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WHAT CAN WE LEARN FROM HISTORICAL PANDEMICS? A SYSTEMATIC REVIEW OF THE LITERATURE

Working Paper 23-10

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December 2023

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Highlights

- Historical studies of pandemics measure their mortality, economic, morbidity and in utero impacts.
- The 1918 Spanish Influenza pandemic is the most heavily studied historical pandemic of the last 200 years.
- Other pandemics need closer study as 1918 may not be the most appropriate analogy for policymakers today.
- Most studies of historical pandemics are published in health sciences journals, including epidemiology.
- Few studies join insights from social and medical sciences together.
- Few studies compare the impacts of different pandemics, or the same pandemic across different study sites.

Abstract

What are the insights from historical pandemics for policymaking today? We carry out a systematic review of the literature on the impact of pandemics that occurred since the Industrial Revolution and prior to Covid-19. Our literature searches were conducted between June 2020 and September 2023, with the final review encompassing 169 research papers selected for their relevance to understanding either the demographic or economic impact of pandemics. We include literature from across disciplines to maximise our knowledge base, finding many relevant articles in journals which would not normally be on the radar of social scientists. Our review identifies two gaps in the literature: (1) the need to study pandemics and their effects more collectively rather than looking at them in isolation; and (2) the need for more study of pandemics besides 1918 Spanish Influenza, especially milder pandemic episodes. These gaps are a consequence of academics working in silos, failing to draw on the skills and knowledge offered by other disciplines. Synthesising existing knowledge on pandemics in one place provides a basis upon which to identify the lessons in preparing for future catastrophic disease events.

Keywords: systematic review, historical pandemics, mortality, interdisciplinary research.

JEL Codes: I15, I18, J11, N30.

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1. Introduction

On 5 May 2023, after enduring more than three years of public health restrictions, the WHO declared that Covid-19 was no longer a 'public health emergency of international concern', thus formally marking the end to a turbulent period in modern epidemiological history. Now is therefore an opportune time to take stock and prepare for whatever the future might have in store. With global climate change, future pandemics are considered more likely (Marani et al., 2021). Some scholars even warn that we have entered a 'pandemic era' (Morens et al., 2020); Honingsbaum (2020) even argues that we have long been in one – although he has a rather idiosyncratic definition of what constitutes a pandemic that takes in small localised outbreaks of novel diseases such as Ebola and Zika. Here we contribute to future reflections by looking backwards into the past, beyond the recent history of Covid-19. We collect and collate in one place as many lessons as we can find from reviewing the literature on all the pandemics of the Modern Era that occurred prior to the 2019 Wuhan outbreak of the novel SARS-CoV-2 virus.

Pandemics result from the emergence and spread of a novel pathogen. They differ from epidemics in that they have wider geographic spread and affect all people, and consequently are associated with a higher mortality and economic impact. Pandemics are also different from endemic diseases, the amount of disease usually present within a community, as they represent a distinct and temporary deviation from baseline morbidity and mortality (see Doshi (2011) and Kelly (2011) for further debate over pandemic definition). Pandemics constitute a global catastrophic risk, a type of event with the potential to cause serious damage to human wellbeing on a global scale. Bostrom and Cirkovic (2008) set a threshold for defining these events at either an excess mortality exceeding 10 million people, or economic damage more than $10 trillion.

Covid-19 was clearly a pandemic, by any definition. It also clearly meets both of Bostrom and Cirkovic's (2008) criteria of constituting a global catastrophic risk event. Global

excess deaths for Covid-19 are estimated at 18.2 million between 1 January 2020 and 31 December 2021 (Wang et al., 2022). And this figure would have been higher were it not for the various mitigation efforts implemented globally. The economic costs associated with Covid-19 were staggering; estimated costs for the US alone amount to $16 trillion (Cutler and Summers, 2020). But the Covid-19 catastrophe is not completely unprecedented. The Modern Era – the two centuries since the Industrial Revolution – has seen numerous pandemic-like health crises. These potentially offer lessons on the impact of pandemics and how we can deal with them in the future.

In his survey of historical pandemics, Kilbourne (2008) argues that 'we must be guided by the lessons of the past, so it is essential that we reach a consensus on what these lessons are'. In this current paper we carry out the necessary spadework to do exactly that. We conduct a systematic review of studies across all scientific fields on the topic of the impact of pandemics that took place across the 200 years prior to Covid-19. We make use of the *Web of Science* academic journal database, a comprehensive database of high-quality peer-reviewed journal articles, as well as a secondary search of *JSTOR,* a repository of over 2,000 academic journals which has a better coverage of publications before 1975. We select all relevant journal articles that were published before the start of the Covid-19 pandemic, to gauge what was already known about these pandemics before the most recent one emerged. We then supplement this by adding all new journal articles about historical pandemics that have been published since 2020. From this, we categorise and summarise their contents in an accessible way – and, more importantly, identify the gaps in the literature which we think should now be addressed. This review purposefully does not include literature about Covid-19 as there is still a shifting consensus which has already sparked new systematic reviews and reviews of reviews (Wurth et al., 2022).

There have been several high-quality reviews of historical pandemics published since Covid-19 emerged. These have either contextualised them within demographic and epidemiological transitions (Shaw-Taylor, 2020), or have focused on specific historical episodes such as the Black Death, the 1918 Spanish Influenza, or modern infectious disease (Arthi and Parman, 2021; Beach et al., 2022a; Bloom et al., 2022; Jedwab et al., 2022). However, these studies have not taken explicitly multidisciplinary or interdisciplinary perspectives. Nor have these scholars undertaken *systematic* literature reviews; these articles are written based on partial or selective sets of studies and have not undergone the rigorous search and classification process demanded of a systematic review. For an introduction to this methodology, see Centre for Reviews and Dissemination (2009). For guidelines on current best practice, see Page et al. (2021). Unlike other literature reviews, ours is designed to be comprehensive; we do not omit studies with low citation counts, studies in disciplines outside our own, or studies published outside high ranked field journals. The benefit of a systematic review is that it offers a "data-led approach" to summarising the literature; rather than restricting our search to a particular methodology or perspective of a single discipline or journal, the systematic review methodology has the power to reveal to us what are considered to be the most important topics and questions being addressed across all disciplines and journals. Ultimately, a systematic review helps uncover gaps in the literature and identify possible avenues for future research (Cooper and Hedges, 2009).

There have long been calls for more interdisciplinary studies of historical pandemic episodes (see, e.g., Simonsen et al., 2011). Our review encompasses 169 articles from across the social and health sciences. We find the articles published in journals with a health science focus in particular offer many insightful answers to the question of the impact of historical pandemics. Such journals are not always on the radar of economists, historians and social scientists. Despite regular calls for greater interdisciplinarity, we find few truly

interdisciplinary studies that engage with research from different disciplines in one place. Each discipline instead operates within its own silo, with its own set of questions, methods, and datasets. We believe there is great scope for new cross-disciplinary work that combines – especially – demography, epidemiology and economics with history. If brought together, this will help to break down the disciplinary divisions that at present result in scholars working in isolated parallel academic communities.

The most striking feature which stands out from our review, and the most important lesson we should take note of, is the fact that studies look at the effects of practically all pandemics in isolation, both temporally and spatially. Very few, if any, connections are made between different effects within the same pandemic, or the same effect across different pandemics. Without taking a comparative and holistic approach, we think it is very difficult to identify which pandemic context is most useful to learn from, to discern common trends across pandemics, or to understand how the mortality impact compares to the economic impact. We will be able to learn much more from historical pandemics if in future there can be a comparative aspect adopted more consistently.

Across all disciplines included in our review, the literature is dominated by studies of the 1918 Spanish Influenza pandemic and its high death toll. For example, Smil (2011) argued that the 1918 Spanish Influenza pandemic was the worst in history by any standard, assumed that the death profile of future pandemics would have a similar pattern as 1918, and argued that 'the massive mortality of people in their prime would also strain the life insurance industry and depress real estate values'. (Despite some debate on its naming, we consistently use the term "1918 Spanish Influenza" to refer to this pandemic, simply because this is the most used term in the literature.) Clearly, this mortality pattern was not replicated in Covid-19 pandemic, where the disease struck down the oldest most severely. Equally, there is no guarantee that the next pandemic will replicate the Covid-19 pattern. So, rather than focusing in on drawing a

single line of comparison, we must therefore prepare for various scenarios by moving beyond the 1918 reference.

The most recent studies published since Covid-19 continue to focus on 1918, even though it is now widely acknowledged that policymakers 'planned for the wrong pandemic' (UK Covid-19 Inquiry, 2023). During times of crisis, policymakers tend to rely on analogical reasoning. In the case of pandemics, the most widely known is the 1918 Spanish Influenza pandemic, which is taught in public health classes around the world. Studies of "milder" and "phantom" pandemics are much less common, and so there is little for public health pedagogy to draw upon. The focus on 1918 is understandable given its associated death toll; however, a lower death toll does not mean the overall societal costs were low. We fear that in their laudable efforts to make the wider policymaking community aware of worse case scenarios, scientists may have distorted societal views of pandemics and informed flawed policy designs.

In a similar vein, studies of the experience of developing countries during pandemics are currently rare. Our review shows articles which include such countries often find their experiences differed from those of more developed regions. The historical data available for developing countries are constantly improving, so there are opportunities available now for future scholars to take existing study designs of pandemics for developed country locations and replicate them for the developing world.

The development of Covid-19 has highlighted the fact policymakers were inadequately prepared, despite the relative frequency with which pandemics and pandemic-like events have occurred. Academic historians traditionally maintain the view that we cannot learn direct lessons from the past because is too easy to 'pick and choose what you want' and justify practically anything by appealing to one or other interpretation of past events (Colvin and Winfree, 2019). We challenge this view and align ourselves instead with the New Applied History movement described in MacMillan (2008). We believe that historical episodes *do*

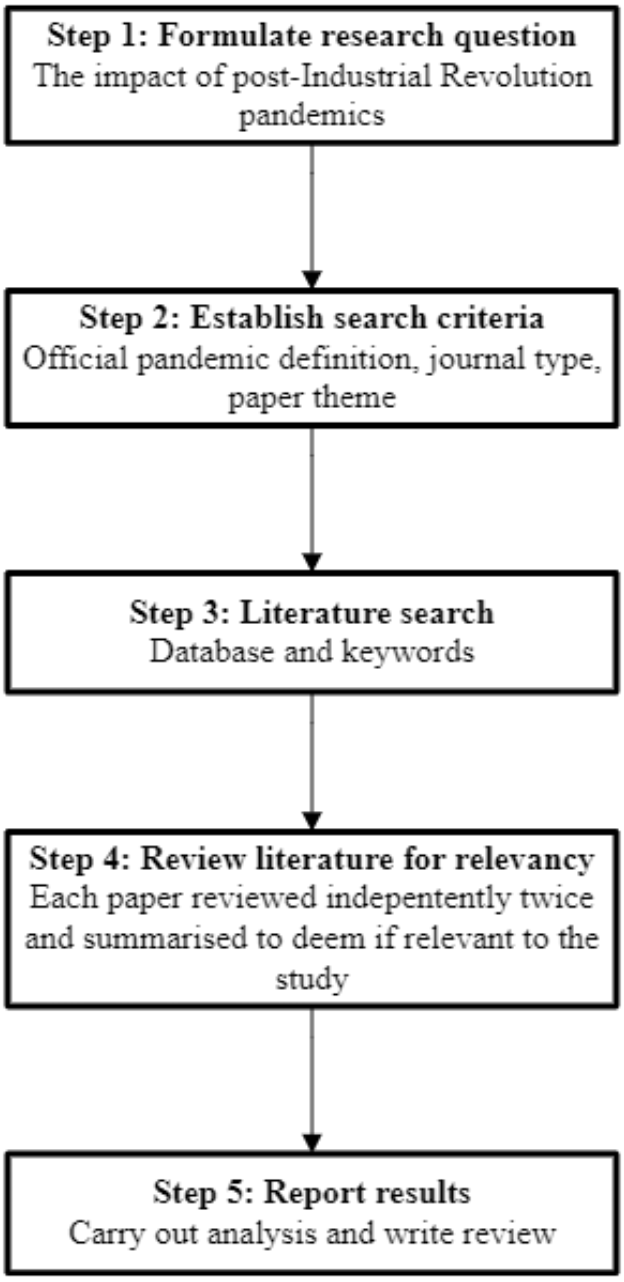
contain useful knowledge – knowledge that can help us to better understand the present. The past has already offered many policy lessons for current issues, such as the 1930s Great Depression during the 2008 Global Financial Crisis (Hetzel, 2012; James, 2013). By revisiting past pandemics, policymakers can see what lessons they offer for both now and the future. As we demonstrate in our paper, we are not starting from scratch.

2. Methods

2.1 Search Criteria

We followed the standard systematic review process (Centre for Reviews and Dissemination, 2009; Page et al., 2021). The aim of our systematic search was to identify research papers which discuss the *impact* of pandemics, namely their demographic or economic impact. We only include full research articles, not journal publications such as letters, reviews, or conference abstracts. We had three phases to our literature selection process which was carried out between June 2020 and September 2023. The main search was carried out using *Web of Science*. We searched all papers containing the term "pandemic" in either their title or abstract. This search was then supplemented by searches of *JSTOR* to accommodate papers published prior to 1975. We then examined the bibliographies of returned papers for any articles missing from our search. We also carried out a search of pre-print working paper series, following through to see what papers were subsequently peer-reviewed and published, to capture the developments in research that have been carried out in the wake of the Covid-19 pandemic. Our criteria for "historical" are studies of past events, so we make a distinction between contemporary observations that are descriptive in nature and studies that are analytical. (For example, contemporary coverage of the 1890 pandemic in British medical journals was descriptive.) Figure 1 outlines the overall process of the systematic review.

Figure 1: Systematic Review Methodology



2.2 Eligibility Criteria

The titles and abstracts of papers returned by the initial search were each screened by one member of the research team based upon pre-determined eligibility criteria. To be included, articles had to pertain to a pandemic that took place prior to the outbreak of Covid-19 and discuss the impact of the pandemic, in terms of either economic, mortality, morbidity or in-

utero impact. (Articles published in early 2020 were also deemed eligible as they would have been written prior to the spread of Covid-19.) The pandemic in question must have been a disease event which had occurred since 1815 and met the definition of a pandemic. These disease events are listed in Table 1. Search returns which did not meet these criteria, or which were from non-peer reviewed journals, books or conference abstracts, were excluded.

Table 1: Pandemics of interest

Pandemic	**Date**	**Death toll**	**Infectious agent**	**No. of papers**
Cholera	1817-23	3 million	Cholera	4
Third Plague	1855-60	12-15 million	Bubonic Plague	4
1889-90 Influenza	1889-90	1 million	Influenza *or* HCoV-OC43	5
Encephalitis Lethargica	1915	500,000	Encephalitis	1
Spanish Influenza	1918-19	50 million+	Influenza A H1N1	97
Asian Flu	1957-58	1.1 million	Influenza A H2N2	13
Hong Kong Flu	1968-70	1 million	Influenza A H3N2	8
SARS	2002-04	774	SARS-CoV	8
Swine Flu	2009-10	151,700-575,400	Influenza A H1N1	38

Notes: Pandemics are ordered chronologically by date of first outbreak; date represents core period of outbreak identified in the literature, accepting that different scholars define these periods differently; number of papers does not equal the total number of papers included in the review as some papers cover more than one pandemic. There are several speculated episodes of influenza epidemics and pandemics in the period, for example 1830-31, 1836-37, and 1847-48. Patterson (1985) suggests that the 1830-31 epidemic is a pandemic, although it left Africa and South America unscathed; the other events were deemed to be epidemics. Similarly, Potter (2001) classifies influenza pandemics by excess mortality, but this is complicated by overlapping pandemics, such as Cholera.

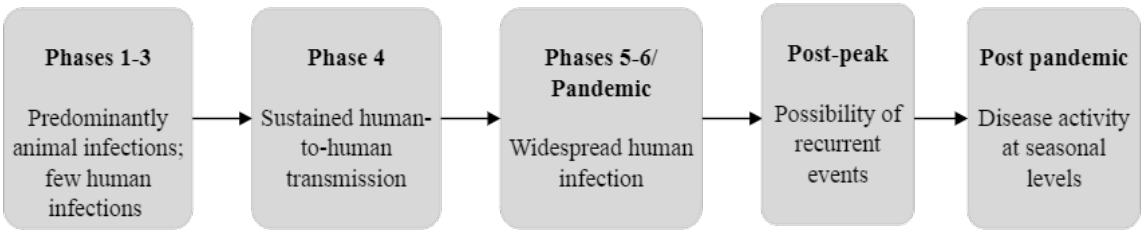
Sources: Ravenholt and Foege (1982); WHO (2003, 2010); Hays (2005); Stenseth (2008); Spreeuwenberg et al., (2018).

