Diarrhea outbreaks in northeastern Brazil in 2013, according to media and health information systems – Surveillance of climate risk and health emergencies

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Abstract *This study has the objective of analyzing information about diarrhea outbreaks in Brazil's northeast in the year 2013. Information came from electronic media and from health information systems. A total of 33 news events related to diarrhea outbreaks were identified, some of them mentioning causes and aggravating factors. The analysis of spatial and temporal distribution of the news, admissions and deaths showed that more than 100,000 persons were affected and, according to the news analyzed, the most affected states were Alagoas and Pernambuco, with a greater extent in the months from May to July. The use of alternative sources of water such as ponds, wells, water trucks and household water reservoirs were identified as the most immediate causes of these outbreaks. However, other underlying factors such as precarious water supply systems in the semi-arid region, the exceptional conditions of drought, considered the worst in the last 60 years, as well as the capacity of the health sector to respond to a large number of cases, should be considered to recover the context in which these outbreaks are produced.*

Key words *Diarrhea, Semiarid region, Extreme climate events, News, Health surveillance*

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Introduction

Drought is a natural phenomenon occurring in arid and semi-arid areas, and may even occur in wet areas during prolonged periods of drought. In this particular case, drought is an anomalous climate condition compared to the normal balance between precipitation and evaporation, most often caused by high temperatures[1]. The first reports of drought in Brazil date back to the 16th century, and in fact held up the Portuguese occupation of the Northeast hinterland. The 1,135 municipalities in the Brazilian semi-arid have been affected by increasingly frequent and prolonged droughts. This could suggest that this is no longer an adverse climate condition, but a climate disaster. The increased frequency and intensity/length of drought events could have important repercussions on the nation's economy and local health conditions[2]. In this sense, drought may be considered an extreme climate event capable of causing environmental and social damage[3]. In Brazil, 20 years of records of natural disasters (1991 - 2010) show that most of the declared states of emergency or public disaster were due to drought. This corresponds to 57% of the events and 50% of the people affected by disasters[4].

Among the different types of drought considered by the National Water Agency[1], the interaction between meteorological drought and hydrological drought is of primary interest to this paper due to its importance in producing risk conditions for water-borne diseases. *Meteorological drought* refers to a prolonged period of less than normal rainfall and above-normal temperatures, and can lead to other types of drought affecting water supply and farm output. *Hydrological drought* on the other hand, has to do with water reserves in the environment or a prolonged period in which water levels in rivers, creeks, lakes, reservoirs and even underground water tables remain below average. This process can affect both the quantity of water for human consumption and its quality due to contamination by chemical and biological agents.

If on the one hand water is a basic health need, on the other, when there is drought, it may become a source or enabler of infectious agents. Less water available for supply compromises personal hygiene and the cleanliness of the foods consumed[5]. Changes in quality can turn water into a means of transmission for infectious diseases, such as Acute Diarrheal Disease (ADD).

Outbreaks of ADD have a strong water-borne component, although they may also be associated with contaminated foods and involve a large variety of pathogens (virus, bacteria and parasites) in the environment. Environmental sanitation is an important element to ADD transmission. In undeveloped and developing nations, this includes environmental issues, which are rarely considered in epidemiological studies[6]. Major outbreaks of diarrhea have occurred in areas with limited coverage of sanitation services, and in situations where water supply is interrupted or massively contaminated. While water shortages and poor quality may make it impossible to keep homes and their surroundings clean, facilitating the cycle of diarrheal disease transmission, the collapse of water supply systems has been responsible for major outbreaks of the disease[7,8]. Climate and the environment, conditions outside the supply systems, can worsen these risk situations in semi-arid regions[9] or those subject to climate variability[10]

According to a report by Medeiros et al.[11] on the urban water supply in what is known as the Brazilian semi-arid - the region most subject to droughts - although 95% of the urban population is supplied with water, water losses in the distribution process are as high as 45%, and supply interruptions are frequent. The main source of water in the region comes from surface watersheds (64% of the 1,135 municipalities), all of which are vulnerable to pollution, especially by domestic sewage. Although 98% of these cities treat their water, 50.4% of the water supplied only partially meets the Ministry of Health potability standards. Thus poor water quality overlaps with issues of distribution and access[11]. During dry periods, the problem may become more acute, as the drought lasts for several years, such as the most recent one between 2011 and 2014, lasting a period of four years.

