

ORIGINAL ARTICLE

Ineffective responses to unlikely outbreaks: Hypothesis building in newly-emerging infectious disease outbreaks

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Abstract

Over the last 30 years, there has been significant investment in research and infrastructure aimed at mitigating the threat of newly emerging infectious diseases (NEID). Core epidemiological processes, such as outbreak investigations, however, have received little attention and have proceeded largely unchecked and unimproved. Using ethnographic material from an investigation into a cryptic encephalitis outbreak in the Brong-Ahafo Region of Ghana in 2010–2013, in this paper we trace processes of hypothesis building and their relationship to the organizational structures of the response. We demonstrate how commonly recurring features of NEID investigations produce selective pressures in hypothesis building that favor iterations of pre-existing “exciting” hypotheses and inhibit the pursuit of alternative hypotheses, regardless of relative likelihood. These findings contribute to the growing anthropological and science and technology studies (STS) literature on the epistemic communities that coalesce around suspected NEID outbreaks and highlight an urgent need for greater scrutiny of core epidemiological processes.

KEYWORDS

emerging infectious disease, field epidemiology, Ghana, global health, hypothesis-building

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INTRODUCTION

Newly emerging infectious diseases (NEID) are infectious diseases that have not been observed in a specific population before. Although they occur more frequently in resource-limited settings in countries in the tropics and subtropics, their unknown pandemic potential means that they are often treated as threats to global health (Jones et al., 2008; Morens et al., 2004). Since NEIDs were established as a major public health priority in the late-1980s, there has been substantial investment in developing new diagnostic technologies, bench research and international outbreak surveillance and response infrastructure (Brende et al., 2017; Institute of Medicine, 1992; King, 2002). Comparatively little attention, however, has been applied to reviewing and augmenting the core processes involved in the initial investigation of outbreaks, even though effective investigation is a prerequisite to effective mitigation and containment. In this paper, we use an ethnographic case study of a suspected outbreak of a newly emerging viral zoonosis that occurred in the Brong Ahafo Region (BAR) of Ghana between 2010 and 2015 to document and explore such investigative processes. We pay particular attention to the processes of hypothesis building that took place and their relationship with the specific configuration of local and foreign professionals who coalesced around this suspected NEID outbreak. We pay particular attention to elucidating the specific configuration of local and foreign professionals who comprised the responses to the BAR outbreak and the processes of hypothesis building that took place across them. The responses to the BAR outbreak were ultimately unsuccessful, neither generating meaningful public health intervention nor firm epidemiological insights; however, their unfolding provides a rare opportunity to explore how recurring transnational assemblages of outbreak investigators can negatively impact the development and promulgation of hypotheses and the overall effectiveness of NEID outbreak responses.

The relative lack of scrutiny these core processes have previously received can, in part, be attributed to the two distinct ways such investigations are typically characterized. In outbreak investigation guidelines and training materials, investigations are usually presented as a series of standardized activities (e.g. event verification, case findings and application of a case definition, laboratory testing, etc.) that, if performed correctly, will inevitably identify an underlying causative agent and generate an adequate, actionable, explanation for the event (European Centre for Disease Prevention and Control [ECDC], 2012; World Health Organization Regional Office for Africa, 2014; Centers for Disease Control & Prevention, 2016). Accounts of outbreak investigations published in scientific journals tend to echo this stepwise, linear rendering of the process. Conversely, popular accounts of outbreak investigations, such as those found in films, the biographies of prominent epidemiologists, and the public facing outputs of public health agencies such as the US center for disease control (CDC), often depict investigations not as a mundane series of tasks but as creative processes undertaken by “elite disease detectives” (Beaubien, 2018; Contagion, 2011; Lynteris, 2016; Pendergrast, 2011). This rendering also deflects interrogation, as it renders investigative processes the internal, black box workings of brilliant individuals.

Underpinning both depictions are implied or, in the case of some epidemiological manuals, explicitly stated processes of hypothesis building and testing through which plausible, and assumedly actionable, accounts of the outbreak are developed and substantiated. These processes start with a hypothesis or set of hypotheses being developed based on initial observations. Further evidence is then collected, sometimes directly aimed at testing existing hypotheses, and the hypotheses that are found to be at odds with the accumulating evidence are then either modified or discarded. This process can then be repeated with new hypotheses and modified earlier ones till what might be considered an adequately substantiated or fitting account of the event emerges. What constitutes an adequately substantiated hypothesis is rarely stated; however, in most epidemiological manuals and guidance documents, the step following those concerned with hypothesis building tends to be “laboratory testing,” suggesting that laboratory confirmation of a suspected causative agent or implicated source is important.

The fidelity of these depictions is brought into question by ethnographic accounts of outbreak investigations (Briggs & Mantini-Briggs, 2016; Briggs & Mantini-Briggs, 2003; David & Lachenal, 2018; Latour, 1988; Lindenbaum, 2009; Murphy, 2006; Perrocheau et al., 2023). Although not specifically concerned

with elucidating processes of hypothesis building, these primarily anthropological accounts of investigations show that evidence gathering and interpretation are rarely the work of a sole individual or discrete team and seldom progress along linear, stepwise trajectories. Further, what laboratory testing is acquired is rarely conclusive. The need to empirically scrutinize the assumed unfolding and orientation of these ostensibly immutable and effective processes is reenforced by STS and anthropological scholarship on the in many ways analogous processes of clinical diagnosis. These accounts, rather than showing clinical diagnosis taking the often-assumed form of a stepwise process directed at correctly categorizing an illness for the purposes of subsequently treating it, reveal piecemeal processes, often focused on finding direction or closure rather than identifying a definitive causative agent or condition (Chandler et al., 2008; Jephcott et al., 2017; Livingston, 2012; Street, 2011).

Across both bodies of literature, investigative processes are shown to be both constrained and actively informed by the material and social environments in which they occur. This indicates that in trying to understand processes of hypothesis building that take place during suspected NEID investigations, it is important to pay attention to the social and material scaffolding of the response. In most of sub-Saharan Africa, at least in states such as Ghana, which have adopted the Integrated Disease Surveillance and Response (IDSR) framework, it is a local multidisciplinary team that is meant to oversee outbreak investigations (World Health Organisation & Centers for Disease Control & Prevention, 2010). In theory, when confronted with larger or more complex outbreaks, these teams receive supplementary expertise and resources from the higher tiers of the national health system while maintaining oversight of the operations in their district. In practice, however, when confronted with a suspected NEID outbreak, senior public health officials tend to take a more prominent role in the response. Non-state and parasitatal actors, such as researchers, including those based overseas, also often become involved in these investigations, as do non-governmental organizations (NGOs) and, on occasion, private companies (Perrocheau et al., 2023). This expanded network of actors generating and interpreting evidence can be attributed to the need for specialist resources and expertise when dealing with an unusual or ambiguous causative agent and the perceived public health threat of a potentially novel pathogen, though there are also significant personal and professional incentives associated with participating in high-profile NEID investigations (Ergonul et al., 2016; Leach & Hewlett, 2010).

