

Archaeological Insights to Modern Pandemics: Contemporary Inferences from the Antonine Plague

Katya M. Sajovec

The COVID-19 pandemic highlights the lack of preparatory measures in place for mass disease events. The lack of hospital beds, overflow of bodies from morgues, closure of businesses and subsequent job loss demonstrates the failure of the government and medical officials to develop effective pandemic preparations. However, analyzing past pandemics, like the Antonine Plague, through archaeology can better inform experts for disaster protocol development. The archaeological analysis of the Antonine Plague, arguably the first pandemic experienced by humanity, demonstrates macro phenomena contingent to human pandemic experience. The spread of infection, mass death and breakdown of funerary practices, humanity's response to pandemics, mobility due to disease, economic effects and reemergence of the disease are all consistencies prevalent within pandemic experience of the Antonine and Covid-19 Pandemics that occur through micro variations dependent on present culture. Archaeology offers pandemic insight to modern society furthering knowledge of humanity's contemporary relationship with disease.

Introduction

The COVID-19 pandemic prompts questions surrounding how to mitigate the effects of severe disease outbreaks as well as what future pandemics will entail. Pandemics affect a variety of societal components including socio-political, economic and cultural institutions. An interdisciplinary approach to pandemic research provides an extensive conceptual understanding of the far encompassing effects of pandemics. While much of society turns to scientific technique to develop systems to diminish the impact of the disease, a sole reliance on the medical field mitigates the opportunity of developing an extensive plan for pandemic events. One sector, often not acknowledged as a field offering vital information to modern questions, is archaeology.

The COVID-19 pandemic is a significantly deadly disease caused by the SARS-CoV-2 virus. Experiences of individuals who contract the virus range from asymptomatic to respiratory failure, leading to death. While humanity struggles to cope with this new reality, the world is reminded of times when humankind has been inflicted with other deadly diseases. The Antonine Plague is one such disease event. Arguably humanity's first pandemic, the Antonine Plague struck the Roman Empire from 165-189 CE (1, 2). A critical analysis of the Antonine Plague through an archaeological lens highlights the continuity of pandemic experiences across time. While other historical diseases, such as the 1918 Flu Pandemic and "Black Death", also provide significant insight into humanity's relationship with disease, the Antonine Plague occurred nearly 2,000 years prior to modernity, and therefore, an analysis of this pandemic

uniquely demonstrates the extent to which humanity's experiences of pandemics are perpetuated across a vast time scale.

The archaeological study of the Antonine Plague exhibits macro phenomena consistent between humanity's experiences of these two pandemics: transmission, mass death and breakdown of traditional burial norms, unique responses to mass disease, mobility, economic impacts, and reemergence. The pandemic phenomena develop through variations conditional to the cultures prevalent during the pandemic. Through a case analysis of the Antonine Plague, macro pandemic phenomena which persist through time and culture become apparent through their presence in the COVID-19 pandemic.

By critically analyzing the Antonine Plague in conjunction with today's COVID-19 pandemic, the connectivity across humanity's experiences of disease is illuminated, particularly macro phenomena experienced by humanity conditional with the onset of a pandemic. The similarities in conditions leading to the vast spread of disease as well as varying responses illustrate the shared human experience of illness across the ages. This in turn demonstrates not only the recurrence of experiences but allows further insight into modern conditions of humanity.

This article highlights that the COVID-19 pandemic is not a unique experience or rare phenomenon, but part of the long-standing story of humanity's relationship with disease, in essence, repeated continuously through various points in time. The analysis displays the phenomenon of macro disease effects which occur through differentiations in the specific experiences of each phenomenon, varying as a

result of cultural transitions over time and place.

Background

The Antonine Plague is a pandemic event that occurred in the Roman Empire from 165 to 189 CE, during the reign of Marcus Aurelius. Notably, it is also referred to as the Plague of Galen, as Galen, a famous Roman physician during the period, documented the disease (1-3). Argued as the first pandemic, it is the first mass disease event known to extend across a vast region, including Asia Minor, Egypt, Greece, and Italy (1, 4). While previous disease outbreaks occurred, such as the Plague of Athens, evidence indicates they existed in a relatively limited region and consequently due to reduced geographical spread are not regarded as pandemic events (1).