Despite meeting the inclusion criteria, we chose to exclude the HIV/AIDS pandemic from our study as there are a substantial number of systematic reviews, and even dedicated journals, which already exist (see, e.g., Dixon et al., 2002; Globerman et al., 2017; Altice et al., 2019; and Arias-Colmenero et al., 2020). Indeed, the CDC has a database of systematic reviews of HIV/AIDS literature. This pandemic also differs from the others in terms of its transmission mechanism.

The definition of the term pandemic is particularly important. Debate exists regarding the exact definition due to changes which were made by the WHO during the 2009 Swine Flu pandemic (Doshi, 2011; Kelly, 2011). The terms 'epidemic' and 'pandemic' have been used interchangeably in both policy discussions and the academic literature. However, there is an important distinction. Drawing on Porta (2016), if a disease incidence rises above expected levels and can be clustered either spatially or temporally, then we refer to these as epidemics. A pandemic is an epidemic on a larger scale: "an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting a large number of people" (Porta, 2016).

The overall phases of a pandemic identified by the WHO are outlined in Figure 2. Porta's (2016) definition aligns with *Phase 6*, when human-to-human transmission of a disease occurs in at least three WHO regions. On the surface, Bostrom and Cirkovic's (2008) threshold for defining a catastrophic event is not met for many of the pandemics listed in Table 1. However, accounting for lower historical population levels – for example the global population is estimated at 1.6 billion in 1900 – and lower levels of economic activity, these pandemics were in fact quite devastating.

Figure 2: WHO Pandemic Phases



Source: World Health Organization (2009).

Our review is historical in nature. By this we mean the papers we include are backwards looking, pertaining to the past. This approach means we capture works that cover all phases of the WHO's schema in Figure 2, rather than focusing on just the beginning phases. We chose

1815 as the start year of our study window as it coincides with the end of the tumultuous period of world history encompassing the French Revolution and the Napoleonic Wars. This date marks the spread of the Industrial Revolution beyond British borders. Most significantly, it coincides with the collection of the first detailed public health statistics on which many historical studies are based – this development being a by-product of the first cholera pandemic (McGrew, 1960). For example, vital statistics were utilised in one of the first difference-in-difference studies as undertaken by John Snow (1849, 1855) when he sought to understand the cause of a cholera epidemic in London. In his study Snow made use of the relatively recent efforts at collection of vital statistics and was able to identify the cause of the epidemic to a contaminated water pump at Broad Street (Tulchinsky 2018; Caniglia and Murray 2020).

Starting in 1815 is not to deny the severity of pre-1815 pandemics and pandemic-like episodes, such as the introduction of smallpox, an endemic disease in Europe, to the Americas where it is estimated to have led to 56 million deaths and a 90 per cent fall in the indigenous population of the Americans (Koch et al. 2019). But for these disease events there are a number of high-quality literature reviews (see Stathakopoulos, 2000; Alfani and Murphy, 2017; Eisenberg and Mordechai, 2019). Our intention is for this paper to be read in conjunction with these other reviews. We are concerned here exclusively with the post-1815 period, the Modern Era, because such reviews are non-extant; there is little *collective* focus placed on the pandemics of the past 200 years.

2.3 Search Results

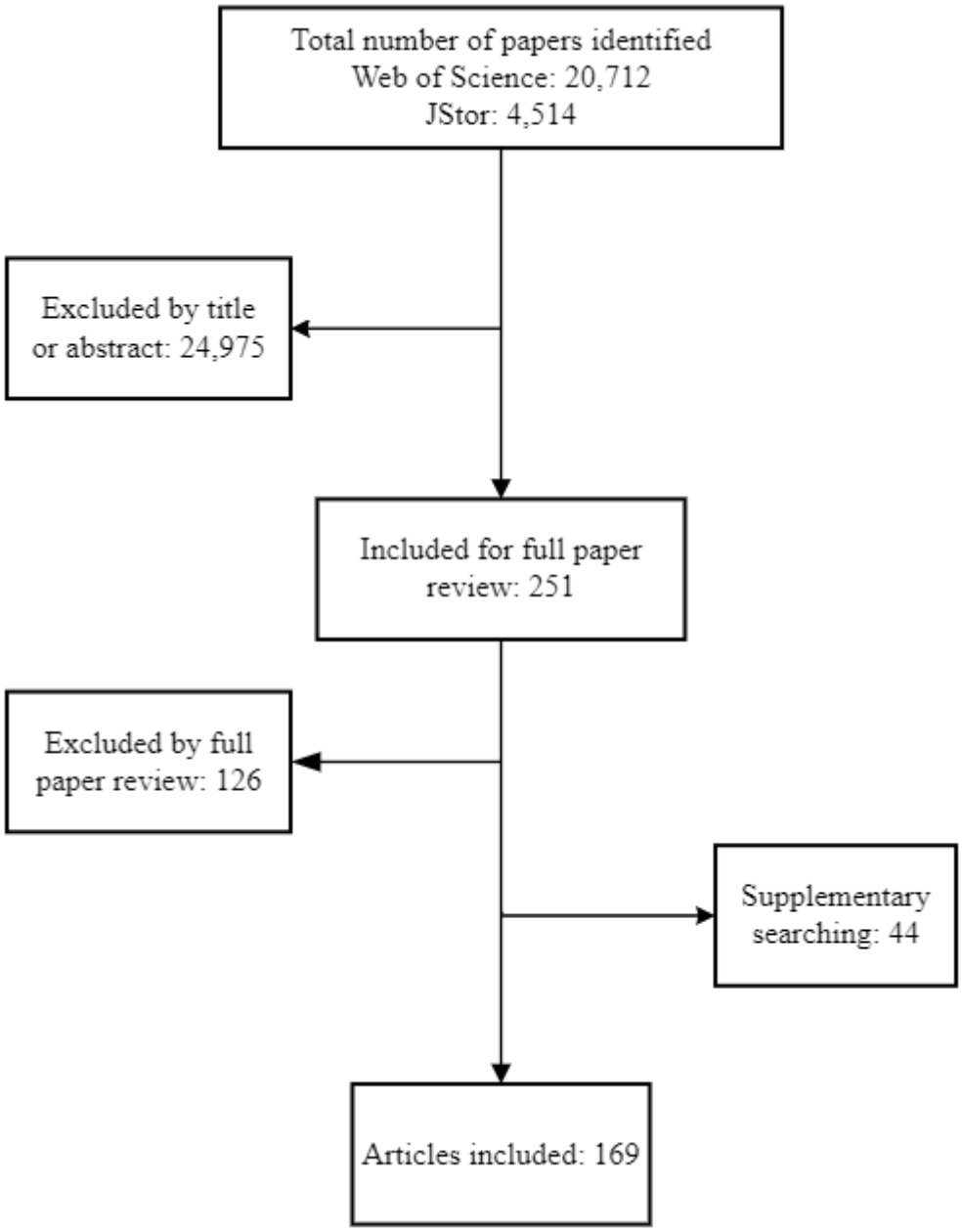
The process of study selection is shown in Figure 3. Over 25,000 papers were returned during the initial search. The majority were excluded based on title and abstract screening as they did not meet the eligibility criteria. The remaining papers were each assigned to two members of the research team to individually screen based on the full text of the paper to determine whether

they were eligible to be included within the review. A review by the third member of the team was used in the case of discrepancies.

Those papers which were deemed eligible after this second stage of screening are the subject of this review. A supplementary search of their bibliographies was also carried out to capture other relevant papers which may not have been returned during the initial search. We then topped up our search by looking at all research conducted on pre-Covid pandemics that has appeared as a pre-print working paper since the start of the Covid-19 pandemic, in 2020, and have since been published following peer review. The series we looked at were the CEPR's Covid Economics Papers, the NBER's various working paper series, searches of the open access RePEc database, Elsevier's SSRN database and the medRxiv preprint server. Of the papers we found and deemed to be relevant to our search criteria, we traced 26 of these to final publication in academic journals.

In total, using our systematic review and supplementary searches, 169 articles were deemed relevant. A large proportion of the literature focuses on the 1918 Spanish Influenza. Milder pandemics, such as the Asian Flu, Hong Kong Flu, or SARS pandemic, are much less studied across all fields. The only pandemic which did not return any dedicated papers was the Encephalitis Lethargica pandemic in 1915; it was mentioned in just one study, and only in among other pandemics.

Figure 3: Flowchart of study selection



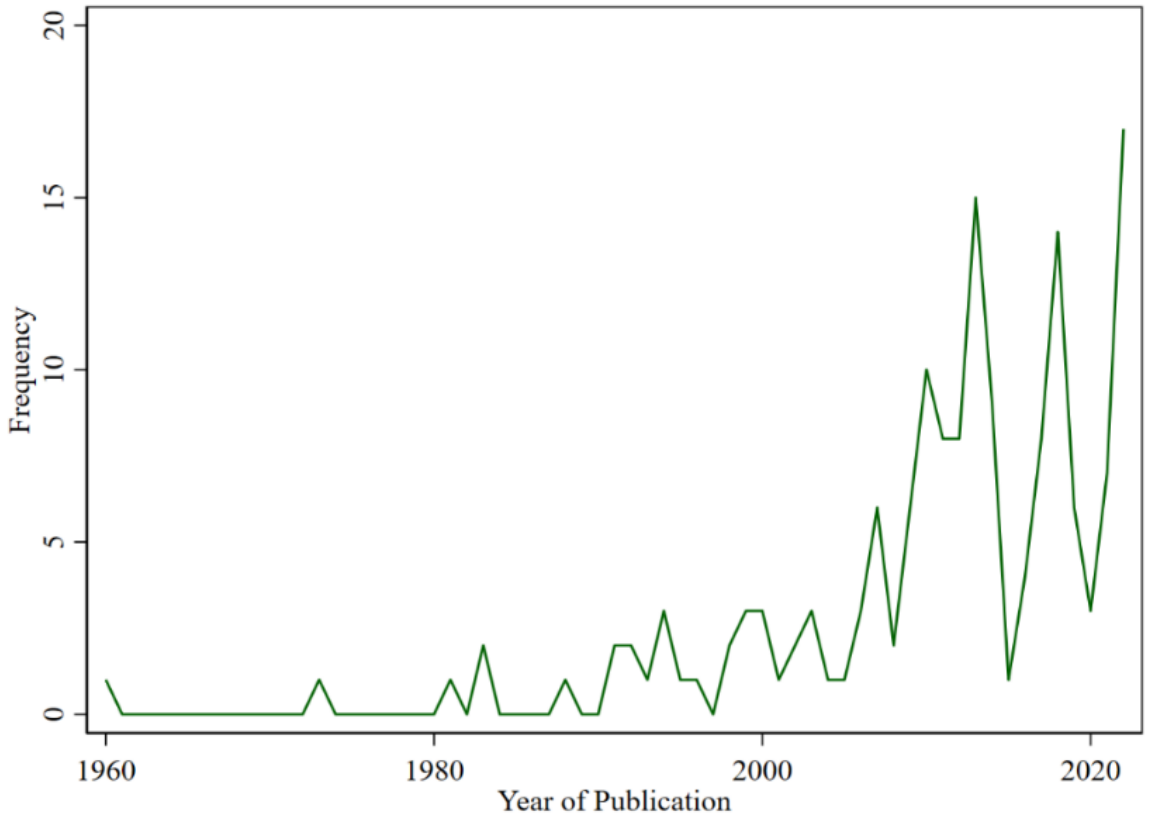
Papers from more than 100 journals are included in our review. Table 2 reports the 10 which appear most. They are largely concentrated in the areas of medicine and epidemiology. Beyond the top selection however there are journals covering a vast range of disciplines. The breadth of journals highlights how the topic of pandemics is of interest to a multitude of disciplines.

Table 2: Top returned journals

Journal	**No. of returned papers**
American Journal of Epidemiology	7
Emerging Infectious Diseases	7
Influenza and Other Respiratory Viruses	7
PNAS	6
Bulletin of the History of Medicine	5
Emerging Infectious Diseases	5
Social Science & Medicine	5
PLoS ONE	5
Vaccine	4
BMC Infectious Diseases	3
Demography	3
Health Economics	3

Figure 4 tracks the year of publication for all papers contained within the review. There has been an overall upward trend in interest in the topic. There are noticeable spikes which coincide with the Swine Flu pandemic, the centenary of the 1918 Spanish Influenza, and unsurprisingly Covid-19.

Figure 4: Year of publication of articles reviewed



The mortality impact of pandemics is the dominant theme across the literature, followed by their economic impact. There has been less focus placed on the morbidity and the in utero impact of the various pandemics. This may be explained by the availability of data; it is much easier to count the bodies of those who die during a pandemic than those who got sick and recovered. In the absence of diagnostic testing, estimates of morbidity are largely based on anecdotal rather than medical evidence. However, even in more recent influenza pandemics, diagnostic testing was only used systematically for the most severe cases requiring hospitalisation. Comparisons between pandemics based on infections alone are therefore very difficult.

With our relevant literature gathered, we synthesise their findings and establish what we already know about pandemics, the issues within the existing literature, gaps for further

research, and how future scholars can contribute. The rest of our paper is arranged by the frequency which these topics appear in the literature.

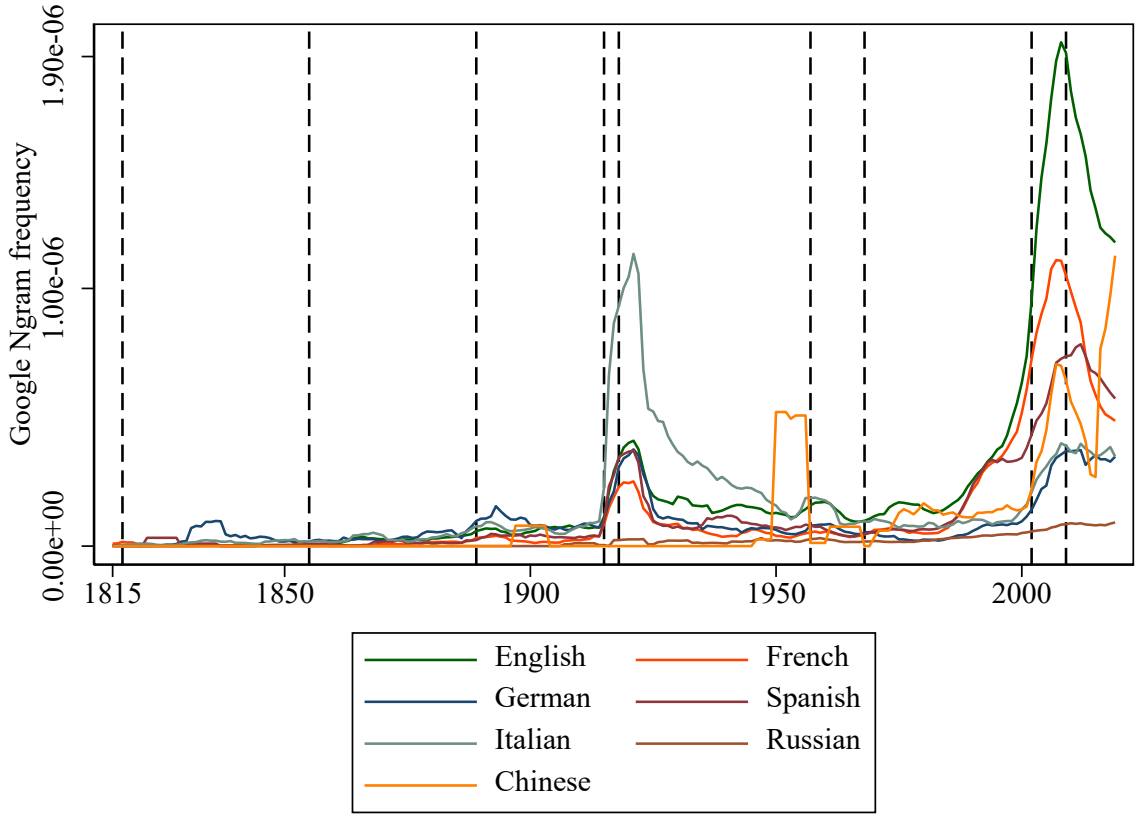
2.4 Limitations

English is the lingua franca of international scientific research communication today but this was not always the case. Most famously German was a dominant language in the late nineteenth century. Our search databases contain primarily English language publications. By relying on these databases we may miss nuanced findings written in the vernacular. Particularly pandemic impacts in the past that were geographically specific may be under-documented in English.

Another aspect of our literature search is that we focus on published research articles rather than monographs. This was a feature of our data sources which focused more on journal articles than on monographs. This is understandable as the primary mode of publication in the medical sciences in research article, but this choice biases our study against the humanities, where monographs tend to be the primary outlet for scholarship.