In the following sections, we provide some further detail on the methods used for this study and the case study at the center of it, before explicating the exact configuration of professionals that coalesced around the BAR outbreak and its effect on the processes of evidence gathering and hypothesis building that took place. Through examination of the intended outputs from the BAR outbreak investigations, namely presentations, draft publications, and research proposals, we go on to posit a possible mechanism by which flawed processes of hypothesis building and the organizational structures of the response that engendered were obscured. We conclude the paper by discussing the implications of our findings for strategies of NEID containment in resource-limited settings.

METHODS

The communicative structures of an organization largely determine the “sensemaking” it undertakes (Weick et al., 2005). As such, when the responses to the BAR outbreak failed to generate any meaningful public health intervention or insights, it seemed pertinent to explore the communicative structures underpinning the response and how they had impacted upon the processes of hypothesis building that took place. The primary ethnographic focus of this study was therefore on elucidating the exact configuration of officials and experts, or “sensemakers”, involved in investigating the BAR outbreak and tracing the generation, formulation, interpretation, and spread of evidence and broader explanatory narratives across them.

An initial annotated timeline of the responses was developed using primary documents from the time, such as email chains, laboratory notebooks, personal notes, and draft research proposals. This was then augmented through interviews with the professionals involved, which allowed us to

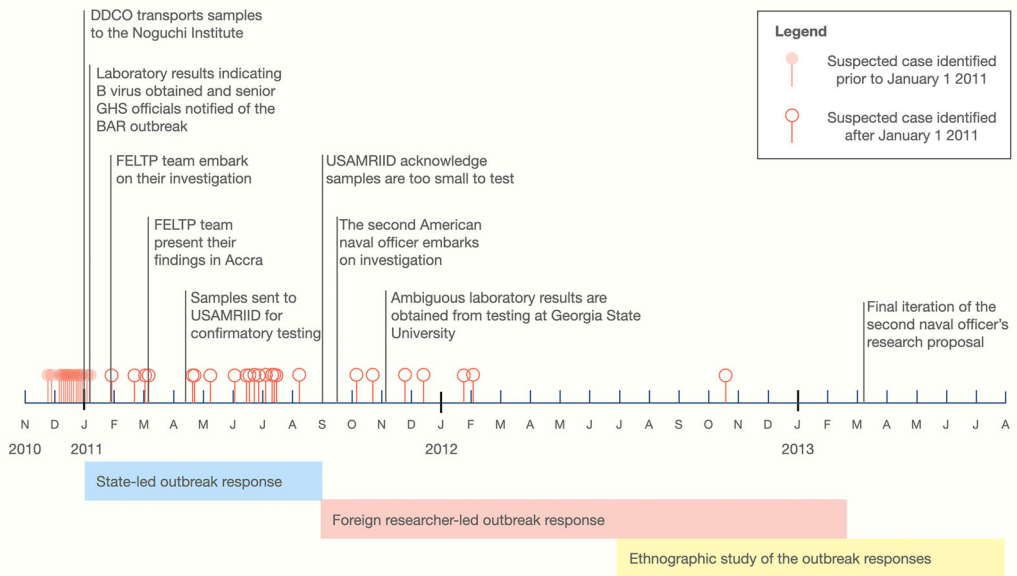


FIGURE 1 Timeline of the responses to the BAR outbreak. [This figure appears in color in the online issue]

incorporate undocumented communications, such as phone calls and in-person conversations, and helped us identify where the primary documents were not accurate renderings of what had actually occurred. While some communications will have been missed, for every recorded instance of an actor having or transmitting data or a hypothesis, there is an earlier record of them receiving it, which suggests that the key chains of communication have been fully captured. A simplified visualization of the spread of information, which removes redundant communications where no new information or formulations of theories are shared, is provided in Figure 2.

The detailed documentation of the BAR outbreak response upon which this paper depends was made possible by the presence of the first author, a field epidemiologist and then medical anthropology graduate student, working on a separate research project that happened to involve many of the sites and actors involved in the BAR outbreak. In 2014, their close but informal following of the BAR outbreak response was converted into a formal ethnographic study. By then, the unsuccessful nature of these initial responses was becoming apparent, and many of the professionals involved wanted to understand what had gone wrong. As a result, most of the responders to the outbreak were not only willing and able to provide primary documents from the time, but also willing to be interviewed and observed. A number of these responders are co-authors on this paper, having subsequently helped to develop the factual timeline (diagrammed in Figure 1) and to provide further context for the events prior to 2012.

RECOUNTING THE BAR OUTBREAK

Between 21st of November and 17th of December 2010, 16 children were admitted to the pediatric ward of a mission hospital in the city of Techiman in the BAR of Ghana with signs of acute neurological illness, including seizures and paralysis. There was no obvious geographic clustering of the cases, with only two of the children coming from the same community and the rest either coming from distinct parts of the city or satellite towns in the surrounding districts. Upon assessing the children, a German pediatrician working at the hospital determined that the cases likely reflected an outbreak of viral encephalitis. In line with national protocols, the District Health Management Team (DHMT) was notified, and a District Disease Control Officer (DDCO) was sent to the hospital to investigate. The responding district officer

rejected the pediatrician's report, stating that the children were probably suffering from meningococcal meningitis or cerebral malaria. A second district officer, a personal acquaintance of the hospital's public health nurse, was subsequently sent and accepted the pediatrician's report. He immediately arranged for samples taken from the children to be transported to a virologist he knew working at the Noguchi Memorial Institute for Medical Research (NMIMR) in Accra. Using a multiplex PCR platform, four of the samples tested positive for B virus, a simian herpes virus found in macaque monkeys in East Asia and not previously described in Africa. Although rare in humans, the virus is associated with the development of an often-fatal encephalitis.

