussed the role of Catholicism in the upsurge of infant mortality that afflicted some regions of the Netherlands in the late 19th century. While Van Poppel (1992) blamed the reluctance towards breastfeeding induced by the conservative involution of Dutch Catholicism, Walhout (2010), Janssens and Pelzer (2014), and Van den Boomen and Ekamper (2015) argued instead that the differences in breastfeeding between Catholics and Protestants were much smaller than supposed, and that locality influenced individual behaviour more than religion.

3 HISTORICAL CONTEXT AND SOURCE MATERIAL

Around mid-19th century, Venice was a large but impoverished city. After the end of the aristocratic regime in 1797, the economy had collapsed and the population shrunk by one third, from around 180,000 to less than 120,000 inhabitants. The 1850s were one of the worst periods in Venetian history. The city had not yet recovered from the defeat in the 1848–1849 revolution, a harsh siege by the Austrian army, and a devastating cholera epidemic. The agrarian crisis of 1854–1855 tripled the cost of food, while the presences in the poor workhouse soared from 114,000 to 315,000. The registered poor entitled to receive public support were 35,000, one fourth of the total population, though only 3,000 received some daily relief (Derosas & Munno, 2022). American writer W.D. Howells (1878) described Venice as "a gloomy and dejected city". It was also one of the deadliest European cities to live in: crude death rate was around 30 per 1,000, life expectancy at birth was around 33 years, and infant mortality rate around 240 per 1,000 (Derosas, forthcoming).

In 1876, Cesare Musatti (Venice, 1846–1930), a Jewish doctor and one of the first paediatricians of his time, published an interesting book of instructions and recommendations on child rearing. He claimed that a few simple attentions could avoid the countless infant deaths that afflicted Venetian families. Breastfeeding was by far the most important remedy to adopt. Musatti urged mothers to breastfeed for at least six months, but few followed his recommendations. Many were too poor to afford breastfeeding, and often abandoned their children out of despair of being unable to raise them. Others turned to artificial feeding after two or three months. Infants were fed cow, goat or donkey milk. Solid food included paps of sago, tapioca, arrowroot, breadcrumbs, wheat flour, or semolina, which mothers often pre-chewed and salivated to make them digestible. Musatti was also aware that his middle-class readers preferred resorting to wet-nurses, and devoted a large part of the chapter on infant nutrition to advices about properly choosing and dealing with them (Musatti, 1876).

This study tests hypotheses derived from Musatti's observations. The main source is the city population register, established in 1850 and updated until 1869. Population registers are a sort of dynamic census, in which information on individuals and families is systematically updated as events occur, for instance when a new entry or exit changes the composition of a household. To improve the data quality, the information from the population register has been verified and integrated with data from the parish registers, the municipal registers of deaths, and the city census of 1869. Furthermore, local newspapers provided daily data on wheat price and outdoor temperature.

The dataset includes four parishes representing Venice's socioeconomic spectrum. San Luca was among the richest parishes of the city centre, mainly inhabited by members of the elites. San Geremia and Santa Eufemia were working-class parishes, with many employed in glass factories, at the railway station, or in hemp and leather workshops. Finally, San Raffaele Arcangelo was the poorest parish, inhabited by fishermen, boatmen, porters, and day labourers. The quality of dwellings and overall hygienic conditions were rather poor. The majority of houses had no running water. Poor sewage arrangements were common and most houses in the poorest areas had no toilet facilities.

According to the 1869 census, the four parishes had 15,825 inhabitants. The dataset includes 26,894 individuals, observed for spells of different length between 1850 and 1869. The total person-years adds up to about 272,000, with 8,802 births and 7,102 deaths. I categorised socioeconomic status (SES) according to the social position and the presumptive level and continuity of income of the household head. SES includes day labourers (fishermen, porters, boatmen); wage workers; artisans and shopkeepers; members of the middle and upper class (employees, civil servants, professionals, bankers).