One way to assess how these issues may bias the findings from our systematic review is to search the frequency of the term ‘pandemic’ across languages and in books and to assess whether trends match our own findings in terms of frequency of the word in scientific articles. Figure 5 shows Google Ngram frequencies for the terms in multiple languages. In general, the patterns of mentions of the words coincide. But English language usage of the term increases notably in the early twenty-first century, which coincides with the 2009 Swine Flu pandemic and the nearing of the centenary of the 1918 pandemic. The pattern is also consistent with the trend shown in Figure 4 of article publication dates.

Figure 5: Frequency of the word pandemic across languages



Notes: Pandemics of interest highlighted in vertically dashed lines (Table 1).

Sources: Google Ngram (https://books.google.com/ngrams/info). Data obtained using R package 'ngramr'. Ngram refers to frequency of word in a given language based on google books. Words searched: "pandemic"; "pandémie"; "pandemie"; "pandemia [Spanish]"; "pandemia [Italian]"; "пандемия"; "大 流行". Corpuses used: en-2019 (Books predominantly in the English language published in any country.); fr-2019 (Books predominantly in the French language); de-2019 (Books predominantly in the German language); es-2019 (Books predominantly in the Spanish language); it-2019 (Books predominantly in the Italian language); ru-2019 (Books predominantly in the Russian language); zh-Hans-2019 (Books predominantly in simplified Chinese script).

Our focus is on pandemics post-1815 as we noted above. Does this provide a biased representation of past pandemics? For example, two of the most devastating pandemics in recorded human history are the Justinian Plague (541-740 CE) and the Black Death (1300-1400s) when death rates were estimated to have been between 20-40 and 20-60 per cent of the population (Kilbourne 2008). Although even here the evidence about the extent of catastrophe

of the former pandemic has been called into question (e.g., Mordechai et al,. 2019; Sarris, 2022).

There are several differences that make 'modern' (post-1815) pandemics more commensurate with the present. First is the continuous improvements in medical knowledge about the underlying cause and transmission of disease which make public health management practices more relevant. The two aforementioned pre-modern pandemics were bacterial in origin and the underlying cause was unknown to contemporaries (Glatter and Finkelman, 2020). Thus while not all our modern pandemics had pharmaceutical interventions readily available, there was growing understanding of the cause of transmission, similar to the early days of the Covid-19 pandemic, which enabled the use of nonpharmaceutical interventions. Although quarantines were as a NPI in the case of plague (e.g. Newman 2012), the duration of quarantine was arbitrarily defined (Tognotti 2013). Secondly, the world has become more global since the Plague of Justinian and the Black Death; greater communication between all regions of the globe enables the wider and quicker dispersion of pathogens. The emergence of nation states and central bureaucracy encouraged the collection of vital statistics which many of the studies rely on. However, official statistics remain patchy and incomplete in many developing country contexts, a point discussed in Jerven (2013) for the African context.

We believe a focus on pandemics post-1815 is justified because of the improvements in medical knowledge in the Modern Era which have enhanced the management of public health crises such as pandemics; we believe this marks a distinction between pre- and post-1815. Thus while events such as the Plague of Justinian and the Black Death were probably the most devastating pandemics known to man, they also took place in an era without basic medical knowledge and low life expectancies. Looking towards the future, much of the focus of the anticipated health impacts associated with climate change are the spread of tropical and subtropical disease such as malaria, dengue, and yellow fever. While there is real concern on

this front, take for example, recent autochthonous cases of dengue transmission in France in 2022 (Cochet et al., 2022), in practice, diseases such as malaria appeared to be contained; WHO (2021) highlight the increasing number of countries that have achieved an elimination of malaria.

Lastly, our search of the various databases for the impact of pandemics runs the risk of excluding works that discuss historical pandemics but do not describe them as such in the title or abstract. This is a significant limitation. There could be several studies which classify a particular pandemic as being only an epidemic, for example. Our justification for maintaining this limitation is that we are interested in the rather narrow task of finding out what the users of popular academic journal databases would learn if they were per se interested in finding out about pandemics at a rather high level. The fact that some studies of historical pandemics do not appear in our search highlights the importance of scholars adopting consistent nomenclature, and journal reviewers and editors enforcing this nomenclature.

3. Mortality Impact

The mortality impact is the most common theme across the literature. It highlights both the variation in death toll between the various pandemics, and the variation in factors contributing to it. This section assesses these factors and how they have been studied across the literature. Table 3 outlines the articles in our review with a focus on mortality. Of the 65 pandemic papers listed here, 45 deal with 'Spanish flu', 21 with Swine Flu, 2 with 'Russian flu', 4 with 'Asian flu', and 1 with 'Cholera'.

Table 3: Articles examining mortality impact

Study	Pandemic	Period	Location	Question
McGrew (1960)	Cholera	1817-23	Global	Overview of the pandemic
Pool (1973)	1918 Spanish Influenza	1918	New Zealand	Effect of the pandemic on the Maori population

Ohadike (1981)	1918 Spanish Influenza	1918-1919	Niger	Population impact of the pandemic
Patterson (1983)	1918 Spanish Influenza	1918-19	Africa	Estimating mortality impact
Patterson & Pyle (1991)	1918 Spanish Influenza	1918-19	Global	Geography of the Spanish Influenza
Tomkins (1992)	1918 Spanish Influenza	1918-1919	Samoa	Impact of the pandemic
Rice & Palmer (1993)	1918 Spanish Influenza	1918	Japan	Mortality patterns and official response
Herring (1994)	1918 Spanish Influenza	1918-1919	Norway	Mortality impact
Killingray (1994)	1918 Spanish Influenza	1918-1919	British Caribbean	Spread of the disease across islands
Simonsen et al. (1998)	1918 Spanish Influenza	1918	United States	Age distribution of mortality
Gernhart (1999)	1918 Spanish Influenza	1918	United States	Public health response
Noymer & Garenne (2000)	1918 Spanish Influenza	1918	United States	Effect on sex differentials
Johnson & Muller (2002)	1918 Spanish Influenza	1918	Global	Death toll in 1918
Langford (2002)	1918 Spanish Influenza	1918	England & Wales	Age pattern of mortality
Afkhami (2003)	1918 Spanish Influenza	1918-1919	Iran	Social and demographic effects
Taubenberger & Morens (2006)	1918 Spanish Influenza	1918-1919	Global	Age pattern of mortality
Tuckel et al. (2006)	1918 Spanish Influenza	1918-1919	United States (Hartford)	Factors influencing mortality
Ahmed et al. (2007)	1918 Spanish Influenza	1918	Global	Explaining the "W-shaped" mortality curve
Ansart et al. (2009)	1918 Spanish Influenza	1906-22	Europe	Mortality burden
Richard et al. (2009)	1918 Spanish Influenza	1915-23	Japan, United Kingdom & United States	Age-specific mortality
Donaldson et al. (2009)	2009 Swine Flu Pandemic	2009	United Kingdom	Establish mortality from 2009 pandemic

Shanks et al. (2010)	1918 Spanish Influenza	1914-19	Australia	Understand mortality risk
Muscatello et al. (2010)	2009 Swine Flu	2003-09	Australia	Estimate mortality impact
Wilking et al. (2010)	2009 Swine Flu	2009	Germany	Estimate mortality impact
Andreasen & Simonsen (2011)	1918 Spanish Influenza	1918	Global	Using excess mortality to measure mortality burden
Louie et al. (2011)	2009 Swine Flu	2009-10	United States (California)	Adult mortality due to Swine Flu
Valtat et al. (2011)	1889 Influenza	1889-90	Europe & United States	Age distribution of cases and deaths
Nikolopoulos et al. (2011)	2009 Swine Flu	2009-10	30 European Countries	Socioeconomic determinants of pandemic mortality
Charu et al. (2011)	2009 Swine Flu	2000-10	Mexico	Mortality burden of Swine Flu compared to seasonal influenza
Ma et al. (2011)	1957 Asian Flu	1951-99	Canada	Estimating who is at greatest risk of death from influenza
Pearce et al. (2011)	1918 Spanish Influenza	1918-1919	England & Wales	Risk factors for mortality
Mytton et al. (2012)	2009 Swine Flu	2009-10	England	Comparing Swine Flu mortality in England in first and second wave
Dawood et al. (2012)	2009 Swine Flu	2009	Global	Estimate global mortality impact
Chandra et al. (2012)	1918 Spanish Influenza	1891-1941	India	Estimate mortality impact
Lemaitre et al. (2012)	2009 Swine Flu	1997-2010	France	Estimating excess mortality
Chandra (2013)	1918 Spanish Influenza	1918-19	Japan	New mortality estimates for Spanish Influenza in Japan
Rajatonirina et al. (2012)	2009 Swine Flu	2009	Madagascar	What was excess mortality

Mamelund et al. (2013)	1918 Spanish Influenza	1918	Alaska & Labrador	How culture and environment influence patterns of spread of infectious disease
Chandra (2013)	1918 Spanish Influenza	1917-40	Indonesia	Re-estimating demographic impact of pandemic
Nguyen & Noymer (2013)	2009 Swine Flu	2009-10	United States	Burden, timing and age-distribution of pandemic deaths
Charu et al. (2013)	2009 Swine Flu	1990-10	United States	Timelier way of estimating pandemic mortality burden
Gagnon et al. (2013)	1918 Spanish Influenza	1918	United States & Canada	Comparing 1890 and 1918 pandemics
Simonsen et al. (2013)	2009 Swine Flu	2005-09	Global	Estimating H1N1 mortality
Yu et al. (2013)	2009 Swine Flu	2004-10	China	Regional mortality impact of Swine Flu in China
Green et al. (2013)	2009 Swine Flu	2006-12	England & Wales	Impact of influenza on all cause and cause specific mortality
Wu et al. (2013)	2009 Swine Flu	1998-2011	Hong Kong	Excess mortality during two waves of H1N1
Yang et al. (2014)	1918 Spanish Influenza	1915-23	United States (New York)	Patterns in age-specific timing, mortality and transmission
Chowell et al. (2014)	1918 Spanish Influenza	1918-19	Spain	Spatial-temporal excess mortality patterns
Ergönül et al. (2014)	2009 Swine Flu	2009-10	Turkey	Predictors of fatality from swine flu
Pérez-Flores et al. (2013)	2009 Swine Flu	2009-10	Mexico	Quantify the mortality impact
Chowell et al. (2014)	1918 Spanish Influenza	1918-21	Chile	Death patterns during the pandemic

Cobos et al. (2016)	1957 Asian Flu	1954-61	United States (Arizona)	Transmissibility and mortality burden at local level
Viboud et al. (2016)	1957 Asian Flu	1957-59	Global	Mortality burden of the pandemic
Grantz et al. (2016)	1918 Spanish Influenza	1918-20	United States (Chicago)	Social factors influencing mortality
Chowell & Viboud (2016)	1918 Spanish Influenza	1918	United States (Chicago)	Social factors influencing mortality
Liu et al. (2017)	2009 Swine Flu	2010-15	China	Mortality burden of the disease
Chowell et al (2017)	1957 Asian Flu	1957-59	Chile	Risk factors for severe mortality impact across regions
Ramiro et al. (2018)	1889 Influenza	1889-90	Spain (Madrid)	Age-specific excess mortality
Spreeuwenberg et al. (2018)	1918 Spanish Influenza	1916-20	Global	Reassessing the global mortality burden
Dahal et al. (2018)	1918 Spanish Influenza	1918-21	United States (Arizona)	Age-specific mortality
Clay et al. (2018)	1918 Spanish Influenza	1918	United States	Impact of air pollution on pandemic mortality
Van Wijhe et al (2018)	1918 Spanish Influenza	1918	Denmark	Understanding high death rate in young adults
Wilson et al. (2018)	1918 Spanish Influenza	1918	New Zealand	Socio-economic gradients and mortality rates
Bengtsson et al. (2018)	1918 Spanish Influenza	1815-21	Sweden	Social class and excess mortality
Nunes et al. (2018)	1918 Spanish Influenza	1916-22	Portugal	The regional variation in the impact on Portugal
Cilek et al. (2018)	1918 Spanish Influenza	1918-20	Spain (Madrid)	Age-specific mortality rates
Rayes et al. (2018)	1918 Spanish Influenza	1916-1920	British India	Spatiotemporal mortality patterns
Clay et al. (2019)	1918 Spanish Influenza	1918	United States	Cross-city variation in mortality

Lobo et al. (2019)	2009 Swine Flu		United States	Excess mortality associated with Swine Flu
Økland & Mamelund (2019)	1918 Spanish Influenza	1918-1919	United States	Race and mortality
Paskoff & Sattenspiel (2019)	1918 Spanish Influenza	1918-20	Newfoundland	Sex and age-based differences in mortality
Salto-Quintana et al. (2019)	2009 Swine Flu	1998-2014	Mexico	Excess mortality after the pandemic

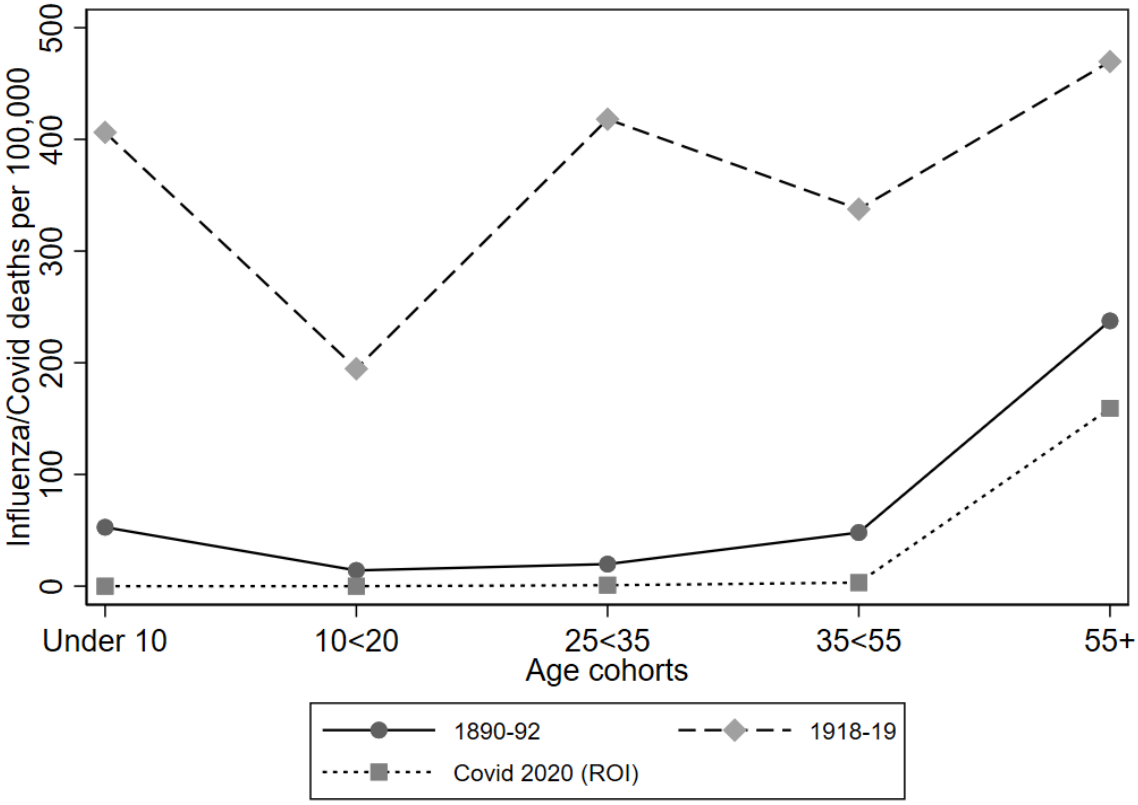
A common determinant of mortality across the literature is age. Valtat et al. (2011) studied the age distribution of deaths in various developed countries during the 1889 influenza pandemic and conclude that death rates increased with age, indicative of a "J-shaped" mortality curve. This was despite the clinical attack rate remaining relatively constant across those aged 1 to 60. Ramiro et al. (2018) also find evidence of a "J-shaped" mortality curve for this period.

Asian Flu in the late 1950s also displays a positive relationship between age and mortality across global studies (Viboud et al., 2016; Cobos et al., 2016). Chowell et al. (2017) find the same relationship in Chile, while also noting the mortality burden was up to five times as severe compared to that in higher income countries.

Other pandemics displayed a different age-mortality pattern. The most notable is the 1918 Spanish Influenza and its "W-shaped" mortality curve, where those aged 18-30 had higher mortality rates than in the other pandemic episodes. (Taubenberger (2006, figure 2) shows a stark contrast between the "J-shaped" influenza mortality pattern from 1911-15 in the US and the "W-shaped" influenza mortality pattern in 1918, however his study is primarily a genomic sequence of the 1918 influenza virus from frozen lung tissue and not a study of mortality per se.) Despite evidence of strong regional variation in mortality in Richard et al. (2009), a common feature of 1918 Spanish Flu in Japan, the UK, and the US was the highly elevated mortality risk in young adults compared to older cohorts. The "W-shaped" curve has

also been found in other studies (Ohadike, 1981; Rice and Palmer, 1993; Chowell et al. 2014; Yang et al., 2014; van Wijhe et al., 2018 and Paskoff and Sattenspiel, 2019). This distinctive feature of the 1918 Spanish Influenza was first discovered by door-to-door surveys carried out by doctors and statisticians across 10 American cities during the height of the pandemic (Gernhart, 1999). However, Cilek et al. (2018) find evidence of a "J-shaped" curve in Madrid and argue that more studies in different populations are needed to fully understand the impact of the 1918 pandemic. Similarly, Herring's (1994) analysis of parish registers in Norway does not show evidence of a "W-shaped" curve.