In response to the unexpected laboratory findings, a Ghana Health Service (GHS)-backed team of Field Epidemiology and Laboratory Training Program (FELTP) residents was sent to the BAR to investigate. Upon returning to Accra, the FELTP team presented the findings of their investigation to a gathering of senior Ghanaian public health officials. The team suggested that the children had contracted the virus through interacting with a local monkey population while their parents were away farming and attributed the wide geographic distribution of the cases to a forest-belt, which they claimed connected all of the affected communities. At the conclusion of the FELTP team's presentation, it was determined that the virologist should obtain confirmatory testing of the samples at a recognized reference laboratory. With the help of an American naval officer temporarily stationed at the American Naval Medical Research Unit-3 (NAMRU-3) in Accra and working at the NMIMR, four of the samples were shipped to the United States Army Medical Research Institute for Infectious Diseases (USAMRIID) in the United States for further testing. However, 6 months later the scientists at USAMRIID announced that the samples were too small to test, and that no results would be forthcoming. In the interim, the state-mediated response to the outbreak had dissipated without any further action except the drafting of an academic paper by the FELTP team. The paper was never submitted for publication, but mention of the investigation did appear in a published review of the Ghanaian FELTP later that year (Wurapa et al., 2011).

Over the following months, a consortium of researchers, led by a newly arrived NAMRU-3 American physician-cum-naval officer and including the virologist at NMIMR, the German pediatrician, and some peripheral European and North American research groups, was formed to investigate the outbreak further. Although their research was never fully realized, it did result in confirmatory testing at a simian herpes virus reference laboratory in the United States. The results of this testing saw herpes virus papio 2, a simian herpes virus carried by baboons, replace B virus as the foremost causative candidate. Over the following 2 years, further isolated cases were recorded by the pediatrician, equating to approximately 42 suspected cases in total, but the simian herpes virus etiology was not pursued further. By March 2013, two and a half years after the event had first been reported, the investigations had ceased entirely, with no meaningful public health intervention having taken place (Figure 1). No generalizable knowledge was generated about the outbreak either, and while throughout the process numerous manuscripts describing the outbreak were drafted, none were ever submitted for publication.

Upon closer scrutiny, the epidemiological and laboratory data available from the time do not support the hypothesis that there was a simian herpes virus outbreak in the BAR between 2010 and 2012. The affected children's medical records show varied clinical presentations, many of which were inconsistent with viral encephalitis. For instance, a number of the children were reportedly afebrile with normal white blood cell counts and prior to the sudden onset of seizures had seemed well. The test that had originally indicated that a simian herpes virus was involved was an experimental multiplex PCR assay that had been developed for East Asian settings (Katano & Kano, 2011). Japanese researchers visiting NMIMR some years earlier had left it with the virologist, and it is possible that by the time it was used for the BAR outbreak it had been degraded through this prior use. Further, the subsequent testing that had reportedly taken place at the reference laboratory in the United States and had supposedly indicated the presence of herpes papio 2 was undocumented, and those involved struggled to recall much about the testing or the results, except that only two samples had been used and that these were from later cases. Regardless, herpes papio is not known to be zoonotic, making it an especially unlikely candidate (Eberle & Jones-Engel, 2017). The laboratory findings become more questionable in light of the lack of

wild monkeys in the affected areas, most notably the lack of macaques, which are not found anywhere in sub-Saharan Africa, and baboons, which though found in Ghana, have not been identified in any of the affected communities. The FELTP team's investigation lasted 6 days in total, with just three of them spent in affected communities. Only 3 of the 16 affected families were interviewed as part of the investigation. The FELTP team's report of monkeys in the area was based on the father of one child recalling having seen a monkey on his farm many years earlier, the presence of a monkey sanctuary elsewhere in the region, and a single pet patas monkey in another village that had subsequently tested negative for B-virus. The notion of a forest-belt connecting the affected communities had also arisen from their investigation and was based entirely on their observation of a cluster of trees at the edge of one of the affected communities (Jephcott, 2023). The largest cluster of cases was in fact from the sprawling, largely barren, city of Techiman.¹

None of this is to say that a newly emerging simian herpes virus that had never been seen before in humans was not responsible for the large number of children presenting to the mission hospital with signs of severe neurological illnesses, only that this is extremely unlikely. Further, the credibility of the emerging simian herpes virus hypothesis is not in itself problematic; such creative leaps are common early on in epidemiological hypothesis building and are potentially crucial in identifying an unusual etiology. The problem lies in the on-going and exclusive pursuit of this hypothesis despite growing incongruence with the epidemiological evidence and the availability of more plausible, unexplored theories (these will be described in more detail below). This suggests there was a departure from the expected process of hypothesis building, which is typically characterized as a sort of evolutionary process in which the chief selective pressure is plausibility (Weick, 1989). Instead, what appears to have happened is that iterations of the pre-existing NEID theory were being preferentially advanced over other hypotheses, regardless of their relative likelihood. To understand what features of the response brought about this unanticipated selective pressure, it is helpful to now look at how information was being shaped and shared across the configuration of professionals that constituted the BAR outbreak investigation.

THE ORGANIZATIONAL FEATURES OF THE OUTBREAK INVESTIGATION AND EFFECT ON PROCESSES OF HYPOTHESIS BUILDING

Figure 2 visually represents the spread of information across the various actors involved in investigating the BAR outbreak. The Figure shows that the processes of theory building took place across a diffuse network of actors rather than being the work of any distinct or autonomous individual or group. Individuals or groups that may not have been aware they were collaborating or building on each other's work, or even aware of each other at all, are shown to be the recipients of each other's interpretations of evidence and to have developed their own hypotheses based on this exchange. This was evident in the second American naval officer's integration of the "forest belt" into his research proposals and draft manuscripts despite him never having interacted with the FELTP team and being largely unaware of their undertakings (Figure 3).

Within this rendering of the spread and transmutation of information and hypotheses, the predominate structure is interweaving chains of communication made up of dyadic interactions, mostly representing phone calls and emails. When examining the information that was being passed across these dyadic interactions, it becomes clear that most professionals involved in the hypothesis-building did not belong to some pre-existing form of generic outbreak response infrastructure. The engagement of many of the people most central in the hypothesis-building had a strong element of happenstance to it. Neither the second district officer, nor the virologist, nor the naval officers were contacted through a formal notification system. Instead, they were piecemeal additions that came about when individual actors took the initiative to draw upon their own personal and professional networks to source relevant expertise and resources. As such, most of the professionals were recruited to the response by a particular narrative. The pediatrician was recruited by the simple narrative that something unusual had occurred.