In early May 2013, cities in the Brazilian Northeast, where most of the semi-arid region is located, suffered outbreaks of diarrhea lasting about five months. According to online news sources, these outbreaks affected primarily municipalities in the interior of Alagoas and Pernambuco.

To an extent, these outbreaks were recorded by the structured healthcare information systems (SIS), either because patients were hospitalized, or died as a result of diarrhea, in the more serious cases. However, these records are merely an approximation of the total cases of diarrhea in the period, in particular the milder cases where no medical attention was sought.

Other cases were recorded in non-structured sources of information available online in blogs,

postings and online news. According to Silva et al.[12], non-structured sources quickly provide reports and complaints by the population about health problems not recorded in official information systems. Systematization of this data would provide quick estimates of the epidemic potential of certain diseases, providing subsidies for research and assessment of the incidence of such events, considered public health emergencies and affecting the health of the population[13,14]. Furthermore, this information helps find the collective cause and effect relationships between the disease and the environmental context that led to or contributed to it.

The goal of this effort is to check how information about these outbreaks is reported by the health information systems (SIS) and the news, especially online news. A comparison between the data about the incidence of diarrhea recorded by the SIS and news about diarrhea outbreaks could show similarities and differences between these systems, contributing to the development of quick and sensitive warning systems to detect outbreaks of diarrhea related to extreme climate events.

Methodology

Northeast Brazil covers 1,561,177 square kilometers, or about 18.3% of the territory. There are nine Northeast states: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe, with a combined population of about 53,081,950 [15]. Some 886,000 km² are located within what is known as the semi-arid, an area covering the north of Minas Gerais and the dry interior (*sertão*) of Sergipe, Alagoas, Bahia, Pernambuco, Ceará, Paraíba, Piauí and Rio Grande do Norte[16].

The methodology used for this paper consisted of online searches for news of diarrhea outbreaks in Northeastern Brazil in 2013. Initial searches used Google News®, a powerful online search tool that provides free access to the content of several online newspapers. The keywords used for the searches were outbreak, diarrhea and Northeast (in Portuguese).

The information collected was placed in a spreadsheet with the following fields: title, date, source, city or town, state, number of cases reported, number of deaths reported, reported cause of outbreak, emergency measures recommended and a link to the actual news item.

We also collected monthly information on hospitalizations due to diarrhea presumably of infectious origin) in Alagoas and Pernambuco, using the tables in the SIH/SUS Hospital Information System available from Datasus (http://www2.datasus.gov.br/). Monthly information about deaths due to diarrhea was obtained by tabulating the Mortality Information System (SIM) for Alagoas and Pernambuco - states with the largest prevalence of outbreaks according to online news. This data was tabulated and inputted into the Geographic Information System (SIG), georeferencing the main city in the municipality as a reference. All municipal maps were dated 2005 and provided by the IBGE[17]. Climate and vegetation data obtained from the INSA (National Institute for the Semi-Arid) website was used to describe local environmental conditions. All of this information was converted into layers in a SIG environment using Terraview (version 4.2.2).

We also collected data on ADD cases and deaths recorded by the state departments of health in Alagoas and Pernambuco to assess the coverage of the SIM and SIH (health information systems) databases.

To compare this data between cities and towns in the Northeast semi-arid declaring drought with outbreaks of diarrhea - both those disclosed in the media and those registered by the healthcare services, we used Civil Defense data to find where states of emergency or public disaster had been declared due to drought in 2013.

