Past Pandemics and Social Inequality

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Summary

Pandemics are recurring events throughout human history, and there have been many different pandemics of variable etiologies through time. That is, pandemic diseases are not limited to viral respiratory infections but can rather be bacterial in nature and/or transmitted via nonrespiratory pathways. Some past pandemics were so severe that they were erroneously considered indiscriminate in nature and that anyone who became infected with the pathogen and manifested the disease would be equally likely to suffer severe health outcomes (namely, death). However, research has shown that social inequality is a key feature of unequal pandemic experiences, including socioeconomic status, sex and gender, urban versus rural residence, and on the basis of socially marginalized racial categories.

Contemporary research on past pandemics has increasingly focused energy and resources on disentangling these past social inequalities to better understand how acute pandemic events disproportionately impacted some populations over others. This body of research is rapidly growing and depends on many fields with integrated, transdisciplinary perspectives of human population health, demography, infectious disease ecology, public health, and epidemiology. Biological anthropologists frame pandemic studies through evolutionary lenses, including epidemiologic transition theory, biocultural anthropology, evolutionary medicine, and syndemics. Social inequalities in historical pandemic research can be uncovered using diverse datasets that can be used independently or in concert with one another to reveal multiple dimensions of past experiences. Such data may exist in the form of human skeletal material, the written historical record, art, statistical vital records, and immunological data. Anthropology contributes critical insights into past pandemics and social inequalities due to anthropologists' holistic perspective of the human experience in all times and in all places; infectious diseases—and pandemics—have been central to the human experience for thousands of years. Pandemics are anthropogenic, and their origins can be traced to our evolutionary histories, cultures, interactions with the natural and built environments, and human social organization. The anthropological investigation of past pandemics and social inequalities will contribute important insights into past pandemics and how their consequences have shaped contemporary population health. Although proximate causes of pandemics (e.g., causal pathogens) have changed through time, ultimate determinants of unequal pandemic experiences have been remarkably stable. Therefore, the deep understanding of these determinants in past pandemic experiences is highly applicable to our knowledge of how a new acute infectious threat with pandemic potential may unequally affect today's world.

Keywords: plague, cholera, 1918 flu, epidemiological transitions, biocultural, evolutionary medicine, bioarchaeology

Subjects: Biological Anthropology

Introduction

Infectious diseases are central to the history, livelihoods, culture, and demography of humans. Anthropologists' unique interdisciplinary interests and strengths, such as those related to the integration of biology and culture to study human health, human-pathogen coevolution, demography, evolutionary medicine, underlying social inequalities, and population genetics make them well suited to study the human relationship with infectious diseases through time and space (Dimka, van Doren, and Battles 2022). Though the definition of a "pandemic" is not standard across fields, Dimka, van Doren, and Battles (2022) offer a definition that addresses geography, time constraints, and the nature of the pandemic pathogen, and its epidemiology: "an epidemic that affects large regions, multiple countries, or even the whole world approximately simultaneously . . . typically caused by novel pathogens or strains against which there is limited or no immunity" during which "substantial morbidity and mortality can occur" (257). Anthropologists' holistic expertise and interests can be specifically applied to the study of pandemics through time, especially in uncovering determinants, health outcomes, and social consequences of pandemics.

Pandemics have sometimes been erroneously considered indiscriminate killers, but research on pandemics through time has shown that this notion is overwhelmingly false. While severe pandemics may result in high mortality that crosscuts all levels of society, historical and bioarchaeological data continue to reveal the many dimensions of past pandemic inequality. The fields of public health, historical demography, and epidemiology, as well as biological or biocultural anthropology and bioarchaeology have contributed substantially to our knowledge of unequal past pandemic outcomes. Often, past pandemic inequalities, for which the bulk of research exists in relation to the 1918 influenza pandemic, are discussed in terms of socioeconomic inequalities (see systematic reviews by D'Adamo et al. 2023; Mamelund, Shelley-Egan, and Rogeberg 2021). These studies have uncovered the general observation that those of lower socioeconomic status suffered more severe epidemiologic outcomes during the 1918 influenza pandemic than those of higher socioeconomic status. However, this generalization is not the only way to understand inequality in pandemic impacts through time.

Evolutionary frameworks commonly used in anthropological inquiry for understanding the underlying embodied inequality of human populations can help contextualize and explain quantitative epidemiological observations. These frameworks distinguish between proximate and ultimate explanations of phenomena: proximate explanations answer "how?" questions, while ultimate explanations answer "why?" questions. These two broad categorizations of research motivations that emerged from Tinbergen's "four questions"—What is it for? How does it work? Why did it develop? What is its evolutionary history?—are a way to address both the meaningful descriptions of a trait or behavior, as well as how and why it exists in the 21st century (Bateson and Laland 2013; Tinbergen 1963). In terms of the relationship between infectious diseases and humans, answers to proximate ("how?") questions can explain infectious processes, pathology, immune response, and epidemiology. Answers to ultimate ("why?") questions can explain human-pathogen coevolution, social inequalities, and susceptibility to infections based on underlying health status, to name a few. Biological anthropology can thus provide important insights into the ultimate determinants of unequal pandemic experiences that supplement, rather than detract from, proximate epidemiological descriptions.

Through the synthesis of existing collective knowledge, scholars have pushed for new paradigms in pandemic preparedness that include intentional reduction of existing, nonpandemic social inequalities (Mamelund and Dimka 2021a, 2021b). The assertion is that unequal pandemic outcomes are the products of baseline inequalities in health and mortality. Thus, reducing those baseline inequalities will result in less dramatic heterogeneous pandemic outcomes, making this avenue a strong contender for a primary area of pandemic preparedness focus. There is no doubt that deep and increased understandings of past pandemic inequality have powerful lessons for informing present and future pandemic preparedness and ultimate impacts (e.g., DeWitte and Wissler 2022; Short, Kedzierska, and van de Sandt 2018; van Doren et al. 2024). However, the anthropological study of past pandemics and social inequalities is a highly valuable field of research in itself, with important applications for theory and practice in biological anthropology, improvements in our understanding of population health and dynamics through time, and the nature of humans' relationships with infectious diseases.

There are a few general reasons why biological anthropological research on past pandemic inequality is a robust line of research for current and future anthropologists to pursue. First, it is inherently valuable to study historical events and compare those events across various sociocultural, international, and transnational spaces. Anthropologists can apply their training in cross-cultural comparison to pandemic experiences within, between, and among populations. Further, data availability is often sufficient to make conclusions about those experiences, though there are, of course, some important limitations depending on the data sources and their ages. For example, data sources and availability differ dramatically between inquiry related to the 1918 influenza pandemic and the Black Death, the latter of which occurred nearly six centuries earlier. Research on the 1918 influenza pandemic often draws upon the written historical record for qualitative data, as well as historical vital records for quantitative data. The latter are difficult, if not impossible, to draw upon for the Black Death, which occurred in the 14th century, since the practice of maintaining a systematic register of deaths did not begin until the 17th century in England with John Graunt's Bills of Mortality (Graunt 1662) and did not become ubiquitous until much later (Brothman 2006). Finally, the most well-known historical pandemics, namely the Black Death and the 1918 influenza pandemic, resulted in substantial mortality in a short period of time, resulting in shocks that likely affected demography, epidemiology, and even biology of humans for decades—if not centuries—afterward (e.g., DeWitte and Lewis 2020; Gaddy and Ingholt 2023 ; Moalem et al. 2002). As a field, biological anthropology is well-equipped to answer more specific questions within these three general lines of inquiry.

Theoretical Approaches to Studying Historical Pandemic Inequalities

Anthropologists can study pandemic inequalities in ways that successfully integrate biology and culture over a long period of time, often by capturing evolutionary effects on demographic composition and intergenerational health transmission. The application of evolutionary theory to pandemics is one of the primary points of entry for biological anthropologists into the broad realm of pandemic studies, which spans many fields such as biomedicine, biology, and the humanities. Anthropologists' strengths in uniting knowledge of human biology with behavior and culture, as well as the highly heterogeneous nature therein, makes them particularly well suited for interdisciplinary research about health inequalities. This section introduces major theoretical approaches used in anthropology to discuss pandemic inequalities specifically.

Epidemiologic Transitions

The *epidemiologic transitions* describe points in time during which there were fundamental, long-term, irreversible changes in human behavior and culture that affected the trajectories of cause-specific mortality (Harper and Armelagos 2010). From the Paleolithic baseline, during which human populations were primarily highly mobile, low density, dependent on subsistence hunting and gathering, and susceptible to primarily environmental pathogens (Armelagos, Ryan, and Leatherman 1990; Buikstra, Konigsberg, and Bullington 1986; Harper and Armelagos 2010), there have been three major epidemiologic transitions. The first began in the Neolithic period (~12–10 thousand years ago [kya]) in various locations around the globe alongside the intensification of the agricultural mode of subsistence. This transition led to increases in population size and density, increasing fertility (the number of live births a woman may have in her lifetime) and mortality (the number of deaths per population size), sedentary lifestyles, and the emergence of common crowd diseases such as smallpox, cowpox, and measles (Armelagos, Brown, and Turner 2005; Barrett and Armelagos 2013; Barrett et al. 1998).