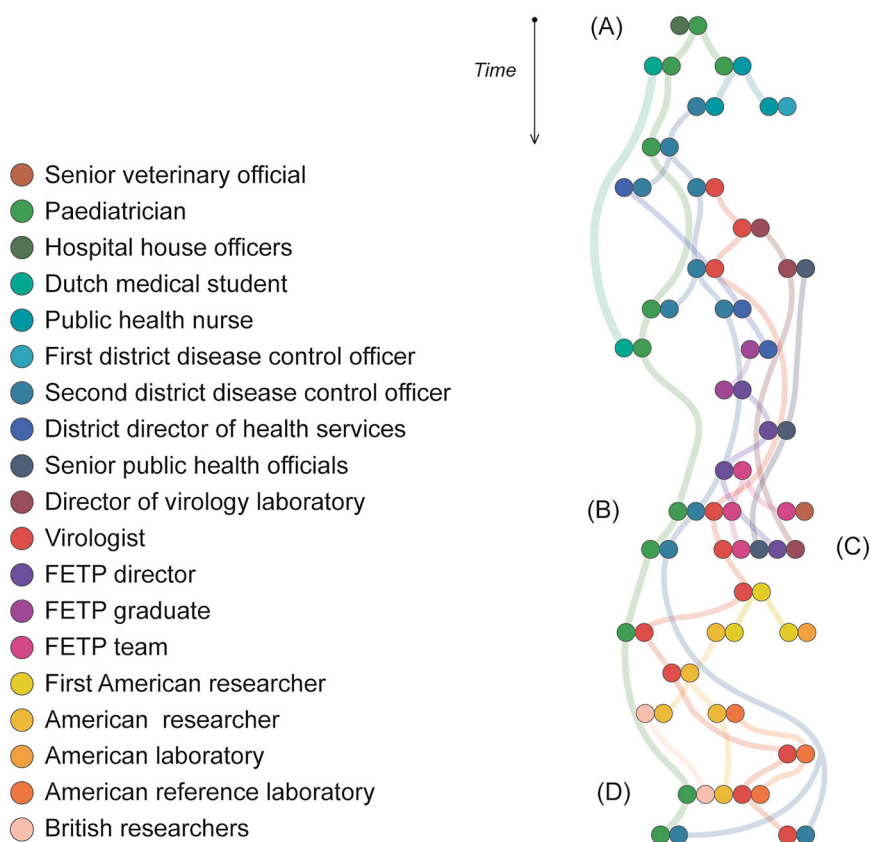


FIGURE 2 A simplified rendering of the passing of information between participants in the response to the BAR outbreak over time. Each participant or discrete group of participants in the response is represented by a circle in a particular color. Adjoining circles represent the passing of information relating to the BAR outbreak between groups or individuals. This includes email exchanges, phone calls, the passing of documents containing information pertaining the outbreak, and face-to-face exchanges. (A) The first interaction represented in the figure is when the house officers first notified the paediatrician of the sick children and the paediatrician characterized the event as an outbreak. The majority of the interactions captured are dyadic in nature. There are three notable exceptions to this: (B) the FELTP team's field investigation where the FELTP team, accompanied by the district officer, met with the paediatrician and took advice from the virologist via phone; (C) the meeting where the FELTP team presented the findings from their investigation to senior public health officials in Accra; and, (D) the email chain through which the second American naval officer, (labelled the "American researcher" in the figure) circulated drafts of the research proposal with the other members of the research coalition. [This figure appears in color in the online issue]

Her interpretation of this unusual cluster of cases as a possible novel viral encephalitis outbreak, relayed via the district officer, recruited the virologist to the investigation. The virologist's interpretation of the subsequent laboratory results as indicative of a newly emerging monkey-borne herpes virus recruited the rest of the actors.

This narrative-specific recruitment produced an immediate structural confirmation bias in the investigation. The virologist ran a multiplex panel exclusively for known causes of human viral encephalitis in response to the paediatrician's clinical impression that the cases were likely a viral encephalitis. Any false positives were immediately made more credible by the paediatrician's clinical impression and simultaneously reinforced the impression itself. This was further compounded by the FELTP team's subsequent pursuit of evidence of monkeys in the area based on these laboratory findings, which when somewhat successful—they found monkeys, just not the right kind and in quite the right area—reinforced the paediatrician and virologists' findings.