Results

News about diarrhea outbreaks

We found 33 reports of diarrhea outbreaks published by the online media between May and October 2013. Most of these were news items with very little data on the source of the outbreaks. For the most part, these news items talked about the form of transmission and the number of reported cases, which according to one source was over 100 thousand[18] in Pernambuco alone. According to our study, July had the largest number of online news items about the outbreak (a total of 15 items published). In the Northeast, Alagoas and Pernambuco had the largest number of news items published in the electronic media. According to the news, of the 25 of the 102 municipalities in Alagoas reported diarrhea outbreaks, with increased frequency in Água Branca, Arapiraca, Estrela de Alagoas, Girau do Poncia-

no, Palmeira dos Índios and União dos Palmares. According to our media search, Pernambuco also reported a large number of cases of ADD - over 130,000 according to the news clippings, with the largest number of cases being in Caruaru, Goiana, Macaparana and São Vicente Ferrer In terms of deaths due to diarrhea, according to the news clippings there were a total of 67 deaths, 54 in Alagoas and 13 in Pernambuco. Diarrhea outbreaks were also mentioned in the states of Ceará and Piauí, with no deaths.

Regarding the possible cause of the outbreaks, 67% of the news clippings (22) reported that the water used by the population, which had come from alternative sources, was contaminated with bacteria, virus or parasites. The other 33% of the clippings did not mention any cause for the outbreaks.

Alternative sources wells, cisterns and water holes were listed as potential sources of infection[19], as well as water distributed to the population in tank trucks[20]. According to the online media, in Alagoas CASAL (the State Sanitation Company) was called in to explain the contamination and absence of chlorine in the water distributed[21]. These sources also mentioned climate and environmental factors such as prolonged drought and a proliferation of flies in areas with domestic waste disposed of inappropriately[22] might have contributed to the outbreaks.

The state departments of health implemented emergency measures such as the distribution of sodium hypochlorite to disinfect water prior to use. Professionals were reassigned to handle emergency cases, and monitoring of diarrhea cases in the municipalities was enhanced. The state also provided supplies for lab tests, monitoring the rivers and other water reservoirs, and experts went to the field to explain about the importance of keeping water tanks and other reservoirs clean. Joint efforts by the state departments of health, the army and civil defense were created disinfect water in tank-trucks, and worked with FUNASA (National Health Foundation) to analyze the water.

Records in health information systems

In 2013 there were 4,380,256 reported cases of ADD in Brazil[23]. Of these, about 10,319[24] were reported in Alagoas, and about 130,219[25] in Pernambuco. These numbers coincide with the numbers we found in the online news clippings.

However, the same is not true when we look at hospitalizations and deaths due to ADD, where the numbers in the media differ from those reported by Datasus. According to the online media, there were 13 deaths in Pernambuco due to ADD between May and October 2013, well below the 423 deaths reported in SIM for the entire year. We get yet another number when we look at the data provided by the state health department, or 339 deaths due to ADD between January and September[25].

Deaths due to diarrhea were reported by the media and recorded in SIM in six municipalities in Pernambuco: Afrânio, Arcoverde, Caruaru, Goiana, Iati and Salgueiro. Santa Terezinha appears to have reported one death, but we found no record of it in SIM. The other deaths reported in SIM for Pernambuco occurred in municipalities not mentioned in the media.

In Alagoas, the online media reported 54 deaths due to ADD between May and October, while SIM reveals a total of 237 for the year. The Alagoas state department of health reported 201 deaths between January and October 2013[24], and SIM 213 deaths, also between January and October. These differences may be due to deaths due to diarrheal diseases not part of an outbreak and not directly related to the crisis in water supply.

The online media reported deaths [due to ADD] in eighteen municipalities in Alagoas: Água Branca, Barra de São Miguel, Cacimbinhas, Canapi, Carneiros, Estrela de Alagoas, Inhapi, Maceió, Maragogi, Mata Grande, Olho d'água das Flores, Olivença, Palmeira dos Índios, Porto Calvo, Rio Largo, Santana do Ipanema, São José da Tapera and União dos Palmares. Ouro Branco had one death reported in the media and not recorded in SIM. The other deaths reported in SIM for Alagoas include municipalities not mentioned in the media.