4 SURVIVAL ANALYSIS

Table 1 presents infant and child mortality rates by SES, calculated from population register data. The results reveal a consistent social gradient across all age groups, with one notable exception: neonatal mortality (0–28 days), where elite rate nearly equalled that of day labourers (137 vs. 124 per 1,000).

Table 1 *Infant and child mortality rates by SES. Venice 1850–1869*

SES	Neonatal (0–28)	Post-neonatal (29–365)	Infant (0–1)	Child (1–4)
Day labourers	137	201	275	96
Wage workers	110	157	226	72
Artisans, shopkeepers	97	140	202	70
Middle, upper class	124	100	193	39
Unknown	67	213	218	73
Total	117	168	238	79

Source: My elaboration on population register data.

Table 2 presents the results of three multilevel Cox proportional hazards models, analysing mortality across neonatal (days 1–28), post-neonatal (days 29–365), and early childhood (ages 1–4 years) periods. To avoid potential misclassification of stillbirths (as parents occasionally baptized stillborn infants), the analysis excludes perinatal mortality, commencing observation from the second day of life.

The primary exposure variable is socioeconomic status (reference category: day labourers), with models adjusted for:

1. Sex (reference: male).
2. Seasonal weather patterns, based on daily distributions of outdoor temperature (reference: mild, mean 12°C, min -2, max 24):
   - Hot season: June to mid–September (mean daily temperature 19°C, min 12, max 39);
   - Cold season: December to March (mean daily temperature 2°C, min -10, max 12).
3. Economic stress periods (reference: normal/low prices):
   - Defined as days when wheat price reached the top quartile of the daily distribution.
4. Cholera outbreaks (reference: non-epidemic periods):
   - Four major epidemics occurring August–October 1854, May–September 1855, September–October 1866, and July–October 1867.

The models incorporate household-level random effects to account for intra-cluster correlations in mortality outcomes.

The analysis reveals striking socioeconomic disparities in infant and child mortality, though with an important exception during the neonatal period. From infancy through early childhood, children of day labourers faced mortality risks approximately twice as high as those of elite families, with artisans' and skilled workers' children experiencing intermediate risks (20–25% lower than day labourers but still significantly higher than the upper classes). This social gradient, however, breaks down in the first month of life, where neonatal mortality shows no significant class differences — a finding that aligns with the patterns visible in Table 1. The elite's neonatal rates nearly matched those of the poorest families.

Surprisingly, cholera outbreaks did not have a significant influence on infant and child survival.

Economic crises showed delayed effects. While food price shocks left infant mortality unaffected, they increased childhood mortality risks by 29%, possibly through gradual malnutrition or compounded health stresses. It should be noticed, however, that the estimate violates the proportionality assumption.

Table 2 *Cox regressions of infant and child mortality. Venice 1850–1869 (Fixed coefficients only)*

	Model 1: Neonatal			Model 2: Post-neonatal			Model 3: Child		
	Obs.	Events	Schoenfeld residuals	Obs.	Events	Schoenfeld residuals	Obs.	Events	Schoenfeld residuals
	11,779	688		43,133	1,128		125,049	1,696	
Fixed coefficients	exp(coef)	p	p	exp(coef)	p	p	exp(coef)	p	p
Sex: female (ref: male)	0.86	0.054	0.342	0.87	0.022	0.078	0.84	0.001	0.862
Head's SES (ref: day-labourer)			0.588			0.123			0.105
Wage worker	0.79	0.023		0.82	0.010		0.80	0.000	
Artisan, shopkeeper	0.72	0.010		0.75	0.002		0.76	0.000	
Middle, upper class	0.89	0.650		0.43	0.002		0.57	0.002	
Unknown	0.66	0.320		0.68	0.210		1.12	0.580	
Weather (ref: mild)			0.049			0.000			0.000
Cold	1.83	0.000		1.15	0.054		0.96	0.530	
Hot	0.40	0.000		1.39	0.000		1.35	0.000	
Food price: high (ref: low)	0.89	0.210	0.864	1.05	0.460	0.834	1.29	0.000	0.000
Cholera epidemic (ref: absent)	0.88	0.620	0.063	0.93	0.640	0.103	1.22	0.059	0.882

Source: As in Table 1.