The second epidemiologic transition is characterized by the major population health consequences of the industrial revolution during the 19th century in Western Europe and parts of North America. The second epidemiologic transition explains the decrease in infectious disease mortality and a proportionate increase in mortality due to chronic diseases, which include degenerative conditions that emerge in older age groups such as cardiovascular disease, respiratory disease, and cancer (Omran 1971, 1977). Importantly, this cause-specific shift in mortality was a major factor in the overall decline in all-cause mortality, which, together with simultaneous declines in fertility, led to population growth and increased life expectancy (this broader population transition that takes into account fertility, mortality, and population size, is referred to as the *demographic transition*; Davis 1945; Kirk 1996; Thomspon 1929). The third epidemiologic transition is characterized by new and reemerging infectious diseases, with the emphasis that newly recognized and truly novel pathogens and infectious diseases are significant contributors to morbidity and mortality patterns (Barrett et al. 1998; Harper and Armelagos 2010). Additionally, and importantly, infectious diseases that were receding in prior decades are reemerging, this time with adaptations that make them more difficult to address with modern medical intervention, such as the evolution of antibiotic resistance.

Despite this rapid overview of massive demographic and cultural change over several millennia, there are a couple of important considerations for historical pandemic researchers that make epidemiologic transition theory a particularly good lens through which to study inequality. First and foremost, pandemics, by definition, afflict more than one continent at the same time. It is critical to remember that pathogens do not recognize human political or sociocultural boundaries;

inequalities in public health infrastructure, as well as natural, biomedical, and socioeconomic resources, may be exacerbated when stressed by acute infectious disease outbreaks. By and large, the second epidemiologic transition during the industrial revolution in many parts of the world simultaneously brought infrastructural adjustments in public health, nutrition, and water sanitation that help protect against infectious diseases in general (McKeown 1976; Szreter 1988, 2002). These are important advancements because they contributed to improved population health long before the discovery and widespread use of biomedical interventions like antibiotics. However, this explanation should also be interpreted with some caution, as it does imply a linear progression toward the "modernity" of Western society, which at its core is a colonial ideology; populations are adapted to their specific ecologies, and the classic second epidemiologic transition described by Omran (1971) is not the only way to model health transitions (Caldwell 2001; Defo 2014; Santosa et al. 2014; van Doren 2022). The diversity and dynamics of human settlement types through time and across space makes it clear that there is no single way in which these settlements, or the processes of urbanization, impact population health (Dorsey 2024).

Despite this, the framework of the epidemiologic transitions allows anthropologists to weigh factors such as demographic composition and dynamics, competing causes of death, and cultural change through an evolutionary lens. Anthropologists' holistic perspectives of human nature and culture is a major strength in the applications of epidemiologic transition theory because cultural and demographic change are always dynamic; these changes may be shaped, in part, by prevalent pathogens of the time, but they are always happening in the background when acute infectious disease pandemics strike (van Doren 2022). For example, the epidemiologic transition framework makes it clear that prior to the first transition, which accompanied agricultural intensification relatively simultaneously in a dozen places around the world, pandemics were virtually impossible for a couple important reasons. First, prior to agricultural intensification, human groups were small and highly mobile (as described by the Paleolithic baseline period of the transition framework). This meant that populations were at highest risk of infection from environmental pathogens that were specific to their own contexts, and those risks changed with mobility patterns. Second, most (though not all) epidemic and pandemic diseases emerged from zoonotic pathogens to which humans became exposed after the initial domestication of herd animals. Thus, what we refer to as our infectious crowd diseases such as smallpox (now eradicated in nature), measles, or influenza likely did not afflict Paleolithic populations. This is important baseline context for understanding the transition in health from Paleolithic, mobile humans to sedentary agricultural populations starting in the Neolithic period (~12–10 kya). The knowledge of how human evolution, health, kinship, and demography interact is primarily an anthropological topic.

Additionally, during the second epidemiologic transition period in the 19th and 20th centuries in most Western nations, during the 1918 influenza pandemic, there was significant inequality worldwide. Anthropologists may be interested in learning how the underlying health transitions influenced inequality both between and within populations, especially when infrastructural and public health advancements during the second epidemiologic transition preceding 1918 may have led to different pandemic outcomes than in populations that underwent a similar transition post-1918 or not at all (van Doren 2022). A similar line of thinking can be applied to the contemporary context, in which populations that have not undergone infrastructural and sustainable public health advancements are at elevated risk of a double burden of existing, new, and reemerging pathogens (e.g., Agyei-Mensah and de-Graft Aikins 2010; Amuna and Zotor 2008; Ciccacci, Majid, and Marazzi 2020). These are the conditions against which 21st-century pandemics have occurred and future pandemics will occur; the same contextualization is important for an historical understanding of inequality and variable outcomes of past pandemics. Altogether, epidemiologic transition theory provides substantial and critical context against which historical pandemics have occurred, providing important insights into heterogeneous epidemiological and demographic outcomes.

Biocultural Anthropology

Biocultural theory in anthropology and human biology is also an approach based in evolutionary theory to investigate and interpret the coevolutionary nature of human culture and biology through time and their resultant effects on health. This theoretical framework highlights that human culture and biology are fundamentally integrated, and, depending on context, culture can become embodied and come to characterize "local biologies," or features of the physical body that are products of macrosocial socioeconomic forces (Leatherman and Goodman 2020; Lock 1993, 2017; Wiley and Cullin 2016). Over time, human biologists and biological anthropologists have conceptualized not just the physical elements of the environment, such as infrastructure and living spaces, but also plants, animals, and insects (Weiner 1964), as well as political economic (Goodman and Leatherman 1998) and political ecological contexts (Dorsey 2024). Anthropologists interested in the relationship between infectious diseases and humans argue that pathogens should also be a part of this story; even though pathogens are not strictly "macrosocial socioeconomic forces," they are indeed critical members of the many environments in which humans live, and thus place evolutionary pressures on human biology and culture.

The biocultural framework has been useful in describing many facets of the human condition. These include but are far from limited to the embodiment of food and water insecurity (Brewis et al. 2020; Dent, Berger, and Griffin 2021; Ruiz et al. 2015), biological impacts of socioeconomic stratification and structural violence (Beatrice et al. 2021; Redfern and DeWitte 2011; Schell 1997), adaptations to past environments through paleopathology and paleoepidemiology (Kelmelis and Pedersen 2019; Lallo, Armelagos, and Rose 1978), and health manifestations of sex- and gender-based stressors (DuBois et al. 2021; Flaherty et al. 2023; Šlaus 2000). Further, anthropologists have long applied the biocultural framework to the study of humans' relationships with pathogens, recognizing that pathogens are substantial stressors on health from the molecular to individual to population levels. One of the earliest applications of biocultural thinking to an infectious disease context was Livingstone's (1958) description of how the protective heterozygous genotype for sickle cell anemia evolved in regions afflicted with endemic malaria. This conclusion was made by taking into account cultural adaptations to the environment in West Africa (e.g., settlement types, materials used for dwellings), behaviors related to subsistence, and the types of animal hosts and natural materials the mosquito vector favors; that is, the vector species that carries the malaria pathogen tends to favored the materials people in West Africa used to build their homes.

Livingstone's (1958) research provided valuable context for Allison's (1954) preceding research that uncovered that the genetic mutation that causes sickle cell anemia is not strongly selected against in certain contexts because the heterozygous genotype provides protection against malaria infection. Livingstone's study was, in effect, possibly the first to apply an infectious disease as an environmental and pathogenic stressor on the evolution of humans (Dufour 2006). Together, these two advancements in biological and anthropological knowledge effectively show how human behavior and culture can result in evolution of human biology.

