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Research Article

Disease Dynamics, Communication, Anxiety, and Public Response: Lessons for and from COVID-19

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Abstract

Background: The novel coronavirus has emerged as one of the deadliest diseases of the 21st century. This essay explores the roles that information sharing, public health messages, and emotional and behavioral responses of the general public play in outbreaks like coronavirus disease 2019.

Materials and Methods: This paper endeavors to present a creative and multifaceted discussion of the role of public anxiety during outbreaks, and to raise important questions about how outbreaks like this one are addressed not only on a policy level, but on a social level. The resources utilized to formulate this discussion include published medical and psychological research, national and international specialized public health agency publications, and articles and communications from various news agencies and periodicals.

Results: Public anxiety varies in response to how significant or personal a threat is perceived to be, as does the inclination to adopt protective behaviors. As perception of threat declines, it is vital to keep the public interested and to actively promote health-protective behaviors.

Conclusion: Public anxiety or even panic may not be avoidable, but it can be mitigated by early, frequent, clear and consistent communications by public health officials, as well as by efforts to interact with the public on their own preferred platforms.

Keywords: Communication; Community health; Coronavirus; COVID-19; Pandemic; Social media

Abbreviations: SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus-2; COVID-19: Coronavirus Disease 2019; WHO: World Health Organization; PUI: Person under Investigation; USA: United States of America; HCWs: Healthcare Workers; MMR: Measles, Mumps and Rubella; SARS: Severe Acute Respiratory Syndrome; MERS: Middle East Respiratory Syndrome; PPE: Personal Protective Equipment

Background

December 2019 ushered into China a cluster of cases of pneumonia that was initially thought to originate from a live animal market [1]. On January 7, 2020, severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was identified as the causative agent of coronavirus disease 2019 (COVID-19). By the end of January 2020, the World Health Organization (WHO) declared the COVID-19 outbreak to be a Public Health Emergency of International Concern [1]. As with previous outbreaks, the emergence and global spread of COVID-19 forced health officials to contemplate the range of scenarios that could result as the affected population grows. This led to early recommendations for travel restrictions, increased hand hygiene, and quarantine of infected persons and Persons Under Investigation (PUI) [1], and later expanded to include international travel bans, closure of schools, and shutdown of restaurants and other businesses. As infection spreads, so does the public's fear and desire for information, instruction and protection, raising important questions about how outbreaks like this one are addressed not only on a policy level, but on a social level. COVID-19 is only one of many outbreaks, making it all-the-more important to understand the roles that information sharing, public health messages, and the general public's emotional and behavioral responses play in outbreaks. How were these issues dealt with in previous outbreaks, and were efforts successful? Are there lessons we've missed that

are still applicable, and, if so, what can be done differently in the future?

Public Anxiety: Understanding and Addressing Risk and Reaction

On March 23, 2014, the WHO declared an outbreak of Ebola in West Africa, resulting in more than 11,000 deaths [2-4]. As patients were transported to the United States of America (USA) and Europe for treatment, the media overplayed the potential for an Ebola pandemic, resulting in panic and paranoia [3,5]. Journalists who traveled to affected regions were barred from attending events, and Healthcare Workers (HCWs) who cared for Ebola patients were treated as potentially infected and were either monitored by public health officials, or encouraged/mandated to self-quarantine even without evidence of disease [2,5-7]. Such reactions suggest the public tends to misjudge threats to health, perceiving a higher risk than actually exists [3].

Unlike the predominantly geographically-limited Ebola outbreak, the influenza virus circulates globally and annually, with new strains evoking feelings of both novelty and familiarity. H1N1, or "swine flu," is an influenza A virus that spreads rapidly via droplet and fomite transmission [8]. The WHO declared the 2009 outbreak a global pandemic in June of that year [9]. By the end of the month, the CDC estimated at least 1 million people had been infected in the USA, and by early September at least 477 had died [10]. In the absence of a vaccine, the public was encouraged to adopt preventative behaviors (hygiene, social distancing) [11]. In the years following the H1N1 pandemic, a number of studies evaluated public feelings about and responses to the virus. Although results are somewhat mixed, most suggest the public tends to adopt certain protective behaviors even when the perceived risk of infection, or risk to overall health in the setting of infection, is low [12-15]. This is consistent with the assertion by Goodwin et al. that increased concern for self and family wellbeing predicts a greater willingness to prepare (i.e. buy face masks) and a lesser willingness to travel via airplane or public transit [8].