During the second century CE, Rome held a vast network of extensive trade routes as well as a strong Roman military presence with significant mobility (5, 6). Along with extensive trade and a notable army, this period also witnessed significant natural disasters. Earthquakes, volcanoes, droughts and diseases all occurred throughout the Roman Empire in the 160s through 180s (7-9). Food shortages caused by these events weakened the immune systems of individuals, leaving them malnourished and susceptible to disease (10).

As a result of the lack of knowledge surrounding the transmission and treatment of illnesses, communicable diseases significantly affected the Roman Empire populace. At the time, deadly epidemics were a common feature of ancient life (8). During the period which the Antonine Plague hit, individuals believed that “Plagues were caused by miasma, polluted air, an angry god, or some indecipherable combination of divine wrath and environmental disturbance” (5). One disease particularly afflicted the population annually, malaria, which often left surviving victims in poor health, specifically causing malnutrition, increasing disease susceptibility (5).

During the 2nd century CE prime conditions existed for the onset of a pandemic. The vast trade led to a global network that allowed for the mass spread of disease within a short period of time (5). Military mobility was another potential avenue for disease transmission between locations (6, 11). Additionally, earthquakes, droughts and volcanic eruptions predated and occurred in the Roman Empire during this period, wreaking damage on the population and increasing the vulnerability of the masses to disease (7-9). High rates of endemic disease also advanced the potential for a pandemic to develop. While a variety of conditions persisted to aid in the onset of the Antonine Plague,

ultimately, “The commercial links exposing Rome to the emerging infectious diseases of the world outside its borders were the most fateful constituent of the Roman disease ecology” (5). The conditions in Ancient Rome proved prime to initiate the arrival of the Antonine Plague.

Results and Discussion

A comparative analysis between the COVID-19 pandemic and the Antonine Plague highlights six common phenomena that occur between both pandemic events: disproportionate spread of infection reliant on social factors and living conditions, mass death and breakdown of funerary practices, mobility due to disease, economic effects from the pandemics and disease reemergence. While these factors vary individually between pandemic events, both are consistent between the pandemics and should be acknowledged to mitigate the effects of future mass disease events.

Spread of Infection

The novel coronavirus from 2019 is said to have originated in Wuhan, China, and from there, spread around the world, hitting major economic cities first (12). In addition to the rapid appearance of large-scale infection in areas with high rates of international travel, communities situated in close quarters also experienced significant effects of the pandemic. Two examples represent stark instances of the virus’ potential devastation: cities and nursing homes (13, 14). Both areas consist of populations living close together with many other individuals.

Similarly, during the Antonine Plague, disease spread was also affected by factors such as travel, contact with other populations and population subsets. While a variety of conditions persisted to aid in the onset of the Antonine Plague, ultimately, the commercial and trade industries prevalent throughout the Roman Empire were the major components for infectious disease introduction and spread (5). Additionally, the significant presence of the Roman army may also have furthered the spread of disease, as disease dispersal appears to have started within the army and inflicted towns in the wake of their presence (11, 15).

In addition to disease dispersal between societies, disease spread within communities is also an imperative concern surrounding pandemic events. During the Antonine Plague outbreak specific population sectors held disparate disease experiences. Due to living conditions, various population subgroups experienced rapid spread of transmission. The Roman Empire witnessed the devastating effects of the Antonine Plague on the Roman army, due to their tight quarters, as well

as the quick spread of the infection between servants and enslaved individuals followed by the subsequent infection of other individuals within the household.

Through close interactions, prime conditions existed for the fluid diffusion of a pathogen across a group of individuals. Archaeologists found that “The pandemic was raging among the troops in Aquileia by...168 [CE], advancing from one node of population to the next, unevenly diffusing in fractal spirals across the west. According to Jerome’s chronicle, the army was devastated in...172 [CE]” (5). As illustrated, disease is particularly devastating for individuals interacting with and living in close proximity with a large number of individuals (7). The evidence left by Jerome particularly displays the inability of members of the army to fend off the disease. The documentation further develops knowledge that the pathogen afflicted healthy, young men as well as older members of the military as typically the army consisted of men of a variety of ages (16). The analysis of the spread of disease within the army, illustrates the importance living conditions hold in the development of pathogen dispersal.