In terms of past pandemics, biocultural theory can provide insights into baseline health inequities that can become evident and/or amplified in the event of an acute infectious disease threat. For example, the prevalence of tuberculosis can often be identified as an outcome of poor nutritional status, dense living quarters, coinfection with cocirculating pathogens, smoking, and labor that carries risks associated with the compromise of the respiratory system and intense physical activity (e.g., mining, industrial work; Bates, Marais, and Zumla 2015; van Doren 2022). These are societal and behavioral determinants of adverse health characteristics that are deeply intertwined with the persistence of tuberculosis in afflicted populations. Not only can a persistent burden of tuberculosis and the products of its disease process be conceptualized as a health consequence related to low socioeconomic status, but it was also a major risk factor for mortality during the 1918 influenza pandemic via direct (i.e., pathogen interaction) and indirect (i.e., persistent poor health increasing vulnerability in specific subpopulations) selective mortality pathways (Bradshaw, Smith, and Blanchard 2008; Noymer 2009, 2011; van Doren and Sattenspiel 2021). That is, individuals with active or even latent tuberculosis infection were at higher risk of advancement of tuberculosis if they were to become infected with the novel influenza pathogen during the 1918 influenza pandemic, accelerating their decline and increasing risk of mortality (Noymer 2009). This selection disproportionately impacted people of lower socioeconomic status, as many of the determinants of tuberculosis are those related to poor living conditions and poor overall health status (e.g., Cantwell et al. 1998). This is just one example of how infectious diseases and social inequalities intersect to produce increased risk of severe outcomes during a pandemic event.

Other Relevant Theoretical Frameworks: Evolutionary Medicine and (Paleo)syndemics

Beyond epidemiologic transition theory and biocultural anthropology, biological anthropologists draw upon other frameworks that can be used to understand pandemics and their inequalities. One such framework is *evolutionary medicine*, which, like the previously discussed theories, applies evolutionary thought to human health and disease (Nesse and Williams 1994; Trevathan 2007; Williams and Nesse 1991). Among others, applications of evolutionary medicine include how famine and nutritional stress impact long-term individual and population health (Roseboom, de Rooij, and Painter 2006), human childbirth constraints (Dunsworth and Eccleston 2015), the embodiment and negative health manifestations of socially constructed race categories (Kuzawa and Sweet 2009), allergies (Armelagos and Barnes 1999), and cancer biology (Aktipis and Nesse 2012). In a more specific and broad-scope application to diseases specifically, Reijo Norio (Norio 2002) published a three-part series about the Finnish Disease Heritage, which is a group of relatively rare hereditary diseases that are overrepresented in Finland. The series covers a description of the profile of over-represented diseases in the population and some potential causes (Norio 2002); the population prehistory and genetic origins of the Finnish population are discussed as critical context for the contemporary rare disease profile (Norio 2003a); and discussions of the specific individual diseases (Norio 2003b). Population health research can be dramatically improved when health history and evolutionary determinants are also part of the discussion.

In specific applications to infectious diseases, evolutionary medicine has been described within the context of human–pathogen coevolution via the Red Queen Hypothesis. This hypothesis borrows imagery from *Through the Looking Glass* by Lewis Carroll to evoke a sense of two opposed actors pushing and pulling on one another to achieve evolutionary favorable conditions (Siddle and Quintana-Murci 2014; Van Valen 1973). The manifestation of inequality in susceptibility to severe outcomes in infectious diseases can—and often do—have evolutionary origins, which are ultimate explanations that add context to proximate epidemiological observations. Biological anthropologists typically receive considerable training in evolutionary theory and are therefore generally more interested in ultimate contextual explanations of infectious disease inequalities, although proximate epidemiological questions are of high interest as well. Evolutionary medicine is a framework that can work in conjunction with epidemiologic transition theory and biocultural theory to investigate the precise mechanisms of human–pathogen coevolution and its applications to population health. Since evolutionary medicine also uses language around biology and evolution that is recognized across disciplines, anthropological pandemic studies that integrate this approach can both appeal to and incorporate knowledge from disparate disciplines such as public health, epidemiology, and molecular biology.

Biological anthropologists are also interested in describing infectious disease inequalities within the context of the *syndemic* framework, which originated in the subfield of critical medical anthropology with Merrill Singer (Singer 1994, 1996; Singer and Clair 2003; Singer et al. 2017). The context of syndemics is most clearly defined as "*syn*ergistic epi*demics*," whether pathogenic, social, or behavioral, that afflict individuals or populations simultaneously and accelerate the deterioration of health (Singer and Clair 2003). The key element of syndemic conditions is the *clustering* of adverse health conditions, such as dangerous co-circulating pathogens, poverty, and risky behaviors. For instance, Singer (1996) defined the SAVA syndemic as the co-occurring nature of substance abuse, violence, and AIDS; in this case, HIV, the virus that can lead to the disease AIDS, is the infectious disease of interest, but the syndemic is not complete without the clustering of substance abuse and violence, as well.

Syndemics have been primarily described in contemporary contexts, but there is a growing subset of anthropological inquiry that applies syndemic theory to historical contexts, as well, and even to those for which written records are not available. Tripp, Sawchuk, and Saliba (2018) and Tripp and Sawchuk (2023) showed how the 1918 influenza pandemic was syndemic with other diseases of the time, namely, tuberculosis and measles, while Battles and Roberts (2024) suggest a historical syndemic between measles and scarlet fever in late 19th century Australia. Other anthropological work has also pointed out the syndemic nature of the 1918 influenza pandemic and tuberculosis in other contexts (van Doren and Kelmelis 2022; van Doren and Sattenspiel 2021). Sawchuk, Tripp, and Samakaroon (2022) have additionally commented on the syndemic of cholera, poverty, crowding, and smallpox in Gibraltar. Larsen and Crespo (2022) have suggested the concept of *paleosyndemics*, going further into the past and additionally considering human skeletal material, immunological data, and cultural context through a paleoepidemiological lens. There are significant opportunities for further inquiry into inequalities in pandemic outcomes within the syndemic framework, especially due to its intentional focus on the clustering of adverse health conditions that can be signals of inequalities.

Inequalities in Past Pandemics

Although much pandemic research has focused exclusively on acute respiratory infections, pandemics of differing etiologies have occurred through time and have produced unequal outcomes during their scourges. This section reviews some of the known unequal outcomes of three pandemics of differing pathogens and modes of transmission: the Black Death, which was a plague pandemic caused by the bacterium *Yersinia pestis* (Bos et al. 2011; Wagner et al. 2014) and transmitted via vector (flea); the 19th and 20th century cholera pandemics, also caused by a bacterium, *Vibrio cholerae*, and transmitted via water (e.g., Cottingham, Chiavelli, and Taylor 2003); and the 1918 influenza pandemic, an H1N1 influenza A virus transmitted via air (e.g., Oxford 2000). Research by anthropologists is prioritized in this discussion, but research from other fields such as history, historical epidemiology, and demography are present as well. Inequalities in pandemic experience are commonly discussed in terms of socioeconomic inequality, but by discussing inequalities through an anthropological lens, this section highlights how important factors such as age and sex are imbued with critical social roles that are also integral to pandemic outcomes.

The Black Death

In terms of the percentage of the population affected that suffered and died from plague, the Black Death is likely the deadliest pandemic in recorded human history. The Black Death, which primarily occurred through the years 1347 to 1351, is estimated to have resulted in the deaths of around one-third of Europe’s population (Herlihy 1997). Rigorous historical research has argued for not one pan-European Black Death but rather four parallel and contemporaneous, rather than sequential, Black Death outbreaks spanning throughout central Eurasia, the Mediterranean, and China (Green 2020). The tremendous mortality that accompanied the Black Death led to the erroneous notion that it killed indiscriminately, with no regard for how embodied social inequalities, or underlying frailty, may have led to heterogeneity in its impacts on the basis of socioeconomic status, age, or sex (DeWitte and Wood 2008). Anthropological research on the Black Death has been primarily bioarchaeological and paleoepidemiological in nature, with specific foci on embodied health inequalities and the study of body size (e.g., stature) and frailty through osseous lesions. Critically, anthropological research on the Black Death and its unequal outcomes blends knowledge of individual health and population health with the conditions in which people lived while they were alive, rather than a primary focus on the skeletal material itself; this integrated conceptualization is central to the field of paleoepidemiology (Boldsen and Milner 2012; Milner and Boldsen 2017).

The bioarchaeological study of skeletal material in general, and around the Black Death specifically, requires engagement with the osteological paradox, which describes the counterintuitive implications of skeletal samples that exhibit lesions versus those that do not. The osteological paradox suggests that skeletal populations with a high frequency of lesions can be incorrectly interpreted as universally unhealthy; however, lesions take a long time to form in skeletal tissue and therefore may not imply general poor health while alive but rather that individuals were healthy enough to live with conditions for the period of time required to manifest skeletal lesions (Wood, Milner, and Harpending 1992). Paleoepidemiologists and bioarchaeologists additionally recognize that biological markers of frailty are only part of the story. Other sources of stress are social, and may include occupational risks, risk-taking behaviors, racism, classism, or sexism (DeWitte and Stojanowski 2015; Yaussy 2024).