Using mathematical modeling, Fast et al. evaluated how the spread of disease influences social responses [16]. The authors noted discrepancies between perceived risk and actual risk of infection [16]. While one might expect social response to be proportional to overall disease burden (i.e. that low probability, high severity diseases and high probability, low severity diseases will elicit little social response), the authors noted that the high probability, low severity diseases tend to elicit low or no response while high severity, low probability disease elicit significant response [16]. The authors point out that part of this response can be attributed to the media, which plays a role in influencing the population when novelty and severity are high, even if disease incidence is low [16]. This was demonstrated by the responses of the media and the public, to the Ebola outbreak. While COVID-19 is novel and considered high severity, unlike Ebola it demonstrates high probability more akin to the flu, a feature that contributed to early public anxiety.

Early reports of high mortality rates from COVID-19, combined with its high incidence, also led some high profile figures (with the media soon to follow) to draw comparison to the 1918 influenza pandemic (the "Spanish flu") which infected 500 million and killed 50 million worldwide over the course of only one year [10,17]. Research suggests that "risk events are rarely recognized and thought of separately from their historical and cultural context [11] ". This often leads laypeople to attribute features of a previous event to a new one even though such attributions may not be accurate or relevant [11]. For example, deaths in 1918 influenza largely attributable to secondary bacterial pneumonia at a time when there were no antibiotics, whereas at this time there is an arsenal of agents available for use in such a setting. For almost a year after it emerged, COVID-19-like the 1918 influenza at the time-also lacked effective treatment, but for different reasons: while COVID-19 can indeed cause severe pneumonia, it tends to occur as a direct consequence of the virus rather than from secondary bacterial infection, which is an important distinction [18]. Given prevention tends to be preferable to treatment, the COVID-19 virus requires a vaccine.

Vaccination: Expectation versus Reality

As 2020 came to a close, several vaccines against COVID-19 became available for administration to HCWs and those considered high-risk. As availability increases, however, it remains unclear how many will ultimately refuse to receive it. Over the course of the H1N1 pandemic Lin, et al. found that perceived risk of infection in China appeared to decline, as did the likelihood of the public to engage in preventative practices [14]. Furthermore, throughout the study, reported immunization rates in respondents were 10.8% at most [14]. This suggests that most preventative practices adopted by the public are more "immediate" in nature, demonstrating preference for quick, temporary fixes over more long-term solutions (i.e. vaccination)-but why? Research suggests that perceived susceptibility to and severity of a disease, in conjunction with perceived barriers to and benefits of an action, determine whether people will ultimately take action [8]. If this is true, historically low vaccination rates suggest that perceived barriers typically outweigh perceived benefits of vaccination.

Once an H1N1 vaccine became available the French government ordered enough doses that 75% of the population could receive two; however, only ~9% of the population accepted the vaccine by January 2010 [11]. While several authors argued that the pandemic triggered public panic, the few studies that collected longitudinal data over that period demonstrated only a moderate level of fear or anxiety among the public [11], consistent with other studies performed at the time [12-15]. The authors point out that "the failure or success of any prevention program is ultimately determined by how the public thinks about and evaluates health threats, as well as the effectiveness of mitigating measures promoted by the health authorities" [11]. Research on

risk perception reveals that some risks tend to be perceived as more acceptable (such as those naturally occurring, being familiar, having clear benefits, or involving choice) while others are perceived as less acceptable (being imposed, having intangible or deferred benefits, appearing new or exotic, or being human-made) [19]. The aforementioned findings, however, suggest even further hierarchy among these factors. Although the medical community recognizes vaccination's demonstrable benefits, laypeople may not perceive these benefits, or they may perceive them as intangible or deferred. Any perceived benefit, in fact, may be outweighed by perceived risk associated with vaccines being human-made. Familiarity with influenza-even in the presence of novel strains-may also lead disease to be a more acceptable risk than vaccination.