Another subset of the population that lived in close proximity and quickly felt the effects of the pandemic were enslaved people. Enslaved individuals lived within a unique subsection of society in which they consistently experienced exposure to and close contact with other individuals. From records left by Galen, experts recognize that “Galen lost a whole household of slaves to the plague” (3). The information left signifies not only the high contagion of the illness, but also provides insight into the close quarters which enslaved people likely lived in allowing the virus to quickly spread. However, the pathogen causing death during the Antonine Plague affected all factions of the population. With the Antonine Plague, “The plague carried off the rich and powerful and pious people and sinners alike” (17). While the plague may have ravaged through particular population subsets first, such as the army and enslaved individuals, it eventually affected those in power, causing devastation among all. As a contingent factor in pandemic experience, the trajectory of the diseases’ impact remains a phenomena of considerable importance.

Mass Death and the Breakdown of Funerary Practices

A notable aspect of the COVID-19 pandemic which has garnered international attention is the inability of many towns, cities and countries to properly dispose of the recently deceased. Due to the high number of deaths incurred by the presence of the pathogen, hospitals, morgues and funerary homes

did not possess enough space to properly preserve and handle individuals who had been infected and died from COVID-19 (18). In an attempt to handle the overflow of bodies, hospitals set up morgues in their parking lots. Within cities, rooms and mobile coolers possessed bodies piled on top of one another (19).

The pandemic outbreak not only caused mass death, but also lead to a breakdown of funerary practices. Due to the danger of mass gatherings and interactions with outsiders to an individual’s household, funerals and other burial practices became essentially halted. Families, loved ones, and friends, unable to lay their loved ones to rest instead held online memorials or grieved their loss alone (20). The social disruption surrounding burial practices serves as a phenomenon consistent with high mortality pandemics also observed in the Antonine Plague.

The population living during the time of the Antonine Plague also observed mass death. This was documented by accounts left by predominant individuals, such as Galen, as well as census records (3, 9). Multiple papyri were discovered, detailing the significant loss of life during this period (9). Other documents record the presence of an unknown disease that killed a significant number of individuals in villages (9). Specifically, the document P. Thmouis 1, a report from 172-173 CE, reports deaths in villages from an unknown disease a few years prior (9). Due to the dating of the reports, the Antonine Plague is a plausible source of infection. As a result of the mass death, the public witnessed a breakdown of funerary practices during the Antonine Plague. This is illustrated through the high number of mass graves and the burial of multiple individuals in the same grave. During this period, the Romans held strict rituals for the dead and often believed the absence of the normalized burial practices resulted in the dead’s inability to enter into the afterlife (21). Consequently, the breakdown of traditional practices, such as the use of mass graves, mark a significant event in history and devastation upon the population.

Within England, archaeologists discovered a Roman grave site, in which many individuals were buried in a large grave (21). Upon archaeological analysis, archaeologists determined that some of the bodies were tangled, likely indicating the burial of the bodies at the same time. Additionally, there appears to be a lack of exposure of the skeletons to sunlight as well as scavengers, leading archaeologists to believe that the mass grave was not opened and utilized for a long period of time, but that the bodies were placed in it within a short sequence of one another (21). The burial of the bodies without the typical form of ritual and individuality indicates a disaster event in which the rate of death is high. Furthermore, the mass

grave, dated between 70-240 CE, held individuals that showed no skeletal signs of conflict and likely died as a result of disease (21). While the Antonine Plague has yet to be biomolecularly identified as the cause of the pandemic, the characteristics of the burial indicate the Antonine Plague may have been the source (21). While radiocarbon is one method of dating graves, artifacts are another tool implemented by archaeologists to date sites (21). With the mass grave objects such a pottery jars, brooches and hairpins were identified (21). These objects date the site to the later part of the second century, further aligning the burial with the Antonine Plague (21).

Similarly, archaeologists study the structure of graves and placement of burials to gain further insight into the events surrounding the period. Another mass grave exhibiting the breakdown of funerary practices during the period of the Antonine Plague was found in the catacomb of Saints Peter and Marcellinus in Rome, Italy (22). Within the site, archaeologists determined remains were arranged in a way to maximize space and placed with little care (22). The lack of traditional burial customs and significant care for the dead was abnormal for the Roman culture during this period (21). Furthermore, the cut of the grave signified signs of haste and there was a lack of sediment between some of the bodies, indicating that they were buried within short periods to one another (22). Lastly, the presence of plaster on the bodies depicts that the individuals were buried with a form of ritual, indicating that funerary practices did not break down completely (22). The information deduced from this site, leads archaeologists to believe that an epidemic caused these deaths. Specifically, archaeologists believe the site may be a result of the resurgence of the Antonine Plague (22). The haphazard formation of the burial sites as well as the lack of apparent care, normally reserved for the dead, displays the extent to which disease dismantled the traditional funerary practices of the period.

