



ORIGINAL ARTICLE

Public health reforms and the mortality decline in nineteenth-century Italy

Francesco Maria Salvatore Fiore Melacrinis¹ | Mauro Rota² 

¹Department of Economics, Management and Statistics (DEMS), University of Milan – Bicocca, Milan, Italy

²Department of Methods and Models for Economics, Territory and Finance (MEMOTEF), Sapienza University of Rome, Rome, Italy

Correspondence

Mauro Rota

Email: mauro.rota@uniroma1.it

Tweet: The health reforms of 1887–8 in Italy led to a significant decline in mortality from infectious diseases. Enhanced sanitary governance and sanitary surveillance were crucial in this process, emphasizing the passive modernization pattern of Italy.

Abstract

This study examines the impact of Italy's 1887–8 health reforms on mortality, contributing to the historical debate on the state's role in Europe's health transition. Leveraging event-study-style difference-in-differences approach, we assess the effectiveness of the Crispi–Pagliani reforms, which strengthened public health governance and introduced targeted non-pharmaceutical interventions to mitigate deaths from infectious diseases. Mortality from targeted diseases decreased by 8.5 per cent relative to non-targeted diseases within 5 years of the reforms. The results highlight the role of sanitary surveillance and coordinated governance, particularly effective in less-educated regions, where public authorities compensated for limited health knowledge and prompted information flow in a broader process of top-down modernization.

KEYWORDS

diff-in-diff, infectious diseases, mortality, non-pharmaceutical interventions, passive modernization

JEL CLASSIFICATION

I15, I18, N33

The stabilization of mortality rates across Europe since the mid-eighteenth century marked the end of an era where deadly epidemics shaped daily life and survival. Yet, it was not until the late nineteenth century that a true revolution in public health occurred, as the persistent threat

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2025 The Author(s). The *Economic History Review* published by John Wiley & Sons Ltd on behalf of Economic History Society.



of endemic infectious diseases finally began to recede.¹ The reasons for this shift span from improvements in nutrition² to accelerating economic growth,³ as well as the spread of medical knowledge and better public health infrastructures.⁴ Empirical analysis has so far concentrated on northern and continental European countries and the United States, often overlooking southern Europe.⁵ The distinctive geographical characteristics and living standards of Mediterranean countries created an epidemiological environment markedly different from the rest of the continent, making this region a valuable case for broadening our understanding of the health transition in Europe.

This study investigates the effects of public health reforms enacted in Italy between 1887 and 1888 on mortality rates. The Italian government reformed the health system by strengthening public health governance and introducing non-pharmaceutical interventions (NPIs) to mitigate infectious diseases. Analysing mortality trends during and after these reforms, we observe a significant reduction in death rates from infectious diseases targeted by these interventions, in contrast to chronic and systemic illnesses, which remained beyond the reach of medical science at the time. The results reveal an 8.5 per cent decrease in death rates from targeted diseases relative to non-targeted diseases within 5 years of the reforms.

The new policies introduced sanitary surveillance, mandatory quarantine, and regular inspections of unhealthy neighbourhoods, conducted by health officers and medical engineers. Central to these reforms was the enhancement of coordination and sanitary governance, led by the General Directorate of Health, a public organization responsible for overseeing nationwide health management. To coordinate control and mitigation measures, provincial branches of this central authority were established. Within this framework, provincial physicians and municipal health officers played pivotal roles in coordinating actions and enforcing public health measures.

Using the health reforms as a quasi-natural experiment in event-study-style difference-in-differences (diff-in-diff) approach, we identify a neat nexus between the new policies and the reduction of mortality rates. Our identification strategy assumes that the new rules reduced mortality caused by the targeted diseases but were not effective, in a significant way, when it came to mortality caused by untreatable illnesses.

We explored the possible channels that facilitate the success of the reforms. The effectiveness of sanitary surveillance emerged as a paramount factor, while the supply of medical services was not a significant determinant. Moreover, we find that the reforms were more effective in undereducated areas. This leads to two interpretations. First, it suggests that public authorities acted as a substitution vehicle for a lack of health-related knowledge, replacing education-based compliance with surveillance and containment measures. Second, local and national layers of governance promoted the information about the content of the reform more effectively in areas with higher illiteracy rates. Thus, the reforms not only improved the coordination of different levels of accountability but also enhanced the overall quality of public governance, supporting the hypothesis of a top-down modernization across Italy.

¹ Schofield and Reher, 'Decline of mortality'.

² McKeown, *Modern Rise*.

³ Fogel, 'New findings'.

⁴ Costa 'Health and the economy'.

⁵ See Gallardo-Albarrán, 'The global sanitary revolution', for a review.



Our results contribute to two different strands of the historical debates. First, we add further evidence to the revised beneficial role of government intervention in reducing mortality in the second half of the nineteenth century in the Western world.⁶ While several recent studies have assigned a decisive role to public investments in water sanitation and supply⁷ or to mandatory health insurance scheme,⁸ we underscore the importance of sanitary surveillance and management coordination in curbing several infectious diseases, both waterborne and airborne.

In addition, our findings shed new light on the decline in mortality and the associated increase in life expectancy,⁹ during the so-called health transition in Italy. Although general mortality was slowly falling in Italy because of the improved nutrition of the population since 1861,¹⁰ only in the last decades of the nineteenth century did Italian mortality rates begin to catch up with Western European standards,¹¹ a process driven to a large extent by the containment of infectious diseases.¹² Our analysis has shown that mortality declined not just because of improved economic conditions but mainly because of the state intervention in public health management, which targeted specific diseases sensitive to non-pharmaceutical interventions. This argument is supported, in a very general context, by Fogel, who considered nutrition improvements dominant in curbing mortality only until 1875, when their contribution declined.¹³

The second strand of literature we contribute to is the debate on Italy's economic development, which emerged in the last decade of the nineteenth century as domestic institutions strengthened and sound policies were adopted.¹⁴ The top-down structure of the public health system and the devolution of public hygiene management to municipalities generated high coordination costs, yielding a limited reduction in mortality until 1886. The reforms of 1887 and 1888 introduced the provincial physicians, a missing link between the central authority and the local government, lowering transaction costs associated with agency problems between the central state and municipalities. Because public health reform was a key institutional change that reinforced the quality of governance and because it was more effective in curbing mortality in the South and in cities with lower levels of education, our findings align with the idea of top-down modernization advanced by Felice and Vasta.¹⁵

The remainder of the paper is organized as follows. Section I presents the background and content of the public health reforms of 1887 and 1888. Data and sources are detailed in section II. The methodology and main results are presented in section III. Section IV explores the heterogeneous effects across cities and diseases, while potential mechanisms running from the reform to mortality rates are studied in section V. Conclusions are drawn in section VI.

⁶ Chapman, 'Contribution of infrastructure'; idem, 'Interest rates'; Szreter and Mooney, 'Urbanization'.

⁷ Szreter and Mooney, 'Urbanization'; Cutler and Miller, 'Role of public health'; Ferrie and Troesken, 'Water and Chicago's mortality'; Kesztenbaum and Rosenthal, 'Sewers' diffusion'; Alsan and Goldin, 'Watersheds'; Gallardo-Albarrán, 'Sanitary infrastructures'; Troesken, Tynan, and Yang, 'What are the health benefits'. Other studies tend to downplay the alleged effect of public health policies (Anderson, Charles, and Rees, 'Reexamining the contribution') or discuss the conditions for the success of public investments (Gallardo-Albarrán, 'Global sanitary revolution').

⁸ Bauernschuster, Driva and Hornung, 'Bismarck'.

⁹ Caselli, 'Mortalità'.

¹⁰ Federico, 'Heights'.

¹¹ Chesnais, *The demographic transition*.

¹² Caselli, 'Health'; Breschi and Pozzi, *Salute*.

¹³ Fogel, 'Second thoughts'.

¹⁴ Felice and Vecchi, 'Italy's modern economic growth'.

¹⁵ Felice and Vasta, 'Passive modernization?'.

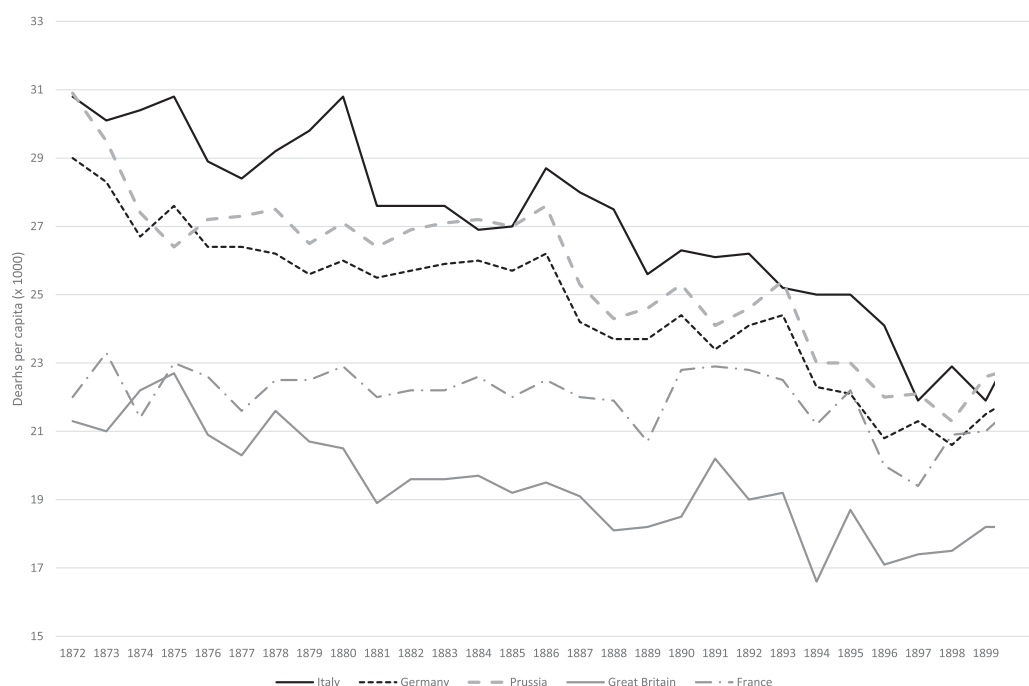


FIGURE 1 European death rates. *Source:* Chesnais, *The demographic transition* for France, Great Britain, Germany, and Italy. Hohorst 'Bevölkerungsentwicklung' for Prussia.