According to SIM, the municipalities in Pernambuco with the largest percentages of the ADD deaths were Caruaru (3.5%), Garanhuns (3%), Jaboatão do Guararapes (5.6%), Olinda (5%), Paulista (4%), Pesqueira (2.6%), Petrolina (3%) and Recife (18.2%). In Alagoas these municipalities with the largest percentages of the ADD deaths were Arapiraca (11%), Maceió (22%) and Palmeira dos Indios (5.9%).

According to SIH for 2013, there were 11,872 hospitalizations due to ADD in Pernambuco and 3,790 in Alagoas. Online news for this period did not mention hospitalizations due to ADD.

Comparing data in the news and the official records in the health information systems

Figure 1 is a month-by-month comparison of outbreak numbers in the news and the hospitalization (SIH-SUS) and death (SIM) numbers for the states of Alagoas and Pernambuco in 2013. Hospitalizations and deaths, while happening in since January, peaked in May, which is when the first reports were found in online media.

Analyzing the chart above it is clear that the first reports on the 2013 ADD outbreak in the Brazilian Northeast came out in the online media in May. Hospitalizations and deaths due to ADD in Alagoas and Pernambuco had already been happening since January. There was a peak in hospitalizations and deaths in the month of May, which is when the online media picked up the outbreak.

The maps in Figure 2 show the spatial distribution of hospitalizations and mortality due to ADD in municipalities in Alagoas and Pernambuco, and the municipalities mentioned in the news as being the sites of outbreaks of diarrhea between May and July 2013. This information is compared to the region's climate classification.

The maps make it clear that the higher incidence of diarrhea measured by mortality, hospitalization and news of outbreaks in the media happened in the western part of Alagoas and central Pernambuco, almost entirely within the region known as the *Agreste*. In Alagoas, outbreaks were also reported in the *Zona da Mata*, closer to the coast. It is important to point out that the most severe droughts have been observed in the *Sertão* and *Agreste* regions of Alagoas and Pernambuco ever since 2012. The drought became even more severe in April 2013, as measured by an NDVI (*Normalized Difference Vegetation Index*) of less than 0.2[26]. This index had climbed back to 0.4 to 0.6 in the subsequent months, when the diarrhea outbreaks were recorded, showing that the drought was improving due to rains and increased humidity.

According to the map, the municipalities with the highest rates of hospitalization due to diarrheal diseases in the period (Figure 2) are not the same ones reporting the highest numbers of deaths due to diarrhea (Figure 2.b). These differences may be due to the nature of the information systems, which record health events that are not necessarily related. Hospitalization and death are, at least conceptually, opposites as hospitalization may avoid a worsening of the disease and death. On the other hand, death may reveal situations of extreme absence of healthcare[27].
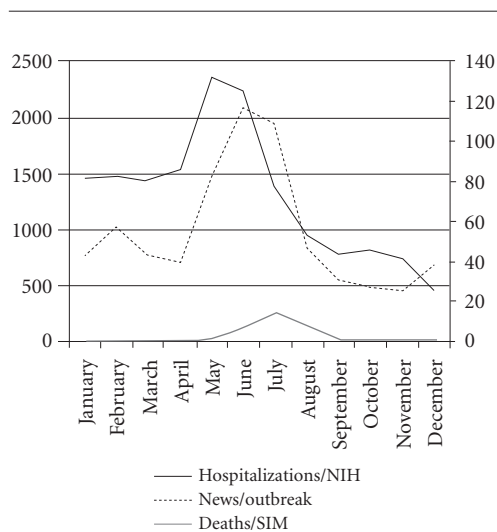

Figure 1. Comparison between the numbers of ADD outbreaks in the news, reported hospitalizations (SIH-SUS) and deaths due to ADD (SIM).

Fonte: SIH/SIM (Datasus) e jornais eletrônicos.

State of Emergency and Public Disaster due to drought in 2013

The declaration of state of emergency due to drought in municipalities in the Northeast states and in the North of Minas Gerais were analyzed to check the extension and magnitude of the drought in this region. For 2013, we checked the municipalities where a state of drought was declared, according to the National Civil Defense Department. Figure 3 shows the municipalities where a state of emergency was declared in 2013 due to drought.