Notably, mass graves are predominantly an urban phenomenon and during the Antonine Plague, eyewitness accounts document large mass graves within some of the grand cities of the Roman Empire (23). In contrast, due to the space and smaller populations located in the countryside, mass graves are found less frequently, with a larger rate of communal graves indicating a disaster event instead (23). This is particularly observed when multiple family members die within a short period of time of each other, which can be a result of disease within the household.

Two collective graves found in Moesia Inferior, an ancient Roman province situated in the modern Balkans bordering the Black Sea, held six and three bodies, respectively, and is expected to be a result of the

Antonine Plague (11, 24, 25). Additionally, other graves found in the same region contain multiple individuals appearing to have considerable wealth, providing information as to the susceptibility of all populations to the plague (11). Archaeologists studied two graves containing three deceased individuals: two adults and one child with evidence indicating familial relations between the individuals (11). Similarly, another grave discovered contained two individuals, believed to be a couple. Artifacts discovered with the bodies consisted of expensive objects such as "...gold jewelry, silver and bronze, pieces of glass and pottery" indicating the financial wealth of these families (11). Through these artifacts it is apparent that the wealthy also responded to the high numbers of familial deaths with communal graves.

The presence of communal graves also provides archaeologists with information to deduce the age population the pathogen affected most severely. One grave held five individuals of various ages ranging from childhood to adulthood and had a fresco depicting a funerary banquet of all the diseased, indicating familial relation and a short period between deaths (11). The burial is suspected to be the result of the Antonine Plague and consequently may highlight the broad range of ages killed by the disease (11).

Additionally, the breakdown of funerary practices is exhibited not only through mass graves developed at a singular time, but also the addition of bodies to graves. One sarcophagus holding two graves, dating between the late second and early third century CE, the period of the Antonine Plague, lacked iron staples (11). Archaeologists deduced the lack of this feature to be the result of the addition of another body to the grave, a teenager (11). The dress of the individuals as well as grave goods indicate that the individuals were not buried together due to a lack of finances, but because of a short interval between deaths (11).

The presence of mass death during periods of significant pathogenic infection leads to a breakdown of traditional funerary practices. The abnormal presence of mass and communal graves indicates a breakdown of this societal institution during the Antonine Plague. Through archaeological analysis, archaeologists can determine the period of a grave site, a likely cause of death, circumstances surrounding the grave, time span between the burial of the individuals, and which subpopulations of society perished due to the pandemic. The knowledge of the breakdown of funerary practices uniquely provides insight into the issues which humanity face during mass disease events. In times of pandemics with high mortality rates, the phenomena of the breakdown of funerary practices remains a consistent feature between humanity's experience of the Antonine

Plague and Covid-19 pandemic.

Humanity's Response to Pandemic

Often, with disaster comes intense human emotion. The craze of hysteria, with the onset of disease in particular, leads some individuals to have renewal in their religious faith or exhibit xenophobia (26, 27). For example, after the initial onset of the Covid-19 pandemic America witnessed xenophobia towards Asian communities, perpetuated by leaders and news outlets referring to it as the "Chinese virus" (27). During the pandemic, conspiracy theories were also developed surrounding the origin of the pathogen (28). Additional reactions to COVID-19 outbreaks include surplus buying and hoarding of goods (29). Understanding the various responses of humans to disaster assists in the development of disaster protocols. Through an analysis of past actions in times of disease and subsequent comparison to the present, the continuity of humanity's reactions throughout history is illuminated. The variations in which humanity responds to pandemic events is contingent upon differing cultures prevalent at various points in history, however across time, individuals continue to react to disease through unique avenues.

The Roman population reacted to the presence of the Antonine Plague with unique responses including the development of disease origin stories, use of oracles, and amulets (5, 7, 30). While multiple disease origin stories existed one particularly stands out. Individuals believed that the disease originated in the city of Seleucia, a port on the Persian Gulf (5). After the Roman army took over this city, a vapor was released from a golden casket within the temple of Apollo in the city, spreading across the Roman Empire (7). While the vapor did not originate in Apollo's temple, it is possible that the virus was present in Seleucia when the Roman army sacked the city, providing an opportunity for the Romans to contract the disease and then carry it with them throughout the Roman Empire, furthering the spread of the pathogen (5). The response of the population to develop an answer to the pandemic's origin illustrates the desire of humans to ground the cause of their experience into comprehensible material (31).