I | THE ITALIAN PUBLIC HEALTH SYSTEM

Following the unification of the kingdom, Italy struggled with one of the highest mortality rates among Western nations. By 1881, the mortality rate stood at 27.6 per thousand, nearly matching that of Prussia, while France's was around 22 per thousand and Great Britain's at 18.9 per thousand. At the dawn of the reforms in 1886, mortality in Italy was still above that of France and Prussia (figure 1). Compared with northern European countries, the nosographic reports highlight a prevalence in Italy of infectious diseases, such as typhoid fever, malaria, and syphilis, and a significant frequency of deaths from enteritis, diarrhoea, and respiratory inflammations. In contrast, deaths from tuberculosis, alcoholism, tumours, and acute rheumatism were lower than in the rest of Europe.¹⁶

Italian public authorities were aware of the exceptionally high mortality rates and, from the unification onward, tried to organize a system of public health. The Ricasoli Law, part of the administrative unification of the kingdom, entrusted the Ministry of the Interior with the responsibility of safeguarding public health (Act 2248/1865, Annex C). This duty was further delegated to provincial intendants and mayors, who received guidance from specialized councils composed of medical professionals and legal experts appointed by the king and the Ministry of the Interior. However, their role was purely advisory, lacking any authority to inform central or local public health policies. This system of public hygiene turned out to be ineffective. Indeed, the difficulty of staffing medical councils was compounded by the presence of approximately 4800 municipalities in Italy with fewer than 1000 inhabitants and limited financial resources. Moreover, several

¹⁶ MAIC-DGS, *Statistica delle cause di morte. Anno 1882*.



mayors hesitated to consult these councils, fearing potential electoral repercussions, given that citizens perceived public hygiene advice as an interference with their private lives.¹⁷

The reform of public health architecture was made possible by the accumulation of medical and scientific knowledge in the second half of the nineteenth century. The germ theory, developed through the discoveries of scientists such as Pasteur and Koch, questioned the dogma of the zymotic theory that traced disease outbreaks back to Aristotle's philosophical concept of spontaneous generation of life. The recognition of the role of transmission vectors spread throughout Europe, particularly within academic circles, fixing a new medical paradigm. Nonetheless, the identification of bacteria or vectors of transmission did not immediately lead to the discovery of pharmaceutical treatments, which often emerged much later in the twentieth century. Indeed, it showed the road to adopting potential actions for limiting the spread of infectious diseases.

In 1884, the Italian government promoted a nationwide investigation into the sanitary and hygienic conditions of municipalities. The findings of this inquiry, known as the *Inchiesta sulle condizioni igieniche e sanitarie nei comuni del Regno* (Investigation into the Sanitary and Hygienic Conditions in the Municipalities of the Kingdom), revealed unhealthy living conditions for Italians, particularly in the southern regions of the country.¹⁸ Italy's mortality rates for noninfectious diseases were broadly in line with those of other Western European countries, according to the report.¹⁹ On the contrary, mortality rates for infectious diseases,²⁰ such as smallpox, measles, typhoid fever, and malaria, were higher in Italy compared with its European counterparts. Additionally, Italy stood out for its deaths due to diphtheria and tuberculosis, second only to the German cities.

Spurred by the profound impact of the cholera epidemic of 1884–5,²¹ the government revamped the public health system, recognizing the urgent need to ameliorate the unsatisfactory sanitary conditions prevalent in the Italian cities. In May 1887, Francesco Crispi, then minister of the interior (and future prime minister from July 1887), called upon Luigi Pagliani, the first professor of hygiene at the University of Turin. The aim was to establish an effective public health system, prioritizing hygienic improvements and the containment of infectious diseases.²² The collaborative effort between politics and science resulted in a series of legislative measures starting in 1887, which extended into the subsequent year and consolidated through the enactment of Law No. 5849 in 1888, known as Crispi–Pagliani reform.²³ Public health improvements were driven by a bipartisan commitment to healthcare, as a knowledge-based approach to designing new interventions gained traction among Italy's political and cultural elites during the 1880s.²⁴

The collaboration between politics and science became evident in July 1887 through the implementation of two measures; Royal Decrees No. 4704 and 4878. The first established the Directorate of Public Health in the Ministry of the Interior. The second measure appointed a team of sanitary

¹⁷ Della Peruta, 'Sanità'.

¹⁸ DGS, *Risultati dell'inchiesta sulle condizioni igieniche e sanitarie nei comuni del regno. Relazione Generale*.

¹⁹ Ibid., p. CXCVI, and onwards.

²⁰ An overview of the relative importance of different causes of deaths in Italy before and after the reforms of the 1880s is presented in Table 1B of Appendix 2.

²¹ Del Panta, 'Epidemie'.

²² Pagliani 'Costituzione'.

²³ Italian historiography regards the Law of 1888 as a defining moment in the development of Italy's healthcare institutions (Cea, *Governo*).

²⁴ Fiore Melacrinis, 'Quando la conoscenza'.



engineers to supervise and ensure hygienic standards in public spaces and private residences. Their duties extended to the supervision of sewage systems and waste disposal systems. Moreover, regular inspections of water sources and sewage systems were mandatory, along with testing the quality of drinking water and wastewater. The periodical inspections by the sanitary engineers helped in monitoring the hygiene standards of municipalities and, in instances of poor hygienic conditions, to activate the sanitation measures. In September 1887, another significant step was taken with Royal Decree 4937/1887, which delineated stringent criteria for the selection of members of the sanitary directorate. Potential members had to be university professors or individuals who had published scientific works on hygiene and related subjects for the press.

Finally, these efforts culminated with the enactment of the Crispi–Pagliani Law (CPL), which consolidated the previous decrees and introduced additional measures to further improve public health standards. Operative instructions were finally set by the Unified Regulation (UR) for the execution of the Crispi–Pagliani Law issued in 1889.

Two new elements were central to the reforms. The first was a set of non-pharmaceutical interventions tackling infectious and contagious diseases. Sanitary surveillance became mandatory for anyone practising a medical profession. Once physicians or other medical professionals were aware of an outbreak of contagious diseases, they had to inform the mayor and the municipal sanitary official (CPL art. 45). In the case of omitted reports, non-compliant professionals may have been fined. The diseases surveilled comprised smallpox, measles, scarlet fever, typhus, typhoid fever, diphtheria, puerperal fever, cholera, and syphilis (UR art. 108). The containment of deadly infectious diseases was delegated to the inspections of the municipal sanitary officials (UR art. 109). If a case of any infectious and contagious disease was detected, the health officers had the power to implement sanitation in private and public areas and to isolate infected people at home or in a hospital with the support of a physician. Indeed, respect for the isolation of infected individuals was grounded on voluntary compliance (UR art. 109).

The list of diseases subject to mandatory and public notification excluded tuberculosis and acute pneumonia. In this case, the isolation was advised by the personal doctor of the infected person rather than by a public official, but the sanitization of homes or public places was expressly required by law in the case of tuberculosis (UR art. 111).

The containment of waterborne diseases was instead designed through the mandate for each municipality to provide the population with a system of drinkable and clean water pipelines (CPL art. 44). Other pivotal measures were introduced to ensure the flow of water in the reclamation areas (CPL art. 36) to mitigate malaria, to build and maintain an efficient sewer system for private dwellings, and to bury dead people properly. Moreover, the CPL introduced the mandatory vaccination for smallpox, which was provided for free (art. 51 and 52).

The second pillar of the reforms was the coordination within the public health system. The sanitary surveillance and the enforcement of mandates were reinforced through a chain of command involving the municipal health officer, the provincial physician, and the prefect who should adopt the mitigation and containment measures. On the municipal level, the health officer (CPL art. 12–13) monitored the hygienic and health conditions, promptly reporting to both the provincial physician and the mayor any situation demanding special health measures or highlighting transgressions against health laws and regulations. The provincial physicians were expected to oversee the health service and the hygienic conditions of municipalities, thereby serving as a crucial intermediary between the local and central authorities (CPL art. 10–11). They had to maintain constant correspondence with municipal health officers, ensuring compliance with health laws and regulations. The provincial physicians were also responsible for informing the prefect of any public health concerns and suggesting urgent measures for public safety. Furthermore, they



could propose disciplinary actions against health personnel and other medical professionals for any misconduct or violation of health standards. This structured hierarchy and neat distribution of responsibilities between the provincial physician and the municipal health officers played a significant role in the implementation of the public health reforms.

Additional regulatory provisions established the Higher Health Council at the Ministry of the Interior, provincial health councils under prefect control, and mandated municipal health services, including at least one physician and hygienic oversight (CPL art. 2). Municipalities with over 20 000 inhabitants were also required to establish laboratories. Article 3 provided free medical and obstetrical care for the poor and introduced local hygiene regulations tailored to each municipality's geographic and local conditions.

A coeval provincial physician, Michele Pietravalle, defined the rules introduced in 1887 and 1888 as measures of the sanitary police. He published a guide, largely used by practitioners, summarizing the tasks, prerogatives, and tools available to sanitary officials.²⁵ After reviewing the main measures introduced by the reforms, he emphasized the achievements of the sanitary police in curbing mortality from infectious and contagious diseases. At the same time, he observed, the fatality rates of the so-called common diseases, that is, systemic and chronic illnesses, had remained unchanged since the introduction of the reforms. When Pietravalle listed the infectious and contagious diseases targeted by the reforms, he included both the diseases subjected to sanitary surveillance and the diseases subjected to preventive measures, thus including different types of tuberculosis, acute pneumonia, and malaria.²⁶

As we shall demonstrate in the following sections, the legislative innovations of 1887 and 1888 would have a decisive impact on reducing mortality of targeted diseases, but a negligible effect on chronic and systemic diseases for which medical and pharmaceutical treatments were hardly ever available and for which non-pharmaceutical interventions were ineffective.

II | DATA ON THE CAUSES OF DEATH

The records of causes of death in Italy trace back to 1881, when the government made it mandatory to fill out death certificates for each deceased individual. The *Direzione Generale di Statistica* (General Directorate of Statistics) compiled an annual report offering a comprehensive overview of causes of death across the 284 provincial and district capital cities. These certificates, indicating the causes of death, were completed by either a medical doctor or a coroner. The requirement to submit death certificates has extended to the entire national territory since 1887. Official statistics aggregated data at the provincial level, while figures for the 284 main cities continued to be published separately. In compiling data, we gathered information from 1883 to 1892 to ensure symmetry in the time frames between the pre- and post-reform periods.²⁷

Our sample of 284 provincial and district capital cities, involving more than seven million inhabitants, is representative of the country's mortality patterns. The mortality trends observed in those provincial and district capital cities closely reflect those of the country (figure 2a in Appendix 2). This assurance alleviates any concern regarding the potential bias resulting from the arbitrary selection of the sample, establishing a solid basis for our research findings.

²⁵ Pietravalle, *Polizia sanitaria*, pp. 52–3.

²⁶ Ibid., pp. 44–51.

²⁷ Although the collection of causes of death started in 1881, we excluded the reports of 1881 and 1882 due to incomplete information. See Appendix 1 for the reports we consulted and the detailed references.