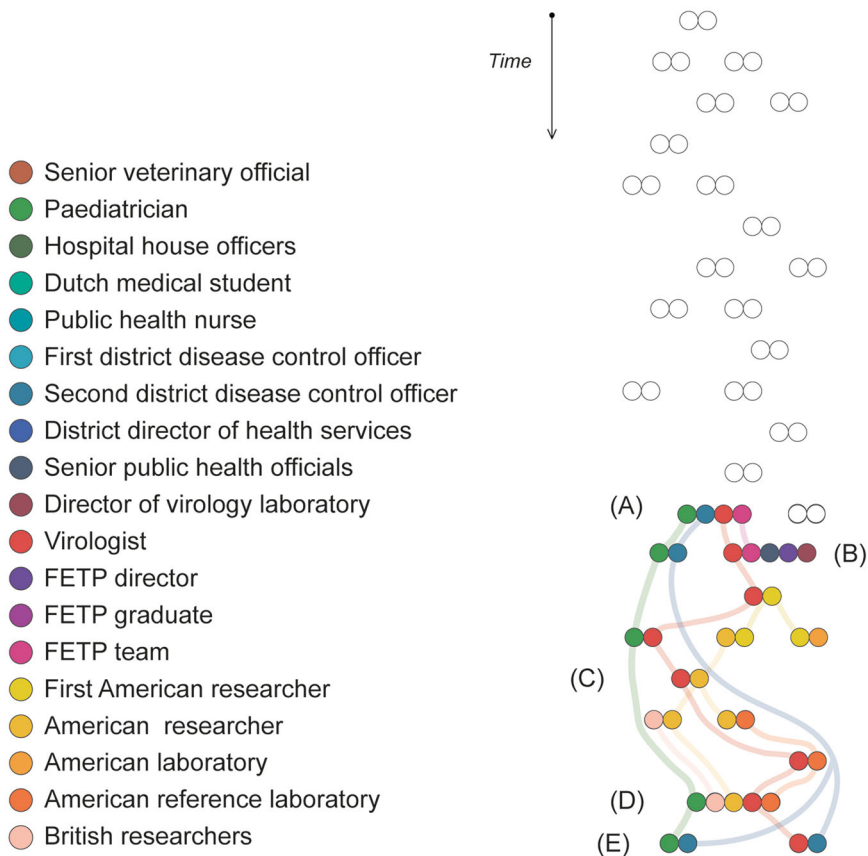


FIGURE 3 The spread of information pertaining to a supposed forest-belt. (A) The idea of a forest-belt first arose in an interview conducted by the FELTP team during a visit to an affected community when a community member identified a forest at the edge of the village and explained that it had previously been inhabited by monkeys. The forest was subsequently referred to as a “forest-belt” which reportedly connected the affected communities and was used as an explanation for the wide geographic distribution of cases. (B, C, D, E). The forest-belt and the monkeys supposedly in it became a central feature of the narrative around the outbreak and featured in most of subsequent documents produced describing the outbreak. (A) “At that community we visited we were told there was a forest around the community where they had found monkeys in the forest.” (Interview, district officer, Techiman, January 2011). (B) “All effected districts were surrounded by a natural forest-monkey belt.” (Minutes from the FELTP presentation, Accra, March 2011). (C) “The source likely emanated from human-monkey interactions within a known forest and “monkey” belt” (Draft manuscript prepared by the second American naval officer, Accra, September 2011). (D) “The surrounding forest of all districts afflicted with suspected cases was surveyed, and monkeys identified...Monkey species within this natural forest-monkey belt include Mona, Colobus, Green monkeys, baboons, and Patas, without macaque species.” (Draft research proposal prepared by the second American naval officer, Accra, February 2013). “It is a rural area with mostly farming land and with a forest belt extending from Akomadadan over Toubodom and Nkoranza to Kintampo...we found out, that it is papio 2 virus, transmitted through baboons, which are domestic in this forest belt...” (Draft research proposal prepared by the pediatrician, Techiman, February 2013). [This figure appears in color in the online issue]

There was a further, perhaps more profound, structural bias evident in the BAR investigation, one specifically tied to the inclusion of so many senior outsiders in the response. Because the bulk of professionals were subject-area experts recruited by a specific narrative, the social and material scaffolding of the investigation—that is, the network of professionals who had assembled around the outbreak and the material resources available to them—was only really able to support the pursuit of iterations of the early hypothesis, specifically, that the outbreak was caused by a newly emerging zoonosis. As such, the hypotheses that were preferentially developed and explored were not those that represented the most

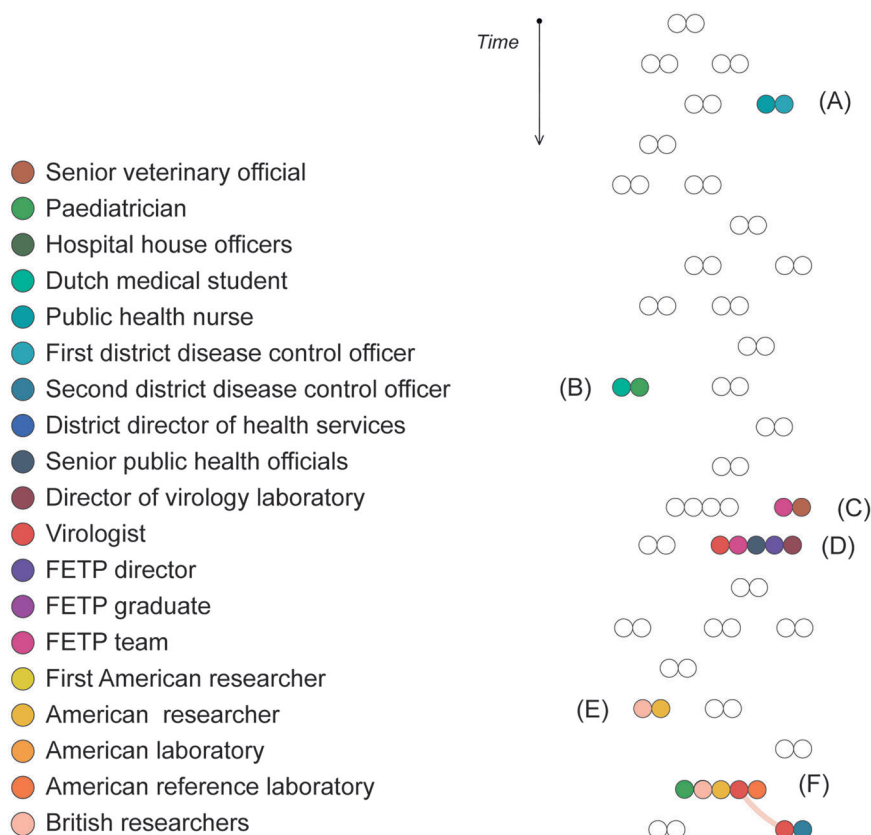


FIGURE 4 Points during the response where features of the dominant emerging monkey-borne virus outbreak narrative were challenged. Features of the dominant outbreak narrative that were challenged include: (A) the notion that there was an unusual outbreak occurring; (B, C, E, F) the proposed B virus etiology and the presence of an appropriate monkey vector; (D) and the hypothesis that the children had been infected through interacting with monkeys while their parents were away. In all but one of these instances (F) the particular point of contention or doubt was not communicated further than the initial communication it arose in. (A) “First someone came from municipal and wanted to see the cases. They said it is meningitis and I said, ‘no, it is encephalitis, I know meningitis.’” (Interview, public health nurse, Techiman, November 2012). (B) “In my opinion the a priori chance of false positive results is higher than the a priori chance of a Monkey B virus outbreak at Techiman.” (Literature review prepared a Dutch medical student visiting Holy Family Hospital, Techiman, January 2011) (C) “I told them, we are not having the correct monkeys and this virus is very unlikely.” (Interview, veterinary officer, Accra, April 2015). (D) “[A GHS official] questioned the theory because one of the children was only 6 months old and would not be left alone on the farm.” (Minutes from FELTP presentation, Accra, March 2011). (E) The junction at which the British researchers reportedly told the American researcher that they thought that a toxic etiology was more likely than B virus. (Interview, second American naval officer, Cambridge, 2013). (F) “Stressing our acknowledgement that the B virus results from last years’ cases haven’t been confirmed, we endeavor to cast a wide net in our laboratory investigations to capture potential microbiologic etiologies.” (Draft research proposal prepared by the second American naval officer, Accra, August 2012). [This figure appears in color in the online issue]

likely account of what happened or presented the greatest imminent threat to public health, but those that remained close enough to the original theory to remain actionable amongst the responders.