Figure 6: "J" and "W" curves for several pandemic episodes in Ireland



Sources: Deaths directly attributed to influence (1890-92 & 1918-19) and Covid-19 (2020). Register of Births, Deaths, and Marriages 1890, 1891, 1892, 1918, 1919 and HSPC (2020).

Figure 6 demonstrates the "J" and "W" shaped mortality curves using data from 1890, 1918 and Covid. Ireland is presented solely as an illustration of the wider findings in the reviewed studies – and as a case site that is newly documented. Ireland was chosen because all three co-authors of the present study are based there and have convenient access to the necessary historical mortality data.

One factor which may help explain the age-specific mortality pattern is exposure to prior influenzas. The so called "doctrine of antigenic sin" implies that childhood exposure to influenza creates an antibody response to the dominant antigen of the virus (Davenport and Hennessy, 1956; Francis, 1960). Gagnon et al. (2013) argue that exposure to the 1889-90 Russian Flu pandemic in early childhood contributed to mortality patterns during the 1918 pandemic. Similarly, some populations of over-60s are found to experience lower mortality rates, with this thought to be caused by exposure to previous influenza strains in adult life (Mamelund et al., 2013). Exposure to the 1889 pandemic may help to explain variation in mortality both within and between countries during the 1918 pandemic (see also Wilson et al., 2024, for a discussion of this), but this remains to be assessed, with Simonsen et al. (1998) noting the reasons for this high mortality in young people compared to in other pandemics have not yet been adequately explained. This speaks to the need to study sequential pandemics collectively rather than individually.

This experience was not unique to 1918. Those born during the 1957 Asian Flu pandemic had increased mortality risk during the 2009 Swine Flu pandemic, while those exposed to other H1N1 viruses which circulated between 1918 and 1940 had a decreased risk (Gagnon et al., 2018). This may explain the high excess deaths experienced by the under-65s during the 2009 pandemic. In Mexico, the under-60s were disproportionately affected compared to their experience with seasonal influenza (Charu et al., 2011), while in the US 79 per cent of excess deaths occurred in those under 65 (Charu et al., 2013) – again with the young

disproportionately affected compared to seasonal influenza (Ma et al, 2011; Nguyen and Noymer, 2013).

Aside from age, socio-economic status (SES) is a strong focus of research throughout the 1918 Spanish Influenza mortality literature. For example, working-class suburbs in New Zealand show evidence of higher pandemic mortality rates (Wilson et al., 2018), with this also thought to be at least one reason why the Maori population were more severely impacted (Pool, 1973) and the Black population in America (Økland & Mamelund, 2019). A similar relationship is also found in North America (Mamelund et al., 2013) and Sweden (Bengtsson et al., 2018). (A monograph outside our search parameters (Milne, 2018) advances the idea that the increased exposure of this age group is explained by their employment patterns; they are in more public-facing jobs.) Distinct class differences in infection and mortality have also been shown in studies of Cholera in Canada (McGrew, 1960). Other demographic and social factors found to play a role in the North American context include literacy, population density, unemployment rates and home ownership (Grantz et al., 2016).

Further studies also speak to the effect of population density and urbanisation. In Chile, Iran, Portugal, and Spain, rural areas report higher excess mortality rates compared to urban areas during the 1918 Spanish Influenza (Afkhami, 2003; Chowell et al., 2014; Nunes et al., 2018). Iran also experienced significantly higher overall mortality (Afkhami, 2003). Rural excess mortality rates were nearly three times higher than those in urban areas in China during the Swine Flu outbreak (Yu et al., 2013). This could be driven by the high disease environment of cities (i.e., high baseline mortality) meaning pandemic viruses operate in competition, or because of reduced access to healthcare in rural areas. However, there is also countervailing evidence that points to the negative effects of urbanisation. For example, Clay et al. (2018; 2019) show that high coal use contributed to tens of thousands of excess deaths is US cities during the 1918 Spanish Influenza compared to those cities with low coal use. Nigeria also

experienced higher mortality during 1918 in urban areas compared to rural ones (Ohdike, 1991). Urban areas also suffered higher mortality rates during Cholera outbreaks (McGrew, 1960).

A handful of studies pick up other factors which contributed to mortality. Evidence shows the higher mortality in the second wave of the Swine Flu pandemic was associated with behavioural factors (Mytton et al., 2012): the public became more complacent, leading to a reduction in the adherence to public health guidelines and preventative measures. While it is probably true that behavioural factors were associated with the spread of other pandemics, we found no papers which specifically examined it. Mytton et al. (2012) note the higher mortality in the second waves of the twentieth century pandemics were the result of genetic drift. The Swine Flu pandemic also reveals an inverse relationship between per capita government expenditure on health and mortality (Nikolopoulos et al., 2011).

The mortality impact can also persist after the official end of a pandemic. Research shows 1918 Spanish Influenza had a long-run impact on gender-specific mortality patterns. Those with tuberculosis (TB) were more likely to die during the influenza. As males were more likely to have TB than females, more males died. This lowered the pool of future males with TB, causing male life expectancy to converge with female life expectancy in the US (Noymer and Garenne, 2000). A mortality effect also persisted after the Swine Flu pandemic. Hospital mortality associated with Swine Flu influenza in Brazil continued to be high for years after the official end (Lobo et al., 2019).

While a limited number of studies within this review focus on mortality rates in developing countries during pandemics, those which do suggest they are more likely to be severely impacted. In Ghana alone during the 1918 Spanish Influenza, Patterson (1983) estimates that between 80,000 and 100,000 people died. Similar numbers were reported in the

Caribbean (Killingray, 1994), while Western Samoa lost 22 per cent of its population (Tomkins, 1992).

However, a limitation of many of these studies is the fact that they focus primarily on mortality without controlling for the impact of mitigation strategies in reducing mortality. Pandemics in the absence of such mitigation strategies could have been worse but many studies do not highlight the contribution of mitigation strategies in reducing this impact. Future studies could estimate counterfactual mortality in the absence of such intervention drawing on historical pandemics as many had limited mitigation strategies and limited pharmaceutical intervention.

4. Economic Impact

Pandemic policy interventions require clear benefit-cost calculations. This necessitates better information on the possible costs. As with mortality, the economic impact has varied across pandemics, countries, and time. An initial short-run negative economic impact sometimes made way for a more positive impact in the medium to long-run, depending on how the pandemic affected the labour market. Table 4 highlights the articles which focus on the economic impact and the questions they ask. This table lists 19 papers. Four deal with 'Spanish Influenza; 5 with SARS; 5 with a hypothetical pandemic; 3 with Swine Flu; 1 with 'multiple pandemics'; and 1 with ‘plague’.

Table 4: Articles examining economic impact

Study	Pandemic	Period	Location	Question
Risse (1992)	Plague	1907-1908	United States	Overview of plague in San Francisco
Meltzer, Cox & Fukuda (1999)	Hypothetical	Hypothetical	United States	Estimating potential economic impact
Brainerd and Siegler (2003)	1918 Spanish Influenza	1919-30	United States	Impact of Spanish Influenza on economic growth

DeLisle (2003)	SARS	2003	China	China and globalisation through SARS
Lee and McKibbin (2004)	SARS	2003	Global	Global economic impact of SARS
Wong (2007)	SARS	1994-2003	Hong Kong	Impact of SARS on property prices
Garrett (2008)	1918 Spanish Influenza	1918	United States	Economic impact of Spanish Flu
Keogh-Brown & Smith (2008)	SARS	2003-04	Global	How reality matched predictions
Garrett (2009)	1918 Spanish Influenza	1914-19	United States	Effect of Spanish Influenza and WW1 on wages
Smith et al. (2009)	Hypothetical	Hypothetical	United Kingdom	Modelling hypothetical pandemic response and impact
Yoldascan et al. (2010)	Hypothetical	Hypothetical	Turkey	Estimate potential economic impact
Keogh-Brown et al. (2010)	Hypothetical	Hypothetical	United Kingdom	Possible macroeconomic impact of an influenza pandemic
Keogh-Brown et al. (2010)	Hypothetical	Hypothetical	UK, France, Belgium & the Netherlands	Estimates of macroeconomic impact of pandemic influenza
Kim et al. (2013)	2009 Swine Flu	2009-10	South Korea	Assess the socioeconomic burden
Smith & Keogh-Brown (2013)	2009 Swine Flu	2004-09	South Africa, Thailand & Uganda	Macroeconomic impact of the pandemic
Karlsson et al. (2014)	1918 Spanish Influenza	1911-30	Sweden	Economic impact of the Spanish Influenza
Duarte et al. (2017)	2009 Swine Flu	2009	Chile	Impact on labour productivity
Chen at al. (2018)	SARS	1998-2008	Asia	Impact of SARS on stock market integration
Ceylan et al. (2020)	Multiple pandemics	1918 onwards	Global	Historical evidence for economic effects of Covid-19

As with studies of mortality, the 1918 Spanish Influenza has been of great interest to researchers of the economic impact of pandemics. During this pandemic in Sweden, stock returns fell by 5 to 10 per cent, while poorhouse numbers also increased at a rate of four for every pandemic death (Karlsson et al., 2014). In the US context, one working paper links the high mortality rate with a decrease in the supply of labour, which pushed up wages throughout the 1920s. Another working paper also finds the pandemic had a large, positive effect on per capita income growth over the course of the decade. (These findings are from unpublished pre-print working papers rather than articles published in peer reviewed journals: Garrett (2009) and Brainerd & Siegler (2003). We include them here because they are highly cited.) . The pandemic also led to a substantial increase in people taking out life insurance, which coupled with the high mortality rates threatened the solvency of some companies (Galishoff, 1969).

Despite the global impact of the Swine Flu pandemic, studies of its economic impact are limited. Smith and Keogh-Brown (2013) examine the impact on the economies of three lower- and middle-income countries and assess the consequences of sickness, death, or school closures on the labour market. The results showed there was less than a 1 per cent loss of GDP across each of the three countries, with labour-intensive sectors suffering the most due to productivity losses. Meanwhile, the indirect costs of the pandemic accounted for 60 per cent of the total costs incurred (Kim et al., 2013).

While the 1918 Spanish Influenza and Swine Flu both had high mortality impacts, the SARS pandemic did not; fewer than 1,000 people died. However, the economic cost was high. Estimates show it caused a $3 trillion loss in global GDP and $2 trillion fall in equity markets (DeLisle, 2003). Lee and McKibbin (2004) note there are three main mechanisms through which the SARS pandemic had economic consequences: (1) retail and tourism were impacted as people tried to avoid infection; (2) uncertainty about the outcome of the pandemic led to a fall in trade and investment; (3) while people-orientated industries faced the costs of disease

prevention. These factors contributed to the economic cost of SARS being far greater than the health impact.

SARS also offers lessons in estimating the economic impact of a pandemic. When the pandemic first broke out, models were used to estimate the potential economic cost. Keogh-Brown and Smith (2008) compare the macroeconomic impact to estimates made in 2003 and find the impact was much smaller than predicted. The authors note the models used were confounded by the conflict in Iraq occurring simultaneously to the SARS pandemic. The WHO also took an active role in the outbreak and may have helped limit the progression of the disease. Arguably, the most important determinant of the lower-than-expected economic impact was the low death toll. The main limitation to the models was that the epidemiological or demographic impact of the disease was unknown in the early stages of the pandemic.

Models have also been developed to estimate the impact of future pandemics based on the experience of past pandemics. Keogh-Brown et al. (2010) estimate a pandemic similar in severity to the Asian or Hong Kong Flus in the UK would equate to a 3.35 per cent loss of GDP in the first quarter of the pandemic and 0.58 per cent GDP loss that year, with losses increasing with death toll, leading up to a 6 per cent loss of annual GDP. They also note the economic consequences would be most severe if the pandemic led to prolonged school closures. Meanwhile, Meltzer, Cox & Fukuda (1999) estimated a 21st century influenza pandemic in America could have an economic impact close to $170 billion, not including disruptions to commerce and society. They also estimate the potential savings of vaccinations, noting the benefits of offering vaccinations to the overall population depend on vaccine costs and gross attack rates.

From the existing literature, it is clear pandemics present as much an economic threat as a health threat. This was evidenced by the response to Cholera in San Francisco. Officials initially tried to deny the outbreak due to fears of the economic implications, and when they

did respond, the response was dictated by commercial interests (Risse, 1992). This reflects past experiences of quarantines where commercial interests were opposed to such measures (Ackerknecht 1948).

5. Morbidity Impact

Mortality is typically the focus of any pandemic discussion; an overlooked area is the majority who become ill and recover. Morbidity can have long-term impacts, both on health and the economy. Table 5 highlights that we find very few articles on pandemic morbidity. Those we do find focus on the 1918 Spanish Influenza and Swine Flu pandemics. This table lists 16 papers, six of which deal with 'Spanish Influenza'; 7 with 'Swine Flu;' and one each with 'plague', 'cholera', and '1889 flu'.

Table 5: Articles examining morbidity impact

Study	Pandemic	Period	Location	Question
Patterson & Pyle (1983)	1918 Spanish Influenza	1918-1919	Africa	Diffusion of the pandemic
Wong & Fung (1988)	Plague		Global	Overview of the pandemic
Ohadike (1991)	1918 Spanish Influenza	1918-1919	Nigeria	Diffusion of the pandemic
Smith (1995)	1889 Influenza	1889-1894	United Kingdom	Demographic impact of the pandemic
Cockrell (1996)	1918 Spanish Influenza	1918-1919	United States	Public health response in North Carolina
Patterson (1994)	Cholera	1823-1923	Russia	Disease diffusion and mortality impact
Schoch-Spana (2000)	1918 Spanish Influenza	1918	United States	Lessons on how to deal with future pandemics
Hatchett et al. (2007)	1918 Spanish Influenza	1918	United States	NPIs and morbidity
Lemaitre & Carrat (2010)	2009 Swine Flu	1978-2009	France & United States	Age distribution of morbidity
Eshima et al. (2011)	2009 Swine Flu	2009	Japan	Morbidity by age and sex
Luyt et al. (2012)	2009 Swine Flu	2009	France	Long-term impact on survivors

Gefenaite et al. (2014)	2009 Swine Flu	2008-09	Netherlands	Predictors of influenza
Duarte et al. (2017)	2009 Swine Flu	2009	Chile	Effect of pandemic on absence from work
Choi et al. (2017)	2009 Swine Flu	2009-10	South Korea	Disease burden and complications in pregnant women
Lau et al. (2018)	2009 Swine Flu	2004-11	England	Costs of hospital admissions
Mamelund (2018)	1918 Spanish Influenza	1918	Norway	Relationship between socioeconomic status and morbidity

These studies above give insight to the characteristics associated with morbidity. The Norwegian city of Bergen shows evidence of a relationship between SES, proxied by apartment size, and morbidity during the 1918 Spanish Influenza (Mamelund, 2018). During the first wave, there was a negative relationship between SES and influenza-like illness. The authors suggest their findings show the poor are more vulnerable, potentially through increased exposure, to disease and should be prioritised during vaccination programmes. The article also found a relationship between gender and morbidity.

The gender relationship was not unique to 1918. Eshima et al. (2011) use data for more than two million confirmed cases of Swine Flu in Japan to calculate the male-to-female morbidity ratios. Males under 20 were more likely to be infected than females of the same age. In the US and France, the age distribution of morbidity during the Swine Flu pandemic was broadly similar to the distribution during seasonal influenza (Lemaitre and Carrat, 2010). The main difference was in mortality. The proportion of under-60s who died was much higher than in standard flu seasons.

Studies of both Cholera and 1918 Spanish Influenza have pointed to the role of transport networks, in particular railways, in facilitating the spread of disease across populations. These patterns have been found in Africa, Russia, America, and Iran (Patterson and Pyle, 1983; Patterson, 1994; Cockrell, 1996; Afkhami, 2003). There is also evidence the Third Plague

outbreak became a global disease outbreak after it was spread via sailing ships (Wong and Fung, 1988).

Regardless of who falls ill, there are economic knock-on effects. Illness of anyone in the working population means time lost from work and a loss of productivity. Duarte et al. (2017) examine the impact of absence from work due to Swine Flu in Chile. They find the pandemic increased the average number of days missed due to flu by 800 per cent compared to the sample mean. Nigeria also experienced productivity impacts due to sickness during the 1918 Spanish Influenza (Ohadike, 1991). The contagious nature of influenza pandemics means the absenteeism and labour productivity effects are significantly larger compared to other forms of illness.