The Roman Empire's population reacted to the onset of the disease through other avenues as well, including the use of oracles. Three main oracles, delivered from Caesarea Trocetta, Pergamum, and Callipolis, are documented from the period of the Antonine Plague, all acknowledging the presence of disease during that time (7). Archaeologists believe these oracles originated from the Antonine Plague; however, the conjecture is not

conclusive (7). The search for knowledge and guidance in times of disease demonstrates humanity's need to understand the cause of the phenomenon. In times of medical disasters, individuals seek answers, and while the forms through which they turn to varies over time, the human desire to rationalize the situation at hand continues (32).

The use of oracles is instrumental in understanding the actions and practices of the individuals living during this perilous time. The population referred to oracles as a source of information and assistance. During the COVID-19 pandemic in the United States of America, the public turned towards the media for guidance. For example, news outlets advised the public's use of gloves when in public locations in an attempt to protect oneself from the virus (33).

Individuals living through the Antonine Plague also responded to the pandemic through the use of amulets, appealing to the gods for help (30). Particularly archaeologists recovered one amulet in London that presents inscriptions referring to an oracle coming from the time of the Antonine Plague (30). Notably, the amulet refers to the god Apollo, believed to be the god of plagues and acknowledges a ban on kissing (30). Again, the amulets depict one of humanity's unique responses to severe disease during the second century CE.

The evidence from origin tales, oracles, and amulets demonstrates humanity's response to disease events with unique actions. Paralleled through instances of xenophobia, conspiracy theories, and surplus buying during the COVID-19 pandemic, the phenomenon of humanity's divergence from daily norms is highlighted (27-29). New practices, beliefs and fears become prevalent or are reinforced during times of pandemics. The phenomenon further demonstrates the continuity of general themes between the Antonine Plague and Covid-19 pandemic experiences.

Mobility and Population Changes Due to Disease

Another consistency prevalent between the pandemic experiences is the movement of individuals due to disease. This phenomenon is observed in the COVID-19 pandemic during the early stages of the pandemic through the temporary influx of individuals into rural areas and out of cities and closely populated communities (34). The migration phenomenon also occurred during the Antonine Plague and is known through the discovery of papyri holding evidence of individuals fleeing towns.

The recovery of carbonized papyri allows archaeologists and historians to identify population changes in small Egyptian villages (35). One recovered document specifically indicates that population decline

during the period was predominately caused by anachoresis (35). Notably, individuals may have fled villages to escape the Antonine Plague or the effects of disease, such as increasing tax burdens (35). Similarly, information found on one papyrus highlights, "...that villages which had formerly been populous were now reduced to a few men" (7). Previous studies highlight the plague as a likely cause for this population decline (7).

Human movement events initiated by pandemics contribute to modern knowledge of the human condition and relationship with disease. Factors such as high taxes may have caused the surge in movement (35). Particularly, the Antonine Plague may have stimulated the increase in the tax burdens upon these towns, leading farmers to abandon their farms (35). Through the evidence left by papyri, the deaths from the Antonine Plague are not the sole cause of the decline in communities (35). Additionally, prominent individuals fled cities during the Antonine Plague to escape disease. In particular, Galen, a highly regarded physician of the period, left Rome upon the arrival of the virulence in 166 CE (11). The privilege to leave as well as the fear the pestilence caused leading to flight are highlighted in this prominent figure's city escape.

During times of disease and distress human mobility alters. For the Antonine Plague, papyri records individuals leaving small Egyptian towns (35). However, the exact reason for the population's decline and move to other locations is unknown. A possible cause is the presence of disease and the desire to escape the sickness and death, preserving one's chances of survival. However, taxes that may have been affected by the Antonine Plague are another potential factor (35). Galen's flight from Rome upon the plague's initial arrival to the city similarly exhibits the pandemics impact on individuals and society (11).