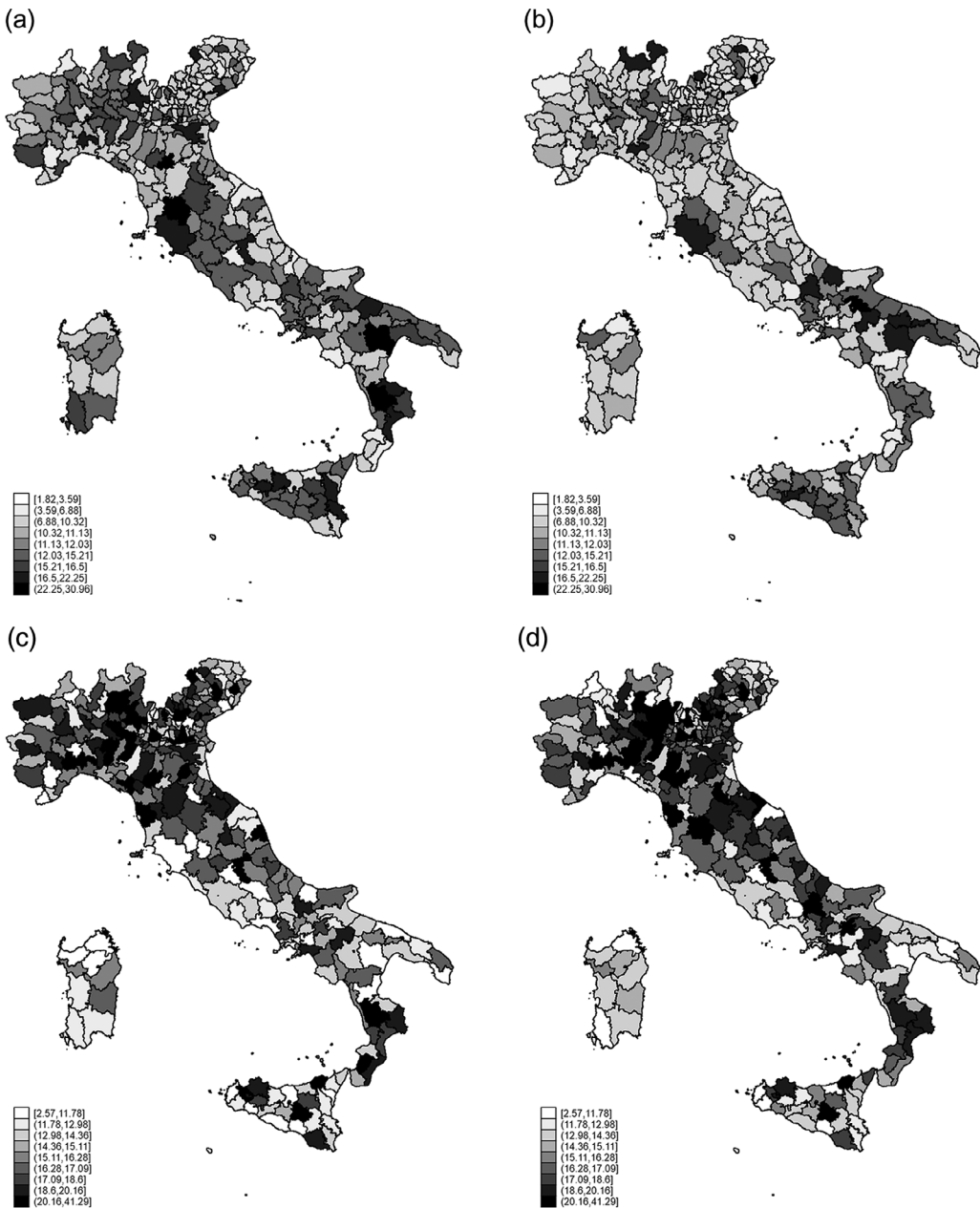


FIGURE 2 Local distribution of death rates per capita ($\times 1000$). Targeted disease in 1883 (a), Targeted disease in 1892 (b), non-targeted disease in 1883 (c), non-targeted disease in 1892 (d). *Notes:* data refer to the district capital city of each area. See Table 1 and Appendix 1 for sources.

For the research design, we selected the diseases targeted by the reforms and indicated in the practical guide of the provincial physician Pietravalle.²⁸ Thus, the diseases targeted by the reforms are smallpox, measles, scarlet fever, typhoid fever and typhus, malarial fever, syphilis, diphtheria,

²⁸ Pietravalle, *Polizia sanitaria*.



TABLE 1 Summary statistics of mortality rates of targeted and non-targeted diseases (×1000).

Disease	N	Mean	SD	Min	Max
Non-targeted diseases	2840	15.9	3.9	2.6	49.7
Targeted diseases	39,760	0.8	1.3	0	51.2
<i>Cholera</i>	2840	0.2	1.2	0	26.7
<i>Diphtheria</i>	2840	0.6	1.4	0	51.2
<i>Enteritis</i>	2840	2.9	1.7	0	14.4
<i>Malaria</i>	2840	0.5	1.0	0	8.7
<i>Measles</i>	2840	0.5	1.0	0	14.3
<i>Pneumonia</i>	2840	2.1	1.1	0	10.9
<i>Puerperal fever</i>	2840	0.1	0.1	0	1.5
<i>Scarlet fever</i>	2840	0.2	0.7	0	10.0
<i>Smallpox</i>	2840	0.3	1.1	0	18.8
<i>Syphilis</i>	2840	0.1	0.2	0	2.2
<i>Pulmonary tuberculosis</i>	2840	1.7	0.9	0	5.2
<i>Other tuberculosis</i>	2840	0.6	0.6	0	10.4
<i>Typhus and typhoid fever</i>	2840	0.8	0.6	0	6.3
<i>Whooping cough</i>	2840	0.3	0.5	0	5.6

Notes: Sample: 284 district and provincial capital cities from 1883 to 1892. Typhus and typhoid fever are different diseases but they are grouped together in some of the reports we consulted. However, typhoid fever accounted for at least 96% of the total cases. *SD* stands for standard deviation.

Source: Our computation on population and causes of death. For sources see Appendix 1.

whooping cough, acute pneumonia, puerperal fever, enteritis, and tuberculosis. The comparison group comprises deaths attributed to diseases for which preventive measures and effective treatments were lacking or for which NPIs were not effective. The diseases not targeted by the reforms include systemic and chronic ailments.²⁹

In 1883, deaths from targeted diseases accounted for 42 per cent of total deaths, increasing to 44 per cent by 1886. However, from 1887 onwards, their percentage began to decline, reaching 38.8 per cent in 1892. Consequently, deaths from targeted diseases decreased from 72.5 per cent in 1883 to 63.5 per cent in 1892 relative to the non-targeted group. Analysing deaths per capita in 1883, there were, on average, 16.4 deaths from non-targeted diseases per thousand inhabitants and 11.9 deaths from targeted diseases per thousand inhabitants. In the post-reform years, deaths from the non-targeted group remained stable, while deaths from targeted diseases decreased to 10.2 per thousand inhabitants.

As seen in table 1, among the targeted diseases, enteritis showed the highest average mortality rate (2.9 per thousand inhabitants), with a maximum of 14.4, followed by pneumonia, with an average rate of 2.1 and a maximum of 10.9. These values suggest that these infections, likely due to their widespread reach and the severity of their symptoms, represented a primary cause of mortality among infectious diseases of the time. Other ailments, such as diphtheria, malaria, and measles, show lower average mortality rates (all below 1 per thousand inhabitants) but still exhibit notable peaks in certain areas. For instance, diphtheria reaches a maximum value

²⁹ The main categories include cardiovascular diseases, perinatal conditions, degenerative diseases, tumours, and neurological disorders.



of 51.2, indicating the presence of particularly intense local outbreaks. Similarly, cholera and smallpox, which have average mortality rates of 0.2 and 0.3 per thousand inhabitants, respectively, show significant peaks – reaching up to 26.7 per thousand inhabitants for cholera and 18.8 per thousand inhabitants for smallpox – highlighting the severe impact these diseases can have.

Looking at the local distribution of mortality rates (figure 2), the targeted diseases in 1883 (Panel A, left) were somewhat evenly distributed across the entire peninsula, with a denser presence most evident in central and southern areas. In contrast, non-targeted diseases in 1883 (Panel B, left) were mainly concentrated in central and northern regions, without a specific pattern. Five years after the reforms, the intensity of the targeted diseases decreases (Panel A, right), while the distribution of mortality from non-targeted diseases (Panel B, right) expanded more uniformly across Italy, reflecting a broader presence.

Figure 3 illustrates the year-by-year evolution of both categories of deaths per capita, indicating a shared pattern before the reforms, but a noticeable divergence from the introduction of earlier reforms in 1887 onwards. In the following section, we provide statistical evidence demonstrating that the divergent patterns observed in deaths from reform-sensitive diseases can be attributed to the tailored interventions implemented by the Crispi government in 1887 and 1888.

III | THE EFFECTIVENESS OF CRISPI'S PUBLIC HEALTH REFORMS

We employ an event-study-style difference-in-differences estimator to assess the effects of the reforms. Based on the reading of the main acts of the public health reforms, our baseline assumption suggests that the reforms targeted specific infectious diseases while leaving other diseases unaffected. This assumption is grounded in the considerable medical and scientific knowledge available to the medical community at the time of the reform. By the time of the reforms, the European scientific community had already integrated the latest advances in understanding the transmission mechanisms of several infectious diseases. Hence, any discontinuity observed in the pre- and post-reform periods cannot be attributed to a significant break in scientific knowledge. Instead, the application of these new scientific and medical principles drove the divergent patterns observed in the various causes of death.

In our difference-in-differences approach, we compare deaths from targeted diseases with deaths from systemic or chronic diseases (the non-targeted group) in the years preceding and following the reforms. We collected data for 14 diseases targeted by the reforms and one non-targeted group, encompassing chronic and systemic diseases, observed across 284 district and provincial capital cities during the period 1883–92. This yields a total of 42,600 observations ($15 \times 284 \times 10$). We also perform the analysis for the sub-sample of 69 provincial capital cities, whose results are presented in a series of tables in Appendix 2.

Let us define y_{ijt} as the death rates per capita (per thousand) for i disease in city j at year t . We define D_i as a binary variable taking the value 1 if the disease is targeted by the reforms and 0 otherwise. The specification includes the year fixed effect (T_t), disease fixed effects (α_i), city fixed effects (β_j), and an error term (ϵ_{ijt}). We also include time-invariant covariates (Γ_j) and time-varying covariates (X_{jt}) at the city level.³⁰ Thus, we use the following specification, which

³⁰ The differences-in-difference literature suggests including time-invariant and pre-treatment variables and allowing them to interact with both time fixed effects and treatment status (Roth, Sant'Anna, Bilinski, and Poe, 'What's trending'). In contrast, time-variant variables are allowed to interact with the treatment status only.