The goal of "herd immunity" is "reduction of infection or disease in the unimmunised segment as a result of immunising a proportion of the population" [20]. When an immunization program is initiated, the incidence of the target disease in the unimmunized proportion is expected to decrease. Although the exact number varies depending on the vaccine, a relatively high percentage of people need to be vaccinated to establish herd immunity. In the USA, current guidelines for 2020 call for an annual vaccination goal of 70% in noninstitutionalized adults aged 18 and older and 90% in healthcare personnel for seasonal influenza [21]. Despite this, the USA Centers for Disease Control and Prevention (CDC) data reflect the fact that neither of these goals are being met, nor have they been met for years [Figure 1A] [10]. Only approximately 50% of the American public receive the vaccine and annual deaths number in the tens of thousands [Figure 1B] [10].

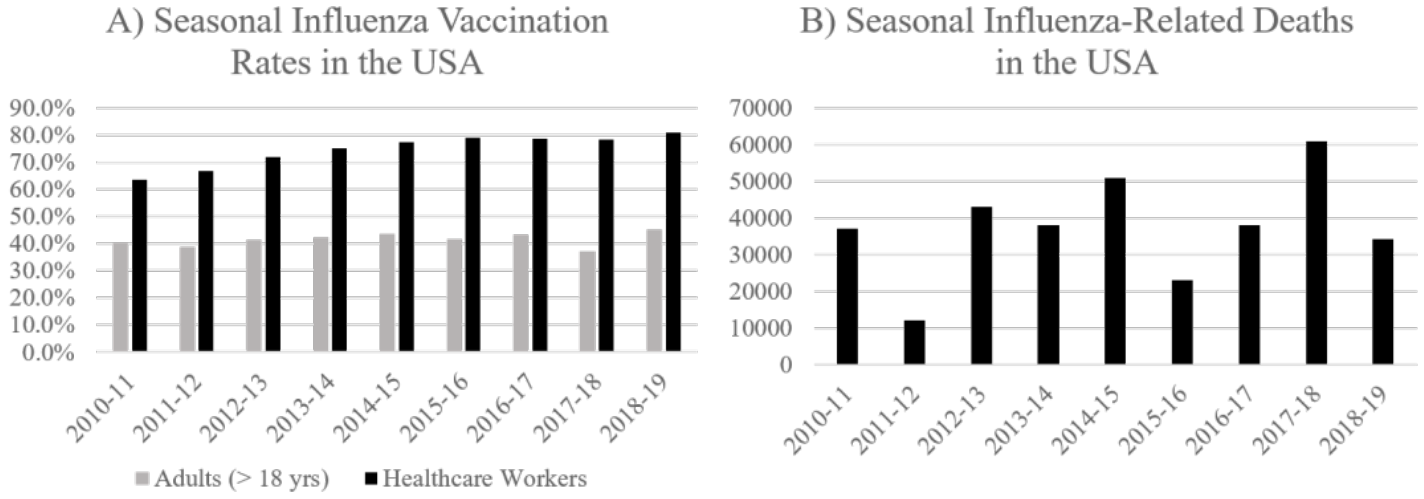

Figure 1: Data from the CDC[10] demonstrating: A) yearly death tolls in the USA from seasonal influenza; and B) seasonal influenza vaccination data for adults and healthcare workers in the USA.

Less than ideal vaccination rates are not limited to seasonal influenza. Prior to vaccine development in 1963, measles caused more than 20 million deaths each year worldwide, with 3 to 4 million cases of measles, ~50,000 hospitalizations, 1,0000 cases of measles encephalitis, and several hundred deaths annually in the USA alone [22,23]. Even with a vaccine, measles killed more than 140,000 people-mostly children-globally in 2018 [22]. While only two doses of the measles, mumps and rubella (MMR) vaccine are 97% effective at conferring immunity, recent anti-vaccination propaganda and vaccine-related anxiety have led to vaccination refusal and an increase in measles cases in the USA from 37 cases in 2004 to 1282 cases in 2019 [23,24].

