

Oracle: The History Journal of Boston College

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Volume III | Issue I

Article 3

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**As Seen From Space: Tele-Epidemiological Data as Pandemic Memory**

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## AS SEEN FROM SPACE:

### TELE-EPIDEMIOLOGICAL DATA AS PANDEMIC MEMORY

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**Abstract:** In the modern world, data is instrumental in historical storytelling. The magnitude of events, who they impacted, and the degree to which the events were managed are all, very often, told through the lens of data. The COVID-19 pandemic is a prime example of such data-driven history, where statistics on infections, death, vaccination, and average mobility are used to tell the story of how the pandemic unfolded in a given locale. While such statistical history is useful, it can also efface the histories of locations that lack access to the proper surveillance infrastructure, or are otherwise unable to deploy it. This produces an erasure of pandemic memory in healthcare-challenged areas, as deaths and infections go unrecorded and undocumented. This paper proposes the use of satellites to correct this, using Earth observation technologies to track viral vectors and find and document mass burial sites to produce a fuller picture of pandemic history, with an emphasis on filling the statistical gaps between the developed and developing world.

#### “I just didn’t want to talk about COVID anymore”

March 13, 2020—give or take a few days—is among the dates that will find themselves lodged in society’s memory for years, decades, or even centuries to come. Hordes of consumers flooded their local grocery and department stores, stockpiling toilet paper and milk. Food aisle shelves were emptied as frightened citizens, like vultures to an exposed carcass, picked them clean for all they were worth, leaving behind only the skeletal remains of their local grocery stores.<sup>2</sup> Students, first elated to learn of extended spring breaks as schools and universities grappled with how to approach the oncoming wave of coronavirus,<sup>3</sup> were quickly disabused of their

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<sup>2</sup> Grace Chua et al., “The Determinants of Panic Buying during COVID-19,” *International Journal of Environmental Research and Public Health* 18, no. 6 (March 2021): 1-2, DOI: 10.3390/ijerph18063247.

<sup>3</sup> Shannon Najmabadi and Naomi Andu, “Texas colleges and universities are going online because of coronavirus. Here’s what they’re doing,” *The Texas Tribune*, March 12, 2020, <https://www.texastribune.org/2020/03/11/texas-universities-extending-spring-break-prepare-coronavirus/>.

misconception that they were on a vacation when they were thrust into “Zoom University.”<sup>4</sup> Restaurants, movie theaters, and shopping centers were vacated and the streets of major population centers were left barren as people, on the advice of health officials, retreated into their homes.<sup>5</sup> Undoubtedly, the political consequences of the COVID-19 pandemic will be immortalized in official narratives: the coincident invigoration of popular social justice movements,<sup>6</sup> declining confidence in capitalism (or at least the current expression of capitalism),<sup>7</sup> and the rise and expansion of vaccine skepticism.<sup>8</sup> As I write this, the Omicron variant wave has subsided in the United States, but an increase in cases has epidemiologists worried about another possible wave of infections, this time driven by an Omicron subvariant called BA.2,<sup>9</sup> despite initial optimism that the highly infectious Omicron variant would have naturally immunized enough people to ward off another major wave.<sup>10</sup> Today, it seems impossible that any living adult or adolescent could possibly forget March 2020 or the pandemic-dominated years that would follow. But what if there comes a time where COVID-19, the very virus that has upended global life since March 2020, is forgotten—or, at the very least, rarely spoken about?

To insert a personal anecdote, at the onset of the pandemic, my family—cousins, aunts, uncles, siblings, parents, my grandmother—had frequent Zoom meetings. As an Italian-Catholic family, even so much as a few weeks apart was a foreign experience to us, and the emergent Zoom platform became the medium over which we were able to connect. The calls were regular during March and April of 2020, but had begun to taper by May, in both regularity, frequency, and attendance, before stopping altogether by June. Months later, when it was safer to hold in person gatherings again, my cousins and I reflected on the early days of the pandemic and reminisced about the Zoom calls. When discussing how the family gradually lost interest, my cousin quipped,

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<sup>4</sup> Natasha Mascharenhas, “Tired of ‘Zoom University’? So is edtech,” *TechCrunch*, February 18, 2021, <https://techcrunch.com/2021/02/18/edtech-zoom-university/>.