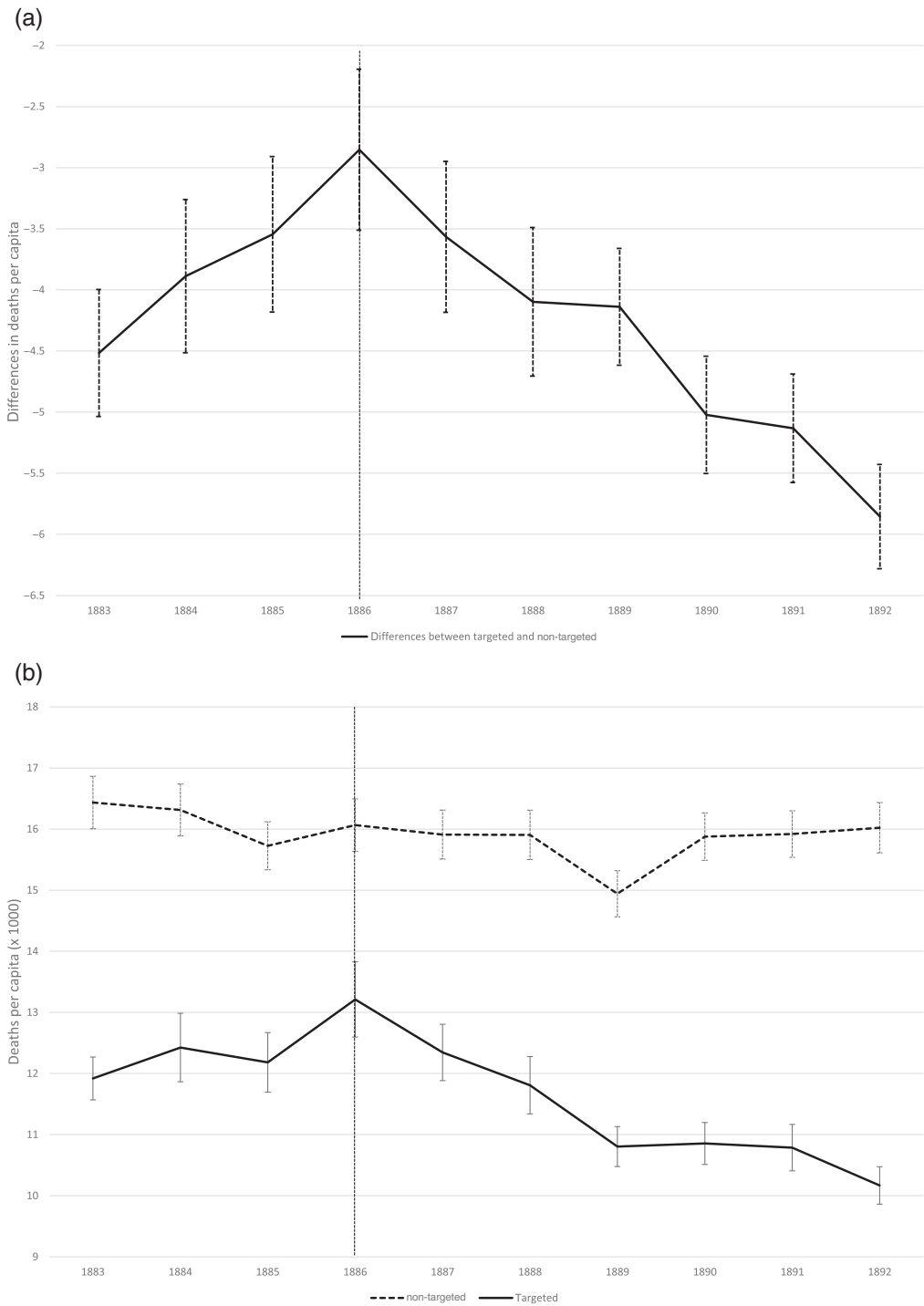


FIGURE 3 Per capita death rates for targeted diseases versus non-targeted diseases in 284 district and provincial capital cities with confidence intervals (95%). *Notes:* The Panel (a) shows the average deaths per capita ($\times 1000$) of the targeted and non-targeted diseases. The Panel (b) reports the differences between the deaths per capita ($\times 1000$) of targeted and non-targeted diseases. See Appendix 1 for sources. For the definition of targeted and non-targeted diseases, see the text in sections I and II. The last year before the reforms was 1886.



closely echoes the one used in [Alsan et al.](#)³¹:

$$y_{ijt} = c + a_i + b_j + T_t + \sum_{t=1883}^{1892} \beta_t (D_i * T_t) + X'_{jt} * D_i * \gamma + \sum_{t=1883}^{1892} \delta_t * T_t * \Gamma'_j + \Gamma_j * D_i * \vartheta + e_{jit} \quad (1)$$

The coefficients of interest are the β_t elements. Because death rates have a positive skew in the data and to handle, at the same time, a non-negligible number of zeroes, our regressions use the log of $(1+y_{ijt})$ as the dependent variable, in line with the literature in this field.³² Recent contributions have emphasized the problematic use of the log transformation, as the scale of the dependent variable can bias the coefficients of interest.³³ In Appendix 2, we performed three checks to stress the robustness of our results. Indeed, table 2d uses the inverse hyperbolic transformation³⁴ of the dependent variable, and Table 2e removes zeroes from the sample.³⁵ These models show that manipulating the dependent variable does not invalidate our main findings in qualitative terms. Third, we have also employed the Poisson quasi-maximum likelihood regression as an alternative estimation method, getting findings that align closely with those from table 2 and even suggesting a stronger impact of the reforms on the targeted diseases (table 2c of Appendix 2).

We condition the effect of the reforms on several control variables commonly used in studies on mortality rates of the nineteenth century.³⁶ These include the coverage of the sewer system and the quality and quantity of public water, both observed before the reforms. Rainfall and temperature, defining the environmental context to which diseases are susceptible, are introduced as time-invariant controls. We also included population density as a time-variant variable.³⁷

Moreover, we introduce real wages to account for the alternative that the reduction of mortality rates depends on improved economic conditions. The hypothesis of better living standards causing a decline in mortality is central in Federico's analysis of Italy³⁸ and is more generally accepted in the literature linking mortality to socio-economic status,³⁹ although specific case studies downplay the role of social gradient.⁴⁰ Real wages data covering the entire period for our sample units were only available before the reforms were introduced.⁴¹ Consequently, we treat real wages as a time-invariant variable, assuming that the reforms do not immediately affect real wages in a short period. While reductions in mortality can influence real wages over time through changes

³¹ [Alsan, Atella, Bhattacharya, Conti, Mejía-Guevara, and Miller](#), 'Technological progress'.

³² [Alsan and Goldin](#), 'Watersheds'; [Gallardo-Albarrán](#), 'Global sanitary revolution'.

³³ [Chen and Roth](#), 'Logs'.

³⁴ The arcsine transformation suffers from limitations similar to those of the log-transformation.

³⁵ Removing zeroes results in 'shutting off' the extensive margins, which means undervaluing the reduction in mortality that involves zero cases. In this case, we use the method described in 'Logs' section V.B., point 3, in [Chen and Roth](#). Let us note that this method should be applied with caution because our data are not monotonic, as assumed by the underlying model. In other words, we are not in a situation where some observed outcomes monotonically fall to zero. Instead, deaths frequently jump to zero from positive values both before and after the treatment for certain diseases and cities.

³⁶ Summary statistics of control variables are available in table 1a of Appendix 2.

³⁷ Moreover, in table 2.1a of Appendix 2, we tested whether the age structure of the population modifies our results. The exercise, conducted only for the 69 provincial capital cities because of data availability, does not reveal a specific role for the age structure in our context.

³⁸ [Federico](#), 'Heights'.

³⁹ [Bengtsson and Van Poppel](#), 'Socioeconomic inequalities'.

⁴⁰ [De Haro, Pujadas-Mora, and García-Gómez](#) 'Inequality in mortality'.

⁴¹ [Federico, Nuvolari, and Vasta](#), 'Origins'.



TABLE 2 Effects of the reforms on mortality rates from targeted diseases.

	(1) Entire country	(2) North	(3) South
Targeted × 1883	−0.020 (0.014)	−0.010 (0.016)	−0.041 (0.028)
Targeted × 1884	−0.040*** (0.013)	−0.022 (0.014)	−0.076*** (0.026)
Targeted × 1885	0.011 (0.013)	0.021 (0.015)	−0.011 (0.025)
Targeted × 1886	0.018 (0.012)	0.032** (0.014)	−0.011 (0.021)
Targeted × 1888	−0.003 (0.011)	0.005 (0.012)	−0.023 (0.024)
Targeted × 1889	0.032*** (0.012)	0.037** (0.015)	0.022 (0.023)
Targeted × 1890	−0.052*** (0.013)	−0.039** (0.015)	−0.083*** (0.026)
Targeted × 1891	−0.062*** (0.015)	−0.031* (0.017)	−0.130*** (0.027)
Targeted × 1892	−0.089*** (0.014)	−0.069*** (0.015)	−0.134*** (0.027)
Constant	0.204 (0.162)	0.193 (0.187)	0.060 (0.290)
Observations	42,600	29,250	13,350
R ²	0.841	0.878	0.803
Cities	284	195	89
Cities fixed effect	Yes	Yes	Yes
Disease fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The dependent variable is log(1 + deaths rates). Controls include temperature, rainfall, quality of public water, sewerage coverage, wages, and population density. Standard errors are in parentheses and clustered at municipality level.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Source: Authors' own calculations.

in individual preferences, we believe such effects are more likely to manifest in the medium- to long-term rather than within the 5 years after the reforms.⁴²

In table 2, we assess the effects of the reforms through the coefficients of the event study. Before 1887, our baseline year, the coefficients are insignificantly close to zero, excluding 1884, indicating

⁴² Indirect evidence provided by the average calorie intake during this period reassures that our results are likely not driven by changes in physical health conditions, provided that real wages and calorie intake are strongly interrelated. The calorie intake of the Italian population did not improve in the 5 years after the reform, as suggested by Barberi, *Consumi*, and Federico, 'Heights'.



that deaths from targeted infectious diseases and those from non-targeted diseases followed similar patterns before the reforms were introduced. Five years after the implementation of public intervention (1892), we estimate for the full sample (column 1) a reduction in death rates from the targeted diseases of 8.5 per cent compared with the control group.⁴³

A further aspect analysed in table 2 is the regional inequality in mortality rates (columns 2 and 3). In figure 3, we observed a notable disparity in mortality causes between northern and southern Italy before the reform. Municipalities in southern Italy exhibited a higher prevalence of deaths resulting from infectious diseases compared with their counterparts in the north. Del Panta demonstrated that child mortality rates in the first month of life were higher in the North, while the reverse was true for deaths occurring between 9 and 12 months of age.⁴⁴ In this context, regional disparities in life expectancy began to experience improvement only from the late 1880s, initiating a gradual convergence with the rest of the country.⁴⁵ Our estimates suggest that the reforms were twice as effective in the southern cities as in their northern peers by 1892, leading to a decline of mortality rates from targeted diseases of 12.5 per cent, compared with non-targeted diseases, in the poorer areas of the country. The stronger effect in the South cannot be confounded with the influence of the environmental context, as our specifications control for climate factors, which can push upward mortality rates, especially those of infectious diseases. Therefore, the differences between North and South can be explained by a higher potential of the reforms in the *Mezzogiorno*, likely because of more scope for sanitary governance and coordination in executing sanitary surveillance efforts and non-pharmaceutical measures.