Economic Effects of the Pandemic

Along with pandemic impacts on the mobilization of populations, significant effects on the economy are also observed. Not only does mass death and widespread illness result in a decrease in available labor, but the upheaval society experiences during disease also impacts the economic industries. During the COVID-19 pandemic a significant number of businesses closed, and many workers were laid off due to decreasing revenue (36, 37). Fulfilling rent payments was also an issue for many individuals during the pandemic (38). In an effort to combat the issue, the United States government released stimulus checks for eligible individuals (39). While there is some form of action by the government to help individuals economically suffering from the

pandemic event, many continued to struggle during a time of not only disease, but economic hardship as well.

Similarly, significant economic effects were also observed following the introduction of the Antonine Plague. Specifically, during the Antonine Plague, the shortage of labor particularly affected the mining industry. Some mines were deactivated between 170 and 180 CE, resulting in a significant decrease in the town surrounding the mine's population (11). The decrease in mining and alterations in the surrounding demographics may be a result of worker mortality and increasing costs of labor due to the Antonine Plague (11). Similarly, the decrease in population size due to high mortality from the Antonine Plague may have led to diminished demand for mining products (8).

Economic effects due to disease were felt in other sectors of the economy as well, including tree-felling (8). Archaeologists found that "The sharp decline in tree-felling during the main plague period suggests sudden change. It implies reduced building and construction activity in these regions, and possibly less demand for wood and charcoal" (8). During the period of the Antonine Plague, the prices in real rents experienced a decline (40). Similarly, according to records from the period, the price of nominal goods doubled (40). The rise in prices is notable in commodities, particularly wheat, and is theorized to be caused by the Antonine Plague (40).

Additionally, small wage increases may also have been present during and directly after the Antonine Plague. Wage increases were likely caused by the scarcity of labor due to the large mortality of the plague (40). Specifically, papyri sources indicate "...that losses to trade and technology were offset by the greater scarcity of labor..." (40).

Pandemics significantly impact the economy through multiple modes. Not only do societies experience economic impacts during the height of the pandemic, but also within the post-pandemic economy. In particular, the mining industry and tree-felling experienced declines due to loss of labor, decreased demands because of population decline and the migration of individuals from settlements centered around these forms of labor. Additionally, the cost of land and rents decreased, while price of commodities increased, as a likely result of the Antonine Plague. The resulting economic changes of the Antonine Plague, signal a relationship between disease and the economy, illustrating the importance of economic preparation for pandemic events. The macro-occurrence of economic effects of pandemics through micro variations in the mode which the economy is impacted develops the consistency of humanity's experience of pandemics throughout time.

Reemergence of Disease

When looking back on the history of disease, it is common to observe a reemergence of diseases (11, 41). This may occur due to a variety of conditions. The Antonine Plague is one such disease event which involved a reemergence of the pathogen after the initial wave of the pandemic. The historian, Cassius Dio records an event in 189 CE, regarded as another outbreak of the pestilence causing the Antonine Plague, stating that as many as two thousand people died daily in Rome (11). The resurgence of the pathogen illustrates the possible reemergence of the disease after the first phase of a pandemic, further providing insight into humanity's experience of pandemics.

The reemergence of the Antonine Plague in Rome during the period after the initial wave of the disease provides an ominous warning for modern pandemic populations, highlighting the importance of recognizing and preparing for pandemic resurgences. This facet of the disease experience is further illuminated by the resurgence of COVID-19 during the summer of 2021 and in 2022 (42, 43). Consequently, it is essential to consider the potential for future outbreaks and resurgences, with varying degrees of severity, as COVID-19 becomes a facet of 'normal' life.

Micro Experiences of Pandemics

Consistencies between pandemic experiences are illustrated through the archaeological analysis of the Antonine Plague and subsequent comparisons with the current COVID-19 pandemic, however, the phenomena demonstrated vary through the modes which they occur in each period. While generalized consistencies of the spread of infection, mass death and the breakdown of funerary practices, humanity's response to pandemics, mobility due to disease, economic effects of the pandemic, and reemergence of disease retain form throughout millennia, the particular mode through which individuals experience these pandemic phenomena vary. With the variance of time and place, cultural settings are constantly remodeled through the institutions and values present. Therefore, due to the differentiation between societal states during the Antonine Plague and COVID-19 pandemic, the individual pandemic experience on a micro scale is significantly diverse. The micro variance of pandemic experiences are the particular forms that each of the macro, or generalized experiences, occur through. Consequently, generalized pandemic preparation and protocol can occur through the knowledge of experiential themes from past pandemics, however, the details of the plans must be developed within a modern context,

recognizing the contemporary social and cultural institutions at large. The macro phenomena: spread of infection, mass death and the breakdown of funerary practices, humanity's response to pandemics, mobility due to disease, economic effects of the pandemic, and reemergence of disease, prevalent during the Antonine Plague, are paralleled within the modern COVID-19 pandemic experience, however, the mode which each society experiences the phenomena varies between the disease events.