The increase in illness also comes at a cost to health services, in particular hospitals. A study by Lau et al. (2019) estimates the cost of the Swine Flu pandemic to the National Health Service (NHS) in England. They estimate there were 22,103 Swine Flu related admissions at a cost of £45.3 million. The pandemic will have resulted in other costs to the NHS as well, both in the short-term and long-term, meaning the true cost will be far greater than these estimates.

Illness can also have serious long-term health implications. However, as most historical pandemics did not have widespread diagnostic testing, studies are often limited to illness which resulted in hospitalisation. Luyt et al. (2012) track the long-term effects on those admitted to the ICU in France during the Swine Flu pandemic. One-year post-ICU discharge, survivors had lung disabilities, psychologic impairment, and lower health related quality of life than those of the same sex and age in the general population. There is also some evidence those who contracted the 1918 Spanish Influenza experienced fatigue, weakness, and depression which lasted for weeks (Schoch-Spana, 2000). Further studies of these long-term effects are needed. A study of the Russian Flu in Britain finds there was an increase in suicides following the pandemic due to lasting illness following infection (Smith, 1995).

If people develop long-term health conditions because of pandemic-related illness, they will need long-term medical care. This comes at a cost to the individual, the health service, or both, and puts a strain on the health resources available. There may also be long-run effects on the labour force if the lasting effects limit productivity, which can in turn have a knock-on effect to the overall health of the economy.

The long-term effects of pandemic illness may be particularly important for Covid-19. Many patients who have recovered report suffering from "long-Covid". (There has been renewed interest in studying the impact of post-viral infection from past pandemics – see, for example, Islam et al., 2020.) While little is currently known about what exactly this is and how long it lasts, the extensive diagnostic testing that has been carried out during the pandemic should make studying pandemic morbidity much more feasible than has been in previous pandemics.

6. In Utero Impact

An expanding area in the pandemic literature is tests of the fetal origin hypothesis or Barker hypothesis (Currie and Vogl, 2013). Table 6 highlights the fact the literature primarily focuses on the 1918 Spanish Influenza, particularly in the US. This table lists 17 papers. 13 deal with 'Spanish Influenza'; 3 with 'Asian Flu'; and one with 'Swine Flu'.

Table 6: Articles examining in utero impact

Study	Pandemic	Period	Location	Question
Selten, Slates & Kahn (1998)	1957 Asian Flu	1957-1994	The Netherlands	Did in utero exposure lead to increased rates of schizophrenia
Selten et al. (1999)	1957 Asian Flu	1957-1994	The Netherlands	Did in utero exposure lead to increased rates of schizophrenia
Almond & Mazumder (2005)	1918 Spanish Influenza	1918-1996	United States	Test of fetal origins hypothesis

Almond (2006)	1918 Spanish Influenza	1918-80	United States	Long-term effect of in utero exposure
Cohen et al. (2010)	1918 Spanish Influenza	1918-2008	Global	Effects of early life exposure to disease on later health
Nelson (2010)	1918 Spanish Influenza	1912-98	Brazil	Testing the fetal origins hypothesis in a developing country
Kelly (2011)	1957 Asian Flu	1958-2008	United Kingdom	Fetal health shocks and childhood outcomes
Myrskylä et al. (2013)	1918 Spanish Influenza	1918-2006	United States	Influence of pandemic on later life health outcomes
Lin & Liu (2014)	1918 Spanish Influenza	1916-80	Taiwan	In utero exposure to disease impact on long-term development
Parman (2015)	1918 Spanish Influenza	1915-30	United States	Reallocation of resources by parents in response to health shock
Percoco (2016)	1918 Spanish Influenza	1918-87	Italy	Health shocks and human capital formation
Acquah et al. (2017)	1918 Spanish Influenza	1993	United States	Hospitalisation rates of those exposed in utero
Fletcher (2018)	1918 Spanish Influenza	1918-80	United States	Impact of in utero exposure on mortality
Fletcher (2018)	1918 Spanish Influenza	1918-60	United States	Intergenerational impact of in utero exposure
Fletcher (2019)	1918 Spanish Influenza	1918-2011	United States	Impact of early-life exposure on old-age mortality
Helgertz & Bengtsson (2019)	1918 Spanish Influenza	1968–2012	Sweden	Impact of fetal stress on socioeconomic attainment and health
Newsome et al. (2019)	2009 Swine Flu	2009	United States	Outcomes of infants born to women with Swine Flu

Those exposed in utero suffer compared to other cohorts in terms of their long-term health outcomes. Acquah et al. (2017) find in utero exposure to the 1918 Spanish Influenza increased hospitalization rates in old age due to higher rates of functional limitations, consistent with previous work by Almond (2006).

Exposed cohorts in the US have also shown evidence of higher non-cancer mortality rates in old age compared to neighbouring cohorts (Myrskylä et al., 2013), with similar effects also found in Sweden (Bengtsson and Helgertz, 2019). However, mortality effects are not

absolute. Cohen et al., (2010) find no link between in-utero exposure to the 1918 pandemic and mortality in later life once age, period and sex are controlled for in their study across 24 countries. This was despite evidence of high exposure rates across the sample.

Almond's (2006) study also finds an effect on education and income of affected cohorts. For sons whose mothers had pandemic influenza, annual income is approximately $2,500 lower compared to those not affected, due to them being 15 per cent less likely to complete high school. Fletcher (2019) also finds results consistent with this using longitudinal data.

Negative education effects of in utero exposure to the 1918 pandemic have also been found in Italy, Brazil, Taiwan, and Sweden (Nelson, 2010; Lin and Liu, 2014; Percoco, 2016; Helgertz and Bengtsson, 2019), a driver of which may be changes in resource allocation between siblings. Families who were expecting a child during the 1918 pandemic shifted resources to their older children, resulting in those children having significantly higher educational attainments (Parman, 2015). A possible explanation for this finding was given as the impact having an unhealthy newborn might have on future fertility decisions. The unhealthy child may lead a couple to choose to have fewer children, meaning the resources saved from not having more children are instead invested in the older, healthier children. Babies exposed in utero with older siblings may therefore suffer even greater educational effects than those who were first-born or an only child.

In utero exposure has also been linked with family formation patterns later in life, with those exposed, especially females, marrying spouses with lower schooling levels compared to their unexposed counterparts (Fletcher, 2018). Exposed females are also less likely to have children, and if they do, have fewer children.

More recent pandemics give insight to the short-term effects of in utero exposure. Babies exposed in utero during both the Asian and Swine Flu pandemics were more likely to

be born pre-term, be low weight and have low Apgar scores, a test given to new-borns shortly after birth to measure their appearance, pulse, grimace, activity and respiration (Kelly, 2011; Newsome et al., 2019). Future study is needed to see if these short-term effects will also lead to long-term effects as witnessed from the 1918 Spanish Influenza.

There has also been some concern that exposure to the Asian Flu pandemic in-utero was connected to the development of schizophrenia. However, two separate studies based in the Netherlands have failed to find any link (Seltan, Slaets and Kahn, 1998; Seltan et al, 1999).

The articles published prior to the Covid pandemic all point to in utero exposure to pandemic disease potentially having lasting effects on an individual's life. Both health and economic outcomes are affected. This also presents an indirect cost to the wider economy, resulting in the costs of a pandemic continuing decades after its official end.

7. Lessons from the Past

As well as assessing the impacts of past pandemics, the literature uses these historical events to present recommendations on how to limit the impact of future pandemics. Table 7 highlights the articles returned in our search which present such recommendations. This table lists 18 papers. Of these, 2 dealt with multiple pandemics (including 20th-century pandemics); 7 with hypothetical pandemics; 3 with 'Spanish Influenza'; 5 with Swine Flu; and one jointly with both 'Spanish Influenza' and SARS.

Table 7: Articles with recommendations based on historical pandemics

Study	Pandemic	Period	Location	Question
Burg (2000)	1918 Spanish Influenza	1918	United States	How Wisconsin responded to the pandemic
Potter (2001)	Multiple Pandemics	All time	N/A	The history of influenza
Kilbourne (2006)	20th century pandemics	20th century	Global	Overview of 20th-century pandemic influenza

MacDougall (2006)	1918 Spanish Influenza & SARS	1918 & 2003	Canada	Comparing Public Health Department responses
Haber et al. (2007)	Hypothetical	N/A	United States	Effectiveness of interventions to reduce contact rates
Hatchett et al. (2007)	1918 Spanish Influenza	1918	United States	Variation on NPIs and pandemic intensity
Markel et al. (2007)	1918 Spanish Influenza	1918-1919	United States	Variation in mortality due to variation in NPI implementation
Smith et al. (2009)	Hypothetical	N/A	United Kingdom	Estimating potential economic impact of a pandemic in the UK
Hilton & Smith (2010)	2009 Swine Flu	2009	United Kingdom	Public views of the media and government reaction
Lugnér at al. (2012)	Hypothetical	N/A	Germany, Netherlands & United Kingdom	Cost effectiveness of vaccination against pandemic influenza
Mytton et al. (2012)	2009 Swine Flu	2009-10	United Kingdom	Comparing mortality in the first and second wave
Reed et al. (2013)	Hypothetical	N/A	United States	Framework for assessing the impact of influenza pandemics
Matthews Pillemer at al. (2014)	Hypothetical	N/A	Hong Kong, Singapore, Taiwan & United States	Predicting support for NPIs during outbreaks
Fineburg (2014)	2009 Swine Flu	2009	Global	Lessons from Swine Flu for pandemic preparedness
Bjørkdahl & Carlsen (2017)	2009 Swine Flu	2009	Norway	Impact of media on pandemic perception
Prager et al. (2017)	Hypothetical	N/A	United States	Economic cost of potential influenza outbreak in the US
Grieco et al. (2020)	Hypothetical	N/A	United Kingdom	Role of mass vaccination in pandemic preparedness
Porter et al. (2020)	2009 Swine Flu	2009	Global	Seasonal vaccination plans and pandemic preparedness

A key issue noticeable from the literature is the focus on influenza as the likely cause of future pandemics and overlooking other possible causes. For example, many studies have used past influenza pandemic frequency to predict the next pandemic (e.g., Potter, 2001;

Kilbourne, 2006), while others used past influenza pandemics to create benchmarks for measures of pandemic clinical severity (Reed et al., 2013).

Porter et al. (2020) use Swine Flu to show the importance of seasonal vaccination programmes. Countries which had one in place pre-pandemic were more likely to meet the criteria for WHO donated vaccines and had better infrastructure to deploy them. Having vaccination programmes in place can substantially reduce the economic impact and limit the severity of illness (Smith et al., 2009; Lugnér et al., 2012; Prager et al., 2017; Grieco et al., 2020). A key part of any pandemic preparedness plan should involve seasonal vaccination programmes as this will lay the infrastructure for mass pandemic vaccination. This has also been evident in extant pandemic preparedness plans. For example, the 2019 'Crimson Contagion' pandemic preparedness plan used a scenario of a new influenza virus, emanating from China, where a vaccine had not yet been developed but that pre-existing H7N9 vaccine stocks could be used (*New York Times*, 19 March 2020).

Another key step highlighted by previous pandemics is the use of nonpharmaceutical interventions (NPIs) to limit the transmission of disease, particularly when vaccines and antiviral/antibiotics are unavailable. Historical evidence supported mathematical models showing the effectiveness of NPIs (Haber et al., 2007). Hatchett et al. (2007) and Markel et al. (2007) show that US cities which implemented NPIs in the early stages of Spanish Influenza experienced peak mortality rates approximately 50 per cent lower compared to cities which did not implement them. In the British Caribbean, quarantine measures were an important tool to stem infections across islands (Killingray, 1994).

Matthews Pillemer et al. (2014) find that support for NPIs varied depending on culture during the SARS pandemic; this is corroborated by evidence from surveys from Hong Kong, Singapore, Taiwan, and the US in the wake of SARS (Matthews Pillemer et al., 2015). More research is needed on NPIs, especially as they became officially advocated as pandemic policy

by the US CDC in their 2007 pre-pandemic guidance (CDC 2007) and their global use during Covid-19.

The Swine Flu pandemic of 2009 provided an opportunity for governments and global organisations to learn lessons on how to prepare for future pandemics. Based on the experience of Swine Flu, a special review committee offered recommendations to the WHO on dealing with pandemics, including establishing and pursuing a more comprehensive influenza research programme (Fineberg, 2014).

The Swine Flu pandemic also offers another lesson: the role of the media during the pandemic. Bjørkdahl and Carlsen (2017) examine the coverage of the Swine Flu pandemic in Norwegian newspapers and find a lot of discourse about how coverage of the pandemic would cause panic. This was a result of the early coverage being dramatic and fear centric. There was also evidence that reporting shortages of certain medicines resulted in people starting to stockpile who otherwise would not have. The balance must be struck between making people concerned enough that they take the situation seriously while not promoting a panic which will ultimately make the situation worse.

During the second wave of Swine Flu in the UK, Hilton and Smith (2010) carried out focus groups to assess the public's views of the pandemic and how the government had reacted to it. People felt there was little they could do to protect themselves from the, in their eyes, inevitability of becoming ill. Participants stated they paid limited attention to the government's advice and public awareness campaigns as they felt following the advice would not make a difference. This helps explain mortality and morbidity rates (Mytton et al., 2012). The discussion groups also highlighted people felt the vaccine on offer presented more of a risk to their health than the disease itself. It is this fear, the authors argue, which led to the relatively limited vaccine uptake.

MacDougall (2006) compared the Toronto Health Department's response to the 1918 Spanish Influenza and SARS pandemics. They concluded that local health departments are key in containing a pandemic, provided they have adequate coordination, communication and capacity. This is further evidenced by the experience of Wisconsin during the 1918 Spanish Influenza. Public health had already been a priority in the state before the pandemic's outbreak. An extensive health infrastructure and strong public support contributed to the Midwest experiencing below average mortality rates (Burg, 2000). MacDougall also concludes with a key message: "with growing concern about a flu pandemic, the lessons of the past provide a foundation for future communicable disease control activities."

8. Post-Covid Articles

As discussed in Section 2, we supplemented our systematic review of pre-Covid publications with a look at all newly published research on historical pandemics conducted in the wake of our most recent pandemic experience. The 1918 Spanish Influenza pandemic dominates this most recent batch of research on historical pandemics, with 24 of the 26 chosen studies at least partially focused on this pandemic.

Table 8: Articles published since 2020

Study	Pandemic	Period	Location	Question
Aassve et al. (2021)	1918 Spanish Influenza	1918-2018	United States	The impact of the pandemic on societal trust
Boberg et al. (2021)	1918 Spanish Influenza	1915-27	Sweden	How fertility responds to a pandemic
Brzezinski (2021)	Various post-WW2	1950–2019	167 countries	Impact of past pandemics on economic and gender inequalities
Colvin & McLaughlin (2021)	1918 Spanish Influenza	1918-19	Ireland	How to measure the mortality impact of a pandemic
Ledberg (2021)	1918 Spanish Influenza & SARS	1860-2020	Sweden	Excess mortality across pandemic episodes

Lin & Meissner (2021)	1918 Spanish Influenza	1918-19 & 2020	United States	Persistence in public health outcomes across pandemics
Mamelund et al. (2021)	Various across past millennium	N/A	Global	Association between SES and pandemic influenza
Rück et al. (2021)	1918 Spanish Influenza, 1957 Asian Flu & 1968 Hong Kong Flu	1910-1978	Sweden	Link between pandemics and suicide
Ager et al. (2022)	1918 Spanish Influenza	1920-40	United States	Impact of school closures on educational outcome
Beach et al. (2022a)	1918 Spanish Influenza	N/A	N/A	Lessons from 1918 for Covid-19
Beach et al. (2022b)	1918 Spanish Influenza	1918-80	United States	Re-evaluating Almond (2006)
Carillo & Jappelli (2022)	1918 Spanish Influenza	1918-21	Italy	Impact of pandemic on regional economic growth
Chapelle (2022)	1918 Spanish Influenza	1918-25	United States	Medium-run impact of pandemic NPIs
Clay et al. (2022)	1957 Asian Flu & 1968 Hong Kong Flu	1950-76	United States	Value of health insurance during pandemic
Correia et al. 2022	1918 Spanish Influenza	1918-19	United States	Impact of NPIs
Dahl et al. (2022)	1918 Spanish Influenza	1904-29	Denmark	Economic recovery from pandemic
Franke (2022)	1918 Spanish Influenza	1914-25	Germany	Influence on income on pandemic mortality
Fenske et al. (2022)	1918 Spanish Influenza	1901-31	India	Change in women's labour market participation due to pandemic
Galletta & Giommoni (2022)	1918 Spanish Influenza	1910-30	Italy	Effect of 1918 pandemic on income inequality
Guimbeau et al. (2022)	1918 Spanish Influenza	1920-40	Brazil	Short- and medium-run health and literacy impacts of a pandemic
Jordà et al. (2022)	Various across past millennium	N/A	N/A	Impact of historical pandemics on asset prices
Juneau et al. (2022)	Various across past millennium	N/A	Global	Cost-effectiveness of pandemic suppression policies
Rijpma et al. (2022)	1918 Spanish Influenza	1918-1919	Netherlands	Excess mortality during the pandemic

Ogasawara (2022)	1918 Spanish Influenza	1918-1920	Japan	Foetal exposure to influenza and gender imbalance
Velde (2022)	1918 Spanish Influenza	1915-23	United States	Economic impact of pandemic
Gaddy & Ingholt (2023)	1918 Spanish Influenza	1915-1920	Europe	Did the 1918 pandemic cause a 1920 baby boom?
Schroeder et al. (2023)	19th and 20th century pandemics	1838-2000	United Kingdom	Mortality risk following a pandemic

Most of the 1918 Spanish Influenza study sites were the US, which exploited the existing collated data of NPIs by city. There were also studies of other developed countries (Ireland in Colvin and McLaughlin, 2021; Spain in Basco et al., 2021; Denmark in Dahl et al., 2022; Germany in Franke, 2022; Italy in Carillo and Jappelli, 2022; the Netherlands in Rijpma et al., 2022), as well as countries in the global south (India in Fenske et al., 2022; Brazil in Guimbeau et al., 2022). The research questions asked of the 1918 Spanish Influenza pandemic are significantly broader than older studies of this pandemic. The paucity of information related to the Covid-19 pandemic transformed 1918 Spanish Influenza into a policy-relevant analogue of the present. The new addressed issues related to economic impact (Dahl et al., 2022; Velde, 2022), inequality (Furceri et al., 2022), the impact of NPIs (Correia et al., 2022; Chapelle, 2022), importance of health insurance (Clay et al., 2022), occupation and social class (Rijpma et al., 2022) and demographic impacts (Boberg-Fazlic et al. 2021; Colvin and McLaughlin, 2021). Scholars' lived experience of Covid-19 may help to explain the new focus on NPIs.