A failure of alternative hypotheses to gain similar traction to the NEID hypothesis is evident throughout the investigation. From very early on in the response, skepticism around the BAR outbreak being caused by a monkey-borne virus was intermittently voiced, with some actors even suggesting alternative hypotheses. However, as illustrated in Figure 4, the content of these interjections does not appear to have been communicated beyond the initial interactions in which they arose. For example, in an early conversation between the American researcher and some visiting British researchers, it was agreed that

the monkey-borne virus theory was unlikely and that the clinical picture supported a toxic etiology rather than an infectious one. The sudden onset of the children's symptoms, their frequent afebrile presentation, and the development of non-progressive permanent paralysis, sometimes in the form of opisthotonos, were all seen as indicative of a toxic etiology. Not only was this possibility seemingly not transmitted beyond this conversation, but their joint research proposals continued to focus exclusively on exploring infectious, primarily zoonotic, etiologies, even after the possibility of a simian herpes virus had been largely abandoned.

The reasons for the external, national figures' failure to pursue any alternative hypotheses are slightly different. In the face of acutely limited resources and a large burden of other public health issues to attend to, the threshold for attention and on-going intervention was high. The 16 cases of neurological illness described to them were considered to be of relatively low public health concern once the possibility they were due to a NEID had been removed. Had the original suggested diagnosis of cerebral malaria remained, it is probable that they never would have been notified of the outbreak in the first place. A suspected mass poisoning might have hit the threshold for further action, due to its unusualness and imminent threat to public health, but the possibility of a toxic etiology had not been raised amongst this group of professionals and the simple presence of an apparently limited cluster of cases of unknown etiology did not elicit further investigation. As one senior official explained "The truth is, if there are not deaths, it is not causing anxiety, and the media doesn't know, then it goes off the radar" (interview, NSU office, Accra, October 2014).

It is unlikely that even if a mass poisoning had been initially suspected, that an alternative, toxicology-oriented investigative scaffolding could have formed in the same way as the emerging zoonosis one did. Not only had the possibility of a poisoning not occurred to the pediatrician, but even if it had, she was unsure whether she would have been able to access the diagnostic testing necessary to confirm such a suspicion. While there was an abundance of zoonosis researchers and public health professionals specifically sensitized to the threat of emerging zoonoses in Ghana at the time, with remits and resources that would allow them to become involved in an outbreak response, there was no such profusion of toxicological expertise and resources.

The differences in available investigative scaffolding can in part be explained by targeted foreign investment in NEID control in Africa from the 1990s onwards, borne from fears of pandemic-prone zoonoses emerging from African wildlife and compounding the infrastructural legacies of colonial power's prioritization of infectious disease control in the region (Calkins, 2021; Crane, 2013; King, 2002; Livingston, 2012; Tousignant, 2013). This suggests that the potential for different hypotheses to be advanced in investigations is at least in part determined by historical as well as contemporary interests, which in the case of public health emergencies in West Africa includes longstanding foreign ones.

The displacement of local authority and the variable disjunction of information

In theory, it should not have mattered that the entangled researchers and senior health officials were only interested pursuing particular lines of investigation, as it was the DHMT who were officially responsible for delivering the response. As public health generalists whose interests are simply the wellbeing of the community, they should have no allegiance to a particular etiology. However, the introduction of senior outsiders to the response had seen the DMHT displaced as the *de facto* leaders. This is evident in the exclusion of the DMHT, including the district officer, from the two junctions where authoritative hypotheses relating to the outbreak were set. They were neither present at, nor invited to, the FELTPs presentation in Accra to senior national public health figures, nor were they included as coinvestigators in the research proposals circulated amongst the coalition of predominantly foreign researchers led by the second American naval officer (these two junctions can be seen in Figure 2). The DHMT lacked the resources to perform their own parallel investigation. Although the American naval officer's proposed budget for his research initiative was approximately 100,000 USD, the district officer had not even been able to source sufficient funds to get fuel for his motorbike and paper for questionnaires to perform basic case finding.

The displacement of the district officer and DHMT as leaders of the investigation had further effects on the overall movement of information and hypothesis-building. Because they were not at the center of the investigation, there was no single repository where all the relevant data was accumulated. Instead, relevant information was dispersed across an uncoordinated, diffuse network of actors, mostly through splaying chains of dyadic communications. The result of this was a “variable disjunction of information,” in which no individual or group had access to all of the available information but, instead, had to draw on incomplete and often poorly relayed packages of information (Turner, 1978). The limited access to raw epidemiological data and the lack of knowledge of the origin of data being circulated impaired actors’ abilities to assess the veracity of the monkey-borne outbreak hypothesis and inhibited their ability to formulate new hypotheses.

Compounding the issues arising from the decentralized nature of the investigation is the inevitable “uncertainty absorption” that occurs during such investigations, especially around information generated by peripheral specialists. According to organizational theorists March and Simon (1958, 143), uncertainty absorption happens when “inferences are drawn from a body of evidence and the inferences, rather than the evidence itself, are then communicated.” The influence of this phenomenon on the processes of hypothesis building during the BAR outbreak investigation can be seen on a number of occasions. For example, the pediatrician communicated a simplified, overarching clinical picture of the cases to other members of the investigation. Relaying the variations in salient patient information and clinical presentations for even just the first 16 cases would have been lengthy and largely unproductive, especially as few other people in the response team would have had the necessary clinical background to interpret this information. The slimming of the clinical information and the packaging of it in relation to the monkey-borne outbreak hypothesis meant that most people involved in the hypothesis building were only aware of certain signs and symptoms, such as seizures and high white blood cell counts, which supported the hypothesis that it was a viral encephalitis outbreak. Few people were aware that a number of the cases exhibited symptoms more suggestive of a toxic etiology. A similar situation is evident around the results of the initial diagnostic testing. Although the virologist was aware of the relevant caveats to the testing, it was only feasible for him to communicate a subset of these details when relaying the results to other members of the investigation team. The nuances around the results were blurred even further through subsequent retelling, resulting in the FELTP team initially being told that the BAR outbreak was as a “laboratory confirmed” B Virus outbreak, which implied far more certainty around the laboratory results than was appropriate. The upshot of these organizational features of the response was that responders were largely basing their hypotheses on piecemeal bits of evidence already smoothed and fitted to the pre-existing monkey-borne virus theory. This meant that rather than the accumulating evidence serving to challenge, and potentially collapse, the increasingly aberrant NEID hypothesis, it actually served to bolster it.

The spatial and temporal features of a transnational response

The inclusion and prominence of outsiders also informed temporal and spatial features of the outbreak response. It engendered a brevity and superficialness to the engagements with the afflicted communities and their surrounds, which inevitably impacted on how hypotheses were being constructed, weighed, and advanced. Aside from the city of Techiman, where the pediatrician and the district officer lived, only two of the other thirteen affected communities were visited by any of the responders, and this was by the FELTP team during their brief investigation. None of the other actors involved in the hypothesis building, including the virologist, the senior national officials, the American researcher, or his international collaborators, visited any of the affected communities.