Inferences

An archaeological analysis of the Antonine Plague demonstrates the continuity of humanity's experiences across time, particularly regarding pandemics. However, it also highlights the opportunity to utilize history to mitigate the effects of pandemics and other detrimental events. Understanding the macro phenomenon which occurs through micro variations exclusive to the culture of the period, provides experts with tools to develop programs to diminish the damaging impacts of future pandemics.

The general continuity of humanity's experience with disease two thousand years ago to the present, exhibited by a critical analysis of the Antonine Plague in the contemporary setting of the COVID-19 pandemic, highlights the value in incorporating archeological knowledge into the medical sector and disaster preparation departments. For example, through the knowledge that pandemics often lead to economic challenges, such as a decline in the tree felling industry during the Antonine Plague, at the start of a pandemic event government officials will have the insight to be hyper aware of potential industry crisis, for instance the restaurant industry during the COVID-19 pandemic (8, 44). With this increased awareness, officials can recognize and act on the initial signs of an industrial struggle and develop programs and economic assistance plans early on to prevent significant business closure, job loss, and economic strife. Additionally, insight that pandemics often involve reemergence events will encourage research to develop models predicting reemergence. Subsequently, such data can be employed by the government and medical sectors to effectively prepare for these periods.

Similarly, developing public knowledge of archaeology and popularizing the information it provides society proves valuable through its subsequent integration into multiple institutions. For example, genomic data from ancient pathogens is employed to advance knowledge surrounding modern pathogens and develop more effective treatments (45). Furthermore, archaeology provides long-term insight into climate

change and human resistance in a rapidly changing environment, and consequently, is immensely valuable to research investigating the current climate crisis (46). Advancing public interest in archaeology will further such interdisciplinary collaborations to generate knowledge about and solutions to modern challenges.

The archaeological analysis of the Antonine Plague provides unique insights into the pandemic that literary works on the period do not provide alone. Papyri, artifacts, grave sites and bones allow archaeologists to develop key insights into the pandemic, allowing them to make inferences of humanity's experiences of disease. Understanding the modes through which disease affected humanity in the past, provides the population with stronger tools to understand contemporary challenges, particularly the COVID-19 pandemic.

Additionally, this research demonstrates the need to popularize archaeology within the public sector and subsequently expand public knowledge of the field. Through increased public awareness of archaeological knowledge, archaeological expertise can be incorporated into various institutions to supplement modern perceptions with past experiences. As a result, institutions have the means to procure knowledge from past civilizations to promote growth and develop societies. It is imperative to recognize the lessons which archaeology offers humanity and utilize the knowledge to advance the state of human understanding, especially in the context of pandemics and other crisis, such as global warming. The increase of public knowledge and popularization of archaeology provides unique and valuable insights to humanity at large.

Conclusion

The experiences prevalent during the COVID-19 pandemic are not unique to humanity. In fact, the phenomena confronted through this disaster can be observed through COVID-19's strong resemblance to arguably the first pandemic experienced by humanity: the Antonine Plague. Despite the significant time frame which separates the two pandemics macro phenomena are observed across humanity's experience of these pandemics. Specifically, the spread of infection through travel and within tightly populated communities, mass death and the breakdown of burial practices, humanity's responses in times of stress and disease, migratory events, economic impacts, and disease reemergence. Not only do these phenomena highlight the continuity of humanity's disease experience, but they also illuminate the value the archaeology of disease provides modern society. Particularly, insight into how pandemics impact humanity, enables society to develop mitigative efforts to prevent and combat the pandemics' negative effects

on modern society.

Multiple phenomena, experienced by individuals during the Antonine Plague, occur throughout humanity's encounters with pandemics, as exhibited by the COVID-19 pandemic, through micro variations dependent upon the culture of the period. One such phenomena is the spread of infection. Through international travel, both modern and ancient societies become introduced to the pandemic causing pathogen (5, 12). Disease spread is also disproportionately dispersed within particular population sectors: including those in the army and enslaved during the Antonine Plague, both likely situated in close quarters with one another (5).