As the historical literature focuses on the diffusion of sewers and water supply in reducing mortality, we report the coefficients for these two covariates in a separate table, table 2f, presented in Appendix 2. The main finding is that the sewer system is significant both statistically and economically in reducing overall mortality from the targeted diseases, while the quality and quantity of water do not appear to be relevant. In large cities, the effects are much stronger (table 2g).

The reforms' effectiveness has also been studied by excluding large cities from the sample (table 2b in Appendix 2) and restricting the analysis to the 69 provincial capital cities, yielding similar results (table 2a in Appendix 2).

The results of table 2 are internally valid only in the case that the Parallel Trend Assumption (PTA) holds. Visual inspection of coefficients in column 1 supports that the deaths from targeted diseases and those caused by systemic and chronic diseases followed a parallel trend at least before the reforms, satisfying the pre-PTA assumption for the correct identification (figure 4).

We acknowledge the difficulty in precisely identifying a counterfactual, as the reforms were implemented nationwide and simultaneously, making it impossible to observe a place entirely free from direct influences. However, our identification strategy hinges upon the variations across diseases and years rather than across cities. Violation of the PTA could arise if some places had undertaken individual reforms asymmetrically, absent any national intervention. To mitigate this concern, we assume that past measures taken by each city before 1887 are signals of their experience in the management of public health intervention and, thus, represent the likelihood of implementing an individual reform if nationwide ones had not been enforced. In equation 1, we replace the status of being targeted by the reforms (D_i) with a new variable that captures the number of years a city has been exposed to the previous sanitary regulation

⁴³ We calculate the effect using the method proposed in Kennedy, 'Estimation', for the interpretation of dummy variable in semilogarithmic equations, which is $[\exp(\beta)-1] \times 100$, where β is the coefficient of interest.

⁴⁴ Del Panta, 'Dalla metà del settecento'.

⁴⁵ Felice and Vasta, 'Passive modernization?'

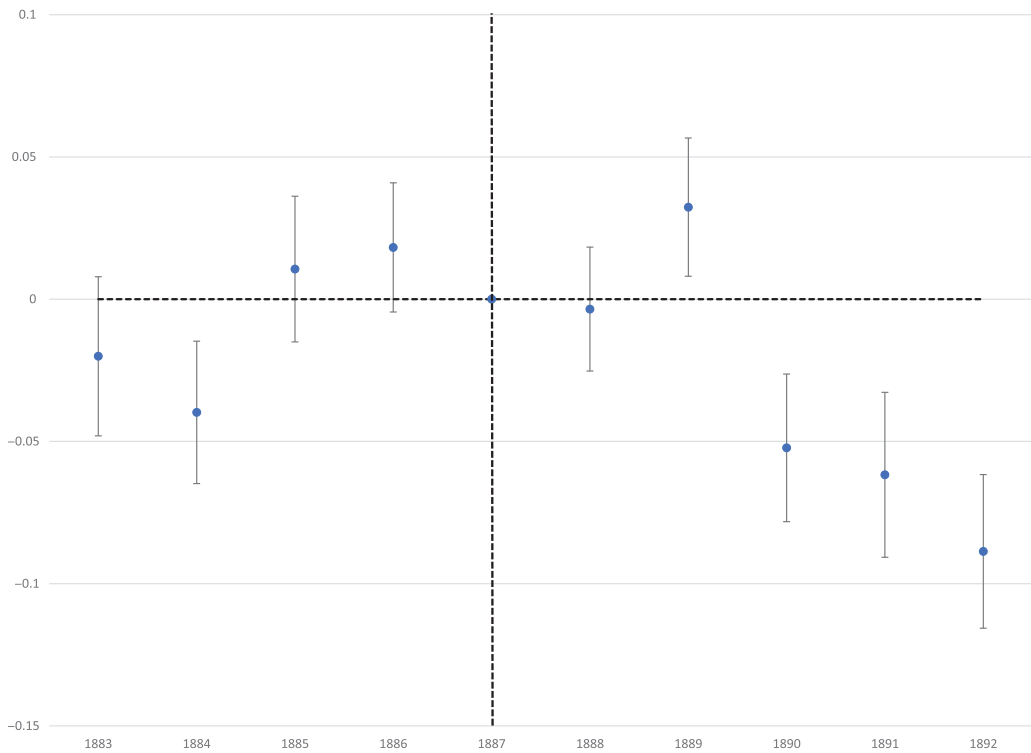


FIGURE 4 Coefficients' plot of the event study. *Source:* Table 2, column 1.

(pre-reform regulation).⁴⁶ Some cities adopted the acts in the early 1860s, while others did so later. This makes it possible to test whether the targeted diseases were affected by pre-reform local health regulations at the municipal level. The local regulations adopted before the reforms turned broadly ineffective in the mortality rates, proving that experience in the management of public health regulation cannot explain the death rates after 1887 (table 3).

IV | THE HETEROGENOUS EFFECTS OF THE REFORMS ACROSS CITIES AND DISEASES

State intervention in public health reduced mortality rates of the targeted diseases across Italy. However, the assumption that these effects were the same across our sample of cities may be restrictive because public health measures could have been applied with a different intensity across cities. One key factor we control for is compliance with implementing the new non-pharmaceutical interventions. Municipalities might have differed in terms of quality or their local bureaucracy's capacity to implement the national public health measures or to enforce the new non-pharmaceutical interventions, potentially leading to variations in outcomes. To measure the intensity of executing and enforcing the reforms, we use a measure of bureaucracies' compliance. In December 1887, the ministry made it mandatory for each municipality to send a monthly report (the *Bollettino Sanitario*) on the causes of deaths for the targeted diseases, to be published in the

⁴⁶ See Appendix 1 for the source from which we retrieved the year of adoption of the pre-reform sanitary regulation across cities.

**TABLE 3** Expositions to pre-reform public health regulation.

	(1) Entire country	(2) North	(3) South
<i>Pre-reform regulation</i> × 1883	−0.002* (0.001)	−0.002 (0.001)	−0.004 (0.003)
<i>Pre-reform regulation</i> × 1884	−0.002 (0.001)	−0.001 (0.001)	−0.005* (0.002)
<i>Pre-reform regulation</i> × 1885	−0.001 (0.001)	−0.001 (0.001)	−0.002 (0.003)
<i>Pre-reform regulation</i> × 1886	0.000 (0.001)	0.001 (0.001)	−0.000 (0.003)
<i>Pre-reform regulation</i> × 1888	−0.001 (0.001)	−0.000 (0.001)	−0.001 (0.002)
<i>Pre-reform regulation</i> × 1888	−0.000 (0.001)	0.000 (0.001)	−0.002 (0.003)
<i>Pre-reform regulation</i> × 1890	−0.001 (0.001)	−0.001 (0.001)	0.000 (0.003)
<i>Pre-reform regulation</i> × 1891	−0.001 (0.001)	−0.001 (0.001)	−0.003 (0.002)
<i>Pre-reform regulation</i> × 1892	−0.002** (0.001)	−0.002** (0.001)	−0.003 (0.002)
Constant	0.297* (0.169)	0.224 (0.197)	−0.015 (0.273)
Observations	42,600	29,250	13,350
R ²	0.841	0.877	0.803
Cities	284	195	89
City fixed effect	Yes	Yes	Yes
Disease fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The dependent variable is $\log(1 + \text{deaths rates})$. The pre-reform regulation variable is always zero for the non-targeted group of diseases. Controls include temperature, rainfall, quality of public water, sewerage coverage, wages, and population density. Standard errors are in parentheses and clustered at municipality level.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Source: Authors' own calculations.

official gazette, *Gazzetta Ufficiale del Regno d'Italia*.⁴⁷ This mandate served to keep the ministry informed of mortality trends by cause and to provide the people with critical information on local epidemiological and sanitary conditions. The reports also identify cities that failed to submit on time in any given month. Using data published in the official gazette, we constructed a variable representing each municipality's compliance, defined as the proportion of reports submitted on

⁴⁷ For the sources, see Appendix 1.



TABLE 4 Intensity of the reforms across cities: compliance with the new rules.

	(1) Entire country	(2) North	(3) South
<i>Compliance</i> × 1889	0.062*** (0.016)	0.046** (0.018)	0.085*** (0.031)
<i>Compliance</i> × 1890	−0.029* (0.017)	−0.031* (0.018)	−0.032 (0.036)
<i>Compliance</i> × 1891	−0.037** (0.017)	−0.025 (0.019)	−0.068* (0.036)
<i>Compliance</i> × 1892	−0.067*** (0.016)	−0.063*** (0.017)	−0.084** (0.037)
<i>Compliance</i>	−0.025 (0.015)	−0.016 (0.017)	−0.033 (0.031)
Constant	0.219 (0.167)	0.184 (0.193)	−0.005 (0.294)
Observations	42,600	29,250	13,350
<i>R</i> ²	0.841	0.877	0.803
Cities	284	195	89
City fixed effect	Yes	Yes	Yes
Disease fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The dependent variable is $\log(1 + \text{deaths rates})$. Controls include temperature, rainfall, quality of public water, sewerage coverage, wages, and population density. Compliance before 1888 is omitted because collinearity. The reference year is 1888. Standard errors are in parentheses and clustered at municipality level.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Source: Authors' own calculations.

time each year (e.g. reports submitted on time out of 12 required per year). This variable is zero for all cities before 1888. From 1888 onwards, if a city is fully compliant in a specific year, the variable takes the value of 1 for that city in that year for the targeted diseases, while the variable always takes the value of zero for the non-targeted group. We interpret this variable as a measure of exposure to the reforms, capturing the different intensities of the public health intervention across cities and years. In equation 1, the binary variable capturing the status of the targeted disease (D_i) is replaced by the new variable we label *compliance*. In table 4, the reference year is 1888, when the monthly reporting mandate was introduced.

The mandate of sending a monthly report on time had a clear impact on the mortality rates of targeted diseases. By 1892, mortality from targeted diseases dropped by 8.8 per cent relative to the non-targeted group in the full sample. Adjusting for a proxy of compliance in implementing and enforcing the new health measures yields an effect comparable to the specification of table 2. We detect qualitatively similar results in both the North and the South.

Another potential measure of the intensity of the reforms across cities is explored in table 4b of Appendix 2, where we studied the role of cumulative city-level hygiene-related public



expenditures, finding no sizeable effects. However, cumulative hygiene expenditures will be used later in the paper to analyse the possible transmission mechanism of the reforms (section V).