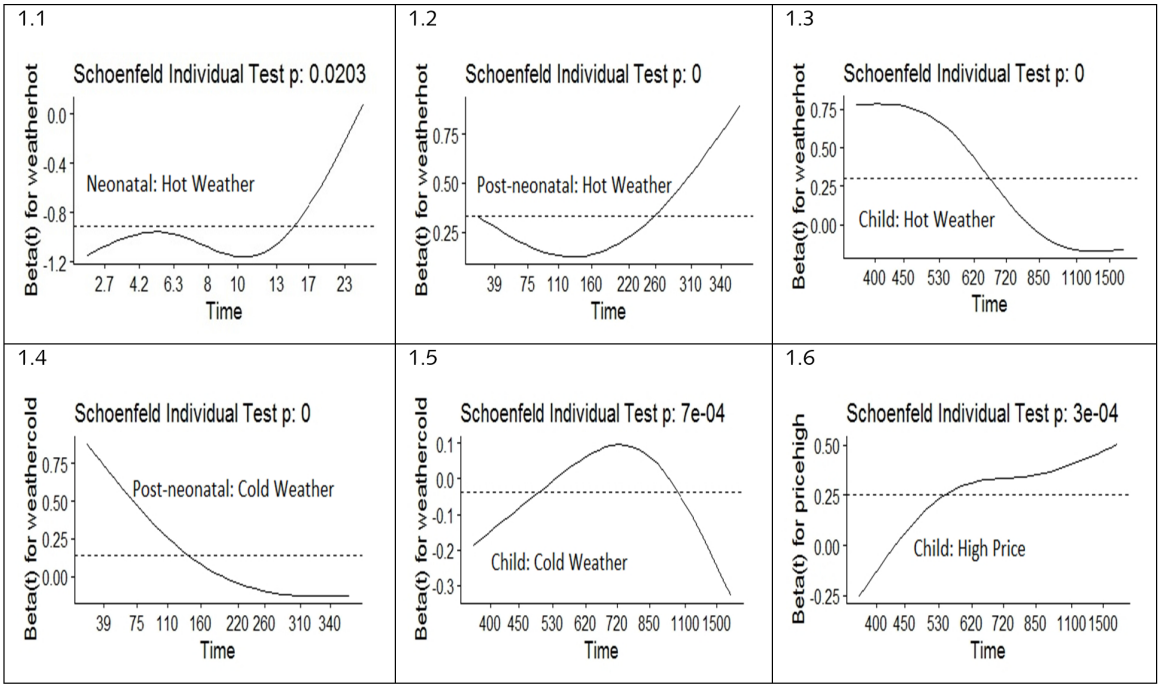
The same is true for the effect of weather in all of the three models estimated. On the one hand, they show that the impact of outdoor temperature shifted dramatically over time. Cold weather proved particularly deadly for newborns, nearly doubling their mortality risk compared to mild periods. Heat, by contrast, offered strong protection in the neonatal phase — likely by reducing respiratory infections — only to reverse into a significant hazard as infants grew older, probably reflecting weaning-related exposure to summer diarrhoeal diseases. On the other hand, the Schoenfeld's tests warn that there is some further time-dependency that needs to be addressed. In other words, these risk factors do not operate uniformly over time but depend on children's developmental stages in ways that demand more nuanced modelling.

Figure 1 illustrates these temporal patterns through smoothed plots of scaled Schoenfeld residuals for the variables violating the proportional hazards assumptions. The dotted lines trace the time-invariant coefficients estimated by the Cox regressions, revealing where actual risks diverge from model assumptions.