Looking at the Figure 3, we see that a total of 581 municipalities declared a state of drought in 2013. It is important to point out that according to the Civil Defense data, some of the municipalities declaring a State of Emergency (SE) or Public Disaster (PD) are located outside the Semi-arid.

Discussion

Online news between May and October 2013 shows that the Brazilian semi-arid was affected by outbreaks of diarrhea, especially the states of Alagoas and Pernambuco. The health information systems also recorded a large number of deaths occurring at almost the same time as a set
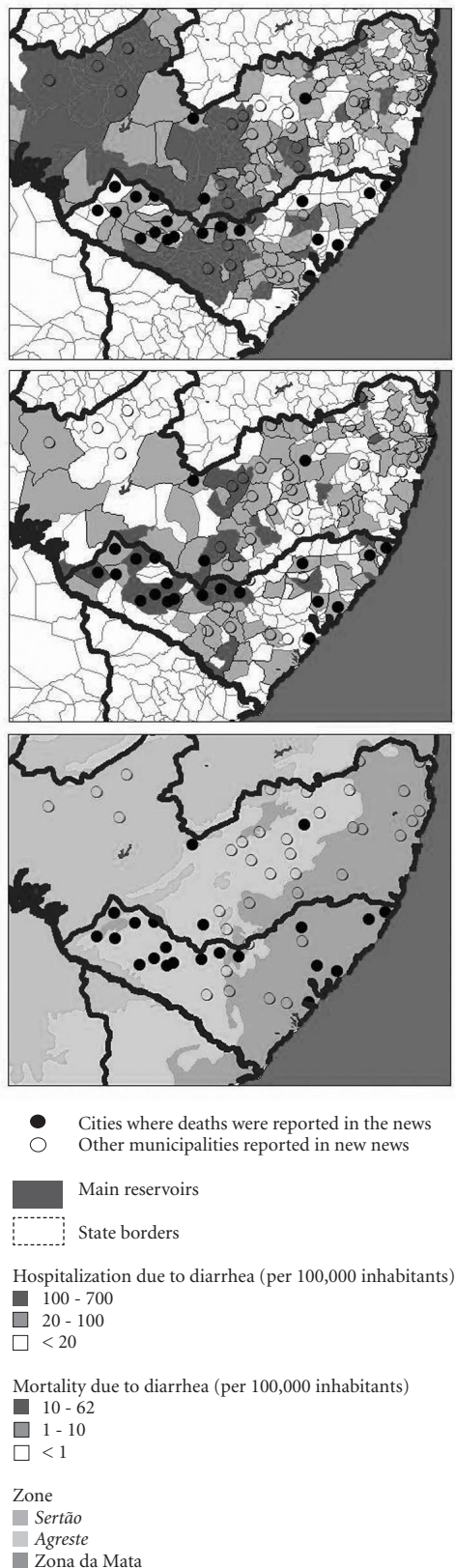
● Cities where deaths were reported in the news
○ Other municipalities reported in new news

■ Main reservoirs

⌐⌐ State borders

Hospitalization due to diarrhea (per 100,000 inhabitants)
■ 100 - 700
■ 20 - 100
☐ < 20

Mortality due to diarrhea (per 100,000 inhabitants)
■ 10 - 62
■ 1 - 10
☐ < 1

Zone
■ *Sertão*
■ *Agreste*
■ Zona da Mata

Figure 2. Hospitality, mortality and news about diarrhea in the states of Pernambuco and Alagoas. May - July 2013.

of outbreaks in the region, most likely associated with the drought and a crisis in water supply.

The hydrology in the Brazilian semi-arid is characterized by very variable rainfall, with some years being very dry and others very wet. This variability is related primarily to the topography and regional climate systems[28]. Periods of more acute drought in the semi-arid, such as in 2012 and 2013[29], increase the risk of diseases related to this type of climate event. A possible system showing the potential means of exposure, illness and healthcare for those exposed is shown in Figure 4.