Overall, research suggests that-whether COVID-19 peaks and declines or becomes a pervasive seasonal viral infection like influenza-public attention is likely to diminish, either because the perceived threat declines along with incidence or because the public learns more about the illness and grows accustomed to its presence. As perceived risk declines, interest in prevention/treatment and preventative behaviors also declines (a phenomenon already witnessed in the USA within the first few months of the pandemic in the form of anti-mask and anti-quarantine sentiment), severely affecting vaccine development and utilization, a supply-and-demand process like any other. Less fear of the pathogen and its potential risk leads to a decline in sentiments regarding vaccination necessity. This, combined with increasing apprehension of potential vaccine side-effects, will inevitably draw people-at one point desperate for infection prevention-away from being vaccinated. There have already been several cases of disease re-emergence that appear to primarily be due to the public's own beliefs and behaviors, including and certainly not limited to the rise of measles in the setting of anti-vaccination sentiments and low vaccination rates in certain communities [22]. When fear of

a vaccine outweighs the fear of illness, a population pre-disposes itself to future outbreaks.

Fashion Trends in Science and Medicine

Decline in perceived risk and subsequent loss of interest is not an issue limited to laypeople. Evaluation of publication rates on certain topics over time suggests the scientific and medical communities fall prey to similar patterns. After September 11, 2001, concern for potential weaponization of smallpox prompted the American government to reinstate smallpox vaccination for military personnel and certain HCWs [25,26]. In response, academic interest in the vaccine also re-emerged and spiked around 2003, but declined again shortly thereafter [Figure 2].

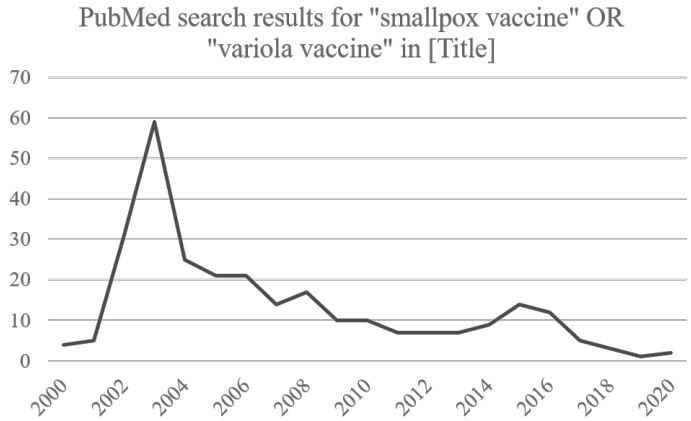

Figure 2: PubMed results from search targeting articles on smallpox/variola vaccine.

Prior to COVID-19, two other coronaviruses made international headlines: severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS). The SARS virus originated in China in 2002 and was short-lived: by 2004, it was declared finished, but not before causing 916 deaths among 8,422 probable cases across 29 countries [27,28]. After the outbreak, SARS-like viruses found in bats were found to infect human cells without adaptation 29). This demonstrated coronaviruses' ability to cross species barriers and cause serious illness in humans, and suggested the potential for re-emergence of SARS or another SARS-like coronavirus [28,29]. Consistent with these expectations, MERS was isolated in June 2012 from the sputum of a patient in Saudi Arabia who died from acute pneumonia and renal failure: from 2012 to the end of November, 2018, there were 2,274 laboratory-confirmed cases with more than 800 deaths in 27 countries [28,30]. The virus was also identified in bats, palm civets, and dromedary camels [28]. As with COVID-19, international travel facilitated global spread of both viruses [28,30].