<sup>5</sup> Alan Taylor, “Photos: The Quiet Emptiness of a World Under Coronavirus,” *The Atlantic*, March 18, 2020, <https://www.theatlantic.com/photo/2020/03/photos-quiet-emptiness-under-coronavirus/608272/>.

<sup>6</sup> See generally Geoffrey Pleyers, “The Pandemic is a battlefield. Social movements in the COVID-19 lockdown,” *Journal of Civil Society* 16, no. 4, DOI: 10.1080/17448689.2020.1794398.

<sup>7</sup> See generally Albert L. Hsu et al., “Sources of Vaccine Hesitancy: Pregnancy, Infertility, Minority Concerns, and General Skepticism,” *Open Forum Infectious Diseases* 24, no. 2 (March 2021), DOI: 10.1177/1368430220981415.

<sup>8</sup> Albenaz Azmanova, “Viral Insurgencies: Can Capitalism Survive COVID?” *Theory and Event* 23, no. 4 (October 2020): S-101, <https://muse.jhu.edu/article/775405/pdf>.

<sup>9</sup> Tara Parker-Pope and Knvul Sheikh, “A New Wave of Covid-19 Is Coming. Here’s How to Prepare,” *The New York Times*, March 30, 2022, <https://www.nytimes.com/2022/03/30/well/live/ba2-omicron-covid.html>.

<sup>10</sup> Helen Branswell, “After Omicron, we could use a break. We may just get it,” *STAT*, January 19, 2022, <https://www.statnews.com/2022/01/19/after-omicron-we-could-use-a-break-we-may-just-get-it/>.

“I just didn’t want to talk about COVID anymore. It was all that we really talked about.” Unknowingly, he had touched upon an important area of historiographical concern central to the thesis of Guy Beiner and company’s *Pandemic Re-Awakenings*. History, after all, is recorded by humans, and what happens when humans do not want to or are not able to record what may be monumental phenomena of history?

## COVID-19 is Being Forgotten

### **Inequality in Data Collection:**

By the end of April 2020, amidst the first of many COVID-19 infection waves to come, those living in low-middle income and low-income countries purportedly constituted only three percent of the world’s COVID-19-related deaths, despite constituting half the world’s population.<sup>11</sup> Taken at face value, this data seemingly indicates that you could improve your chances at enduring the pandemic if you lived in the developing world, inverting expectations that the world’s developed nations, with more advanced public health infrastructure, were better prepared to face a pandemic than the world’s developing nations.<sup>12</sup> Some, sharing this interpretation of the data, celebrated that the developing world would likely be spared the worst of what COVID-19 had in store.<sup>13</sup> Others, however, were quick to point out a clear example of survivorship bias in the data: it was not the case that only three percent of global COVID-19-deaths had occurred in the developing world, but that only three percent of global *reported* COVID-19-related deaths had occurred in the developing world. The selection process, meaning the trial the data had to “survive” to be counted, required the country where the death occurred to have the capacity to register and document the death as COVID-19-related and then make this data accessible to the world. It was at these two points that the developing world’s COVID-19 data was lost, painting a picture of a pandemic worlds away from what was actually being experienced on

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<sup>11</sup> Philip Schellkens and Diego Sourrouille, “COVID-19 Mortality in Rich and Poor Countries: A Tale of Two Pandemics?,” World Bank Policy Research Worker Papers (May 2020): 3, <https://documents1.worldbank.org/curated/en/559181590712052524/pdf/COVID-19-Mortality-in-Rich-and-Poor-Countries-A-Tale-of-Two-Pandemics.pdf>.

<sup>12</sup> Felix Richter, “The Countries Best and Worst Prepared for a Pandemic,” Statista, December 9, 2021, <https://www.statista.com/chart/20629/ability-to-respond-to-an-epidemic-or-pandemic/>.

<sup>13</sup> Schellkens and Sourrouille, “COVID-19 Mortality,” 3.

the ground.<sup>14</sup> This disconnect can be thought of as a form of forgetting, because the stories of countries that lack the infrastructure to collect data on public health are being expunged from global narratives even as these same countries bore (and continue to bear) the pandemic's most severe consequences.<sup>15</sup> This expunging can be seen in journalists trumpeting the "three percent" statistic as a triumph of the developing world's evasion of an oncoming pandemic, rather than seeing the data for what it was: a reflection of the inequality between the developed and developing world's public health and data collection infrastructure. As a result, they have neglected to consider the negative impact this inequality will have on the ability to tell the story of the pandemic in the developing world.