Anthropological research on the Black Death has revealed interesting inequalities in catastrophic burials compared to nonpandemic burials. Individuals with skeletal indicators of frailty (e.g., periosteal lesions of the tibia, porotic hyperostosis and cribra orbitalia, and mandibular/maxillary canine linear enamel hypoplasias, which are indicated by new bone formation in response to trauma, porous and weak bone common in the cranium, and horizontal bands in the teeth from missed enamel development in childhood, respectively; Ortner 2011) were at higher risk during the Black Death in London than prior to the Black Death in a comparative sample from Denmark (DeWitte and Wood 2008). Examples of skeletal lesions that bioarchaeologists and biological anthropologists study when assessing frailty can be found in figures 1 and 2.

Figure 1. Linear enamel hypoplasias are examples of skeletal markers that bioarchaeologists and biological anthropologists assess when studying frailty of deceased individuals. Linear enamel hypoplasias are characterized by visible horizontal lines on the teeth, indicative of substantial nutritional stress in young age.

Source: Courtesy of Otis Historical Archives National Museum of Health and Medicine, photo by Brian Spatola. Licensed under Creative Commons Attribution 2.0 Generic license (CC BY).

Figure 2. Cribra orbitalia in a young child from the medieval site of Helgeandsholmen, Stockholm, Sweden. Cribra orbitalia can be identified from the conglomeration of porous lesions in the orbital.

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Interestingly, the Black Death also increased the risk of death for otherwise healthier people. This led to the conclusion that there was indeed selection based on frailty during the Black Death, but the pandemic was so intense that selection against more frail people was perhaps less during the Black Death than during non-pandemic times (DeWitte and Wood 2008). Relatedly, childhood stressors have been identified as determinants of higher risk of Black Death mortality in adults, particularly those related to nutritional stress (DeWitte and Wood 2008; Franklin, Mitchell, and Robb 2023; Godde, Pasillas, and Sanchez 2020). Shorter stature can be a marker of nutritional stress in early life, and therefore it can be cautiously analyzed as a proxy of socioeconomic status. For example, individuals with below-average adult stature in London and Kyrgyzstan were at higher risk of mortality during the Black Death (DeWitte and Hughes-Morey 2012; DeWitte and Slavin 2013;

Hansen, DeWitte, and Slavin 2024). In a study that relates changes in post-Black Death survivorship to stature, DeWitte (2018) also identified a sex-based difference in stature changes after the Black Death in London: linear enamel hypoplasias and stature increased in men after the pandemic, but women's stature decreased. Differences revealed in post-Black Death changes in stature may indicate sex-based differences in response to acute stressors; DeWitte (2018) suggests that in pre-Black Death years there was greater male sensitivity to environmental stressors, which improved in post-Black Death years, while women did not experience a similar improvement.

Generalizations about sex-based differences during the Black Death are difficult. Castex and Kacki (2016) and DeWitte (2018) identified no variation by sex in a cross-European sample and London, respectively. However, rare 14th-century epigraphic data from Kyrgyzstan shows that young women were overrepresented in the epigraphic data in 1338–1339 compared to the non-Black Death population in 1248–1345 during which there were more men present (Slavin 2023). Curtis and Roosen (2017) showed that in the Southern Netherlands, more women died during the Black Death in 1349–1351, and in recurring plague outbreaks in the following century, compared to nonplague years. DeWitte (2018) showed that there were no survivorship differences between males and females in London before, during, or after the Black Death, but survivorship for both sexes decreased prior to the pandemic and then significantly increased in the decades following.

Finally, there is very little information on age-based inequalities in frailty and risk during the Black Death. Although skeletal samples are generally lacking in accurate representation of some age groups, Kacki and Castex (2014) identified an overrepresentation of five to nineteen year-olds in Spain during the Black Death, and Kelmelis and DeWitte (2021) identified significant increases in survivorship in post-Black Death Denmark for nonadults, possibly indicating that urban environments may have been particularly bad for adults before the Black Death struck. In general, determining precise skeletal age—apart from distinctions between juvenile and adult individuals—is difficult, so differences related to age in skeletal populations are less common.

Some practical limitations of data availability have strong bearing on how inequalities are understood regarding the Black Death. There are, of course, biases in who is represented in skeletal samples, and those biases may be different between catastrophic and attritional burials (Margerison and Knüsel 2002). Catastrophic Black Death burials were often populated in an incredibly short period of time due to the overwhelming rate of mortality, which sometimes resulted in comingled skeletal material that are difficult to individuate during excavation. However, there are also instances in which Black Death victims have been confirmed in very systematized burial grounds in individual coffins, making it clear that there was no single standard practice for pandemic burial and adding ambiguity to issues related to representation bias (Dick et al. 2015). Without additional information, it is difficult to know whether sex ratios represented in catastrophic burials were truly representative of the sex ratio of the living population, the sex ratio of the pandemic's unequal impacts, or of inequalities in burial practices for different sets of the population. Additionally, children are less represented in bioarchaeological samples, and the sex of juvenile skeletons is difficult to determine (Goodman 1993; Lewis 2017; Manifold 2015). Sex and age, therefore, are two elements of intersecting inequality for which there is no generalized understanding during the Black Death. They, in and of themselves and as demographic concepts, are not necessarily strictly inequalities but are, rather, the vehicles for cultural features, such as the roles, responsibilities, and social positions of people of specific sexes and ages. As such, biological anthropologists are well positioned to provide substantial contextual interpretations based on cultural knowledge of the populations of study.

The Cholera Pandemics

Cholera is distinguishable from the other two pandemics discussed in this article in many ways, but especially in one specific and important way: whereas knowledge surrounding the Black Death and the 1918 influenza pandemic are generally, though not exclusively, confined to a small set of years in one acute impact on mortality, the "cholera pandemic" is more accurately conceptualized as up to *seven* pandemics over two centuries. Cholera also has the distinction of being a disease that kills extremely fast, with death resulting in as little as twelve to twenty-four hours of symptom onset (Ryan 2011). Cholera is a disease caused by the bacterium *V. cholerae*, which infects the gastrointestinal system of its victims and causes severe diarrhea and dehydration, resulting in painful and rapid deterioration; however, those who live beyond the initial one- to two-day prognosis can continue to expel *V. cholerae* for up to ten days after the onset of symptoms (Centers for Disease Control [CDC] 2024). Due to the nature of the seven sequential pandemics over the course of two centuries, this section will not attempt to identify inequalities for each individual cholera pandemic but rather attempt to generalize about ultimate explanations for heterogeneity in the impacts of cholera overall.

What follows is a brief overview of the timing and locations of the seven pandemics, which will help provide some insight into the major themes of inequality related to the impacts of cholera. The first recognized pandemic occurred in 1817–1821 and, upon recognizing its dramatic and rapid disease process, quickly became a disease at the forefront of public health concern. It spread from its origins in India throughout Bangladesh, Myanmar, Sri Lanka, Thailand, Indonesia—with one hundred thousand deaths just in Java—the Philippines, and Iraq, where there were eighteen thousand deaths in three weeks (Briggs 1961). The second pandemic occurred in 1829–1833 and was the first to reach the West: the disease spread to Russia, Finland, Poland, Germany, England, Canada, the United States, and Cuba (Evans 1988). The third pandemic occurred in 1841–1859 and had much the same path as the second pandemic, but it lasted much longer and impacted Central and South America more substantially after its first sweep through Mexico a couple decades prior (Evans 1988). This third pandemic of cholera is almost certainly the most famous of the cholera pandemics because of the well-known story of John Snow's spatial epidemiology research in London, resulting in the removal of the Broad Street pump handle which ended the outbreak there (Conniff 2024).

The fourth pandemic occurred in 1863–1875. It was milder epidemiologically but it was possibly the most impactful geographically, including all of Europe, South America, China, Japan, and Southeast Asia (Evans 1988). Only a few years after the end of the fourth pandemic, the fifth began, lasting from 1881 to 1896 and impacting North Africa, much of continental Europe, and some parts of Asia and North America (Evans 1988). This pandemic included pockets of very severe outbreaks, including those in Naples in 1884 causing five thousand deaths; Spain in 1885 causing sixty thousand deaths in Valencia and Murica; Russia in 1893–1894 causing two hundred thousand deaths; and Hamburg in 1892 with 1.5 percent mortality reported (Waldman and Claeson, 2025).

This particular iteration of the worldwide cholera pandemics includes historical evidence of race-based determinants of origins and spread. The introduction of cholera to the port of Damietta, Egypt, at the Suez Canal resulted in racially motivated blame against a Muslim crew member, with what historians have referred to as an “ethnically convenient scapegoat” for the introduction of the disease there (Conniff 2024). There has been no quantitative anthropological research performed to explore inequalities based on socially constructed race categories during this time period; however, social perceptions of how marginalized races are agents of infectious disease spread are old, and such historical evidence provides the knowledge base for contemporary understandings of the potential role of racism in understanding historical epidemics. Figure 3 illustrates an artistic perception of the severity of cholera in the early 20th century.