A promising avenue has been more analysis of the relatively under-studied pandemics, including the two mid-twentieth century influenza pandemics in 1957-58 and 1968-69 (Clay et al., 2022). However, there was also a conflation of epidemics and pandemics which makes the generalisation of findings difficult (Brzezinski, 2022). New post-Covid papers exhibit an increased used of causal methods with efforts to formally identify mechanisms at action, with difference-in-difference approaches widely used. However, many studies took mortality

figures at face value and did not estimate excess mortality which has been shown in the Covid-19 pandemic to differ significantly from the reported deaths directly attributed to the pandemic itself (e.g., Wang et al., 2022; Msembur et al., 2022).

9. Discussion

Despite the increased prominence of works that analyse historical pandemics, many of the gaps which exist in the pre-Covid literature still persist in the new wave of work that has emerged since the start of the recent global catastrophe. Greater critical engagement with the underlying data sources is essential for future research. Death certificates have been a key source for various studies (Cobos et al., 2016; Cilek et al., 2018). However, it is rare that pandemic influenza, or any pandemic pathogen, is listed as the cause of death. This leads to the debate on the measurement of pandemic severity using directly attributed deaths or excess mortality, which is also a key talking point of Covid-19 research (Adam, 2022). Excess mortality is a more reliable indicator of pandemic death toll because of known biases in how cause of death is recorded across countries (Beaney et al., 2020; Wang et al., 2022). This leads to scope for revisiting previous studies which used death certificates as their means of determining pandemic deaths. The latter point was already addressed by Johnson (2003), who highlights how influenza deaths were misdiagnosed and underreported, and that excess deaths better highlight the full extent of the pandemic death toll.

There is also the issue of any estimates being sensitive to the underlying demographic structure of the study site. Our review shows there are many characteristics found to be correlated with mortality. However, authors have not always considered how the underlying age structure may have impacted mortality rates. This was highlighted in recent research for both the Covid-19 and 1918 Spanish Influenza pandemics (Dowd et al., 2020; Colvin and McLaughlin, 2021). These approaches estimate age standardised excess mortality to make like-

for-like comparison between countries with different demographic structures. Without this adjustment, international comparisons of mortality may mislead. And so, when it comes to preparing for future pandemics, we may take policy lessons from the wrong countries.

Another issue within the mortality, and wider pandemic, literature is the large focus on developed countries. Data availability issues and the fact pandemic researchers are often based in developed countries explain this choice. Nonetheless, the lack of coverage on developing countries needs to be addressed as when they have been studied, their experience has been found to be quite different from that of developed countries. Pandemics by definition are global in terms of disease impact; therefore, a global approach is required.

Many studies use a 1918-like death toll as the benchmark for the worst case. This fails to account for improvements in living conditions – including advances in medical knowledge, pharmaceutical medicine, and improvements in health infrastructure – which occurred since the early twentieth century; mortality rates would likely be substantially lower were 1918 to re-occur today. Similarly, judging late-twentieth-century pandemics to be milder does not account for the fact they also took place in substantially improved living conditions with antiviral medications and vaccines. Acknowledging these differences, and incorporating them into research designs, should lead to better comparisons between pandemics.

There is significant scope for additional research on the economic and social impact of pandemics, especially the long-run costs. We know the 1918 Spanish Influenza resulted in higher mortality rates for young adults, particularly males, but we know comparatively less about the cost of this loss in human capital. This is coupled with the long-term health impacts for those who recovered from the disease or who were exposed in utero. The seminal findings of the impact of in utero exposure to pandemic influenza have recently been challenged as they highlight a series of selection biases in the analysis (Beach et al., 2022b). However, the conclusions of in utero exposure studies suffer from the ecological fallacy; findings are based

upon disease rates being high within a given area. The available data and analysis typically cannot accurately identify whether or not a specific individual's parents had influenza. Such studies should be replicated across other study sites to assess whether the original effects still hold. Estimating some form of counterfactual of what the long-term outcome might have been, had the 1918 Spanish Influenza not occurred, would be one way for us to arrive at a better understanding as to its real impact. The same is true of all pandemics.

The 1889 Influenza pandemic in particular offers untapped research opportunities. We know very little about it beyond the existence of a "J-shaped" mortality curve (Valtat et al., 2011). This "J-shape" mortality curve has two implications for our understanding of the subsequent 1918 Spanish Influenza pandemic: it may give an indication of the impact of previous exposures on the age profile of mortality in 1918/19 (the "W-shape"), but also the impact of in utero exposure to pandemic infection on lifelong health and wellbeing. While existing studies focus on the "W-shaped" mortality curve from 1918, this may be a misleading pandemic as the mechanism may have been through affected parents (a dead father or mother) rather than the direct exposure in utero. Census linking could be used to track the outcomes of those born during the 1889 pandemic and compared to the 1918 Spanish Influenza to see whether the effects are consistent.

10. Conclusion

Our systematic review provides a detailed assessment of the current state of the literature on historical pandemics published both prior to and post-Covid-19. We have brought together information on numerous aspects of various pandemics which have often been looked at only in isolation. Carrying out this exercise has given us a much more nuanced understanding of the literature on pandemics, what we can learn from it, and the gaps which can be addressed in future scholarship.

Perhaps our most important lesson is the need for pandemics to be studied collectively rather than individually. As we have documented in the tables above, there are several different pandemic episodes over the past 200 years, but they are typically only studied in isolation. Studies of individual pandemics can only offer limited insight for the future unless we ascertain whether their features represent a common trend across pandemics, or are unique to that event. However, a challenge here is the lure of the 1918 Spanish Influenza pandemic, which we think has diverted attention from elsewhere. If some pandemics have only received cursory treatment, then more in-depth studies are required to redress the balance before any meaningful comparative work can commence.

Many of the other gaps we identify are a consequence of disciplines working in silos. Different disciplines can address the same question but reach different conclusions because they adopt different methodological approaches, or are based on different evidentiary bases. If disciplines work together, we can reach a more holistic understanding of pandemics. The range of journals returned in the search highlights the interest the topic has to a variety of researchers. If we can develop a more robust and rounded literature, we will be in a better position to engage with policymakers. This should then make us better prepared to deal with the pandemics which will inevitably occur in the future.

Indeed, we started this project with the goal that its results could be useful to public policymakers. Our idea was that we would highlight to them the big lessons arising from the state-of-the-art on historical pandemic research, drawn from across *all* the social and medical sciences. Our approach was inspired by the New Applied History movement, which is about providing more rigorous historical cases from which policymakers can draw analogous lessons, and promoting 'historical thinking as an essential element of discussions about the challenges that our societies are now confronted with' (Kaal and van Lottum, 2019). We hope our systematic review represents a first step in achieving this goal.

In his reflection on the role of history in the policymaking process, economic historian Barry Eichengreen (2012) highlights how analogical reasoning is already widely used in times of social and economic crisis. He illustrates his argument with how the lessons of history shaped policy responses to the 2007 Global Financial Crisis. He also highlighted how there is always more than one analogy, and warns that sometimes analogies can be biased because they are the most accessible (i.e., widely taught) rather than being the most relevant and appropriate. We think that same applies to historical pandemics. We have found that the 1918 Spanish Influenza pandemic is by far the most widely studied, but we fear that it may not always be the best analogy for pandemic response policy. The more we know about other past pandemics, the better we can inform future policymaking.

Acknowledgements: We thank Neil Cummins, Alan de Bromhead, Alan Fernihough and John Turner for reading an earlier version of our work, participants of the Royal Economics Society (online, April 2021) and the Pandemics in Economic History workshop (online, March 2022) for early feedback on our approach, and two referees for their detailed advice on how to improve our original submission. We also acknowledge support from colleagues at the Centre for Economics, Policy and History.

Funding: The authors did not receive support from any organization for the submitted work.

Conflicts of interest/Competing interests: None.

Authors' contributions: All authors contributed equally to study design, analysis and interpretation, and drafting and revision of the paper. Doran, the study's lead author, was additionally responsible for conducting the initial literature search and coordinated the systematic review process.

Consent for publication: All authors provided consent for this publication.

References

Archival and Official Sources

British Parliamentary Papers [BPP] (1891). *Twenty-seventh detailed annual report of the Registrar General for Ireland containing a general abstract of the numbers of marriages, births and deaths registered in Ireland during the year 1890*. Dublin, HM Stationery Office.

___ (1892). *Twenty-eigth detailed annual report of the Registrar General for Ireland containing a general abstract of the numbers of marriages, births and deaths registered in Ireland during the year 1891*. Dublin, HM Stationery Office.

___ (1893). *Twenty-ninth detailed annual report of the Registrar General for Ireland containing a general abstract of the numbers of marriages, births and deaths registered in Ireland during the year 1892*. Dublin, HM Stationery Office.

___ (1919). *Fifty-fifth detailed annual report of the Registrar General for Ireland containing a general abstract of the numbers of marriages, births and deaths registered in Ireland during the year 1918*. Dublin, HM Stationery Office.

___ (1920). *Fifty-sixth detailed annual report of the Registrar General for Ireland containing a general abstract of the numbers of marriages, births and deaths registered in Ireland during the year 1919*. Dublin, HM Stationery Office.

CDC (2007). *Interim Pre-pandemic Planning Guidance: Community Strategy for Pandemic Influenza Mitigation in the United States— Early, Targeted, Layered Use of Nonpharmaceutical Interventions.*

Health and Protection Surveillance Centre (2020). Epidemiology of COVID-19 in Ireland (August).

UK Covid-19 Inquiry (2023). Module 1 Public Hearing 19th June 2023.

World Health Organisation [WHO] (2003). Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003.

___ (2009). Pandemic Influenza Preparedness and Response: A WHO Guidance Document

___ (2010). Pandemic (H1N1) 2009 – update 112.

___ (2021). World Malaria Report 2021.
https://www.who.int/publications/i/item/9789240040496

Secondary Literature

Aassve, A., Alfani, G., Gandolfi, F. & Le Moglie, M. (2021). Epidemics and trust: The case of the Spanish Flu. *Health Economics*, *30*(4), 840-857.

Acquah, J. K., Dahal, R., & Sloan, F. A. (2017). 1918 influenza pandemic: In utero exposure in the United States and long-term impact on hospitalizations. *American Journal of Public Health, 107*(9), 1477–1483.

Adam, D. (2022). The pandemic's true death toll: millions more than official counts. *Nature, 601*, 312–315.

Afkhami, A., (2003). Compromised constitutions: the Iranian experience with the 1918 influenza pandemic. *Bulletin of the History of Medicine*, 367-392.

Ager, P., Eriksson, K., Karger, E., Nencka, P., & Thomasson, M.A. (2022). School closures during the 1918 flu pandemic. *The Review of Economics and Statistics*, https://doi.org/10.1162/rest_a_01170.

Alfani, G., & Murphy, T. E. (2017). Plague and lethal epidemics in the pre-industrial world. *Journal of Economic Histor*y, *77*(1), 314–343.

Almond, D. (2006). Is the 1918 influenza pandemic over? Long-term effects of in utero

influenza exposure in the post-1940 U.S. population. *Journal of Political Economy*, 114(4), 672–712.

Altice F., Evuarherhe O., Shina S., Carter G., & Beaubrun A. C. (2019). Adherence to HIV treatment regimens: systematic literature review and meta-analysis. *Patient Prefer Adherence, 13,* 475–490.

Arias-Colmenero, T., Pérez-Morente, M. Á., Ramos-Morcillo, A. J., Capilla-Díaz, C., Ruzafa-Martínez, M., & Hueso-Montoro, C. (2020). Experiences and attitudes of people with HIV/AIDS: A systematic review of qualitative studies. *International Journal of Environmental Research and Public Health, 17*(2), 639.

Arthi, V., & Parman, J. (2021). Disease, downturns, and wellbeing: Economic history and the long-run impacts of COVID-19. *Explorations in Economic History*, *79*, 101381.

Barro, R. J., Ursua, J. F., & Weng, J. (2020). The coronavirus and the Great Influenza Epidemic – Lessons from the "Spanish Flu" for the Coronavirus's potential effects on mortality and economic activity. *National Burereu of Economic Research,* 26866.

Barry J., Viboud, C., & Simonsen, L. (2008). Cross-protection between successive waves of the 1918–1919 influenza pandemic: Epidemiological evidence from US Army camps and from Britain. *Journal of Infectious Diseases, 198*, 1427–1434.

Basco, S., Domenech, J., & Rosés, J. R. (2021). The redistributive effects of pandemics: Evidence on the Spanish flu. *World Development, 141*, 105389.

Beach, B., Clay, K., & Saavedra, M. (2022a). The 1918 Influenza pandemic and its lessons for COVID-19. *Journal of Economic Literature, 60*(1), 41–84.

Beach, B., Brown, R., Ferrie, J., Saavedra, M., & Thomas, D. (2022b). Reevaluating the long-term impact of in utero exposure to the 1918 Influenza pandemic. *Journal of Political Economy*, 130(7), 1717–1991.

Beaney, T., Clarke, J. M., Jain., M, et al. (2020). Excess mortality: The gold standard in measuring the impact of Covid-19 worldwide? *The Royal Society of Medicine*, *113*(3), 329–334.

Bengtsson, T., Dribe, M., & Eriksson, B. (2018). Social class and excess mortality in Sweden during the 1918 influenza pandemic. *American Journal of Epidemiology*, *187*(12), 2568–2576.

Bengtsson, T., & Helgertz, J. (2019). The long lasting influenza: The impact of fetal stress during the 1918 influenza pandemic on socioeconomic attainment and health in Sweden 1968–2012. *Demography*, *56*, 1389–1425.

Berry, K., Allen, T., Horan, R. D., et al. (2018). The economic case for a pandemic fund. *EcoHealth*, *15*(2), 244–258.

Bjørkdahl, K., & Carlsen, B. (2017). Fear of the fear of the flu: Assumptions about media effects in the 2009 pandemic. *Science Communication*, *39*(3), 358–381.

Bloom, D., Kuhn, M., & Prettner, K. (2022). Modern infectious diseases: Macroeconomic impacts and policy responses. *Journal of Economic Literature*, *60*(1), 85–131.

Boberg-Fazlic, N., Ivets, M., Karlsson, M. & Nilsson, T. (2021). Disease and fertility: Evidence from the 1918–19 influenza pandemic in Sweden. *Economics & Human Biology*, *43*, 101020.

Bostrom, N., & Cirkovic, M. (2008). *Global Catastrophic Risk*. Oxford University Press.

Brainerd, E., & Siegler, M. V. (2003). The economic effects of the 1918 influenza epidemic. CEPR Discussion Paper Series, Paper No. 3791.

Brzezinski, M., (2021). The impact of past pandemics on economic and gender inequalities. *Economics & Human Biology*, *43*, 101039.

Burg, S. (2000). Wisconsin and the great Spanish flu epidemic of 1918. *Wisconsin Magazine of History*, *84*(1), 36-56.