Within the targeted diseases, the effects of the reforms may vary depending on the mode of disease transmission. For instance, sanitary surveillance might prove more effective in containing or mitigating airborne diseases compared with waterborne ones. Conversely, inspections conducted by medical engineers and subsequent interventions may be more effective in limiting the transmission of waterborne diseases, as these engineers oversee the control of sewer systems, water pipelines, and cemeteries. Moreover, differences in the behaviour and characteristics of the targeted diseases may exist even if the transmission mechanism is the same. Table 5 examines the heterogeneous effects⁴⁸ across the targeted diseases for the full sample of 284 provincial and district capital cities.⁴⁹

The legislative interventions had varying impacts across diseases, differing in both magnitude and timing. Compared with the non-targeted diseases, the most affected category was typhus, at least 96 per cent of which is composed of cases of typhoid fever,⁵⁰ with a significant reduction in mortality by 21.5 per cent in 1892. Other diseases showing significant declines include diphtheria, whooping cough, scarlet fever, and malaria. Regarding diphtheria, significant reductions in mortality are observed starting from 1890, highlighting a delayed but consistent and steady effect of the reforms. In the case of scarlet fever (column 4), a significant decrease is observed only in 1892, suggesting that the interventions took more time to be effective.

The substantial effectiveness of the reform is associated with diseases transmitted by external vectors. In our sample, this category only includes malaria, and the reduction in mortality can be attributed to the increased use of quinine promoted by municipal doctors introduced by the reforms. Importantly, this effect is independent of the introduction of the so-called *chinino di stato* in 1895.⁵¹

Smallpox requires a separate discussion. Although significant reductions in smallpox mortality were recorded even before the legislative intervention of 1887–8, the new public health interventions reinforced the preventive measures by introducing mandatory vaccination. This contributed to a sustained and significant impact on the reduction of smallpox mortality.

An analysis of individual diseases suggests that major causes of death, such as pneumonia and enteritis, were likely not mitigated by the non-pharmaceutical interventions of the reforms, despite being targeted. Control of pneumonia by public health officers relied on voluntary isolation by individuals rather than mandatory measures. This provision might have turned into low efficiency in containing mortality. Moreover, the pattern of pneumonia reveals an anticipation effect starting in 1884 and a significant increase, compared with the non-targeted group, after 1888. This suggests that the reform not only was ineffective against pneumonia but also failed to mitigate the spread of underlying respiratory infections that triggered acute pneumonia. At the same time, Western Europe experienced the ‘Russian influenza’ pandemic between 1889 and

⁴⁸ We adjust equation 1 to accommodate a triple diff-in-diff as follows: $y_{ijt} = c + a_i + b_j + T_t + \sum_{(t=1883)}^{1892} \beta_t (D_i \times T_t) + \sum_{(t=1883)}^{1892} \omega_t (a_i \times T_t \times D_i) + X'_{jt} \times D_i \times \gamma + \sum_{(t=1883)}^{1892} \delta_t \times T_t \times \Gamma'_j + \Gamma_j \times D_i \times \vartheta + e_{jit}$. In this context the coefficients of interest are the ω_t elements that capture the effects of the reforms on every single disease (a_i).

⁴⁹ For the sake of space, we do not report here equivalent tables for the North and the South. These can be consulted in Appendix 2 in tables 5a and 5b.

⁵⁰ As we stated in table 1, typhus and typhoid fever are grouped together in some reports, but typhoid fever represents at least 96% of total deaths in this category when the breakdown of the two diseases is reported in our sources.

⁵¹ *Chinino di stato* (State quinine) was introduced in 1895. It consisted of the commercialization of quinine at a controlled price in governmental shops accessible without any medical prescription.



TABLE 5 Heterogeneity effects of the reforms on individual targeted diseases (entire country).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Measles	Diphtheria	Pneumonia	Scarlet fever	Smallpox	Pulmonary TBC	Other TBC	Whooping cough
Targeted × 1883	−0.042 (0.039)	0.079** (0.034)	−0.008 (0.028)	−0.000 (0.024)	−0.189*** (0.028)	0.083*** (0.021)	−0.048** (0.021)	−0.051* (0.028)
Targeted × 1884	−0.120*** (0.037)	0.043 (0.034)	−0.084*** (0.023)	0.019 (0.028)	−0.160*** (0.030)	0.070*** (0.020)	−0.094*** (0.019)	−0.059** (0.029)
Targeted × 1885	−0.108*** (0.038)	0.086*** (0.032)	−0.055** (0.023)	0.041 (0.029)	−0.070** (0.032)	0.102*** (0.018)	−0.023 (0.019)	0.013 (0.029)
Targeted × 1886	−0.124*** (0.038)	−0.007 (0.025)	0.009 (0.024)	0.014 (0.023)	−0.015 (0.031)	0.074*** (0.020)	−0.050*** (0.017)	−0.016 (0.012)
Targeted × 1888	−0.032 (0.043)	−0.027 (0.023)	0.088*** (0.021)	−0.013 (0.022)	0.014 (0.036)	0.038** (0.017)	−0.030* (0.018)	0.003 (0.012)
Targeted × 1889	−0.085** (0.036)	−0.019 (0.027)	0.083*** (0.022)	0.047*** (0.024)	0.018 (0.035)	0.102*** (0.019)	0.019 (0.019)	0.052*** (0.017)
Targeted × 1890	−0.154*** (0.034)	−0.229*** (0.028)	0.110*** (0.023)	−0.021 (0.025)	−0.110*** (0.032)	−0.007 (0.020)	−0.046** (0.021)	−0.038* (0.022)
Targeted × 1891	−0.086** (0.035)	−0.172*** (0.030)	0.081*** (0.024)	−0.030 (0.024)	−0.189*** (0.027)	−0.054** (0.021)	−0.031 (0.022)	−0.073*** (0.026)
Targeted × 1892	−0.161*** (0.036)	−0.192*** (0.028)	0.118*** (0.024)	−0.046* (0.026)	−0.216*** (0.027)	−0.053*** (0.019)	−0.063*** (0.021)	−0.143*** (0.028)
Constant	0.476*** (0.167)	0.514*** (0.165)	1.150*** (0.164)	0.267 (0.163)	0.342** (0.163)	1.022*** (0.162)	0.603*** (0.163)	0.353** (0.165)
Observations	42,600	42,600	42,600	42,600	42,600	42,600	42,600	42,600
R ²	0.846	0.846	0.846	0.846	0.846	0.846	0.846	0.846

(Continues)



TABLE 5 (Continued)

	(9) Cholera	(10) Enteritis	(11) Typhus	(12) Malaria	(13) Puerperal fever	(14) Syphilis
Targeted × 1883	−0.096** (0.023)	−0.049** (0.023)	0.003 (0.022)	0.039** (0.018)	−0.008 (0.015)	0.007 (0.015)
Targeted × 1884	0.006 (0.030)	−0.130*** (0.022)	−0.036* (0.020)	−0.003 (0.017)	−0.012 (0.014)	0.003 (0.013)
Targeted × 1885	−0.029 (0.026)	0.025 (0.022)	0.071*** (0.023)	0.051*** (0.017)	0.013 (0.015)	0.030** (0.014)
Targeted × 1886	0.349*** (0.050)	−0.032** (0.013)	0.042** (0.019)	0.028* (0.017)	−0.014 (0.012)	−0.004 (0.014)
Targeted × 1888	−0.076*** (0.023)	0.021* (0.012)	−0.027 (0.018)	−0.026* (0.014)	0.007 (0.011)	0.012 (0.012)
Targeted × 1889	−0.014 (0.023)	0.083*** (0.016)	0.001 (0.021)	0.035** (0.016)	0.055*** (0.014)	0.077*** (0.014)
Targeted × 1890	−0.085*** (0.023)	0.012 (0.020)	−0.099*** (0.021)	−0.052*** (0.017)	−0.021 (0.014)	0.007 (0.015)
Targeted × 1891	−0.092*** (0.024)	−0.003 (0.023)	−0.161*** (0.023)	−0.026 (0.018)	−0.034** (0.015)	0.006 (0.015)
Targeted × 1892	−0.107*** (0.023)	−0.023 (0.023)	−0.243*** (0.022)	−0.073*** (0.018)	−0.031** (0.014)	−0.009 (0.015)
Constant	0.197 (0.163)	1.409*** (0.162)	0.698*** (0.163)	0.415** (0.166)	0.173 (0.164)	0.178 (0.164)
Observations	42,600	42,600	42,600	42,600	42,600	42,600
R ²	0.846	0.846	0.846	0.846	0.846	0.846

Notes: The dependent variable is log(1 + deaths rates). Controls include temperature, rainfall, quality of public water, sewerage coverage, wages, and population density. All the specifications include city fixed effects, disease fixed effects, and year fixed effects. Cities are 284 district and provincial capital cities. Standard errors are in parentheses and clustered at municipality level.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Source: Authors' own calculations.



1894, which led to widespread acute pneumonia and high mortality rates.⁵² Historical accounts indicate that European physicians were unprepared to manage this unfamiliar disease. In England, doctors were initially reluctant to attribute deaths directly to influenza, instead classifying them as pneumonia or other lung conditions. This practice likely reflected both diagnostic uncertainty and the lack of a clear medical framework to address a novel and rapidly spreading viral infection.⁵³

Regarding the enteritis, non-pharmaceutical interventions were unable to act as a substitute for infrastructural measures such as sanitation and chlorination actions. It is instructive to notice the different effects on enteritis and typhoid fever given the similar transmission mechanism. In principle, both diseases could have been mitigated by an efficient sewerage system. Yet, this was not the case. Thus, the different effects we observe are likely due to the mandate of isolation applied to typhoid fever. As physicians were able to make a differential diagnosis based on clinical observation, the sanitary police were able to intervene and contain the propagation of typhoid fever, but this turned out to be ineffective against enteritis.

The analysis of individual diseases reveals that the reforms worked on targeted ailments in multiple ways, suggesting the existence of multiple mechanisms at stake to improve their efficacy. The following section details such mechanisms.

V | THE MECHANISMS OF THE REFORMS

The heterogeneous effects of the reforms on single diseases suggest that non-pharmaceutical interventions displayed asymmetrical effects in reducing mortality from various targeted diseases. Indeed, by what avenues did public interventions in hygiene and health contribute to the observed outcomes?

To test the potential channels through which the reforms worked, we use a triple diff-in-diff and introduce a triple interaction of the different channels, the status of being targeted by the reforms and the time effects. To simplify the representations of different channels, we employ the following equation:

$$y_{ijt} = c + a_i + b_j + post_t + \beta \times (D_i \times post_t) + \eta \times (D_i \times post_t \times channels) + X'_{jt} \times D_i \times \gamma + \delta_t \times post_t \times \Gamma'_j + \Gamma_j \times D_i \times \vartheta + e_{jit} \quad (2)$$

where the η vector is our focus because it indicates the effects of the channels through which the reforms actually worked. Unlike equation (1), we study the overall effects in the post-reform period (1887–92) for a sharper comparison between different channels at stake. The variable *post* is the usual time variable, being zero before 1887 and one thereafter.