Figure 3. An artistic representation of the severity of cholera in the early 20th century, published in *Le Petit Journal* in 1912.

Source: Author unknown. This image is in the public domain.

The sixth pandemic was almost entirely confined to Asia and North Africa and occurred in 1899–1923. It resulted in thirty-four thousand deaths in three months in Egypt, four thousand deaths in Mecca in 1902 that were linked to Muslim pilgrimage, and another estimated twenty thousand deaths in 1907–1908, again mostly Muslim pilgrims (Evans 1988). After a relatively long reprieve following the sixth pandemic, the seventh pandemic of cholera began in 1961. It officially began in Indonesia and has since spread to Haiti, Pakistan, and Zimbabwe (Ryan 2011) but likely expanded out from the Bay of Bengal in no fewer than three independent waves with a common genetic ancestor in the 1950s (Mutreja et al. 2011). Yemen experienced an outbreak of the seventh cholera pandemic in 2016 in the midst of a brutal civil war, which was likely one of the key determinants in the resurgence of cholera in the country (Al-Mekhlafi 2018; Camacho et al. 2018). One important distinction between the seventh pandemic compared to the previous six is that it is caused by a more resilient pathogen, dubbed *V. cholerae* "El Tor," which can persist longer outside of a host and has the potential to produce a higher proportion of asymptomatic carriers than infections with the preceding type (Ryan 2011).

In general, the paths of cholera during the 19th, 20th, and 21st centuries have illuminated a couple of important dimensions of the human condition that help produce highly unequal pandemic outcomes: urban living and socioeconomic status. Urban areas worldwide suffered higher cholera mortality nearly without exception, specifically those who were poor in urban regions (Briggs 1961). On multiple different continents throughout the two centuries of pandemics, cholera was recognized primarily as a disease of "civilization," referring specifically to the fact that outbreaks mostly occurred in population-dense areas and very rarely affected rural regions (Briggs 1961). This is almost certainly due to the nature of transmission of *V. cholerae*, which is through fecal–oral and waterborne transmission, rather than through the air like influenza or through vector species like plague. During the period of the seventh cholera pandemic, Anbarci, Escaleras, and Register (2012) showed that the number of cholera cases and deaths in fifty-five low-income nations was strongly and negatively correlated with accessibility of clean water. In public health, economics, and epidemiological spaces, this is increasingly considered a function of income and inequality; in effect framing access to clean water as a commodity rather than a human right.

There is little biological anthropological work on inequalities during the historical cholera pandemics. However, scholars have pointed to the 1865 cholera outbreak in Gibraltar specifically as a particularly good example of a syndemic in history (Singer 2009). Specifically, the interaction between cholera and smallpox resulted in considerable acute mortality, especially for the impoverished sector of the population that suffered debilitating social conditions, malnutrition, and multipathogen cocirculation (Sawchuk, Tripp, and Samakaroon 2022). During the cholera outbreak in 1865 in Gibraltar, people of lower socioeconomic status were more at risk of contracting and dying from cholera for two primary reasons. First, the fact that *V. cholerae* moves via waterborne transmission and, second, people of lower socioeconomic status in Gibraltar lived in a very specific type of high-density dwelling: the patio. Communal living was normal, there were an average of 4.7 families per patio in the late 19th century, and there could be one hundred or more residents sharing only a few patios, as well as a single point of entry, well, privy, and sewer (Sawchuk, Tripp, and Samakaroon 2022). Sawchuk et al.'s (2022) anthropological study effectively overlays the settlement type, social organization, and social behaviors of low socioeconomic status historical

Gibraltarians with the risks and ultimate epidemic outcomes of cholera during this period. Although exact numbers vary, as is typical for historical records of epidemics, reports by Gibraltar authority reported between eight hundred to nine hundred cases and four hundred to five hundred deaths in only eleven weeks in 1865 (Sutherland 1867a, 1867b; summarized in Sawchuk, Tripp, and Samakaroon 2022). Alarmingly, the weekly cholera deaths per one thousand population jumped from approximately four deaths per one thousand to fifty-eight deaths per one thousand from week 4 to week 6 of the outbreak (Sutherland 1867b), an effect of the up to ten-day long shedding period of the disease (CDC 2024). In all, the investigation of cholera inequality in 19th-century Gibraltar is an excellent example of how to integrate infectious disease epidemiology and cultural features of the study population to identify unequal impacts of a past pandemic.

The anthropological work by Sawchuk, Tripp, and Samakaroon (2022) also revealed that there was an age-based dimension of inequality in the 1865 cholera outbreak in Gibraltar. Specifically, infants through children aged nine and adults aged sixty to sixty-four and seventy to seventy-four had the highest probability of death from the disease, while those aged ten to fifty-four were at relatively low risk of death. The authors draw on the possibility of increased risk of death in young people who also became sick with smallpox around the same time, as the historical record shows that around 41 percent of children under age sixteen were unvaccinated against smallpox (Flood 1867). Human biology research in other populations has investigated the relationship between age-at-weaning and cholera mortality, which yielded no significant relationship for the cholera pandemic outbreak in 18th–19th-century Italy (Smith et al. 2022). The critical insight that age-at-weaning provides is related to stress in early life, which often has substantial impacts on health throughout childhood and ultimately on adult health. Additionally, breastfeeding is known to confer many significant benefits to lifelong health, including but not limited to increased immunological function (e.g., Abuidhail, Al-Shudiefat, and Darwish 2019; Gollwitzer and Marsland 2015), decreased likelihood of severe gastrointestinal disease (Neville et al. 2012), and decreased inflammation (Walker 2010). In this sense, sources of data aside from vital statistics, such as skeletal material, can also provide substantial evolutionary knowledge to ultimate determinants of cholera mortality inequality on the basis of underlying health conditions.

It is possible to characterize social susceptibility to cholera infection, disease, and death in a relatively straightforward manner: access to clean water is an ideal form of protection against a cholera outbreak. This is almost exclusively true due to the water-borne nature of *V. cholerae* transmission. Aside from major public health infrastructural overhauls that occurred throughout the 19th and 20th centuries in some Western nations, modern public health interventions that are non-permanent but effective and cheap include oral rehydration solution (ORS). In the absence of ORS in the 19th and 20th centuries, populations generally had to rely on public health advancements like water sanitation procedures that allowed access to noncontaminated water for regular consumption. Medical anthropologists have approached studies of cholera as critical public health and social justice issues given the evident inequalities in cholera epidemiology (Wells and Whiteford 2022), especially as climate change advances and rural areas become vulnerable to the disease for novel environmental reasons like flooding, likely well into the future (Ivers and Ryan 2006; Kouadio et al. 2012). However, there is a dearth of biological anthropological research on the historical cholera pandemics, especially those that apply evolutionary approaches—in conjunction with, not in detraction from, public health and political economic approaches—to how and why inequalities existed and persisted during these seven major pandemics.

The 1918 Influenza Pandemic

The 1918 influenza pandemic is likely the most studied historical pandemic in the 21st century. Interest in unequal outcomes in 1918 influenza pandemic mortality were of interest during and in the decades immediately following the major mortality event (e.g., Armstrong and Hopkins 1921; Brewer 1918; Britten 1932; Collins 1931; Frost 1919, 1920; Sydenstricker 1918, 1921, 1931), but otherwise research on this topic fell out of interest for decades. By the turn of the 21st century, interest in social inequalities in 1918 influenza pandemic outcomes was renewed (e.g., Killingray 1994; Mamelund 2003, 2006a, 2006b; Schmitt and Nordyke 1999; Shlomowitz 1990). The centennial of the pandemic in 2018 saw a significant influx of interest and publications, highlighted by a special issue in the *American Journal of Epidemiology* (Viboud and Lessler 2018). Further, the advent of the COVID-19 pandemic in early 2020 furthered interest among the scholarly scientific community.

The path of the 1918 influenza pandemic throughout the world is dubious due to its emergence in multiple places relatively simultaneously. Early accounts of the pandemic originated in Spain during World War I, which led to the long-standing misnomer “Spanish flu” throughout the world; in reality, Spain was simply one of the earliest and only countries publishing news on the influenza outbreak, the origins of which are suggested to date to 1917 in Haskell County, Kansas, in the United States (Barry 2004; Humphries 2014). In all, the 1918 influenza pandemic touched not only belligerent nations during the Great War but also nearly every corner of the globe. It resulted in approximately seventeen million deaths on the low end of mortality estimates (Spreeuwenberg, Kroneman, and Paget 2018) to fifty to one hundred million deaths on the high end (Johnson and Mueller 2002). The discrepancy in these mortality estimates is the product of different counting or estimation methods, the discussion of which is outside the scope of this article (e.g., Checchi and Roberts 2008; Gaddy and Gargiulo 2025).