It can perhaps be assumed that a greater familiarity with the affected areas might have helped address diverting elements of the dominant hypothesis, such as the presumed presence of wild monkeys or an interconnecting forest-belt. Such knowledge would not necessarily immediately reveal these inaccuracies—some responders were in situ and the limited field epidemiology that was performed was already largely at odds with the B virus outbreak narrative—but a longer, closer situated investigation

might have provided greater opportunities to eventually recognize such incongruencies and revise theories. It is also reasonable to assert that because the responders, and the hypothesis-building they were undertaking, was largely physically removed from these communities, and as such not immediately accountable to them, ill-fitting narratives were better able to persist unchecked.

There is a further apparent, though perhaps more amorphous, effect on processes of hypothesis building introduced by these outside responders. This involves a related, but distinct, kind of distance. This is a distance from suffering, mediated by closeness of kinship as well as physical proximity (Nortvedt & Nordhaug, 2008). Across the responders to the outbreak, there were various types of distance from the afflicted communities in play, from differences in nationality and ethnic group, to social class, and even a professional distance that is often a consciously cultivated feature of research and clinical practices. These distances appear to have enabled a certain kind of abstraction of urgency, which manifested in delays and a general irresolution around intervention. This is evident in the 6-months it took for USAMRIID to explain that they could not perform the requested testing and the American researcher's repeated calls for "immediate urgency in prevention and treatment of these encephalomyelitis cases," in his research proposals from September 2011 until March 2014, a full 6-months after the last suspected case had presented to the mission hospital. These delays could also be attributed to the entanglement of researchers and research structures in the response and the differing timelines of public health research and applied work. That said, it seems likely that had the responders felt compelled to attend more closely to the situation on the ground out of some shared hopes and fears for the future of the children and afflicted communities, they would have been oriented more towards effective, and therefore timely, intervention even in the face of enduring uncertainties. It may have even altered what uncertainties they felt compelled to immediately grapple with in their investigations, and the larger vision of a worthwhile epidemiological account they were pursuing, though this is just conjecture.

The exact significance or utility of this "proximity" or "sensitivity" to suffering in terms of inspiring meaningful action and intervention is brought into question by the FELTP team's account of seeing the affected children while visiting the mission hospital. Gazing upon the suffering children's faces during their brief presence in the area clearly impacted several of them, as two of the team members provided detailed, unprompted recollections of it. As one explained: "In fact, I can remember that particular face was shining. Yes, in fact, the shiny face stays in my mind" (interview, Accra, November 2015). However, while this appears to have motivated the team to "take from our own pockets" to pay for milk and acyclovir, the standard treatment for B virus, it did not translate into a longer, more thorough, epidemiological investigation.

"A NICE STORY OF A NICE THING": THE UNCHECKED PROMOTION OF AN INEFFECTIVE MODEL OF OUTBREAK RESPONSES

In a prophetic email early on in the BAR response, the district officer warned the pediatrician about introducing outside researchers into the investigation, suggesting that they should:

...be careful, because the little information people get on this disease they want to publish because it is an emerging disease, however, there is the need for deeper investigation...let's work as hard as possible to answer all the possible questions, irrespective of the years or months that it will take.

When asked about the email in an interview, the district officer explained that in his experience, "They [outsider investigators] will come in, sit down and they will take this one, and this, and then they will come out with a nice story of a nice thing" (interview, DHMT offices, Techiman, October 2015). In this, the district officer not only predicted some of the temporal and spatial effects the inclusion of outsiders would have on the investigation, but also connected them with a preoccupation on the part

of these outsiders with producing tidy stories or accounts of the outbreak, which also appears to have been borne out.

Despite the etiology, scale, and conclusion of the outbreak remaining unresolved and, again, no meaningful intervention having taken place, three presentations, a draft academic poster, numerous research proposals, and four draft manuscripts were produced during the investigation by various combinations of responders. None of the draft manuscripts were ever submitted for publication; however, as stated earlier, mention of the investigation did later appear in a published article reviewing the work of the Ghanaian FELTP, where it is described as a successful investigation into Ghana's first B virus outbreak (Wurapa et al., 2011). What is interesting about these intended outputs of the response, other than their abundance in the face of no actual intervention occurring or generalizable knowledge being produced, is how they depict the processes of investigation and hypothesis building that took place. Of particular interest is the exaggerated rigor of the investigative activities, the specific actors depicted as undertaking them, and the implied effectiveness of what occurred.

A draft manuscript authored primarily by the American researcher, for example, describes a series of seemingly coherent and instructive investigative processes that are not easily recognizable as the piecemeal activities generating ambiguous findings that actually took place. For example, the manuscript fails to mention the uncertainty around the results of the diagnostic testing or the variability in the clinical pictures of the children. It states in the methods section that "An outbreak investigation was performed" (draft manuscript, 6th September 2011), though it does not mention that it only lasted a few days and involved interviews with only three affected families. It also fails to explain that this investigation was carried out by the FELTP team and not the manuscript's authors. In fact, the manuscript does not mention either the FELTP team or the district officer who initiated the formal response and transported the samples to the Noguchi Institute. It lists as co-authors the German pediatrician, the virologist, the first American naval officer who had attempted to facilitate the failed confirmatory testing at USAMRIID, and the Japanese researchers who had developed the PCR platform used in the initial diagnostic tests. Had the manuscript been published, it would have appeared as though the investigation into the BAR outbreak was thorough, producing clear findings, and almost entirely the work of foreign virologists aided by a German-trained Ghanaian virologist and a German pediatrician, and had not been contributed to by any national or parastatal disease control infrastructure or local public health professional.

The FELTP team's draft manuscript similarly describes robust investigative activities with compelling findings, even including a case-control study which they claim demonstrates a statistically significant correlation between contact with a monkey and testing positive for B virus. Obviously, having interviewed such a small number of affected families and none of the affected families having had direct contact with monkeys in a relevant timeframe, this is a significant exaggeration of both their undertakings and the findings from them. In the manuscript they also fail to mention the district officer, who, in addition to his work signaling the outbreak and realizing the initial testing, facilitated their investigation, taking them to the affected communities and relevant health facilities and plying them with much of the relevant context. Had this manuscript been published, it would have left readers with the impression that an FELTP team, largely unaided, had successfully performed a rigorous and conclusive investigation into a newly emerging zoonosis within the constraints of the normal FELTP model of short field deployments.