We simultaneously test four potential channels for 284 district and provincial capital cities (column 1) and for 69 provincial capital cities only (column 2). Finally, in column 3, we test six potential channels, which are available exclusively for provincial capital cities. The first channel we consider is mandatory sanitary surveillance (*surveillance*). Diseases subject to the mandate are listed in the Crispi–Pagliani Law, as discussed in section I. We explore this mechanism by introducing a categorical variable that accounts for three different conditions of the diseases:

⁵² Smith, 'Russian influenza'.

⁵³ Honigsbaum, 'Great dread'.



diseases targeted but not surveilled, those targeted and surveilled, and those not targeted. The second and third channels refer to the supply of medical services: the size of the medical staff⁵⁴ (*doctors per cap.*) and the number of beds in public hospitals (*hospital beds per cap.*). Both physicians and beds are measured before the introduction of the reforms. We do not have complete information on how the reforms changed the supply of medical services at the local level, although national-level data suggest that the number of doctors per capita did not change significantly.⁵⁵ Finally, the fourth channel potentially contributing to the effectiveness of the reforms is the compliance of citizens with the new rules. For instance, the voluntary isolation of infected individuals in cases of acute pneumonia or tuberculosis relied on civic adherence to norms of good conduct, influencing the decision to self-isolate.⁵⁶

In column 1 of table 6, we present the coefficients for the four channels. Mandatory surveillance, as a non-pharmaceutical intervention, emerged as a crucial channel activated by the reforms to lower mortality rates. In the post-reform period, we observed that mortality rates for diseases under surveillance declined by an average of 6.2 per cent relative to the non-targeted diseases. Additionally, citizen compliance enhanced the effectiveness of the reforms, reducing mortality rates by 2 per cent, assuming an increase in compliance by one standard deviation.⁵⁷ The provision of health services, however, does not significantly impact the effectiveness of the reforms.

In column 2, we repeat this analysis for the sub-sample of 69 provincial capital cities. Here, mandatory sanitary surveillance remains the primary channel, with no significant role for citizen compliance or health service provision.

In column 3, we add two more channels available only for the provincial capital cities: illiteracy rates,⁵⁸ a proxy to capture individuals' understanding of the new rules and public hygiene expenditures of municipalities,⁵⁹ which are commonly considered a vehicle that has reduced nineteenth-century mortality. By including all the channels in one specification, we confirm the paramount role played by sanitary surveillance. At the same time, we observe complementary mechanisms at work. First, among medical services, only the endowment of hospital beds is a significant channel, although an increase of one standard deviation in beds per capita reduces mortality rates by only 2.6 per cent. Let us note that such an increase in medical services equals 8.5 more beds for each thousand inhabitants, which is likely costly even by modern standards. Citizens' compliance is confirmed to have a role in the reforms, given that one more standard deviation of compliance cuts mortality by 3.5 per cent. A complementary explanation points to the sharing of information through intermediate social bodies, such as mutual aid societies.

Regarding the illiteracy rate, the reforms were more effective in less-educated areas. Other things being equal, if a city had one standard deviation more in illiteracy, mortality rates would reduce by 5.9 per cent. The effect observed in places with higher illiteracy rates might suggest that the reforms did not operate by fostering greater understanding among citizens regarding the proper management of infectious diseases. Instead, we advance two possible interpretations.

⁵⁴ The doctors considered are the *medici di condotta*, that is, the doctors paid by municipalities.

⁵⁵ MAIC-DSG, *Annuario Statistico Italiano* 1892, pp. 93–5.

⁵⁶ Various metrics of civic awareness or civic capital have been estimated for Italy during the nineteenth century (Cappelli 'Was Putnam wrong?'). We utilize the per capita number of mutual aid societies in each city before the reforms as a proxy of citizens' compliance (Postigliola and Rota, 'Institutional shocks').

⁵⁷ See table 1a in Appendix 2 for the descriptive statistics of the variables used in the paper.

⁵⁸ We gauge illiteracy rates at the city level using census data from 1881. See Appendix 1 for the source.

⁵⁹ See Appendix 1 for the source.



TABLE 6 Channels of transmission of the reforms.

	(1)	(2)	(3)
Targeted $\times$ post $\times$ surveillance	-0.064*** (0.006)	-0.069*** (0.012)	-0.069*** (0.012)
Targeted $\times$ post $\times$ hospital beds per cap.	-0.000 (0.001)	-0.001 (0.001)	-0.003*** (0.001)
Targeted $\times$ post $\times$ doctors per cap.	-0.027 (0.054)	-0.018 (0.077)	0.095 (0.080)
Targeted $\times$ post $\times$ citizens' compliance	-0.180** (0.070)	-0.105 (0.083)	-0.318*** (0.118)
Targeted $\times$ post $\times$ illiteracy rate			-0.349*** (0.104)
Targeted $\times$ post $\times$ cumulative public hygiene exp.			-0.118** (0.054)
Constant	0.360** (0.163)	0.369 (0.370)	1.010** (0.420)
Observations	42,600	10,350	10,350
R ²	0.840	0.877	0.878
Cities	284	69	69
City fixed effects	Yes	Yes	Yes
Disease fixed effect	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Notes: The dependent variable is $\log(1+\text{deaths rates})$. Controls include temperature, rainfall, quality of public water, sewerage coverage, wages, and population density. Cumulative public hygiene expenditures are expressed in logs. Standard errors are in parentheses and clustered at municipality level. *exp.* stands for expenditures.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

Source: Authors' own calculations.

First, public authorities might have overruled the individuals' understanding of health policies through surveillance and containment measures, acting as a substitution vehicle for a lack of health-related knowledge. Second, public authorities might have stimulated the information flow about the content of the reform more pervasively in less-educated areas. In both cases, the results are consistent with one of the possible representations of top-down modernization episodes across history.⁶⁰

Finally, we can assess the impact of public expenditure on health as another potential channel. The reforms introduced in 1887–8 mandated municipal public budgets to allocate resources towards enhancing water sanitation, constructing and maintaining sewer systems, sanitizing cemeteries, providing better compensation for physicians, and investing in sanitary police. Local fiscal data at the individual city level are limited to hygiene police, whereby our empirical exercise does not consider potentially health-related outlays such as waterline construction and

⁶⁰ Prados de la Escosura, 'World human development'; Felice and Vasta 'Passive modernization?'. At any rate, this effect is not driven by differences in income per capita, as our specifications control for real wages.



hospital upkeep. It is worth noting that expenditures for hygiene police constituted the majority, accounting for 75–80 per cent of overall health-related outlays. We introduce this channel using cumulative health spending over the years. As annual expenditures accumulate, this could lead to the completion of health-related infrastructures that started before the institutional reform, which we do not observe. According to the coefficients in column 3 of table 6, a 10 per cent increase in hygiene public expenditure entails a drop in mortality rates of 1.2 per cent. Compared with sanitary surveillance or top-down modernization, it is a second-tier effect. At least in the immediate aftermath of the 1887–8 reforms, infrastructure investments were limited and did not significantly influence the effectiveness of the reforms.

Thus, while infrastructure improvements did become more prominent later on, they likely did not drive the observed reductions in mortality. From a historical viewpoint, our results are in line with the interpretation of the reforms advanced by the coeval provincial medical officer Michele Pietravalle, who in the late 1890s wrote:⁶¹

In the fight against infections (...), we have not found the economic forces of the state and municipalities ready for preventive medicine against infectious diseases, that is, for the urgent works of improving housing conditions in both urban and rural areas. Therefore, in Italy, public health prevention appears to the vast majority as an intrusive and bothersome form of policing [...] preventive measures, which work for the healthiness of inhabited areas and general improvement of infrastructures, rarely and weakly receive attention and financial resources from public administrations.

From a regional perspective, the joint analysis of the channels reveals heterogeneous scenarios between North and South (see column 3 of both tables 6a and 6b in Appendix 2). If sanitary surveillance is significant and central everywhere in making the reforms effective, other channels behave differently. In the southern cities, the contribution of the supply of hospital beds is almost three times larger than in the North. Most importantly, health-related expenditures were a relevant channel in the South, where the lack of infrastructure had been well known since the Unification.⁶² Yet, infrastructure did not have any effect on the northern cities. In turn, in a counterintuitive scenario, the top-down modernization, captured by the illiteracy rate channel, is detected only in the northern municipalities. This means that an appearance of passive modernization, rather than the external imposition of mandatory sanitary surveillance and hygiene police, worked in the less literate areas of the relatively developed North, rather than in the underdeveloped South.

VI | CONCLUSIONS

The sanitary reforms introduced by Prime Minister Francesco Crispi in 1887 and 1888 targeted diseases that could be mitigated or contained through non-pharmaceutical interventions. We have quantified that the reforms led to a remarkable 8.5 per cent reduction in deaths from targeted diseases compared with non-targeted diseases. As a result, Italian mortality rates aligned with those of more developed European countries, and the southern regions reached mortality levels comparable to those of the north.

⁶¹ Our translation from Pietravalle, 'La polizia sanitaria', p. 45.

⁶² Nitti, *Il Bilancio dello Stato*.



We also identified the potential mechanisms underlying the reforms' implementation. The primary factor driving their success was the creation of a hierarchical network for sanitary surveillance and prevention, involving multiple levels of public authority. Alternatively, public spending on health-related infrastructure may have played a marginal role, although significant. In these terms, our findings contribute significantly to the ongoing debate on the efficacy of public intervention in mortality reduction in Western Europe, emphasizing the role of non-pharmaceutical interventions in reducing regional and national variations in mortality rates. Non-pharmaceutical measures and sanitary surveillance represented the main tools of the public hygiene authorities in Italy until the turn of the century. As we found, they may have been added to the toolbox of public policies as effective devices for reducing mortality and increasing life expectancy, in the second half of the nineteenth century,⁶³ along with investments in health-related infrastructure⁶⁴ and mandatory health insurance schemes.⁶⁵

Moreover, the Italian health reforms of 1887–8 exemplify a top-down approach that improved the quality of domestic institutions, adding evidence to the historical beneficial effects of top-down reforms in laggard countries.⁶⁶ By facilitating the coordination between the central government and local authorities, the Italian reforms rationalized governance and reduced transaction costs inherent in Italy's administrative layers. The argument for passive modernization of the Italian economy, already advanced by Felice and Vasta,⁶⁷ appears to gain momentum in light of the public health reforms.