Though the timing of the 1918 influenza pandemic in different regions of the world was variable, it occurred in three main waves over the course of two to three years. Wave I occurred in the summer of 1918, was relatively small, and went unattributed to influenza until retrospective analyses of vital records in many locations (e.g., Mamelund, Haneberg, and Mjaaland 2016). Wave II occurred in the fall of 1918 and was the major mortality event of the pandemic. Wave III was an echo wave that occurred in the spring of 1919 in many locations and not until 1920 in others (Dull and Dowdle 1980; Taubenberger and Morens 2006). Some research has suggested that the 1919–1920 echo wave was not the only echo of the pandemic, and that there were rather recrudescent influenza outbreaks of decreasing size and severity for at least two decades after 1920 (Saglanmak et al. 2011).

Inequalities in epidemiological outcomes of the 1918 influenza pandemic have been observed all over the world and for many different dimensions. One of the most commonly referenced characteristics of the pandemic is its age-based pattern of mortality—indeed, this characteristic has become known as a "signature" of the pandemic. Research also strongly implicates H1N1 influenza A as the causal pathogen of the pandemic, which was a novel form of influenza virus at the time (Luk, Gross, and Thompson 2001). The most observed age-based pattern of mortality during the 1918 influenza pandemic is the "W-shaped" curve, in which younger adults (aged twenty to forty-four) exhibited the highest excess mortality rates compared to a pre-pandemic baseline; infants (less than one year) and older adults (sixty-five plus years) exhibited lower than expected excess mortality rates, even though these latter two age groups are expected to experience the highest excess mortality during typical influenza outbreaks (Luk et al. 2001). The W-shaped curve is illustrated in figure 4. The W-shaped curve has been observed all over the world, including within specific studies of Copenhagen (Andreasen, Viboud, and Simonsen 2008; Saglanmak et al. 2011), Mexico City (Chowell et al. 2010), Spain (Cilek, Chowell, and Fariñas 2018), Australia (Curson and McCracken 2006), Arizona (Dahal et al. 2018), Norway (Nygaard et al. 2023), Alaska (Sattenspiel et al. 2024), New Zealand (i.e., military personnel; Summers et al. 2014), Newfoundland (Paskoff and Sattenspiel 2019; van Doren and Kelmelis 2022), New York (Olson et al. 2005), and Kentucky (Viboud et al. 2013). However, not every location exhibited the W-shaped curve: in Concepción, Chile, people under twenty years and over fifty years had the highest excess mortality while those aged twenty to twenty-nine had the lowest (Chowell et al. 2014a), and in Hawai'i excess mortality was highest in those younger than five years and older than sixty years (Schmitt and Nordyke 1999).

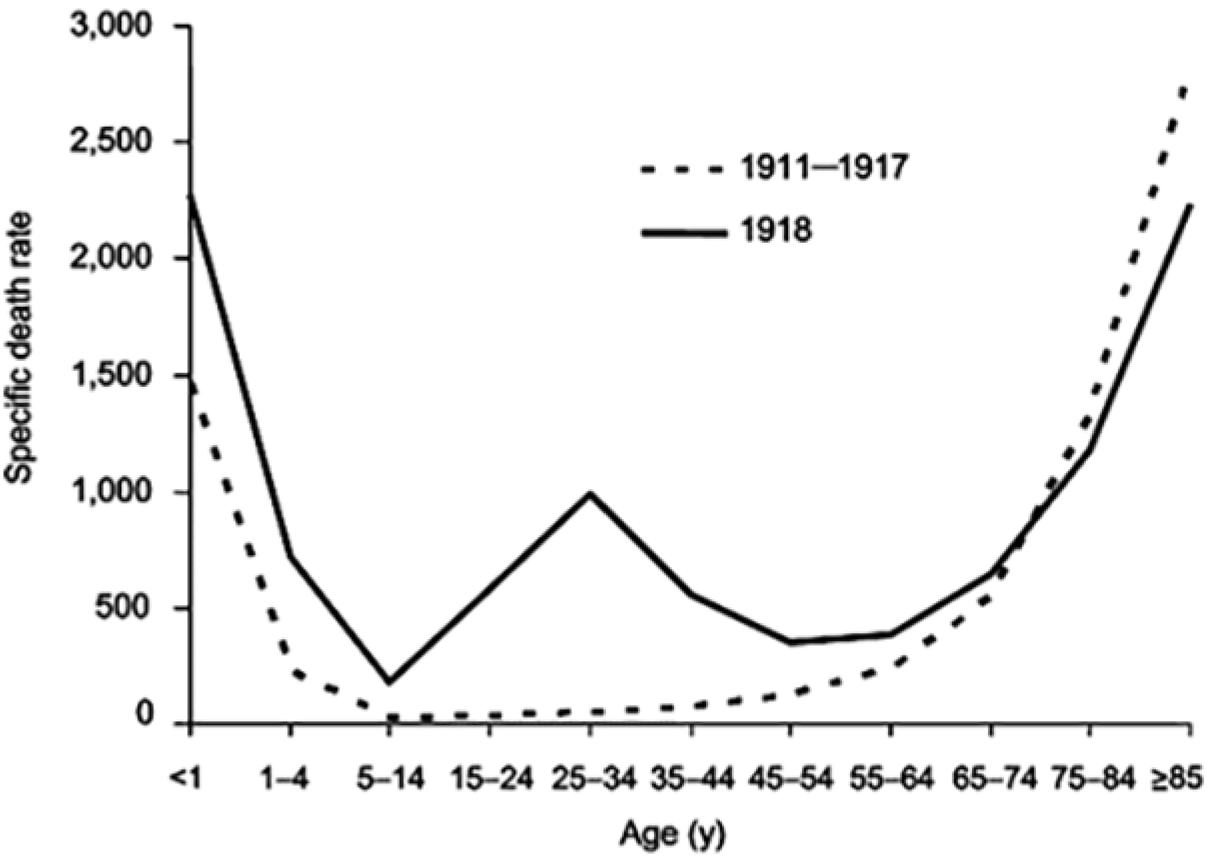

Figure 4. The "signature" W-shaped curve described during the 1918 influenza pandemic. The dashed line represents what may be expected for age-based influenza mortality in a typical nonpandemic flu year (U-shaped), while the solid line exhibits the age-based mortality observed during the pandemic (W-shaped).

Source: This figure was published in Taubenberger and Morens (2006) and is in the public domain.

Further, because most populations experienced at least two waves of the 1918 influenza pandemic, different age classes experienced higher excess mortality dependent on the wave. For example, in Copenhagen, after fifteen to forty-four-year-olds had the highest excess mortality in fall 1918 (46.7 deaths per ten thousand), in the winter 1919 wave excess mortality among fifteen to forty-four-year-olds fell to 14.9 deaths per ten thousand while people younger than fifteen years had the highest excess mortality at 17.3 deaths per ten thousand (Andreasen, Viboud, and Simonsen 2008). In rural Norway, individuals aged twenty to forty-nine had significantly higher excess mortality compared to those aged zero to nineteen in the first wave, but by the second wave the mortality rates were relatively even and not statistically different from each other (Nygaard et al. 2023). In Spain, individuals older than seventy years had triple the excess mortality of those five to fourteen and fifteen to twenty-four in the first spring wave of the pandemic, after which the pattern flipped for the major fall wave (Cilek, Chowell, and Fariñas 2018).

Sex- and gender-based inequalities are also points of interest for studies of 1918 influenza pandemic inequalities, although studies dedicated wholly to sex- and gender-based differences are uncommon. Typically, analyses are stratified by sex to provide a more nuanced perspective of demographic differences in outcomes rather than centering an entire analysis around these factors. Existing research cannot illicit a generalization about observed sex- and gender-based differences during the 1918 influenza pandemic around the world because many populations experienced different inequalities. In the United States, there was higher morbidity and mortality in men (Noymer and Garenne 2000), while there was higher male mortality in Australia (Curson and McCracken 2006) and higher male morbidity in Bergen, Norway (Mamelund, Haneberg, and Mjaaland 2016). However, in Norway, this was dependent on wave: Women had higher morbidity during the major fall wave and men in the spring and echo waves (Mamelund, Haneberg, and Mjaaland 2016). Conversely, the pandemic seemed to impact women more in the Maltese Islands (Tripp, Sawchuk, and Saliba 2018) and in rural Maryland (Mamelund, Haneberg, and Mjaaland 2016). Some studies report no significant differences between sexes, including those in Newfoundland (Paskoff and Sattenspiel 2019), Connecticut (Tuckel et al. 2006), Kentucky (Viboud et al. 2013), Mississippi (Zuckerman et al. 2022), Hawai'i (Schmitt and Nordyke 1999), and Sweden (Bengtsson, Dribe, and Eriksson 2018).