The developing world's insufficient COVID-19 data collection can be attributed to a number of causes. Naturally, in order to ascertain whether a death had been caused by COVID-19, it would be necessary to first establish that a deceased patient had COVID-19. Even getting to this point, however, was often a challenge. The most reliable means of testing for COVID-19, recommended by the World Health Organization (WHO), is through reverse transcription polymerase chain reaction tests, or RT-PCR tests. Such tests, however, require RNA extraction kits, expensive RT-PCR machines, and trained technicians to operate them—physical and human capital frequently deficient in low-income states.<sup>16</sup> Capacity building to augment national tracking infrastructure would further prove to be difficult amidst the onset of the COVID-19 pandemic, as the resources and human capital necessary to do so were dedicated to mitigating the much more felt and present threat of known COVID-19 infections as well as by serious medical emergencies,<sup>17</sup> since the COVID-19-centric health infrastructure in much of the developing world was intertwined with non-COVID-19 health infrastructure.<sup>18</sup> Dedicating scarce medical capital to fighting COVID-19 often meant draining resources from treating survivors of heart attacks or victims of automobile accidents, patients which were often less likely to survive without treatment than COVID-19

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<sup>14</sup> Schellkens and Sourrouille, "COVID-19 Mortality," 21-22: It is worthy of note that authors of this article state that there may be reasons to believe that mortality rates in the developing world are indeed lower than that in the developed world. More information on this can be found in Schellkens and Sourrouille's article.

<sup>15</sup> See generally Nicolas Botton, Bridget Hoffmann, and Diego A. Vera-Cossio, "The Unequal Impact of the Coronavirus Pandemic: Evidence from Seventeen Developing Countries," IBD Working Paper Series (August 2020): DOI: 10.18235/0002451.

<sup>16</sup> Anil K. Giri and Divya RSJB Rana, "Charting the challenges behind the testing of COVID-19 in developing countries: Nepal as a case study," *Biosafety and Health* 2 (2020): 53, DOI: 10.1016/j.bsheal.2020.05.002.

<sup>17</sup> Giri and Rana, "Charting the challenges," 53.

<sup>18</sup> Sansone Pasquale et al., "COVID-19 in Low- and Middle-Income Countries (LMICs): A Narrative Review from Prevention to Vaccination Strategy," *Vaccines* 9, no. 1477 (2021): 5, DOI: 10.3390/vaccines9121477.

patients.<sup>19</sup> Thus, the three percent statistic was not a cause for optimism, but rather a reflection of how poor tracking and data collection infrastructure can produce distorted statistics, expunging the most severely impacted populations from political and historical epidemiological narratives.

Although the developing world faced testing access challenges greater than the developed world, testing access also posed a serious issue in many high-income countries. In the United States, for instance, those living in rural communities, counties with greater uninsured populations, counties with greater populations of color, and/or counties with lower median incomes faced difficulty in accessing testing sites.<sup>20</sup> The inequalities that come with rural living are felt to a unique extent amongst Indigenous communities in the United States, who often reside in geographically isolated regions. These communities frequently lack access to both adequate healthcare and broadband Internet, which in turn inhibits the ability of Indigenous populations to locate and access COVID-19-testing.<sup>21</sup> These findings have raised the justified concern that this inadequate testing capacity would produce biased estimates of infection amongst low-income, uninsured, and rural individuals, as well as people of color in the United States.<sup>22</sup> In a perverse, self-replicating cycle, disparities in data collection beget even further disparities, as inadequate data on infection and death rates among communities with low testing access means that the conditions that have amplified these mortality rates among poor individuals, people of color, and those living in rural communities cannot be adequately studied, allowing the disparities to remain in place, unchecked.<sup>23</sup>

### **Impacts of Inadequate Pandemic Surveillance:**

The impact of inadequate pandemic surveillance is both historiographical and political, and in many ways a combination of the two. When people do not collect accurate COVID-19 data, it erases the stories of the communities who suffered. This is not to say that every individual who

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<sup>19</sup> Giri and Rana, “Charting the challenges,” 54.

<sup>20</sup> Benjamin Rader et al., “Geographic access to United States SARS-CoV-2 testing sites highlights healthcare disparities and may bias transmission estimates,” *Journal of Travel Medicine* 27, no. 7 (October 2020): 2-3, DOI: 10.1093/jtm/taaa076.