ACKNOWLEDGEMENTS

We wish to thank one of the editors of this journal, Leandro Padros de la Escosura, and three anonymous referees for their comments, which helped to substantially improve the paper. This article benefited from the comments by Carlo Ciccarelli, Giovanni Federico, Alessandro Nuvolari, Michelangelo Vasta, Giovanni Vecchi, and Jacob Weisdorf. We are also indebted to the comments from the participants at the 15th European Historical Economics Society Conference (Vienna, 2023), Eternal City Economic History Workshop (ECHEW) Seminars at Bank of Italy (Rome, 2023), Economic History seminars Tor Vergata (Rome, 2023), and PRIN-2020 'EDIT' meeting (Siena, 2024). We acknowledge financial support from Sapienza University of Rome, project no. RM123188F7006790. All errors and omissions are our own.

Open access publishing facilitated by Università degli Studi di Roma La Sapienza, as part of the Wiley - CRUI-CARE agreement.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supplementary material of this article

ORCID

Mauro Rota  <https://orcid.org/0000-0002-5000-884X>

⁶³ Kesztenbaum and Rosenthal, 'Sewers' diffusion'; Chapman, 'The contribution of infrastructure'; idem, 'Interest rates'; Gallardo-Albarrán, 'Sanitary infrastructures'.

⁶⁴ Gallardo-Albarrán, 'Global sanitary revolution'.

⁶⁵ Bauernschuster, Driva, and Hornung, 'Bismarck'.

⁶⁶ Prados de la Escosura, 'World human development'.

⁶⁷ Felice and Vasta 'Passive modernization?'.



REFERENCES

- Alsan, M. and Goldin, C., 'Watersheds in child mortality: The role of effective water and sewerage infrastructure, 1880–1920', *Journal of Political Economy*, 127 (2019), pp. 638–86.
- Alsan, M., Atella V., Bhattacharya J., Conti V., Mejía-Guevara I. and Miller G., 'Technological progress and health convergence: the case of penicillin in postwar Italy' *Demography*, 58 (2021), pp. 1473–98.
- Anderson, D. M., Charles, K. K. and Rees, D. I., 'Reexamining the contribution of public health efforts to the decline in urban mortality', *American Economic Journal: Applied Economics*, 14 (2022), pp. 126–57.
- Barberi, B., I consumi nel primo secolo dell'Unità d'Italia, 1861–1961 (Milan, 1961).
- Bauernschuster, S., Driva, A. and Hornung, E., 'Bismarck's health insurance and the mortality decline', *Journal of the European Economic Association*, 18 (2020), pp. 2561–607.
- Bengtsson, T. and Van Poppel, F., 'Socioeconomic inequalities in death from past to present: an introduction', *Explorations in Economic History*, 48 (2011), pp. 343–56.
- Breschi, M. and Pozzi, L., *Salute, malattia e sopravvivenza in Italia fra '800 e '900* (Udine, 2007)
- Cappelli, G., 'Was Putnam wrong? The determinants of social capital in Italy around 1900', *Rivista di Storia Economica*, XXXIII (2018), pp. 277–313.
- Caselli, G., 'Mortalità e sopravvivenza in Italia dall'Unità agli anni '30' in *Società Italiana di Demografia Popolazione, Società e ambiente. Temi di Demografia storica italiana* (secc XVII–XIX), (Bologna, 1990), pp. 275–310.
- Caselli, G., 'Health transition and cause-specific mortality' in R. Schofield, D. Reher, and A. Bideau, eds., *The decline of mortality in Europe* (Oxford, 1991), pp. 68–96.
- Cea, R., *Il governo della salute nell'Italia liberale: Stato, igiene e politiche sanitarie* (Milan, 2019).
- Chapman, J., 'The contribution of infrastructure investment to Britain's urban mortality decline, 1861–1900', *Economic History Review*, 72 (2019), pp. 233–59.
- Chapman, J., 'Interest rates, sanitation infrastructure, and mortality decline in nineteenth-century England and Wales', *Journal of Economic History*, 82 (2022), pp. 175–210.
- Chen, J. and Roth, J., 'Logs with zeros? Some problems and solutions', *Quarterly Journal of Economics*, 139 (2024), pp. 891–936.
- Chesnais, J. C., *The demographic transition: stages, patterns, and economic implications* (Oxford, 1992).
- Costa, D. L., 'Health and the economy in the United States from 1750 to the present', *Journal of Economic Literature*, 53 (2015), pp. 503–70.
- Cutler, D. and Miller, G., 'The role of public health improvements in health advances: the twentieth-century United States', *Demography*, 42 (2005), pp. 1–22.
- De Haro, V. A. L., Pujadas-Mora, J. M., and García-Gómez, J. J., 'Inequality in mortality in pre-industrial southern Europe during an epidemic episode: socio-economic determinants (eighteenth-nineteenth centuries Spain)', *Economics & Human Biology*, 40 (2021), p. 100941.
- Del Pantà, L., *Le epidemie nella storia demografica italiana: (secoli XIV–XIX)* (Torino, 1980).
- Del Pantà L., 'Dalla metà del settecento ai giorni nostri', in L. Del Pantà, M. Livi Bacci, G. Pinto, and E. Sonnino, eds., *La popolazione italiana dal Medioevo a oggi*, (Roma-Bari, 1996), pp. 133–212.
- Della Peruta, F., 'Sanità pubblica e legislazione sanitaria dall'Unità a Crispi', *Studi Storici*, 21 (1980), pp. 713–59.
- Federico, G., 'Heights, calories and welfare: a new perspective on Italian industrialization, 1854–1913', *Economics & Human Biology*, 1 (2003), pp. 289–308.
- Federico, G., Nuvolari, A., and Vasta, M., 'The origins of the Italian regional divide: evidence from real wages, 1861–1913', *Journal of Economic History*, 79 (2019), pp. 63–98.
- Felice, E. and Vasta, M., 'Passive modernization? The new human development index and its components in Italy's regions (1871–2007)', *European Review of Economic History*, 19 (2015), pp. 44–66.
- Felice, E. and Vecchi, G., 'Italy's modern economic growth, 1861–2011', *Enterprise & Society*, 16 (2015), pp. 225–48.
- Ferrie, J. P. and Troesken, W., 'Water and Chicago's mortality transition, 1850–1925', *Explorations in Economic History*, 45 (2008), pp. 1–16.
- Fiore Melacrinis, F. M. S., 'Quando la conoscenza guida l'azione politica: la Legge Crispi-Pagliani del 1888', *Studi Politici*, 2 (2024), pp. 25–41.
- Fogel, R. W., 'Second thoughts on the European escape from hunger: famines, price elasticities, entitlements, chronic malnutrition, and mortality rates', *National Bureau of Economic Research Working paper series*, 1 (1979), pp. 1–86.



- Fogel, R. W., 'New findings on secular trends in nutrition and mortality: some implications for population theory', in M. R. Rosenzweig, and O. Stark, eds., *Handbook of population and family economics*, vol. 1A (Amsterdam, 1997), pp. 433–81.
- Gallardo-Albarrán, D., 'Sanitary infrastructures and the decline of mortality in Germany, 1877–1913', *Economic History Review*, 73 (2020), pp. 730–57.
- Gallardo-Albarrán, D., 'The global sanitary revolution in historical perspective', *Journal of Economic Surveys*, 39 (2025), pp. 567–98.
- Hohorst, G., 'Bevölkerungsentwicklung in Preußen und in dem Kreis Hagen von 1816 bis 1914' (1978), https://search.gesis.org/research_data/ZA8049 (accessed on 15 January 2024).
- Honigsbaum, M., 'The great dread: cultural and psychological impacts and responses to the 'Russian' influenza in the United Kingdom, 1889–1893', *Social History of Medicine*, 23 (2010), pp. 299–319.
- Kennedy, P., 'Estimation with correctly interpreted dummy variables in semilogarithmic equations', *American Economic Review*, 71 (1981), p. 801.
- Kesztenbaum, L. and Rosenthal, J. L., 'Sewers' diffusion and the decline of mortality: the case of Paris, 1880–1914', *Journal of Urban Economics*, 98 (2017), pp. 174–86.
- McKeown, T., *The modern rise of population* (London, 1976).
- Nitti, F.S., *Il Bilancio dello Stato dal 1862 al 1896–97. Prime linee di una inchiesta sulla repartizione territoriale delle entrate e delle spese pubbliche in Italia*, (Naples, 1900).
- Pagliani L., 'La costituzione e l'opera della prima direzione della sanità pubblica in Italia (anni 1887–1896)', in *IV Congresso della Federazione fra le Associazioni del Personale addetto alla Vigilanza Igienica* (Biella, 1921), pp. 7–8.
- Pietravallo M., *La Polizia sanitaria in Italia. Manuale per gli ufficiali sanitari del Regno* (Milan, 1897).
- Postigliola, M. and Rota, M., 'Institutional shocks and social capital: evidence from the French domination in Italy', *Journal of Modern Italian Studies*, 26 (2021), pp. 237–60.
- Prados de la Escosura, L., 'World human development: 1870–2007', *Review of Income and Wealth*, 61 (2015), pp. 220–47.
- Roth, J., Sant'Anna, P. H., Bilinski, A., and Poe, J., 'What's trending in difference-in-differences? A synthesis of the recent econometrics literature', *Journal of Econometrics*, 235 (2023), pp. 2218–44.
- Schofield, R., and Reher, D., 'The decline of mortality in Europe', in R. Schofield, D. Reher, and A. Bideau, eds., *The decline of mortality in Europe* (Oxford, 1991), pp. 1–17.
- Smith, F. B., 'The Russian influenza in the United Kingdom, 1889–1894', *Social History of Medicine*, 8 (1995), pp. 55–73.
- Szreter, S. and Mooney, G., 'Urbanization, mortality, and the standard of living debate: new estimates of the expectation of life at birth in nineteenth-century British cities', *Economic History Review*, LI (1998), pp. 84–112.
- Troesken, W., Tynan, N., and Yang, Y. A., 'What are the health benefits of a constant water supply? Evidence from London, 1860–1910', *Explorations in Economic History*, 81 (2021), p. 101402.

OFFICIAL PUBLICATIONS

- DGS (Direzione Generale di Statistica), *Risultati dell'inchiesta sulle condizioni igieniche e sanitarie nei comuni del regno. Relazione Generale*. (Roma, 1886).
- MAIC-DGS, Ministero di Agricoltura, Industria e Commercio- Direzione Generale di Statistica, *Statistica delle cause di morte. Anno 1882*, (Roma, 1883).
- MAIC-DGS, Ministero di Agricoltura, Industria e Commercio- Direzione Generale di Statistica, *Annuario Statistico Italiano. 1892*, (Roma, 1893).

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.



How to cite this article: Fiore Melacrinis, F. M. S., and Rota, M., 'Public health reforms and the mortality decline in nineteenth-century Italy', *Economic History Review*, 79 (2026), pp. 527–554. <https://doi.org/10.1111/ehr.70021>