Drought affects water availability in the watersheds such as rivers and dams. These conditions may be monitored using the network of hydrological metering systems available in the region, and important initiatives to monitor damn levels on the part of INSA (the National Institute for the Semi-Arid) and ANA (the National Water Agency). This information enables issuing alarms about the depletion of these watersheds in times of drought. The drought itself may be measured indirectly by measuring soil humidity and primary output, such as the NDVI published by UFAL (Federal University of Alagoas).

Although limited to monitoring water in the supply systems (capture, treatment and distribution), data on water contamination may be obtained from the Ministry of health information system, which runs a program to watch over the quality of water for human consumption (VIGIAGUA). However, this information reveals that in the municipalities located in the Brazilian semi-arid, only 50.4% of the water even partially meets the MoH potability standards[11]. If under "normal" situations half of the municipalities are served by water outside the standards of potability, this situation is worsened during droughts, when water supply decreases and the number of sources from where this water comes increases. Under these conditions, part of the water comes from small alternative sources used by the local population in emergencies. These include water-holes, improvised tank trucks, home and community wells, and other sources that make it impossible to analyze the quality of the water under these conditions[5].

The 2013 drought depleted or contaminated important watersheds in the region. This led to a series of risk situations, from contamination of the public water system through distribution of contaminated water by tank-trucks and other legal and illegal sources of distribution[30]. As a result, part of the population became infected and
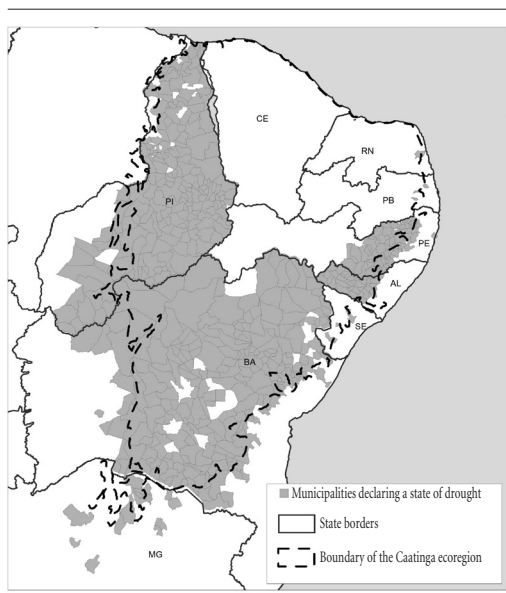
Figure 3. Municipalities in the Caatinga eco-region declaring a state of drought in 2013.

Source: National Civil Defense Department, the authors.

ill. The more severe cases seen by the healthcare services in the region were reported to the Acute Diarrheal Diseases monitoring system (ADDM). Other cases were hospitalized and recorded in the SIH, with diarrhea as the underlying reason for hospitalization. If the person dies, whether or not the death happened in a healthcare establishment, the case of diarrhea is entered into SIM.