The plots in Figure 1 demonstrate clear violations of the proportional hazards assumption, which would require $\beta(t)$ to approximate a horizontal line. Instead, we observe significant temporal variation in all panels. P-values indicate that the correlation between the Schoenfeld residuals and time is statistically significant. For instance, the time-invariant coefficient estimated for the newborns in the hot season is -0.91 (model 1: exp. coeff. 0.40, p-value < 0.001). Panel 1.1 shows that in the first two weeks of life the protective effect of heat — as compared to mild weather — is slightly larger than estimated, and progressively vanishes afterwards. In the post-neonatal period (panel 1.2) the hot season appears moderately dangerous until around the fifth month, and starts a noticeable upward trend thereafter, turning increasingly dangerous. It is only around the third birthday that heat stops being harmful (panel 1.3). The impact of cold follows an inverse trend, with high risks at birth (model 1 above), declining until they disappear around the sixth month (panels 1.4-1.5). Finally, panel 1.6 suggests that children become more sensitive to economic crises as they grow up.

When the proportional hazards assumption fails — as in our case — researchers typically employ several solutions: partitioning the observation period into distinct phases, stratifying the analysis, or incorporating time-dependent coefficients (Therneau & Grambsch, 2000, pp. 142–147). While these approaches can yield statistically unbiased estimates, our focus lies elsewhere. Rather than "fixing" the time-varying effects, we aim to understand what drives them — to interpret these violations of proportionality not as statistical nuisances, but as meaningful bio-social phenomena manifesting across a child's development.

Figure 1 *Schoenfeld residuals from Cox regressions*



Source: My elaboration from Cox regressions in Table 2.

All of these temporal patterns point to nutrition as a critical underlying factor. The counterintuitive seasonal effects — where heat becomes dangerous while cold proves protective after infancy — likely mirror the epidemiology of diarrhoeal diseases, which thrive in summer months when weaned infants face greater exposure to contaminated foods. Meanwhile, the delayed but growing impact of food prices reflects nutritional stress accumulating through early childhood. This raises a pivotal question: did socioeconomic groups show distinct seasonal mortality patterns that might reveal variations in infant feeding practices?

Aalen's additive models offer distinct advantages for our analysis by permitting time-varying coefficients. They estimate how departures from reference conditions (e.g. cold vs. mild weather) contribute additively to mortality hazards through linear hazard modelling (Aalen & Scheike, 2005) — crucial when risks evolve across developmental stages.