<sup>21</sup> Ahmed Goha et al., “Indigenous people and the COVID-19 pandemic: the tip of an iceberg of social and economic inequities,” *Journal of Epidemiological Community Health* 75, no. 2 (February 2021): 207, DOI: 10.1136/jech-2020-214755.

<sup>22</sup> Rader, et. al., “Geographic access to United States,” 1–3.

<sup>23</sup> Kelly Servick, “‘Huge hole’ in COVID-19 testing data makes it harder to study racial disparities,” *Science*, July 10, 2020, <https://www.science.org/content/article/huge-hole-covid-19-testing-data-makes-it-harder-study-racial-disparities>.

contracted and suffered from COVID-19 will be named in future history textbooks; rather, the significance of this erasure focuses less on individuals, and more on the broader communities whose history has been eroded. The plurality of reported data on COVID-19 infections and deaths in the United States covers relatively wealthy individuals from urban or suburban areas with access to health insurance. On a global scale, most reported data comes from high-income nations with robust national diagnostic apparatuses. Yet, it is these same people—those from developed nations, with reliable access to testing centers and quality health services, and with appreciable disposable income—that have been affected the least by the COVID-19 pandemic. The stories of the privileged are, by no means, less worthy of being told, but memorializing the plight of the privileged as the dominant historical narrative of the COVID-19 pandemic would be to ignore the unique (and more severe) experiences of the underprivileged. Both stories are worth telling, but the data today only tells one. Similarly, the impact of inadequate pandemic testing is political in that this testing deficiency makes it difficult to identify hotspots of disease,<sup>24</sup> quickly isolate infected individuals,<sup>25</sup> and make appropriate public health decisions based on accurate and up-to-date infection information.<sup>26</sup> Without these capabilities, it enables the further spread of infectious disease. It has yet to be seen whether COVID-19 will finally alert the world to the importance of robust surveillance capabilities and spur global action to enhance international diagnostic capabilities, particularly amidst innovative strides in the Internet of things, tele-medicine, and the like that, theoretically, should make a robust surveillance regime possible.

At the intersection of the political and the historiographical is the way in which public health planners often refer back to previous crises and the organized response to ascertain what was and was not effective at curtailing the unfolding crisis.<sup>27</sup> When the historical narrative is incomplete, however, this generates a similarly incomplete understanding of what public health measures were effective. This feedback loop may, in turn, inform poor policy. If too much of the

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<sup>24</sup> Hayden Dahmm, “In Low-Income Countries Fundamental Data Issues Remain for COVID-19 Response,” April 17, 2020, <https://www.sdsntrends.org/blog/covid19andlowincome-countries?locale=en>.

<sup>25</sup> “UN/DESA Policy Brief #66: COVID-19 and the least developed countries,” United Nations Department of Economic and Social Affairs, May 1, 2020, <https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-66-covid-19-and-the-least-developed-countries/>.

<sup>26</sup> Irene Torres, Rachel Sippy, and Fernando Sacoto, “Assessing critical gaps in COVID-19 testing capacity: the case of delayed results in Ecuador,” *BMC Public Health* 21, no. 637 (2021): 7, DOI: 10.1186/s12889-021-10715-x.

<sup>27</sup> Stanley M. Lemon et al., “Overview” in *Ethical and Legal Considerations in Mitigating Pandemic Disease: Workshop Study* (2007): 31-33, ISBN: 0-309-10770-9.

available data on COVID-19 centers on the wealthy and privileged within the developed world, then the available data will illustrate a hyperreal version of history where governments were far more successful at confronting the COVID-19 threat than they really were and may erroneously convince officials to pursue similar strategies, to the detriment of the communities that have found themselves similarly neglected by government and public authorities over these past few years. Historiographical concerns are not purely academic when a “past as prologue” approach is taken in devising policy for present and future threats.