Socioeconomic status has also been a point of interest for historical epidemiologists, demographers, and anthropologists of the 1918 influenza pandemic. There has been substantial research to show that there are indeed disparities between and among social strata. Unlike with sex- and gender-based determinants, researchers have been able to make generalizations about how lower socioeconomic status contributes risk factors for severe influenza illness and death. People of low socioeconomic status in Chicago (Grantz et al. 2016), Sweden (Bengtsson, Dribe, and Eriksson 2018), Norway (Mamelund 2006a, 2018), Italy (Manfredini 2022), and Connecticut (Tuckel et al. 2006) were at increased risk of morbidity and mortality during the 1918 influenza pandemic. These studies commonly used variables available in statistical and/or individual historical census data as proxies for socioeconomic status, which is an imperfect but otherwise widely used and generally appropriate method to assess differences with the proper logic for doing so. For example, for two different neighborhoods in Oslo, Norway, Mamelund et al. (2006) used information on apartment size (number of rooms) to estimate socioeconomic status; apartments with more rooms and fewer residents indicated higher socioeconomic status (i.e., higher income needed for a bigger apartment, with only one family per apartment and fewer people per family), while the reverse, fewer rooms and more people, indicated lower socioeconomic status. This analysis strongly drew upon epidemiological knowledge of how influenza is spread through social networks, especially on the basis of crowding. Larger apartments in higher socioeconomic status neighborhoods suggest an important protective factor: Sick individuals could isolate themselves to reduce the chances of disease transmission. However, families in low socioeconomic status neighborhoods often lived in smaller dwellings with more people that were more tightly packed. The risk of influenza transmission to more people was larger in lower socioeconomic status neighborhoods (Mamelund 2006).

Socioeconomic status has also been used to inform the unequal risk of progression to severe flu disease: individuals who work low-paying, hourly jobs are less likely to take time off when they are ill, since this means reduced paychecks and decreased ability to access important resources for themselves and their families. Higher socioeconomic status jobs are more likely to guarantee pay through a salary, or individuals could draw upon wealth to offset the cost of being unable to work (Mamelund 2006). These two explanations are central to how and why historical epidemiological researchers have used information on socioeconomic status in historical populations to explain epidemiological patterns of infectious diseases. Other historical researchers used income directly in analyses rather than as a proxy for other sociocultural factors (Murray et al. 2006), while still other proxies included skilled, semi-skilled, and unskilled labor (Bengtsson, Dribe, and Eriksson 2018; Manfredini 2022), literacy (Grantz et al. 2016), and the proportion of homes rented versus owned (Tuckel et al. 2006).

Other points of interest for studying inequalities during the 1918 influenza pandemic are Indigeneity, race, and ethnicity. Mamelund et al. (2011) published a meta-analysis of research on Indigenous versus non-Indigenous mortality during the 1918 influenza pandemic worldwide, taking into account existing co-morbidities, nutritional status, crowding, the effects of colonialism, discrimination, marginalization, climate, health care access, and genetic diversity. These are all complex and interrelated determinants of health that make studying the impacts of the influenza pandemic in the context of Indigeneity difficult. However, in general, Indigenous Peoples worldwide suffered more severe consequences during the pandemic than settler populations in the same regions (Alves et al. 2022). This was also true in Alaska (Mamelund, Sattenspiel, and Dimka 2013; Sattenspiel et al. 2024), Labrador (Budgell 2018; Mamelund, Sattenspiel, and Dimka 2013), Hawai'i (Schmitt and Nordyke 1999), Belize (Killingray 1994), and Connecticut (Tuckel et al. 2006).

In terms of other racial disparities in 1918 influenza pandemic outcomes, Økland and Mamelund (2019) reviewed racial inequalities in the United States and concluded that Black Americans had lower morbidity and mortality rates but higher case fatality rates (the rate of individuals who die from a specific condition out of all individuals who are known to have that condition) than white Americans. It is almost certain that historical data on influenza morbidity and mortality during the pandemic are less complete for Black Americans, but relatively higher case fatality rates indicate that influenza was more severe, as a disease, for Black Americans than for white Americans.

Eiermann et al. (2022) reported an interesting analysis using early 20th-century US census data in which non-white urban residents experienced higher 1918 influenza pandemic mortality, but the difference in mortality rates was three to four times *smaller* in 1918 than in any other year from 1910 to 1921; the nonwhite/white mortality ratio in 1918 was only 1.35 compared to a pooled ratio of 2.33 in 1910–1917 (Eiermann et al. 2022). Similar to results reported by DeWitte and Wood (2008) for Black Death survivorship between frail and non-frail individuals, the 1918 influenza pandemic was very severe and raised the risk of death for *everyone*, resulting in relatively smaller differences in mortality rates despite higher overall mortality.

Finally, there has been some burgeoning interest in pandemic inequalities on the basis of settlement type, that is, primarily analyses assessing how the pandemic differentially impacted urban and rural locations. Reflection upon influenza as an airborne virus that is easily transmitted via air droplets may lead one to intuit those areas with high population sizes and densities exhibited relatively more severe pandemic outcomes. This is generally true. For example, urban locations like those in Spain (Chowell et al. 2014b), the United States in general (Clay, Lewis, and Severnini 2019), Norway (Nygaard et al. 2023), Iceland (Summers et al. 2013), and New Zealand (Summers et al. 2013) had higher mortality than rural regions in the same countries. However, there is some nuance. Chowell et al. (2010) showed that Mexico City and Toluca, both urban centers in Mexico, had dramatically different levels of excess mortality. Chowell et al. (2011) also showed that excess mortality was three times higher in Iquitos, a metropolis in Peru, compared to Lima, the capital of Peru and one of South America's largest cities. Tripp and Sawchuk (2023) suggest that in Malta, it was rather the suburban regions that suffered the most severe influenza impacts, and van Doren and Kelmelis (2022) show that in Newfoundland, the highest influenza mortality rates were in the most isolated and remote regions of the island. This is similarly true for Alaska, where remote regions like the Seward Peninsula experienced some of the highest mortality impacts of the world (Mamelund, Sattenspiel, and Dimka 2013; Sattenspiel et al. 2024). The variability in influenza pandemic outcomes by settlement type (urban, suburban, rural, or remote) shows that urban populations generally suffered worse outcomes, there may be risk factors related to rural or remote living that elevate risk. It is important to focus historical pandemic research on rural and remote populations, as well, rather than take urban and/or population-level results as representative of the whole pandemic experience.

Future Directions in the Study of Inequality in Anthropological Pandemic Studies

There are multiple possible future directions for anthropological pandemic studies that build upon the already robust body of work described in this article for the Black Death, cholera pandemics, and 1918 influenza pandemic. These future directions are theoretical, conceptual, and methodological, which can build upon knowledge built by old questions and begin to answer new questions.

From a theoretical perspective, the prospect of paleosyndemics is particularly promising, given anthropologists' existing interest in modern syndemics. A paleosyndemic perspective provides the opportunity to integrate biological, ecological, and social factors in an historic—or even prehistoric—context, which can lead to a better understanding of ultimate determinants of health with more temporal depth. With similar goals to paleoepidemiology, which seeks to understand the lived experience of past individuals through their skeletons, paleosyndemics seeks to draw upon one of the key features of syndemics as defined by Merrill Singer: clustering of adverse and deleterious health conditions (Singer and Clair 2003). Anthropologists Clark Larsen and Fabian Crespo seek to apply the concept of clustering to nonliving populations but have additionally highlighted opportunities for the inclusion of conditions such as nutritional status and immunity in the historical and paleoepidemiological studies of frailty, infectious diseases, and demography (Larsen and Crespo 2022). This is especially valuable given the fact that historical epidemiology and historical demography depend on written vital records, but vital records are not ubiquitous worldwide, nor do they cover enough of human history to uncover foundational knowledge of infectious diseases further back in history. The anthropological concept of paleosyndemics encourages the integration of other forms of data to build holistic bodies of knowledge of the contexts that shaped humans' experiences with diseases through time.

Conceptually, two dimensions of human biology and culture that have not been subject to much research on unequal outcomes during the 1918 influenza pandemic are underlying biological frailty and disability. One example of anthropological research on the underlying frailty on inequality during the 1918 influenza pandemic is Wissler and DeWitte's (2023) survival analysis of individuals who died during and survived the 1918 influenza pandemic in Cleveland, Ohio, whose remains are now in the Hamann-Todd Human Osteological Collection at the Cleveland Museum of Natural History (this paper is an extension of the study originally published in Wissler's 2021 dissertation). Wissler and DeWitte (2023) found that in a sample of deceased individuals from Cleveland, frail individuals (those with a higher score of skeletal markers of frailty) had lower survival than the nonfrail. However, the 1918 influenza pandemic increased the risk of death for everyone, not just the frail, so the differences in survival between frail and nonfrail individuals was not as large during the pandemic as they were prior to the pandemic (Wissler and DeWitte 2023). This result is again, as with Eiermann et al.'s (2022) analysis of nonwhite to white mortality rates in the United States, similar to DeWitte and Wood's (2008) conclusions about risks related to underlying frailty during the Black Death.