It important to note that these information systems are complementary and register health events that are not coincidental. In theory, hospitalization due to diarrhea should avoid death, which may explain why the areas with the highest mortality due to ADD have the lowest hospitalization rates and vice-versa. The areas with the larger number of hospitalizations seem to have been able to reduce disease lethality. Between infection, disease and severe disease, one would hope that ambulatory care or hospitalization would reduce the lethality of ADD by diagnosing and treating it in a timely way.
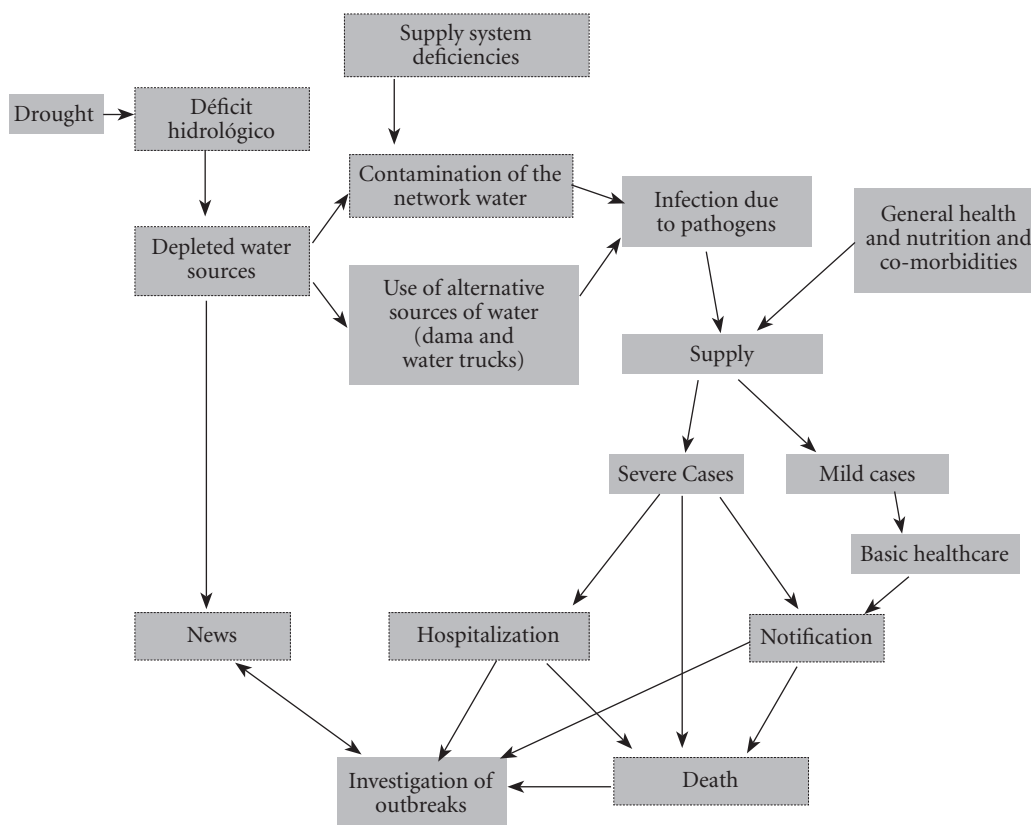

Figure 4. Chain of events during a drought and deaths due to diarrhea. The grey rectangles are assumed events and the rectangles with dotted borders are events that can be monitored using information systems.

However, most of the environmental and health events precipitated by drought and leading to exposure to pathogens in water remain submerged; in other words, they are not registered in official and structured sources of information. It is important to note that individual cases of diarrhea are not required to be notified. However, outbreaks and deaths must be reported using the Computerized System of Epidemiological Surveillance of Acute Diarrheal Diseases[31]. An outbreak means there are "epidemiologically related cases" and the evidence that "the individual shows signs and symptoms after ingestion of a food believed to be contaminated by clinical-epidemiological and/or laboratory evidence". This depends therefore on a critical analysis of the databases available and epidemiological investigations that are normally conducted at the local level[25].

Existing official and structured health information systems are unable, on their own, to detect outbreak and assess collective risk conditions. Health surveillance professionals are responsible for transforming data into useful and timely information that can be used to identify common sources of exposure and reduce or eliminate their effects on the health of the population[32]. Outbreaks can be detected by analyzing a historical series of disease behavior (detected as an unusual number of cases reported). The spatial analysis of these records will also reveal the locations with a higher concentration of cases, providing elements for detecting the likely source of transmission and the risk factors[33]. These studies, both field and statistical, aim to establish a nexus between individual cases and collective risk factors[34]. For example, in 2013 the Pernambuco state department of health issued guidelines for the conduct of several sectors when there is a drought. In this document the department used a control map to point out a large number of cases of diarrhea - "above the expected numbers" but avoiding the work outbreak[26].

A fact or event that becomes public becomes a discussion point[35]. The media cover events such as droughts and floods differently, even though both can lead to medium and long-term health problems[4]. As a drought is often considered a climate event characteristic of certain regions[28] and is accepted as a natural phenomenon, with the media working information to construct a sense of a chronic event, something that has "always happened", and thus it gets less media coverage than a flood.