### **You Can’t Talk to Birds:**

Among the myriad of concerns unearthed by a tumultuous few years of pandemic life is that diagnostic and tracking capacity was and continues to be insufficient to face pandemic-level threats. As *Nature* writer Amy Maxemn eerily put it, despite the decades of research and millions of dollars invested in devising pandemic preparedness protocols and guidelines, “COVID-19 has demonstrated that the world was even less prepared [for a global pandemic] than most had imagined.”<sup>28</sup> A significant reason for COVID-19’s startling reality check was that, like most diseases, its spread significantly predated the first surveillance efforts. It is now generally agreed that COVID-19 had been spreading for several weeks before officials reported a mysterious pneumonia-like virus proliferating across Wuhan, and months before the world truly understood the gravity of the emergent pathogen.<sup>29</sup> In even the small handful of weeks where disease is able to spread unchecked, highly infectious viruses like COVID-19 can make gains that are difficult to counter, particularly as the virus spreads across territory.<sup>30</sup> This, unfortunately, is the normal course of events with diseases. By the time an emergent disease becomes an item of interest among governments, it often has had the opportunity to spread far and wide, putting governments squarely on the defense against a pathogen-at-large.<sup>31</sup> Thus, it would appear that human infection may be a sub-optimal means of tracking a virus, given that it requires the potentially infectious and virulent pathogen to cause damage before trackers can be made aware of its mere presence in human hosts.

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<sup>28</sup> Amy Maxmen, “Has COVID taught us anything about pandemic preparedness?,” *Nature*, August 13, 2021, <https://www.nature.com/articles/d41586-021-02217-y>.

<sup>29</sup> Maxmen, “Has COVID taught us anything.”

<sup>30</sup> Maxmen, “Has COVID taught us anything.”

<sup>31</sup> Maxmen, “Has COVID taught us anything.”



This poses an interesting historiographical question: why are humans at the center of epidemiological histories to begin with? Humans, of course, must be included in the narrative in some capacity, as diseases have been defining experiences of human civilization for millennia. But viruses are not spontaneous phenomena engineered to afflict humans. Assuming that one of the foremost reasons to study history is to learn from the past, then beginning the story of a virus at the time it first afflicts a human tells a truncated, anthropocentric history. This results in a forgetting (if it was known to begin with) of the pre-human history of viruses—and, unfortunately, you can't talk to birds or any of the other common vectors of illness. Once again, the significance of this point is not purely academic. I previously listed a number of social and political consequences brought on by the ongoing COVID-19 pandemic, each of which demonstrates the capacity of viruses (and bacteria) to direct the course of history. Do these consequences not merit investigating? So that we may learn where these diseases come from and how we may avoid replicating the same mistakes in the future and unleashing yet another deadly pathogen into our world. A number of researchers have advocated for focusing surveillance on people based on their daily environments. Most emergent diseases are zoonotic in origin, leading some epidemiologists to argue for the enhanced tracking of those who work in forests or on farms, where they may come into contact with animals who may very well be hosting the world's next supervirus.<sup>32</sup> For the same reason, it is prudent to study the history of viruses, not simply pandemics. If the public was as conscious of the history behind viral emergence as it was about the consequences of viral emergence, perhaps it would spur demand for a public health regime that was proactive and operated on the offensive, extinguishing viruses before they left the barnyard, rather than reacting defensively once the virus has found a human host. Additionally, shifting the focus away from people helps ameliorate the survivorship biases that haunt pandemic studies.

### **What if You Could See Everything?**

#### **Following the Virus:**

Luckily, an emerging technique of epidemiological study has made it possible to both correct the international inequities in virus surveillance and study the histories of the virus themselves. This is the technique of tele-epidemiology. Tele-epidemiology functions by making

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<sup>32</sup> Maxmen, "Has COVID taught us anything."

use of a variety of scientific instruments and functions available to satellites, and using them to predict the movement of potential vectors, including animals, humans, insects, and bacteria, to generate a geographic model of a viruses' predicted dispersion. This model can be helpful in identifying areas particularly vulnerable to infection.<sup>33</sup> While each individual vector cannot, themselves, be monitored by satellites, a number of serious vector-borne diseases are heavily influenced by environmental conditions, namely by virtue of their influence over the movement of the vectors themselves.<sup>34</sup> If the species host of a particular virus is known, however, then individual vectors can be tracked using Earth Observation (EO) technology. Using EO technology has yielded promising results for the use of tele-epidemiology to track disease spread as a function of vector movement.<sup>35</sup> These methods of geospatial viral detection can thus be used to construct useful models of viral dispersion, providing direction to terrestrial researchers for on-the-ground verification and assisting public officials in identifying emerging epicenters of infection.