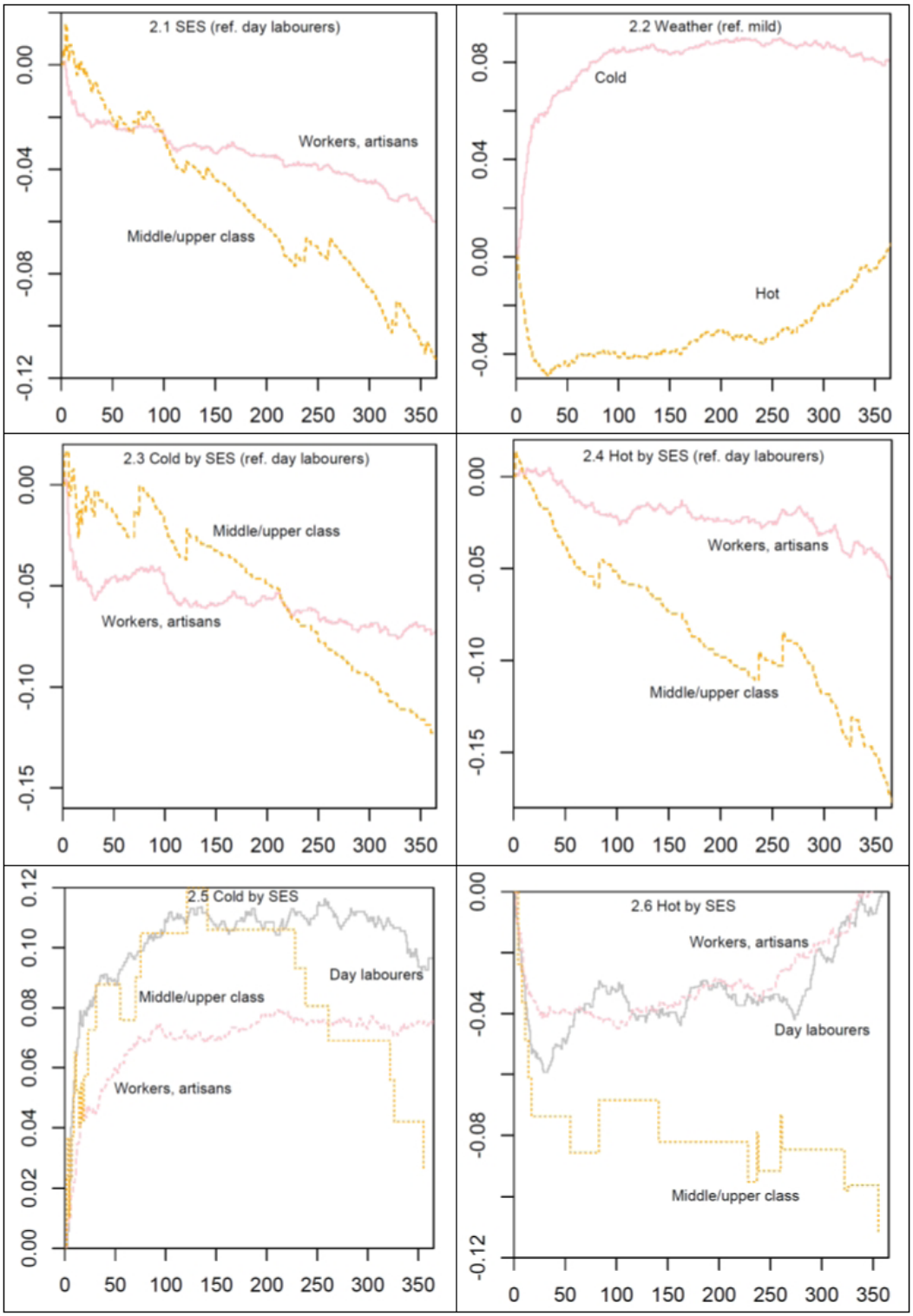
Several simplified models were fitted, incorporating only socioeconomic status and weather as covariates. Given the similar mortality patterns observed across wage workers, artisans and shopkeepers, these groups were consolidated into a single category. Selected results from Aalen's regressions are presented in Figure 2. The plots illustrate the additive contributions of covariate deviations from reference values. To enhance clarity of the central patterns, baseline hazards and confidence intervals were omitted from the visual representation.

The panels collectively reveal consistent mortality patterns through complementary analytical approaches. Panels 2.1–2.2 present global estimates using the complete dataset with both weather and SES as covariates. Subsequent panels employ stratified analyses: panels 2.3–2.4 examine SES effects within weather categories (reference: day labourers), while panels 2.5–2.6 assess weather's effects within SES groups (reference: mild weather).

Panel 2.1 contrasts the cumulative estimated coefficients by SES. It confirms the social gradient already shown in Cox models 1 and 2. This also includes the elite's odd trend: in the first three months of life, their relative advantage over the day labourers is lower than that enjoyed by workers and artisans. In the very first days, they fare even worse than the day labourers themselves. In late infancy, however, the gap in their favour increasingly widens.

Panel 2.2 confirms the specular trends of the effects of hot and cold weather on survival. The hazards of the cold season rocket steeply in the first three months and level off henceforth. Hot temperatures exert instead a strong protective effect in the first month, but become increasingly harmful afterwards.

Figure 2 *Aalen's cumulative hazards plots*



Source: My elaboration from Aalen's regressions.

Panels 2.3 and 2.4 show how the impact of weather varies by SES. Both with cold and hot, the elite and the working class enjoy a clear advantage over the day labourers. However, while cold makes no significant difference between the elite and the working class, in the hot period the advantage of the former is large and consistent.