Carillo, M. F. & Jappelli, T. (2022). Pandemics and regional economic growth: Evidence from

the Great Influenza in Italy. *European Review of Economic History*, *26*(1), 78–106.
Centre for Reviews and Dissemination (2009). *Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care*. CRD, University of York.
Ceylan, R.F., Ozkan, B. and Mulazimogullari, E. (2020). Historical evidence for economic effects of COVID-19. *The European Journal of Health Economics*, *21*, 817-823.
Chandra, S. (2013). Mortality from the influenza pandemic of 1918-19 in Indonesia. *Population Studies*, 67(2), 185–193.
Chandra, S., Kuljanin, G. & Wray, J. (2012). Mortality from the influenza pandemic of 1918-1919: The case of India. *Demography*, 49(3), 857–865.
Chapelle, G., (2022). The medium-term impact of non-pharmaceutical interventions. The case of the 1918 influenza in US cities. *Economic Policy*, *37*(109), 43–81.
Charu, V., Chowell, G., Palacio Mejia, L.S., et al. (2011). Mortality burden of the A/H1N1 pandemic in Mexico: A comparison of deaths and years of life lost to seasonal influenza. *Clinical Infectious Diseases*, *53*(10), 985–993.
Charu, V., Simonsen, L., Lustig, R., Steiner, C., & Viboud, C. (2013). Mortality burden of the 2009-10 influenza pandemic in the United States: improving the timeliness of influenza severity estimates using inpatient mortality records. *Influenza and Other Respiratory Viruses*, *7*(5), 863–871.
Chowell, G., Simonsen, L., Flores, J., Miller, M. A., & Viboud, C. (2014). Death patterns during the 1918 influenza pandemic in Chile. *Emerging Infectious Diseases*, *20*(11), 1803–1811.
Chowell, G., Erkoreka, A., Viboud, C. et al. (2014). Spatial-temporal excess mortality patterns of the 1918-1919 influenza pandemic in Spain. *BMC Infectious Diseases*, *14*(1), 1–12.
Chowell, G., Simonsen, L., Fuentes, R., Flores, J., Miller, M.A., & Viboud, C. (2017). Severe mortality impact of the 1957 influenza pandemic in Chile. *Influenza and Other Respiratory Viruses*, *11*(3), 230–239.
Chowell G. and Viboud C. (2016). Pandemic influenza and socioeconomic disparities: Lessons from 1918 Chicago. *Proceedings of the National Academy of Sciences of the United States of America, 113*, 13557–13559.
Cilek, L., Chowell, G., & Fariñas, D. R. (2018). Age-specific excess mortality patterns during the 1918–1920 influenza pandemic in Madrid, Spain. *American Journal of Epidemiology*, *187*(12), 2511–2523.
Clay, K., Lewis, J., & Severnini, E. (2018). Pollution, infectious disease, and mortality: Evidence from the 1918 Spanish influenza pandemic. *The Journal of Economic History*, *78*(4), 1179–1209.
Clay, K., Lewis, J., & Severnini, E. (2019). What explains cross-city variation in mortality during the 1918 influenza pandemic? Evidence from 438 US cities. *Economics & Human Biology, 35*, 42–50.
Clay, K., Lewis, J., Severnini, E. & Wang, X., (2022). The value of health insurance during a crisis: Effects of medicaid implementation on pandemic influenza mortality. *The Review of Economics and Statistics*, https://doi.org/10.1162/rest_a_01239.
Cobos, A. J., Nelson, C.G., Jehn, M. et al . (2016). Mortality and transmissibility patterns of the 1957 influenza pandemic in Maricopa County, Arizona. *BMC Infectious Diseases*, *16*(1), 1–14.
Cochet, A., Calba, C., et al. (2022). Autochthonous dengue in mainland France, 2022: geographical extension and incidence increase. *Euro Surveillance* 27(44): 2200818.
Cockrell, D.L., (1996). "A Blessing in Disguise": The Influenza Pandemic of 1918 and North Carolina's Medical and Public Health Communities. *The North Carolina Historical Review*, *73*(3), 309-327.
Cohen, A. A., Tillinghast, J., & Canudas-Romo, V. (2010). No consistent effects of prenatal or

neonatal exposure to Spanish flu on late-life mortality in 24 developed countries. *Demographic Research*, *22*, 579–634.
Colvin, C. L., & McLaughlin, E. (2021). Death, demography and the denominator: Age-adjusted Influenza-18 mortality in Ireland. *Economics & Human Biology*, *41*(May), 100984.
Colvin, C. L., & Winfree, P. (2019). Applied history, applied economics, and economic history. *Journal of Applied History*, *1*(1–2), 28–41.
Cooper, H. and Hedges, L. V. (2009). Research synthesis as a scientific process. In Harris Cooper, Larry V. Hedges and Jeffrey C. Valentine (eds). *The Handbook of Research Synthesis and Meta-Analysis*, 2nd edition. Russell Sage Foundation: New York.
Correia, S., Luck, S. & Verner, E., (2022). Pandemics depress the economy, public health interventions do not: Evidence from the 1918 flu. *The Journal of Economic History*, *82*(4), 917–957.
Currie, J., & Vogl, T. (2013). Early-life health and adult circumstance in developing countries. *Annual Review of Economics, 5*, 1–36.
Cutler, D. M., & Summers, L. (2020). The COVID-19 Pandemic and the $16 Trillion Virus. *Journal of the American Medical Association*, *324*(15): 1495-1496.
Dahl, C. M., Hansen, C.W., & Jensen, P.S. (2022). The 1918 epidemic and a V-shaped recession: Evidence from historical tax records. *The Scandinavian Journal of Economics*, *124*(1), 139–163.
Dasgupta, P. (2021). *The Economics of Biodiversity: The Dasgupta Review.* HM Treasury.
Davenport, F., & Hennessy, A. V. (1956). A serologic recapitulation of past experiences with influenza A; antibody response to monovalent vaccine. *Journal of Experimental Medicine*, *104*(1), 85–97.
DeLisle, J. (2003). SARS, greater China, and the pathologies of globalization and transition. *Orbis*, *47*(4), 587–604.
Dixon S, McDonald S, & Roberts J. (2002). The impact of HIV and AIDS on Africa's economic development. *British Medical Journal*, *324*(7331), 232–234
Doshi, P. (2011). The elusive definition of pandemic influenza. *Bulletin of the World Health Organization*, *89*(7), 532–538.
Dowd, J. B., Andriano, L., Brazel, D. M., & Mills, M. C. (2020). Demographic science aids in understanding the spread and fatality rates of COVID-19. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(18), 9696–9698.
Duarte, F., Kadiyala, S., Masters, S.H., & Powell, D. (2017). The effect of the 2009 influenza pandemic on absence from work. *Health Economics*, *26*(12), 1682–1695.
Eichengreen, B. (2012). Economic history and economic policy. *The Journal of Economic History 72*(2), 289–307.
Eisenberg, M., & Mordechai, L. (2019). The Justinianic Plague: An interdisciplinary review. *Byzantine and Modern Greek Studies, 43*(2), 156–180.
Eshima, N., Tokumaru, O., Hara, S., et al. (2011). Sex- and age-related differences in morbidity rates of 2009 pandemic influenza a H1N1 virus of swine origin in Japan. *PLoS ONE*, *6*(4).
Fineberg, H. V. (2014). Pandemic preparedness and response — Lessons from the H1N1 influenza of 2009. *New England Journal of Medicine*, *370*(14), 1335–1342.
Fletcher, J. (2018). The effects of in utero exposure to the 1918 influenza pandemic on family formation. *Economics & Human Biology*, *30*, 59–68.
Fletcher, J. M. (2019). Examining the long-term mortality effects of early health shocks. *Applied Economics Letters*, *26*(11), 902–908.
Francis, T. (1960). On the doctrine of original antigenic sin. *Proceedings of the American Philosophical Society*, *104*(6), 572–578.

Franke, R., (2022). Poverty, pollution, and mortality: The 1918 influenza pandemic in a developing German economy. *The Economic History Review*, *75*(4), 1026–1053.
Gaddy, H. & Ingholt, M.M. (2023). Did the 1918 influenza pandemic cause a 1920 baby boom? Demographic evidence from neutral Europe. *Population Studies*, *3*, 1-19.
Gagnon, A., Miller, M. S., Hallman, S.A., et al. (2013). Age-specific mortality during the 1918 influenza pandemic: Unravelling the mystery of high young adult mortality. *PLoS ONE*, *8*(8), e69586.
Gagnon, A., Acosta, E., Hallman, S., et al. (2018). Pandemic paradox: Early life H2N2 pandemic influenza infection enhanced susceptibility to death during the 2009 H1N1 pandemic. *mBio*, *9*(1), 1–15.
Galletta, S., & Giommoni, T. (2022). The effect of the 1918 influenza pandemic on income inequality: Evidence from Italy. *Review of Economics and Statistics*, *104*(1), 187–203.
Garrett, T. A. (2009). War and pestilence as labor market shocks: U.S. manufacturing wage growth 1914–1919. *Economic Inquiry*, *47*(4), 711–725.
Gernhart, G., (1999). A forgotten enemy: PHS's fight against the 1918 influenza pandemic. *Public Health Reports*, *114*(6), 559.
Glatter, K. A., and Finkelman, P. (2020). History of the Plague: An ancient pandemic for the age of covid-19. *American Journal of Medicine*, *134*(2), 176–181.
Globerman, J., Mitra, S., Gogolishvili, D., Rueda, S., Schoffel, L., Gangbar, K., Shi, Q., & Rourke, S. B. (2017). HIV/STI prevention interventions: A systematic review and meta-analysis. *Open Medicine*, *12*, 450–467.
Grantz, K. H., Rane, M. S., Salje, H., Glass, G. E., Schachterle, S. E., & Cummings, D. A. (2016). Disparities in influenza mortality and transmission related to sociodemographic factors within Chicago in the pandemic of 1918. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(48), 13839–13844.
Grieco, L., Panovska-Griffiths, J., van Leeuwen, E., Grove, P., & Utley, M., (2020). Exploring the role of mass immunisation in influenza pandemic preparedness: A modelling study for the UK context. *Vaccine*, *38*(33), 5163–5170.
Haber, M. J., Shay, D. K., Davis, X. M., Patel, R., Jin, X., Weintraub, E., Orenstein, E., & Thompson, W. W. (2007). Effectiveness of interventions to reduce contact rates during a simulated influenza pandemic. *Emerging Infectious Diseases*, *13*(4), 581–589.
Hatchett, R. J., Mecher, C. E., & Lipsitch, M. (2007). Public health interventions and epidemic intensity during the 1918 influenza pandemic. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(18), 7582–7587.
Hays, J. N. (2005). *Epidemics and Pandemics: Their Impacts on Human History,* ABC-CLIO
Helgertz, J., & Bengtsson, T. (2019). The long-lasting influenza: The impact of fetal stress during the 1918 influenza pandemic on socioeconomic attainment and health in Sweden, 1968-2012. *Demography*, *56*(4), 1389–1425.
Herring, D.A. (1994). "There Were Young People and Old People and Babies Dying Every Week": The 1918-1919 Influenza Pandemic at Norway House. *Ethnohistory*, 73-105.
Hetzel, R. (2012). *The Great Recession: Market Failure or Policy Failure?* Cambridge University Press.
Hilton, S., & Smith, E. (2010). Public views of the UK media and government reaction to the 2009 swine flu pandemic. *BMC Public Health*, *10,* 1–10.
Honigsbaum M. (2020). *The Pandemic Century: A History of Global Contagion from the Spanish Flu to Covid-19*. Cambridge, MA: Penguin.Islam, M. F., Cotler, J., & Jason L. A. (2020). Post-viral fatigue and COVID-19: Lessons from past epidemics. *Biomedicine, Health & Behavior*, *8*(2), 61–69.
James, H. (2013). The Great Depression and the great recession. *Journal of Modern European Hisory, 11*(3), 308–314.

Jedwab, R., Johnson, N., & Koyama, M. (2022). The economic impact of the Black Death. *Journal of Economic Literature*, *60*(1), 132–178.
Jerven, M. (2013). *Poor Numbers: How We Are Misled by African Development Statistics and What to Do about It.* Cornell: Cornell University Press.
Johnson, N. P. A. S., & Mueller, J. (2002). Updating the accounts: Global mortality of the 1918-1920 "Spanish" influenza pandemic. *Bulletin of the History of Medicine*, *76*(1), 105–115.
Johnson, N. (2003). The overshadowed killer: influenza in Britain, 1918-19. In: Phillips, H., & Killingray, D. (eds.), *The Spanish Flu Pandemic of 1918-19.* London: Routledge, 132–155.
Jordà, Ò., Singh, S. R. & Taylor, A. M., (2022). Longer-run economic consequences of pandemics. *Review of Economics and Statistics*, *104*(1), 166–175.
Juneau, C.E., Pueyo, T., Bell, M., Gee, G., Collazzo, P. & Potvin, L. (2022). Lessons from past pandemics: a systematic review of evidence-based, cost-effective interventions to suppress COVID-19. *Systematic Reviews*, *11*(1), 1-17.
Kaal, J., & van Lottum, J. (2019). Editorial. *Journal of Applied History*, *1*(1-2), 1–3.
Karlsson, M., Nilsson, T., & Pichler, S. (2014). The impact of the 1918 Spanish flu epidemic on economic performance in Sweden. An investigation into the consequences of an extraordinary mortality shock. *Journal of Health Economics*, *36*(1), 1–19.
Kelly, E. (2011). The scourge of Asian flu: In utero exposure to pandemic influenza and the development of a cohort of British children. *Journal of Human Resources*, *46*(4), 669–694.
Kelly, H. (2011). The classical definition of a pandemic is not elusive. *Bulletin of the World Health Organization*, *89*(7), 540–541.
Keogh-Brown, M. R., Smith, R. D., Edmunds, J. W., & Beatels, P. (2010). The macroeconomic impact of pandemic influenza: Estimates from models of the United Kingdom, France, Belgium and the Netherlands. *European Journal of Health Economics*, *11*(6), 543–554.
Keogh-Brown, M. R., & Smith, R. D. (2008). The economic impact of SARS: How does the reality match the predictions? *Health Policy*, *88*(1), 110–120.
Kilbourne, E. D. (2006). Influenza pandemics of the 20th century. *Emerging Infectious Diseases, 12*(1), 9–14.
Kilbourne, E. D. (2008). Plagues and pandemics: past, present, and future. In: Bostrom, N. & Cirkovic, M. . *Global Catastrophic Risk*. Oxford University Press, 287–307.
Killingray, D. (1994). The influenza pandemic of 1918–1919 in the British Caribbean. *Social History of Medicine*, *7*(1), 59-87.
Kim, Y. W., Yoon, S. J., & Oh, I. H. (2013). The economic burden of the 2009 pandemic H1N1 influenza in Korea. *Scandinavian Journal of Infectious Diseases*, *45*(5), 390–396.
Koch, A., Brierley, C., Maslin, M. M., and Lewis, S. L. (2019). Earth system impacts of the European arrival and Great Dying in the Americas after 1492. *Quarternary Science Reviews*, 2017: 13-36.
Lau, K., Hauck, K., & Miraldo, M. (2019). Excess influenza hospital admissions and costs due to the 2009 H1N1 pandemic in England. *Health Economics*, *28*(2), 175–188.
Ledberg, A. (2021). Mortality of the COVID-19 outbreak in Sweden in relation to previous severe disease outbreaks. *Frontiers in Public Health*, *9*, p.579948.
Lee, J.-W., & McKibbin, W. J. (2004). Globalization and disease: The case of SARS. *Asian Economic Papers*, *3*(1), 113–131.
Lemaitre, M., & Carrat, F. (2010). Comparative age distribution of influenza morbidity and mortality during seasonal influenza epidemics and the 2009 H1N1 pandemic. *BMC Infectious Diseases*, *10*(1), 1–5.
Lin, M. J., & Liu, E. M. (2014). Does in utero exposure to illness matter? The 1918 influenza