From a historiographical point of view, tele-epidemiology can assist researchers in representing the pandemic experiences of those commonly excluded from historical narratives. While EO and tele-epidemiology do not lend themselves to oral histories like those featured in *Pandemic Re-Awakenings*, these technologies do allow historical researchers to overcome hurdles related to data inequality in historical storytelling by providing a means of measuring the impact of pandemics on civilian populations independent of the robust national tracking infrastructure that many developing states lack. Additionally, with the newly-obtained knowledge regarding the locations of under-treated hotspots, medical planners of the future will be able to build a pandemic response that aims to correct these inequities. The value in tele-epidemiology is its usefulness in tracking what is not visible to eyes on the ground and constructing a narrative that emphasizes the role of viruses in pandemics, so that we may not only understand the true nature of pandemics, but also so that we may create a more inclusive narrative of a virus' human impact.

### **Unearthing the Past—Literally:**

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<sup>33</sup> Stephanie Brazeau et al., "Tele-Epidemiology: Advancing the Application of Earth Observation to Public Health Issues in Canada," *IEEE Earthzine*, May 2, 2014, <https://earthzine.org/tele-epidemiology-advancing-the-application-of-earth-observation-to-public-health-issues-in-canada/>.

<sup>34</sup> Stephanie Brazeau et al., "Tele-Epidemiology and Public Health in the Canadian Context," *Living Planet Symposium* (9–13 May 2016): 2, <https://articles.adsabs.harvard.edu/pdf/2016ESASP.740E...7B>.

<sup>35</sup> Marius Gilbert et al., "Flying Over an Infected Landscape: Distribution of Highly Pathogenic Avian Influenza H5N1 Risk in South Asia and Satellite Tracking of Wild Waterfowl," *Ecohealth* 7 (2010): 455-456, DOI: 10.1007/s10393-010-0672-810.1007/ s10393-010-0672-8.

Not only is the history of COVID-19 actively being forgotten, it is being covered up. Amidst the overwhelming death toll and immense stress placed on public health infrastructure, a number of localities have resorted to storing the dead in mass graves. The deaths accumulated so quickly that it was impossible to truly attend to the dead. And while this challenge was particularly felt in remote areas, where medical staff and supplies were limited, it was not felt exclusively by the isolated and under-resourced.<sup>36</sup> Hart Island, located near the Bronx in New York City, was used as a mass grave for the city's dead whose families could not be identified. In the early days of the pandemic, a spokesperson for New York City's Department of Corrections stated that burials on the island increased five-fold following the arrival of COVID-19 to the United States, with two additional trenches needing to be dug.<sup>37</sup> Crises of public health have long driven civilizations to resort to mass graves to put to rest the ever-increasing number of casualties. In 2015, Pennsylvania construction workers accidentally unearthed what is believed to be a mass grave dug during the 1918 flu pandemic which, much like COVID-19, struck the population with disorienting force.<sup>38</sup> The recent ebola epidemics in Africa had a similar effect, leaving a network of mass graves littered across the impacted sites.<sup>39</sup>

While mass graves are often an expression of desperation by societies ravaged by death, they also represent yet another form of forgetting and historical erasure. Individuals buried in unmarked mass graves necessarily have their stories erased. There is no official commemoration of their deaths and, by extension, no documentation of the public health crisis that caused them. In a vein similar to disparities in data collection, mass graves are more common amongst communities lacking adequate public health infrastructure, such as remote, healthcare-challenged

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<sup>36</sup> Jason Beaubien, "A mass COVID grave in Peru has left families bereft – and fighting for reburial," NPR, December 4, 2021, <https://www.npr.org/sections/goatsandsoda/2021/12/04/1060167105/a-mass-covid-grave-in-peru-has-left-families-bereft-and-fighting-for-reburial>.

<sup>37</sup> Meg Anderson, "Burials On New York Island Are Not New, But Are increasing During Pandemic," NPR, April 10, 2020, <https://www.npr.org/sections/coronavirus-live-updates/2020/04/10/831875297/burials-on-new-york-island-are-not-new-but-are-increasing-during-pandemic>.

<sup>38</sup> Danny Lewis, "Human Bones Found Near Pennsylvania Highway Could Be From the 1918 Flu," August 20, 2015, *Smithsonian Magazine*, <https://www.smithsonianmag.com/smart-news/human-bones-found-near-pennsylvania-highway-could-be-1918-flu-pandemic-180956344/>.