Although a SARS vaccine was developed, it ultimately was not used due to the outbreak's rapid resolution. Academic interest, as reflected by publications, appears to have waned almost as abruptly as the outbreak: PubMed searches for publications on SARS [Figure 3A] and SARS vaccine development [Figure 3B] reveal spikes during the outbreak that rapidly declined. An additional PubMed search using keywords "coronavirus," "China," and "SARS" demonstrates an uptrend in coronavirus publications with the emergence of COVID-19, but also a resurgence of publications on SARS [Figure 4].

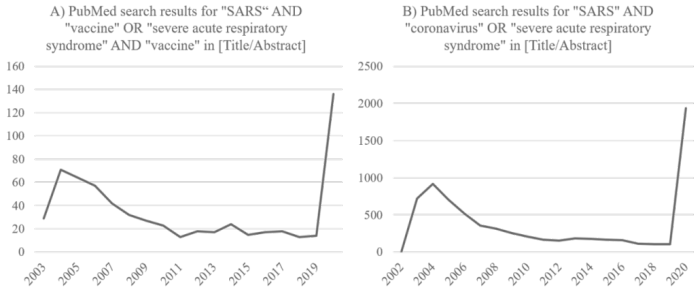

Figure 3: PubMed results from: A) search targeting articles on SARS; and B) search targeting articles on SARS vaccine.

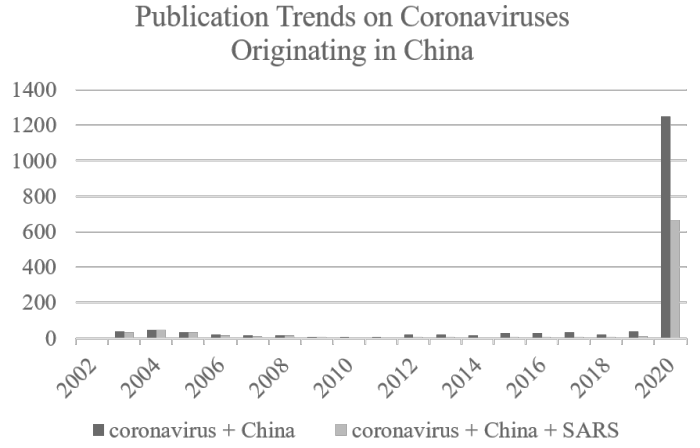

Figure 4: PubMed results from a search targeting research on coronaviruses originating in China (i.e., encompassing publications on both COVID-19 and SARS).

These findings show that the scientific and medical community-much like the public-tends to lose interest in tasks or ideas that are no longer perceived as "imminent." Researchers may drop projects or have trouble finding funding or a place to publish. Either way, progress is arguably lost until imminent need resurfaces, at which point the scientific community is forced to play catch-up.

Information Sharing

In the age of the internet, information is easily accessible and available within seconds, and there is increased use of social media platforms to disseminate messages and retrieve information. Public reactions to outbreaks are shaped largely by how the public interprets information at hand. This is affected by the information

itself, how it is circulated, and who circulates it. The USA has seen two major outbreaks of the mosquito-borne West Nile Virus: an outbreak in 2003 that led to more than 9,000 cases and 265 deaths, and one in 2012 that led to 4,531 cases and 183 deaths [31]. An article analyzing YouTube as a source of information on the 2012 West Nile virus outbreak found that most videos were uploaded by individuals (54.6%) or news agencies (41.8%) rather than healthcare agencies (3.4%), suggesting most circulating information was not verified by authorized healthcare professionals [31]. Although 79.24% of the videos were deemed "useful," or scientifically accurate, viewership for "non-useful" videos (those containing misleading or scientifically unproven information) was significantly higher [31].