Had any of the draft manuscripts been published, the district officer, like most local public health officials, would have had little recourse to challenge these accounts or generate alternative ones that would circulate as widely or carry as much authority. To do so, he would have had to breach professional hierarchies, both domestic and international, and such violations could have compromised his access to needed resources and opportunities in the future (Brown, 2015; Moyi et al., 2015). Further, he would have struggled to create an account tidy enough and with sufficient scientific trappings, such as details of sophisticated laboratory testing, to gain traction within the wider epistemic community (Titanji, 2022). The affected communities would also have struggled to challenge the accounts of the outbreak response produced by the various responders, and their intimations of thoroughness and impact, not least because it seems unlikely they would have been shared with them.

BEYOND THE BAR: IMPLICATIONS FOR CONTEMPORARY STRATEGIES OF NEID CONTROL

Certain features of the BAR outbreak response may seem peculiar or extreme, such as the invented monkey-filled forest belt and the abundance of readily available expert responders; however, it should not be dismissed as an anomaly. In essence, the story of the BAR outbreak response is just the story of a poorly resourced and under-appreciated local health authority ceding control of an investigation into a suspected NEID to an improvised complex of outside experts. By simple dint of these experts' positions as outsiders and specialists, in combination with the concomitant loss of local coordination and oversight, the investigative infrastructure became predisposed towards superficial forms of evidence gathering and sensemaking and bound to advancing iterations of the increasingly ill-fitting early hypothesis that had initially recruited these experts to the response. Such displacement of local authorities by outside experts, both national and foreign, is not uncommon in investigations into suspected NEID outbreaks. And while the exact link between the incursion of outsider experts and the distortion of processes of hypothesis building may not have been drawn out in quite such meticulous detail before, there is evidence of similar downstream effects in other accounts of outbreak responses. Specifically, there are accounts of other brief investigations undertaken by groups of authoritative outsiders, in which limited engagement with the afflicted community occurs and poorly substantiated iterations of early hypotheses are promulgated (Briggs & Mantini-Briggs, 2016; David & Lachenal, 2018; Fairhead & Millimouno, 2017; Leach & Hewlett, 2010; Xiao, 2023).

This heavy involvement of outsiders in responses to suspected NEID outbreaks is not only a matter of happenstance but also an explicit feature of prominent NEID strategy documents. It is worked into the design of many key pieces of outbreak control infrastructure. Short "field visits" are the predominant model of outbreak investigation for most national field epidemiology training programs (FETP) and many international outbreak response mechanisms, including the World Health Organization's (WHO) Global Outbreak Alert and Response Network (GOARN). Within these organizations, "deployments," including international ones, are typically capped at just a couple of weeks. Even on paper, though, the extent to which the role of outsider experts is emphasized within these types of investigations is hard to make sense of. Aside from providing specific technical guidance and assistance with interpretation of evidence, such outsiders seem especially ill-suited to the core work of investigating and containing outbreaks. In addition to a lack of familiarity with the afflicted areas and the inevitable and costly delays in getting them to them, the performance of robust descriptive epidemiology is slow and meticulous work that typically takes months, not weeks, and this is without then considering the work of then translating it into effective intervention (Perrocheau et al., 2023). Further, outside of some specific clinical and laboratory investigations, which many field epidemiologists are incapable of in any case, the bulk of the evidence gathering is similar, if not identical, to what might be considered the regular work of local health authorities in detecting and responding to outbreaks of familiar diseases. While the history behind the prominence of outsiders and concomitant relegation of locals in such work is beyond the scope of this paper, the BAR case study does hint at a possible mechanism by which the weaknesses of this approach are currently being masked and its use sustained.

The various draft and realized outputs of the BAR outbreak investigations show that the outside groups of experts were uniquely well-placed to produce authoritative and wide-reaching accounts of the outbreak response. They also show that within these accounts the authors had routinely exaggerated the robustness and extent of their investigative undertakings, implied an impact in terms of disease control that could not be readily realized or reconciled, and not only obscured the critical work undertaken by the local authorities, but omitted their presence altogether. With the exception of the methodological flaws of the FELTP team's case control study, none of these documents breached any easily identifiable explicit standards or implicit norms of epidemiological publishing. As mentioned at the start of this paper, accounts of outbreak investigations often unduly emphasize the contributions of individual or select group of experts and apply unnaturally linear and progressive trajectories towards clarity and intervention on investigations contemporaneously and retrospectively. The structural advantages of

national and foreign public health professionals, as opposed to local ones, in creating widely circulating accounts is also a well-recognized widespread phenomenon (Bhakuni & Abimbola, 2021; Titanji, 2022). Finally, there are no mechanisms in epidemiological publishing through which the effectiveness of the undertakings detailed in these accounts is routinely checked and the accounts updated to reflect the findings. With all of this in mind, it is easy to see how particular shortcomings within our predominant approaches to NEID control might go unnoticed. It is also easy to see how some of the more obvious pathways to addressing these shortcomings, specifically, a greater recognition of the unique situatedness and capacities of local public health professionals in NEID control and corresponding investment in them, might also go overlooked.

A tendency towards grandiose, projective, and often colonial, storytelling and an attendant ineffectiveness in the here and now, is a recurring criticism of contemporary global health in general and emerging zoonosis initiatives in particular (Richardson, 2019). As historian Guillaume Lachenal (2015, 107) observed in a study of a group of American researchers investigating zoonotic emergence in Cameroon, it is “a world of inaction and impotence—of scientists not doing much, promising a lot, and telling stories to themselves.” In order to realize effective NEID control, it is clear that we need to both diversify the types of accounts of this work being produced and introduce greater checks on their claims and intimations of effectiveness (Biehl & Petryna, 2013; Yoon, 2015). Some of this work of diversifying the accounts is encompassed in the decolonizing global health movement, and hopefully this paper will add further weight to the notion that addressing epistemic injustices is not only a moral imperative but a practical one. This paper also makes a case for the production of further ethnographic accounts of outbreak investigations. In particular, the need for accounts that explicate the exact epidemiological processes being undertaken and compares them to what is often imagined or assumed of these processes and their depiction in the routine, official, outputs of these investigations. If, as the district officer suggests, we are destined to tell stories to ourselves, then we need to be attentive to how these stories are being produced.

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ENDNOTE

¹ A fuller account of the debunking of the “forest-belt” and an exploration of how the notion that there was a forest first arose and gained traction within the responses to the BAR outbreak can be found in Freya Jephcott’s 2023 paper *Propagating Visions of a Forest Reservoir: A Supposed Zoonotic Outbreak in the Brong-Ahafo Region of Ghana*.

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