Interpreting panels 2.5 and 2.6 is less straightforward. The plots compare the relative impact of cold and hot weather for each social group, combining the estimates of three distinct models. For instance, the curve of the day labourers in panel 2.5 represents the cumulative hazards run by day labourers in cold weather, relative to the hazards run by day labourers in mild weather.

Interestingly, cold is relatively as dangerous for the wealthy as it is for the poor, at least until seven months of age. Afterwards, the harmful effect of cold persists for the poor, and almost disappears for the rich. The hazards of cold for workers and artisans grow until the third month of life and then level off.

Panel 2.6 confirms that the trends outlined in panels 2.2 and 2.4 significantly differ by SES. The day labourers follow closely the global trend of panel 2.2, with hot weather turning abruptly from protective to harmful after the first month of life. The small number of events makes it difficult to detect a smooth trend for the wealthy. Nevertheless, the protective effect of hot weather persists throughout infancy, and no evidence of a trend inversion can be detected. In the case of workers and artisans, an upward trend seems instead to start around the eighth month of life.

5 DISCUSSION

These results paint a compelling picture of infant and child mortality in Venice. First, both SES and weather conditions exerted a strong influence on infant and child mortality. Second, social groups exhibited marked disparities in their ability to cope with cold and hot weather. Third, these disparities manifested not only in the magnitude of weather's impact but also in its timing. While the poor faced higher mortality risks under all weather conditions, the social divide was most pronounced during the hot season.

Hot weather initially acted as a protective factor against neonatal mortality (whereas cold weather was extremely harmful), but this effect quickly reversed as infants aged. Panel 2.2 indicates that the shift from protection to risk began around 30 days of age — a pattern driven almost entirely by the day labourer class (panel 2.6). For the working class, the turning point occurred much later (around eight months), while the wealthy showed no clear inversion.

I argue that these turning points signal the onset of weaning and the transition to mixed or artificial feeding. Breastfeeding serves as a critical immune shield for newborns, and its interruption in unhygienic environments exposes infants to pathogens — especially during the hot season, when contaminated food/water and pathogen proliferation are most likely. The timing of hot weather's shift from protective to harmful thus serves as an indirect marker of breastfeeding cessation. In other words, they are a flag that the "weanling's dilemma" is occurring. This does not imply that all mothers abruptly stopped breastfeeding, but rather that a sufficient proportion shifted to riskier feeding practices to alter population-level trends. If this interpretation holds, this analysis suggests that the mothers of the lowest social strata seldom exclusively breastfed beyond one month. The working-class and petty bourgeois mothers typically breastfed for significantly longer durations than the poorest families. Regarding elite families, the interpretation remains more complex. Quite certainly, the excess mortality displayed in the first days of life is not a fictitious result. Similarly, the effect of an environmental disadvantage can be safely ruled out, let alone an economic disadvantage. On the other hand, identifying a behavioural cause is not an easy task. Musatti (1876) reported that some mothers delayed feeding their newborns for three or four days, but he did not suggest that such an unsafe practice was particularly widespread among the wealthy. Possibly, the search for suitable wet-nurses created dangerous delays in establishing suitable feeding. Even if this was the case, the absence of clear early-weaning signals in the elite mortality patterns indicates that, once arranged, feeding practices among wealthy families provided sustained nutritional and hygienic protection.

6 CONCLUSIONS

This paper pursued two objectives: methodological and substantive.