<sup>39</sup> Rebecca Ratcliffe, "Grief etched in stone: Sierra Leone finally lays Ebola to rest - in pictures," April 18, 2017, *The Guardian*, <https://www.theguardian.com/global-development/gallery/2017/apr/18/grief-etched-in-stone-sierra-leone-finally-lays-ebola-to-rest-in-pictures>.

areas,<sup>40</sup> or those that lack the resources to afford a proper burial, such as on Hart Island.<sup>41</sup> Just as is the case of data collection, inadequate burials and the consequent erasure of pieces of pandemic history most prominently affect already-marginalized communities, and shift the focus of pandemic historical study away from those most severely impacted.

EO technology, however, can assist in rectifying this disparity in two ways. The first way is through standard satellite imagery: photographing instances of mass burial. Aerial footage has been useful in publicizing efforts by a number of countries, such as Iran<sup>42</sup> and Indonesia,<sup>43</sup> to dig mass graves. More advanced forms of EO, known as “remote sensing,” have also been shown to be effective at locating concealed mass graves invisible to conventional aerial photography. Among these remote-sensing techniques are ground-penetrating radars (GPR) and electrical Earth resistance, both of which are able to identify abnormal formations and structures beneath the surface, such as mass burials.<sup>44</sup> Another method available is the analysis of “crop marks”—gradients in vegetative health induced by the presence of buried masses that prevent crop roots from penetrating into the soil.<sup>45</sup> Thus, while much history may be lost by the time the mass grave has been filled in, the discovery of these sites can still help establish a just historical record, documenting mass burials and accounting for those who had their memories and stories effaced under the pressure of a pandemic. When employed in real time, EO researchers are able to make predictions on mortality within countries by analyzing mass grave activity. In Yemen, for example, researchers used satellite imagery of mass burial activity to contradict government-reported mortality statistics.<sup>46</sup> In this way, satellites can, within a small time frame, establish a more accurate statistical record of a pandemic’s impact against currents of both intentional and

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<sup>40</sup> Beaubien, “A mass COVID.”

<sup>41</sup> Sarah Goodyear, “If You Die Poor or Alone in New York City, You’ll Be Buried by Prisoners in a Mass Grave,” March 31, 2015, *The Nation*, <https://www.thenation.com/article/archive/there-progressive-way-bury-lonely-poor-huddled-masses/>.

<sup>42</sup> Eric Cunningham and Dalton Bennett, “Coronavirus burial pits so vast they’re visible from space,” March 12, 2020, *The Washington Post*, <https://www.washingtonpost.com/graphics/2020/world/iran-coronavirus-outbreak-graves/>.

<sup>43</sup> Kate Lamb and Stanley Widianto, “Aerial images of expanding graves capture Indonesia’s deadliest days,” July 8, 2021, *Reuters*, <https://www.reuters.com/world/asia-pacific/aerial-images-expanding-graves-capture-indonesias-deadliest-days-2021-07-08/>.

<sup>44</sup> Soren Blau et al., “Exploring non-invasive approaches to assist in the detection of clandestine human burials: developing a way forward,” *Forensic Sciences Research* 3, no. 4 (2018): 307, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6374940/pdf/tfsr-3-1493809.pdf>.

<sup>45</sup> Blau, et. al., “Exploring non-invasive,” 305.

<sup>46</sup> Emilie S. Koum Besson et al., “Excess mortality during the COVID-19 pandemic: a geospatial and statistical analysis in Aden governorate, Yemen,” *British Medical Journal Global Health* 6, no. 3 (2021): 6-8, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7992372/pdf/bmjgh-2020-004564.pdf>.

unintentional revisionism. In both of these ways, satellites can be used to rectify instances of historical amnesia and establish a more accurate—and more just—record of pandemics past.

### **Conclusion**

Tales of pandemics constitute, in large part, a central thread in the wider story of humanity. History has been shaped by illnesses, but as the historical record of these periods becomes enmeshed with sophisticated medical tracking technology, we run a greater risk of marginalizing those living in areas or conditions that do not afford them access to such infrastructure. Being born into such circumstances often means that these individuals find themselves beyond the scope of historical study. Pandemics thus become a story of the more privileged: those with access to healthcare or those living in areas with a more robust public health infrastructure, those able to pay for proper burial, and so on. Such injustices, however, can be (at least partially) ameliorated if we turn to the sky, and take in an aerial view of what we miss with our terrestrial eyes.

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