Similarly, through archaeological findings, the presence of mass death and breakdown of traditional funerary practices during times of pandemic becomes uniquely highlighted. Through an analysis of grave sites, bones, artifacts, records, and papyri, archaeologists gain insights into plague mortality and burial practices. During this period mass burials as well as communal burials indicate a period of significant hardship and large amounts of death, likely due to the Antonine Plague (22, 23). An archaeological analysis of ancient pandemics also develops insight into the human condition. Through analyzing past practices of origin stories, oracles, and amulets, individuals begin to understand the varying responses of humanity in times of strife.

The movement of individuals during the Antonine Plague also strongly parallels the COVID-19 pandemic and is a phenomenon consistent between pandemic experiences. Individuals living during the Antonine Plague appear to have fled towns in an attempt to escape disease (35). Similarly, the physician Galen attempted to flee the plague early on by returning to his home city (11). In this instance, archaeological information provides insights which can be used to predict shifts in population distribution during mass disease events.

Economies are also affected by disease. During the Antonine Plague, various industries, including mining and tree-felling declined and the land and rent prices decreased while the cost of commodities increased (8, 11, 40). As economic struggles are contingent with a global disaster, programs must be prepared to help combat the adversity the population will endure. While the specific economic effects of pandemics vary between events, such as which particular industrial sectors are affected, through an analysis of the economic phenomena supplemented through a modern evaluation of economic conditions and institutions, leaders have the tools to develop programs to mitigate the damaging economic effects of current and future pandemics. Lastly, the 189 CE reemergence of the Antonine Plague

displays the macro phenomena of disease resurgence within pandemics. This disease experience is further illuminated through resurgences of COVID-19 outbreaks and provides a distinct warning for modern civilization surrounding the possibility for additional outbreaks in the future (11, 42, 43).

This research highlights the continuity of humanity's pandemic experience through an analysis of the macrophenomena consistent between two pandemic events, separated by almost two-thousand years: the Antonine Plague and COVID-19 pandemic. Furthermore, the findings illuminate the value an archaeological analysis of pandemics provides society. Specifically, insight into disaster events and the impact of such events can be applied to develop more advanced tools and methods to mitigate the impacts of modern pandemics. Specifically, archaeological knowledge can be utilized to inform modern decisions as well as facilitate the integration of archaeological information into various societal institutions to solve contemporary issues.

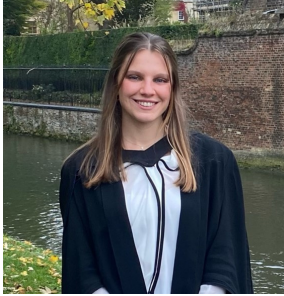
Archaeology acts as a unique avenue to develop society's understanding of humanity's prevalent pandemic condition. The information which archaeology provides modern society allows a unique perspective when preparing for future events. In working towards humanity's progress, the past provides extensive information to better the present condition. The insight which the archaeology of pandemics provides the medical field and societal institutions calls for further inquiry into the valuable knowledge archaeology offers the medical field and society at large.

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Author

Katya Sajovec

Katya M. Sajovec ('21) graduated from the Villanova University Honor's Program majoring in Comprehensive Science and Global Interdisciplinary Studies with a concentration in Cultural Studies. In 2024 she graduated from the University of Cambridge with a master's in Archaeological Science where she continued to pursue her interest in health and disease in the past and its application to contemporary challenges. Katya plans to pursue an M.D., Ph.D. to continue advancing her passion for health and improving the lives of others.



Mentor

Dr. Samer Abboud

Dr. Samer Abboud joined Villanova University in 2018. He is an Associate Professor of Global Interdisciplinary Studies in Villanova's College of Liberal Arts and Sciences. Abboud holds a PhD in Arab and Islamic Studies from the University of Exeter in England, as well as a MA and a BA in Political Science both from Carleton University. He is the author of three books—*Syria*, *Syria 2nd Edition*, and *Rethinking Hizballah: Authority, Legitimacy, Violence*. His research is broadly interested in warfare in Syria and the emergence of an illiberal post-conflict order in the country. Abboud sits on the Editorial Board of Security Dialogue and is a co-editor of Jadaliyya's Syria page.