Another study examining the integration of 6,442,170 tweets, 83 Facebook posts, and Google search trends with 63 chronological Ebola-related events found that, while the number of tweets from official health organizations containing facts and recommendations declined over time, information regarding cases and deaths increased and correlated with an increase in words expressing fear [32]. Facebook and Google Trends reflected peaks in activity similar to those seen with Twitter [32]. These findings may reflect an erroneous assumption by public health organizations that providing background facts, context and recommendations early on is sufficient to inform the public about a disease. This, however, is counter to the observed increase in fear language as information-sharing beyond case and death rates declined. These findings are also consistent with the assertion that panic-related behavior may be related to the type and frequency of language used [32]. The authors suggest that communication of health information should occur throughout an outbreak and not just in the beginning to later dwindle to updates on new infections and death tolls, as these appear to be less informative than they are emotionally triggering [32]. News of Ebola virus was associated with spikes in media reflecting both relevant/fact-based content (likelihood of disease spread to other countries, mortality rate, transmission characteristics) and irrelevant/fear-based content (relationship with seemingly unrelated events, use of the Ebola trend to hide other global topics, concept of the virus being manufactured), highlighting the point that a high degree of online engagement does not imply that the content is accurate [31,32].

Science and medicine operate under the premise that knowledge improves understanding of a disease and decreases irrational fear of spread [5]. It is important to consider, however, that most laypeople may lack the foundation to parse which pieces of information are true versus false, or which resources are reliable versus unreliable. Because of this, knowledge and understanding remain limited, or information sources may be cherry-picked to support preferred assertions regardless of empirical support or scientific accuracy. Lin et al.'s study on public knowledge of and responses to H1N1 highlighted such limitations in the public's knowledge of H1N1 [14]. While 75.6% knew influenza could be transmitted by coughing and sneezing, 61.9% also thought talking face-to-face would transmit the virus and 30.0% believed it could be foodborne [14]. Less than a third knew the virus could be transmitted by fomite spread [14]. The study also found that those who believed themselves to be at high risk of infection more frequently had a college education (or higher) or knew the main modes of transmission [14]. These findings suggest that lack of knowledge may, at least in part, explain why most studies addressing similar concepts noted low risk-perception and/or low adoption of hygiene recommendations [12-15].

Emergence of a new disease is accompanied by a high demand for information. Demand, however, comes at a time when there are still many unknowns under active investigation. Because the internet and social media allow information to be disseminated at a rapid rate, the public is likely to be alerted to an outbreak by any number of sources before public health officials have had a chance to deliver a message [24]. Given that it takes less time to develop and spread a rumor than it does to circulate a message based on scientific investigation and research, initial information received by the public is more likely to be unreliable and from sources that are, in comparison, poorly informed [24]. Furthermore, in the beginning of an outbreak when much remains unknown, high demand for information and a need to try to provide more accurate information than what is circulating may lead health officials to provide information that may later turn out not to be fully accurate. Conflicting information, whether between health officials and other sources or from health officials at different times, inevitably adds to confusion and likely contributes to growing public anxiety [24]. It is therefore vital to recognize the possibility that the public may take action prior to or early on in attempts by health professionals to engage the public: for example, early media coverage in 2009 described attempts to self-immunize via "swine flu parties," a concept likely borne of the memory of "chicken pox parties" and "measles teas" (described as early as 1916), predating varicella and MMR vaccine development [12,33]. Given that the severity of H1N1 was not well understood at that time, such parties were actively discouraged by the CDC [12]. The idea, however, supports the assertion that laypeople may form their own creative interpretations of how to protect themselves from outbreaks and pandemics.

Research on public response to health communications paints a dichotomous picture. Prior research evaluating USA CDC communications strategies found that messages stating a pandemic was not about to occur were interpreted as the opposite, triggering anxiety about bioterrorism [12,34]. Because the public is vulnerable to misinformation, mistrust, and reactivity, public health departments need to anticipate this and optimize communication. Public health messages should be clear and coherent, aiming to inform the public and promote healthy attitudes and behaviors [3,13,32]. Messages should be delivered via platforms most frequently utilized by their target audience, and those in charge of creating them should encourage other networks and agencies to consider content review by health experts prior to disseminating

information [13,32]. Given the role of social media in disseminating propaganda, public health departments should actively monitor social media for misinformation and misconceptions so they can be promptly addressed [3,24]. Social media use should be clear and frequent, and should encourage user engagement, for example, by having public health employees available to actively respond to questions and concerns [24].