Thus far, Wissler (2021) and Wissler and DeWitte (2023) are two of the only studies that engage with bioarchaeological data to better understand 1918 influenza outcomes. There may be several reasons for the lack of biological anthropology research on the 1918 influenza pandemic with bioarchaeological frameworks, and these are outlined at length in DeWitte and Wissler (2022). However, briefly, a few reasons include: first, the 1918 influenza pandemic occurred relatively recently, whereas most bioarchaeological research focuses on time periods hundreds, if not thousands, of years in the past, and *historical* bioarchaeology is not a prominent field; second, those who die from influenza infection and flu disease succumb relatively quickly—too quickly for any markers on the skeleton directly attributable to influenza to develop—therefore, bioarchaeologists may be less likely to consider skeletal populations for flu studies; and finally, the skeletal material across space is generally lacking and inconsistently available, aside from carefully curated museum collections.

In terms of disability, Dimka and Mamelund (2020) found that, among institutionalized patients in Norway, while controlling for all covariates, the institutionalized population had 61 percent lower morbidity than the employees of the asylum in which they lived, but patient case fatality was higher. This means that, controlling for the size of the patient and staff populations, fewer patients became sick, but more of the patients who got sick died. Lower morbidity paired with higher case fatality is an important dimension of inequality that can be more thoroughly parsed with future research in other populations. This result indicates that there are likely specific underlying sociocultural and/or systemic determinants of inequality affecting two different groups in the same place and time.

A general lack of historical pandemic research on disability could be a product of stigmatization of disability, the lack of knowledge around how disabilities intersect with other identities to increase risk, and the bias of data toward historical institutionalized populations rather than historical data that account for disabilities in the noninstitutionalized population. In other words, much of the current knowledge of disabilities in history come from those described in institutionalized populations, the language for which was the product of highly stigmatized perceptions of mental illness and sensory disabilities (Braddock and Parish 2001). However, this knowledge does not account for the broad spectrum of what is recognized as "disability" in the 21st century, which encompasses many conditions that were not recognized in the historical context and would likely never appear in an historical record.

Finally, those interested in studying historical pandemic inequalities may consider exploring interests in pandemics that have yet to be extensively researched. In comparison to the Black Death and 1918 influenza pandemic, the cholera pandemics have been researched by far the least, despite their significant impacts on humans, the socio- and biocultural determinants in unequal populations, integration points with public health advancements and infrastructure, and their co-evolutionary partnership with humans since population growth and density during the intensification of agriculture. In the absence of vital records, which for more modern events carry important demographic and epidemiological information, anthropologists can creatively utilize other forms of historical and biological data that can build an understanding of the cholera pandemics from an anthropological perspective. Relatedly, for existing and future historical pandemic research, interested scientists may seek to expand upon the geographic breadth of existing research to alleviate some of the strong Western bias in historical pandemic knowledge.

Conclusions

There is high value in the application of biological anthropological approaches to studying social inequalities in past pandemics, but there are some important considerations for how to approach the study of particular pandemics. For example, anthropological research on inequalities during the Black Death have been primarily bioarchaeological and therefore rely overwhelmingly—though not exclusively—on skeletal material. Research on the cholera pandemics and 1918 influenza pandemic rely primarily on written historical data, but there are some bioarchaeological studies, as well (e.g., Smith et al. 2022 for cholera and Wissler and DeWitte 2023 for the 1918 influenza pandemic). Further, there is relatively little historical epidemiological work about the 19th and 20th century cholera pandemics compared to the Black Death and 1918 influenza pandemic. This may be due to general data availability, as many populations do not have thorough written historical vital records that predate the 20th century. However, there are some exceptions, particularly those of Finland, where the documentation of births, deaths, causes of death, marriage, and migration were compulsory by law beginning in 1749 (Pitkänen 1977). Another issue impacting data availability for both cholera and influenza is the rapid pace at which these diseases impact populations. It is often very difficult to collect data in real time when faced with a massive and acute public health emergency, and the data collected in the historical context are often not meant to serve the ultimate purposes for which modern researchers use them. Bioarchaeological research using skeletal material can still approach research questions about inequality despite the rapid progression of most acute infectious pandemic diseases precisely because of how they can study embodied health inequalities, and therefore the health effects of frailty, on people before, during, and after the Black Death (e.g., DeWitte and Wood 2008; Smith et al. 2022; Wissler and DeWitte 2023).

There is generally much more research on the 1918 influenza pandemic than the other two pandemics discussed in this article and, indeed, of any major historical pandemic. This may again be due to data availability but also relative historical proximity. However, it is important to note that even for the 1918 influenza pandemic, data availability is skewed toward populations for which historical records were kept. This leaves out many Indigenous populations that were—and continue to be—seasonally migratory, as well as those who were distinctly separate from settler populations in the early 20th century and other populations that did not maintain systematic record keeping practices. Because of this, anthropological work on historical pandemics must always recognize that not all inequalities can be uncovered. Despite this, when piecing together the knowledge created by researchers investigating historical pandemic inequalities through diverse methods and data sources, their ultimate determinants remain relatively consistent through time and space and for pandemics of different etiologies. Some of these are low socioeconomic status, nutritional deficiencies, and urbanicity, all of which can become embodied and manifest in skeletal material over the long term. These are major contextual factors that increase risk of death during pandemics.

The bias in research in general, and anthropological research specifically, on the Black Death and the 1918 influenza pandemic also speaks to perceptions about what precisely constitutes a *pandemic*. Again, a relatively straightforward definition can be "an epidemic that affects large regions, multiple countries, or even the whole world approximately simultaneously . . . typically caused by novel pathogens or strains against which there is limited or no immunity" during which "substantial morbidity and mortality can occur" (Dimka, van Doren, and Battles 2022, 257). It is common to point toward the largest known pandemics that have occupied the public consciousness and caused the most mortality and subsequent social upheaval: The Black Death resulted in the loss of approximately 30 percent of the European population (Ziegler 1969), and the 1918 influenza pandemic resulted in 2.5 percent global mortality (Johnson and Mueller 2002). It is important to recognize that there is a strong bias in financial, biomedical, and academic investment in understanding diseases that are most proximate to oneself; in Western nations, this often means overlooking critical diseases that plague other parts of the world. This was criticized by physician and medical anthropologist Paul Farmer (1996) when he suggested that Western scientists and health practitioners tend to "discover" "emerging diseases" when they first begin to afflict wealthy individuals and nations, even when they are not strictly new (Harper and Armelagos 2010). In the historical context, this sentiment still applies, which is why cholera may be one of the least studied major pandemics from a biological anthropologic perspective. In general, it may be prudent to approach historical studies of tuberculosis, smallpox, malaria, and even pertussis (i.e., whooping cough) as important and substantial pandemics that have shaped human biology and society through time, not only because of perceived distance from these diseases in Western nations but also as important features of our infectious disease landscape that affect many dimensions of humanity as a whole. Anthropologists are well equipped to take up this mantle, especially when they engage with ethnobiological, Indigenous, traditional, and historical knowledge of idiosyncratic communities to build understanding of those pandemics and their unequal impacts (Gaddy 2020).

Biological anthropological approaches to pandemic studies and individual pandemics' unequal impacts sometimes necessitates a broader view, including preexisting baseline population health and inequality, sociocultural, political, and ecological contexts, human behavior and social organization, and the network of cocirculating pathogens in afflicted populations. Additionally, pandemics are acute and significant stressors on society, demography, and population health; therefore, long-term post-pandemic inequalities should be considered part of the body of pandemic knowledge as well. Evolutionary approaches within biological anthropology are excellent frameworks for understanding the many facets of unequal determinants, outcomes, and long-term consequences of infectious disease pandemics. Historical pandemics and their associated inequalities in baseline health, proximate pandemic impacts, and long-term outcomes are an ideal area in which to begin this inquiry, as much time has passed—in some cases, many centuries. Pandemics are regularly occurring phenomena and are no longer considered the indiscriminate killers or great equalizers, and pandemic preparedness measures should be informed by knowledge of inequalities experienced during historical pandemics (Mamelund and Dimka 2021a; van Doren et al. 2024). Beyond the practical application of pandemic preparedness, biological anthropological research into historical pandemic inequalities adds valuable knowledge to our understanding of the complex coevolutionary nature of pathogens, diseases, and the human condition.

Further Reading

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