epidemic in taiwan as a natural experiment. *Journal of Health Economics*, *37*(1), 152–163.
Lin, P. Z. & Meissner, C. M., (2021). Persistent pandemics. *Economics & Human Biology*, *43*, 101044.
Lobo, S. M., Watanabe, A. S. A.,Salomão, M. L. M., et al. (2019). Excess mortality is associated with influenza A (H1N1) in patients with severe acute respiratory illness. *Journal of Clinical Virology*, *116*, 62–68.
Lopez, A. D., Mathers, C. D., Ezzati, M., Jamison, D. T., & Murray, C. J. L. (2006). *Global Burden of Disease and Risk Factors*. Oxford University Press.
Lopez, A. D., & Murray, C. J. (1996). *The Global Burden of Disease*. Harvard University Press.
Lopez, A. D., Murray, C. J. (1998). The Global Burden of Disease, 1990-2020. *Nature Medicine*, *4*(11), 1241–1243.
Lugnér, A.K., van Boven, M., de Vries, R., Postma, M.J., & Wallinga, J. (2012). Cost effectiveness of vaccination against pandemic influenza in European countries: Mathematical modelling analysis. *British Medical Journal*, *345*(7868), 1–16.
Luyt, C.E., Combes, A., Becquemin, M.H., et al. (2012). Long-term outcomes of pandemic 2009 influenza A(H1N1)-associated severe ARDS. *Chest*, *142*(3), 583–592.
Ma, J., Dushoff, J., & Earn, D. J. D. (2011). Age-specific mortality risk from pandemic influenza. *Journal of Theoretical Biology*, *288*(1), 29–34.
MacDougall, H. (2007). Toronto's health department in action: influenza in 1918 and SARS in 2003. *Journal of the History of Medicine and Allied Sciences*, *62*(1), 56-89.
MacMillan, M. (2008). *The Uses and Abuses of History*. Toronto: Penguin Canada.
Mamelund, S. E. (2018). 1918 pandemic morbidity: The first wave hits the poor, the second wave hits the rich. *Influenza and Other Respiratory Viruses*, *12*(3), 307–313.
Mamelund, S.-E., Sattenspiel, L., & Dimka, J. (2013). Influenza-associated mortality during the 1918-1919 influenza pandemic in Alaska and Labrador: A comparison. *Social Science History*, *37*(2), 177–229.
Mamelund, S.E., Shelley-Egan, C. & Rogeberg, O. (2021). The association between socioeconomic status and pandemic influenza: Systematic review and meta-analysis. *PLoS ONE*, *16*(9), p.e0244346.
Marco Marani, M., Katul, G. G., Pan, W. K., and Parolari, A. J. (2021). Intensity and frequency of extreme novel epidemics. *Proceedings of the National Academy of Sciences of the United States of America*, *118*(35): e2105482118.
Markel, H., Lipman, H. B., & Navarro, J. A. (2007). Nonpharmaceutical interventions implemented by US cities during the 1918-1919 influenza pandemic. *JAMA, 298*(6), 644–654.
Matthews Pillemer, F., Blendon, R. J., Zaslavsky, A. M., & Lee, B. Y. (2015). Predicting support for non-pharmaceutical interventions during infectious outbreaks: a four region analysis. *Disasters*, *39*(1), 125–145.
McGrew, R.E. (1960). The first cholera epidemic and social history. *Bulletin of the History of Medicine*, *34*(1), 61-73.
Meltzer, M.I., Cox, N.J. & Fukuda, K. (1999). The economic impact of pandemic influenza in the United States: priorities for intervention. *Emerging infectious diseases*, *5*(5), 659-671
Milne, I. (2018). *Stacking the coffins: Influenza, war and revolution in Ireland, 1918–19*. Manchester University Press.
Mordechai, L., Eisenberg, M., Newfield, T. P., Izdebski, A., Kay, J. E. and Poinar, H. (2019). The Justinianic Plague: an inconsequential pandemic? *Proceedings of the National Academy of Sciences of the United States of America*, *116*(51): 25546-25554.
Morens, D. M., Breman, J. G., et al. (2020). The origin of Covid-19 and why it matters.

American Journal of Tropical Medicine and Hygiene, *103*(3), 955-959.
Myrskylä, M., Mehta, N. K., & Chang, V. W. (2013). Early life exposure to the 1918 influenza pandemic and old-age mortality by cause of death. *American Journal of Public Health*, *103*(7), 83–90.
Mytton, O. T., Rutter, P. D., Mak, M., Stanton. E. A., Sachedina, N., & Donaldson, L. J. (2012). Mortality due to pandemic (H1N1) 2009 influenza in England: A comparison of the first and second waves. *Epidemiology and Infection*, *140*(9), 1533–1541.
Nelson, R. (2010). Testing the fetal origins hypothesis in a developing country: Evidence from the 1918 influenza pandemic. *Health Economics*, *19*, 1181–1192.
Newman, K. L. S. (2012). Shutt up: bubonic plague and quarantine in early modern England. *Journal of Social History*. 45(3): 809-34.
Newsome, K., Alverson, C. J., Williams, J., et al. (2019). Outcomes of infants born to women with influenza A(H1N1)pdm09. *Birth Defects Research*, *111*(2), 88–95.
Nguyen, A. M., & Noymer, A. (2013). Influenza mortality in the United States, 2009 pandemic: Burden, timing and age distribution. *PLoS ONE*, *8*(5), 1–9.
Nikolopoulos, G., Bagos, P., Lytras, T., & Bonovas, S. (2011). An ecological study of the determinants of differences in 2009 pandemic influenza mortality rates between countries in Europe. *PLoS ONE*, *6*(5), e19432.
Noymer, A., & Garenne, M. (2000). The 1918 influenza epidemic's effects on sex differentials in mortality in the United States. *Population and Development Review*, *26*(3), 565–581.
Nunes, B., Silva, S., Rodrigues, A., Roquette, R., Batista, I., & Rebelo-de-Andrade, H. (2018). The 1918–1919 influenza pandemic in Portugal: A regional analysis of death impact. *American Journal of Epidemiology*, *187*(12), 2541–2549.
Ohadike, D.C. (1981). The influenza pandemic of 1918–19 and the spread of cassava cultivation on the lower Niger: a study in historical linkages. *The Journal of African History*, *22*(3), 379-391.
Ohadike, D.C. (1991). Diffusion and physiological responses to the influenza pandemic of 1918–19 in Nigeria. *Social Science & Medicine*, *32*(12), 1393-1399.
Økland, H., and Mamelund, S. E. (2019). Race and 1918 influenza pandemic in the United States: A review of the literature. *International Journal of Environmental Research and Public Health, 16*(14), 2487.
Ogasawara, K. (2022). Pandemic influenza and gender imbalance: Mortality selection before births. *Social Science & Medicine*, *311*, 115299.
Ó Gráda, C. (2020). 'Economic History: 'An Isthmus Joining Two Great Continents'?. University College Dublin Working Paper Series, Paper No. 202001.
Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., et al., (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1), 1–11.
Parman, J. (2015). Childhood health and sibling outcomes: Nurture reinforcing nature during the 1918 influenza pandemic. *Explorations in Economic History*, *58*, 22–43.
La Parra-Perez, A., Munoz, F.F., & Fernandez-de-Pinedo, N. (2022). EconHist: a relational database for analyzing the evolution of economic history. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, *55*(1), 45–60.
Paskoff, T., & Sattenspiel, L. (2019). Sex- and age-based differences in mortality during the 1918 influenza pandemic on the island of Newfoundland. *American Journal of Human Biology*, *31*(1), 1–16.
Patterson, K.D. (1983). The Influenza Epidemic of 1918–19 in the Gold Coast1. *The Journal of African History*, *24*(4), 485-502.
Patterson, K.D. & Pyle, G.F. (1983). The diffusion of influenza in sub-Saharan Africa during the 1918–1919 pandemic. *Social Science & Medicine*, *17*(17), 1299-1307.

Patterson, K.D. (1994). Cholera diffusion in Russia, 1823–1923. *Social Science & Medicine*, *38*(9), 1171-1191.
Pearce, D. C., Pallaghy, P. K., McCaw, J. M., McVernon, J., & Mathews, J. D. (2011). Understanding mortality in the 1918–1919 influenza pandemic in England and Wales. *Influenza and Other Respiratory Viruses, 5*(2), 89–98.
Percoco, M. (2016). Health shocks and human capital accumulation: The case of Spanish flu in Italian regions. *Regional Studies*, *50*(9), 1496–1508.
Pool, D.I. (1973). The effects of the 1918 pandemic of influenza on the Maori population of New Zealand. *Bulletin of the History of Medicine*, *47*(3), 273-281.
Porta, M. (2016). *A Dictionary of Epidemiology*. 6th edn., Oxford University Press.
Porter, R.M., Goldin, S., Lafond, K.E., et al. (2020). Does having a seasonal influenza program facilitate pandemic preparedness? An analysis of vaccine deployment during the 2009 pandemic. *Vaccine*, *38*(5), 1152–1159.
Potter, C. (2001). A history of influenza. *Journal of Applied Microbiology*, *91*, 572–579.
Prager, F., Wei, D., & Rose, A. (2017). Total economic consequences of an influenza outbreak in the United States. *Risk Analysis*, *37*(1), 4–19.
Ramiro, D., Garcia, S., Casado, Y., Cilek, L., & Chowell, G. (2018). Age-specific excess mortality patterns and transmissibility during the 1889–1890 influenza pandemic in Madrid, Spain. *Annals of Epidemiology*, *28*(5), 267–272.
Ravenholt, R.T., & Foege, W.T. (1982). 1918 influenza, encephalitis lethargica, parkinsonism. *The Lancet, 320*(8303), 860–864.
Reed, C., Biggerstaff, M., Finelli, L., Koonin, L. M., Beauvais, D., Uzicanin, A., & Jernigan, D. B. (2013). Novel framework for assessing epidemiologic effects of influenza epidemics and pandemics. *Emerging Infectious Diseases, 19*(1), 85–91.
Reyes, O., Lee, E. C., Sah, P., Viboud, C., Chandra, S., and Bansal, S. (2018). Spatiotemporal patterns and diffusion of the 1918 influenza pandemic in British India. *American Journal of Epidemiology*, *187*(12), 2550–2560.
Rice, G.W. and Palmer, E. (1993). Pandemic influenza in Japan, 1918-19: mortality patterns and official responses. *Journal of Japanese Studies*, *19*(2), 389-420.
Richard, S. A., Sugaya, N., Simonsen, L., Miller, M. A., & Viboud, C. (2009). A comparative study of the 1918-1920 influenza pandemic in Japan, USA and UK: mortality impact and implications for pandemic planning. *Epidemiology and Infection*, *137*(8), 1062–1072.
Rijpma, A., Van Dijk, I. K., Schalk, R., Zijdeman, R. L., & Mourits, R. J. (2022). Unequal excess mortality during the Spanish Flu pandemic in the Netherlands. *Economics & Human Biology*, *47*, 101179.
Risse, G.B. (1992). "A long pull, a strong pull, and all together": San Francisco and bubonic plague, 1907-1908. *Bulletin of the History of Medicine*, *66*(2), 260–286.
Rück, C., Mataix-Cols, D., Malki, K., Adler, M., Flygare, O., Runeson, B. & Sidorchuk, A. (2021). Swedish nationwide time series analysis of influenza and suicide deaths from 1910 to 1978. *BMJ Open*, *11*(7)
Sands, P., Turabi, A. E., Saynisch, P. A, & Dzau, V. J. (2016). Assessment of economic vulnerability to infectious disease crises. *The Lancet*, *388*(10058), 2443–2448.
Sarris, P. (2022). New Approaches to the 'Plague of Justinian'. *Past & Present*, 254(1): 315–346.
Schoch-Spana, M. (2000). Implications of pandemic influenza for bioterrorism response. *Clinical Infectious Diseases*, *31*(6), 1409-1413.
Schroeder, M., Lazarakis, S., Mancy, R. and Angelopoulos, K. (2023). An extended period of elevated influenza mortality risk follows the main waves of influenza pandemics. *Social Science & Medicine*, *328*, 115975.

Selten, J.P., Slaets, J. and Kahn, R. (1998). Prenatal exposure to influenza and schizophrenia in Surinamese and Dutch Antillean immigrants to the Netherlands. *Schizophrenia research*, *30*(1), 101-103.

Selten, J.P., Brown, A.S., Moons, K.G., Slaets, J.P., Susser, E.S. and Kahn, R.S. (1999). Prenatal exposure to the 1957 influenza pandemic and non-affective psychosis in the Netherlands. *Schizophrenia Tesearch*, *38*(2-3), 85-91.

Shaw-Taylor, L. (2020) An introduction to the history of infectious diseases, epidemics and the early phases of the long-run decline in mortality. *Economic History Review*, *73*(3), E1–E19.

Shiller, R. (1991). Discussion. *American Economic Review*, *81*(May), 97–98.

Simonsen, L. *et al.* (1998). Pandemic versus epidemic influenza mortality: a pattern of changing age distribution. *Journal of Infectious Diseases*, *178*(1), 53-60.

Simonsen, L. *et al.* (2011). The need for interdisciplinary studies of historic pandemics. *Vaccine*, *29*, B1–B5.

Smil, V. (2012). *Global Catastrophes and Trends: The Next Fifty Years.* MIT Press. Cambridge, MA.

Smith, F.B. (1995). The Russian Influenza in the United Kingdom, 1889–1894. *Social History of Medicine*, *8*(1), 55-73.

Smith, R. D., Keogh-Brown, M. R., Barnett, T., & Tait, J. (2009). The economy-wide impact of pandemic influenza on the UK: A computable general equilibrium modelling experiment. *British Medical Journal*, *339*, 339.

Smith, R. D., & Keogh-Brown, M. R. (2013). Macroeconomic impact of pandemic influenza and associated policies in Thailand, South Africa and Uganda, *Influenza and Other Respiratory Viruses*, *7*(SUPPL.2), 64–71.

Spreeuwenberg, P., Kroneman, M., & Paget, J. (2018). Reassessing the global mortality burden of the 1918 influenza pandemic. *American Journal of Epidemiology*, *187*(12), 2561–2567.

Stathakopoulos, D., (2000). The Justinianic plague revisited. *Byzantine and Modern Greek Studies*, *24*(1), 255–276.

Stenseth, N. C., (2008). Plague through history. *Science, 321*(5890), 773–774.

Taubenberger, J. K. (2006). The origin and virulence of the 1918 "Spanish" influenza virus. *Proceedings of the American Philosophical Society*, *150*(1), 86–112.

Taubenberger J, & Morens, D. (2006). 1918 Influenza: the mother of all pandemics. *Emerging Infectious Diseases, 12*, 15–22

Tennant, J.P. (2020). Web of Science and Scopus are not global databases of knowledge. *European Science Editing*, *46*, e51987.

Tognotti, E. (2013). Lessons from the history of quarantine, from Plague to Influenza A. *Emerging Infectious Disease* 19(2): 254-259.

Tomkins, S.M. (1992). The influenza epidemic of 1918–19 in Western Samoa. *The Journal of Pacific History*, *27*(2), 181-197.

Tuckel, P., Sassler, S., Maisel, R., & Leykam, A. (2006). The diffusion of the Influenza pandemic of 1918 in Hartford, Connecticut. *Social Science History*, *30*(2), 167–196

Valtat, S., Cori, A., Carrat, F., & Valleron, A. J. (2011). Age distribution of cases and deaths during the 1889 influenza pandemic. *Vaccine*, *29*(SUPPL. 2), B6–B10.

Velde, F.R., (2022). What happened to the US economy during the 1918 influenza pandemic? A view through high-frequency data. *The Journal of Economic History*, *82*(1), 284–326.

Viboud, C., Simonsen, L., Fuentes, R., Flores, J., Miller, M. A., & Chowell, G. (2016). Global mortality impact of the 1957-1959 influenza pandemic. *The Journal of Infectious Diseases*, *213*(5), 738–745.

van Wijhe, M., Ingholt, M. M., Andreasen, V., & Simonsen, L. (2018). Loose ends in the epidemiology of the 1918 pandemic: Explaining the extreme mortality risk in young adults. *American Journal of Epidemiology*, *187*(12), 2503–2510.

Wang et al., (2022). Estimating excess mortality due to the COVID-19 pandemic: A systematic analysis of COVID-19-related mortality, 2020–21. *The Lancet, 399*(10334), 1513–1536.

Wilson, N., Oliver, J., Rice, G., Summers, J. A. et al. (2014). Age-specific mortality during the 1918–19 influenza pandemic and possible relationship to the 1889–92 influenza pandemic. *Journal of Infectious Diseases*, *210*(6), 993–995.

Wilson, N., Mansoor, O. D., & Baker, M. G. (2018). The first analytic evidence for socio-economic gradients in 1918 pandemic influenza mortality rates for New Zealand. *New Zealand Medical Journal*, *131*(1486), 50–53.

Wong, T.W. & Fung, K.P. (1988). The plague pandemics and the discovery of the plague bacillus. *Asia Pacific Journal of Public Health*, *2*(2), 144–149.

Wurth R, Hajdenberg M, Barrera FJ, et al. (2022). Scoping review of COVID-19-related systematic reviews and meta-analyses: Can we really have confidence in their results? *Postgraduate Medical Journal,* 98: 372-379.

Yang, W., Petkova, E., Shaman, J. (2014). The 1918 influenza pandemic in New York City: Age-specific timing, mortality, and transmission dynamics. *Influenza and Other Respiratory Viruses*, *8*(2), 177–188.

Yu, H., Feng, L., Viboud, C. G., et al. (2013). Regional variation in mortality impact of the 2009 A(H1N1) influenza pandemic in China. *Influenza and Other Respiratory Viruses*, *7*(6), 1350–1360.