From a methodological point of view, I suggest an approach that allows making some inference on the duration of exclusive breastfeeding. Neither the "birth-interval approach" nor the "mortality approach" approximate breastfeeding rate or duration. At most, they reflect some greater or lesser predisposition of different social groups towards breastfeeding. My approach tries to estimate the age at weaning,

the most critical moment in infant survival after birth. I use a combination of Cox proportional hazards models and Aalen's additive regression models. While Cox models provide precise (though potentially misleading) estimates of variables effects, Aalen's models reveal how these effects evolve over time, offering a more nuanced understanding of the underlying processes. When time-dependency is a critical feature — as in the case of feeding habits — Aalen's models prove to be a valuable addition to the analytical toolkit. Substantively, my analysis corroborated Cesare Musatti's claim that inappropriate nutrition — due to either premature weaning or a complete absence of breastfeeding — was the primary cause of the high infant mortality that plagued contemporary Venice. Musatti (1876) blamed the widespread poverty that forced many mothers to abandon breastfeeding out of economic necessity. Although ignorance of appropriate feeding methods also played a role, the "weanling's dilemma" that the poor had to face arose from the conflicting needs and constrains of mothers and children. On the other hand, maternal ignorance, malnutrition, and poor health, which also hindered breastfeeding, resulted from socioeconomic deprivation as well.

Inadequate feeding had dramatic consequences: in the population under study, over 41% of infant deaths were due to nutrition-related diseases (diarrhoea, gastroenteritis, marasmus), which spiked during the hot season. Spasms and airborne diseases represented 20% each, but many of them likely affected malnourished children with severe immunodeficiency deriving from previous gastrointestinal infections (Ginsburg et al., 2015; Kirolos et al., 2021). Crucially, the poor bore a disproportionate burden: a cause-specific analysis of mortality in this same population shows that the children of day labourers were three times as likely to die from nutritional diseases as middle/upper-class children, and twice as likely as the children of artisans and wage workers (Derosas, forthcoming).

Although mortality in adult and old age is beyond the purpose of this study, we should also consider that the impact of inadequate nutrition did not only concern infancy but encompassed the whole life-course. The Developmental Origin of Health and Disease (DOHaD) paradigm stresses that maternal nutrition during pregnancy and breastfeeding determine health condition in later life (Bianco-Miotto et al., 2017; Gialeli et al., 2023; Lacagnina, 2019). A growing body of literature shows that early nutrition has an impact on a wide range of outcomes, such as height, functionality, impaired cognitive function, mental health, reproduction, obesity, metabolic syndrome, diabetes, heart diseases, and cancer (Alves & Alves, 2024; Hildreth et al., 2023; McEniry, 2013; Orià et al., 2016).

The Exposomics paradigm stresses that early-life conditions determine the biological capital accumulated in an individual's lifetime, influencing the capability to access to other forms of capital — cultural, economic, and social — with dramatic consequences on life achievements (Vineis & Barouki, 2022; Vineis et al., 2016). Empirical research shows that chronic exposure to stressful environments causes a biological embedding of disadvantage, perpetuating social and racial health disparities (Meloni et al., 2022). Several historical studies confirmed the correlation between exposure in infancy and poor health and social outcome in adulthood and old age (see e.g. Bengtsson & Broström, 2009; Bengtsson & Lindström, 2000, 2003; Cormack et al., 2024; Quaranta, 2014; Schellekens & van Poppel, 2016; van Dijk et al., 2018).

Finally, we should also consider that sick and malnourished children are themselves sources of sanitary hazards and psychosocial stress, contributing significantly to the pathogenic load to which the other members of the household and neighbours are exposed. Individuals are not isolated, and diseases do not come alone. This is the major assumption of the Syndemics paradigm, which emphasizes the connection between interacting, co-present, or sequential diseases, and the social and environmental factors that foster and amplify the negative effects of disease interaction (Singer et al., 2017).

Current social and environmental epidemiology stresses that the consequences of feeding habits go beyond individual survival and well-being, to inform large sections of society and its mortality regime. Recent research on 19th-century Maastricht (Murkens et al., 2023) and Rostock (Mühlichen & Doblhammer, 2025) showed that food- and waterborne diseases were the major component of infant mortality and the key factor of health and social inequalities. Only their dramatic decline made a drastic decrease of mortality rate possible. Qualitative evidence supports the thesis that feeding practices, childcare, and hygiene played a crucial role. A more accurate knowledge of how societies and social groups coped with the "weanling's dilemma" may provide further evidence for this interpretation.

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