As a result, outbreaks and not individual cases are worthy of being reported and debated by the media, which in this case plays an important role in listing the potential causes, the relationship between health and environmental events, and the interpretation of research data[36]. In the 2013 drought, we found a close relationship between the media and the government, shown by the similarity of content between technical reports and online news.

It is up to society and the media to comment, consolidate and critique this data to identify collective risk situations, as the Internet combines a number of important sources and options for the population[37].

As shown by Chunara et al.[13], during epidemics the official data collection and registration structures may be unable to issue early warnings or assess the health situation in the timely way. The press on the other hand, may provide an informal warning that is closer in real time and provide a preliminary assessment of the dynamics of epidemic situations. The state and city departments of health are sometimes unable to detect and warn the population of outbreaks in a timely way, and produce inconclusive reports due to the limitation inherent in the data on which they are based. As the media has better methods to collect data it could help develop disease alerts and monitoring systems based on informal sources of information. These systems are part of the permanent goals of the Health and Climate Observatory coordinated by Fiocruz and INPE (www.climasaude.icict.fiocruz.br).

In this way the news, and thus the media, can help recover overall data on these risk conditions. In this effort we found that news referred to the official SUS data, especially that produced by state health departments. The media also played an important role in identifying risk situations and warning of a set of environmental and climate factors that could be related to the outbreaks. Almost all of the news referred to water and contaminated watersheds as a likely source of infection, either due to interrupted supplies[38], contamination of town water systems, or the use of improper sources to distribute water in tank-trucks[39].

The duration and extent of the outbreak shows there is no common source of contamination and reveals the vulnerability of the water supply systems and the existence of dangerous practices - outside these systems -, such as privatized and restricted access to water and improvised means of supply.

In this sense, one can establish a direct relationship between ADD outbreaks and water

supply crises, which are becoming more and more common in parts of this country. There is an accumulation of structural situations of poor water supply, worsened by a major climate event. According to the Civil Defense, the 2012/2013 drought was particularly severe. Also according to the Civil Defense, in 2013 581 municipalities declared a state of drought.

It is important to consider that several studies[9,10] recognize that there is a relationship between quality of water and climate variability, and that these are involved in a range of intermediating processes that can worsen the health of individuals exposed to them. Not all of this information is easy to recover from official and structured information systems. According to Genser et al.[40], the more severe cases of diarrhea may be the result of existing malnutrition and co-morbidities, as well as inadequate housing and sanitation. The absence or inefficiency of basic healthcare services can also contribute to worsening this situation.

The complexity of these relationships is demonstrated by the large number of interactions between processes and events that may mediate the relationship between drought and the emergence of diarrhea outbreaks. Figure 4 shows some points where water volume and quality monitoring and vigilance using the health systems may work together to create early warning systems. Understanding these processes will help identify gaps and opportunities for prevention.

In addition to the cross-discipline approach proposed by the theme exposed, this article attempted to investigate if there is a direct relationship between the climate in the Northeast of Brazil and ADD outbreaks. Figure 2 shows an initial analysis that found that most municipalities where diarrhea outbreaks occurred re predominantly dry and tropical (*agreste*). The coastal region of the Northeast is humid and tropical (*Zona da Mata*), and had the second largest number of municipalities reporting ADD outbreaks in 2013. Unlike what one might assume, the drier part of this region, the so-called *sertão*, had the smallest number of municipalities reporting diarrhea outbreaks. This distribution of risks may reveal an inability of the transition region (the *agreste*) to adapt to major climate variations such as a shortage of dams and reservoirs, and public policies that increase the resilience of water supply systems.

According to Molion and Bernardo[41], the annual variation in the distribution of rainfall in the Brazilian Northeast in space and time is related to changes in the atmospheric circulation in the region, and the interaction between ocean and atmosphere. In the Southern hemisphere, this variation in rainfall is associated with the climate phenomenon known as El Niño. Ambrizzi et al.[35] report that climate change may worsen this scenario, leading to higher temperatures and less total precipitation in the region, as predicted in models of future scenarios.

Collaborations

R Rufino, R Gracie, A Sena, CM Freitas and C Barcellos participated equally in all stages of preparation of the article.

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