Research suggests that, throughout an outbreak like COVID-19, frequent communication providing information and recommendations focused on increasing public engagement have the potential to keep the public calm even in the presence of the unknown. Regarding recommendations, Jacobsen et al. point out that it is important to disseminate messages that promote adherence to expert recommendations by emphasizing that such behaviors are normative, or even the popular choice: for example, explaining that vaccination rates remain high confers the psychological reassurance that vaccination is the preferred behavior adopted by the public [3]. This suggests that the method and tone used by public health officials to communicate information can encourage or discourage behaviors, and that a positive tone to instructional messages may be more likely to lead to the desired outcomes. Having a trusted source deliver information also appears to result in increased adherence to recommendations [3].

Public Anxiety and COVID-19

COVID-19 overwhelmed the healthcare system with several types of patients: surges of critically ill patients requiring hospitalization, mild or moderately ill patients ultimately requiring only supportive care and best served by adopting home quarantine, and the "worried well" who primarily seek reassurance that they are not infected or proof that they are. This led to hospitals like Elmhurst Hospital in Queens, New York-identified as the "epicenter within the epicenter"-to test and diagnose over 1000 patients by April 1, 2020, requiring assistance from military medics and staffing companies inside the hospital and construction of designated screening tents outside [35].

Low stock of Personal Protective Equipment (PPE) also presented problems early in the COVID-19 pandemic: nonspecific recommendations for use of face-masks led to increased public consumption of PPE typically reserved for HCWs undergoing high frequency engagement with high-risk patients. As the understanding of transmission dynamics changed, so did recommendations for PPE: although initially thought to be limited to droplet spread, high rates of person-to-person transmission suggested COVID-19 may be airborne, requiring HCWs to wear special N95 masks that form a seal around the mouth and nose rather than standard surgical masks. News articles sported titles like "Coronavirus hysteria is leading to mass mask shortages" [36] and "Inside the Desperate Scramble for N95 Masks" [37] as sellers advertised masks for $10 each, or even 160 masks for $800 on Amazon.com [38]. Meanwhile the surgeon general pleaded on Twitter, "Seriously people-STOP BUYING MASKS! They are NOT effective in preventing general public from catching #Coronavirus, but if health care providers can't get them to care for sick patients, it puts them and our communities at risk!" and the WHO executive director of the health emergency program reported "There are severe strains on protective equipment around the world… Our primary concern is to ensure that our frontline health workers are protected and that they have the equipment they need to do their jobs" [38]. Given what previous research has shown about public health messages and panic behavior, it is reasonable to fear that the public may construe these messages as misleading-a type of "do what we say, not what we do" message-and instead interpret them as a suggestion to use 'what the doctors are using.'

The USA became "the only affluent nation to have suffered a severe, sustained outbreak for more than four months" [39]. Despite quarantines and updated recommendations for hygiene and mask-wearing, the persistence of infection in the Unites States is multifactorial. Culture and politics have been cited [39], and both have influenced the dissemination of public health information and the acceptance of recommendations. Based on the available research, however, it is vital to recognize that the peak and subsequent waning of the public's anxiety-response to COVID-19 was (to a degree) predictable. If we recognize this, we may have the power to circumvent it in the future.

Conclusion

Each new outbreak presents a wealth of opportunity for education and adaptation. Public anxiety in response to a perceived threat varies in response to how significant or personal that threat is viewed to be, as does the inclination of the public to adopt protective behaviors (buying and wearing masks versus getting vaccinated). Panic may not be entirely avoidable, but it can be mitigated by early, frequent, clear and consistent communications by public health officials along with greater efforts to interact with the public on their own preferred platforms. As the perception of threat declines-and with it, the public's drive to take protective action-it is vital that those in medicine, science, and healthcare policy recognize their own weakness in keeping the public interested. Instead of moving onto the next novel topic, we must continue to both actively pursue relevant research and promote health-protective behaviors among the masses by a) providing opportunities for engagement, and b) by using positive, normative language that encourages engagement.

Declarations

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author's Contributors

NS and JRM conceived the manuscript. NS wrote the first draft. JRM revised the first draft and subsequent drafts. Both authors approved the final manuscript.

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