

Disasters related to droughts and public health – a review of the scientific literature

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Abstract *In Brazil, the history of droughts has been marked by constant social and health tragedies, with estimates of up to 3 million deaths from the early 19th century until the late 20th century. There is a record of nearly 32,000 events related to the above and more than 96 million people were affected between 1991 and 2010. Although droughts have historically brought disasters to Brazil, which was noted in the scientific expeditions of Arthur Neiva and Belisario Penna that documented these droughts, there have not been many studies on them. The objective of this paper is to present a revision of the scientific articles related to droughts and public health. The following databases were used: PubMed, the Preparation and Response to Disasters Portal from BVS and the Capes Periodical Portal. The descriptors drought and health were used to search titles and summaries of articles in English, Portuguese and Spanish. Among the repercussions related to health that were discovered: malnutrition and nutritional deficiencies, mental health problems, issues relating to water and air quality and commitments made concerning access to health services. As there is a trend for more intense droughts and a scarcity of water until 2030, there is an urgent need for more research and studies in these areas.*

Key words *Disasters, Natural disasters, Drought, Climate change*

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Introduction

In Brazil the history of droughts has been marked by periods of social tragedy and public health problems. The drought that occurred between 1877-1879 caused the death of approximately 500,000 people (deaths were also due to a smallpox epidemic) and 3 million people were displaced and made refugees. In the drought of 1914-1915, approximately 100,000 people died¹. It was between these two droughts that Arthur Nevia and Belisario Penna² from the Oswaldo Cruz Institute carried out, in 1912, their scientific trip to the areas affected by the droughts (their report was completed in 1915 which was the year when the drought was very serious, and it was published in 1916). The trip was done on the request of the Inspectorate for Action Against Droughts that was created in 1909. During their journey they identified a number of diseases that came about as a consequence of poor living conditions and minimal health care in the regions far from the main cities. Using the terms that were in the report, there were a number of diseases that were identified and were related to the living conditions in these remote regions such as: *spasmodic dysphagia*, a disease known as 'vexame do coração' characterized by persistent heart palpitations, *malaria* (owing to the construction of large dams), *tuberculosis*, *diphtheria*, *dysentery*, *eye infections* (mainly in children up to the age of 12) and *typhus*, amongst others².

From the two droughts that occurred at the end of the 19th century and those throughout the 20th century, there were registers of outbreaks and epidemics for the following diseases: daytime blindness (hemeralopia), trachoma, cholera, diarrhea, dysentery, typhus, paratyphoid, yellow fever, smallpox, bubonic plague, leishmaniasis and influenza. Those that migrated to the amazon region, due to having been forced to do so or through fleeing the drought, became ill because of: leprosy, tuberculosis, malaria and beriberi. Suicides by heads of families were registered in drought stricken areas, as many were not able to deal with the consequences of this natural disaster. There were also other problems such as the proliferation of rattlesnakes and rats which led to venomous poisoning and other diseases^{1,3}. Apart from the diseases and deaths that were directly related to the drought stricken regions, there were other indirect effects such as outbreaks of: leprosy, tuberculosis, malaria and beriberi. These diseases affected many who migrated to the amazon region being either forced

to do so, or having to flee disasters. It is estimated that 3 million people died during drought spells from 1825 to 1983, in Brazil¹.

In spite of Brazil's history of having gone through disasters related to droughts (which have been occurring with ever more frequency and with greater intensity) since Nevia and Penna's report in 1916, we were not able to find other publications on the connections between this type of natural disaster and public health⁴. In light of the aforementioned, the objective of this article is to present a revision of the published scientific literature on the connections between droughts and public health. This study can be considered as opportune because such natural disasters are a current concern for us in both the scientific and social arena. This is due to the negative impacts on living conditions and health for affected people.

Droughts as a public health problem

Droughts occur due to a lack of precipitation which affects the agricultural ecosystem, nature and general human activities⁵⁻⁷. According to the available literature⁸⁻¹⁰, information on droughts and their consequences is complex and can be divided into the following areas: meteorology (low rainfall), agriculture (short term droughts affecting the soil during the growth period for plantations), hydrology (a reduction in water currents and in river and lake levels controlled by dams), socioeconomics (effects on living conditions, property and the well-being of people), and the environment (fires, land degradation and sand storms).

Droughts affect the ecological, economic, social and cultural areas^{9,11} causing significant damages and losses for the living conditions of those most affected. The main impacts are: problems in providing water to the population, losses in the agricultural and fishing sectors, populations deciding to migrate to other areas, forest fires, degradation in water quality, health problems, conflicts and increased poverty^{10,12}. Droughts often start slowly and can last from a few months to years, causing multiple impacts. They are considered different to other natural disasters in that they require actions that take into consideration all of its unique aspects.

The level of the impacts caused by droughts depends on the socio-environmental vulnerability of an area. This is connected to the nature and magnitude of the drought and the social structures of societies^{6,12,13}. Where there is a disaster

due to a drought, the magnitude of its impact depends on its duration and the socioeconomic conditions of the affected region and population^{6,13}.

Droughts affect different countries and regions in the world, mainly countries and continents such as: Canada, the United States, Western Europe, Africa, China, Asia, Australia and Brazil¹⁴. It is worth noting that Brazil lacks the technical and scientific body of work that can respond to the challenges brought about by droughts in relation to the collective health of the population⁴.

Recent data from the International Emergency Disasters Database (EM-DAT)¹⁵ (this is a database on disasters that have occurred in the world held by the Center for Investigations on the Epidemiology of Disasters (CRED)) has given an indication of the serious effects of droughts in different countries between 1900 and 2015. According to EM-DAT it estimates that 659 drought episodes occurred during the above period, resulting in 2.21 billion people being affected and 11 million deaths. In relation to economic losses due to the droughts during this period in the United States and Mexico, the losses were about 8 billion dollars. In China the losses were 2.4 billion dollars and in Brazil it was approximately 11 billion dollars^{10,15}.

Future predictions in relation to climate change state that drought occurrences will become ever more intense and frequent during the 21st century¹⁶. According to the United Nations Organization (UN)¹⁷ its prediction is that by 2030 nearly half the world's population will live in areas where there will be a scarcity of water causing severe consequences for public health.

Methodology

Research on droughts and health in specialist journals was carried out using the following databases: PubMed (<http://www.ncbi.nlm.nih.gov/pubmed>), The Preparation and Response to Disasters Portal BVS (<http://response.bvsalud.org/>) and the Capes Periodical Portal (http://www-periodicos-capes.gov.br.ez68.periodicos.capes.gov.br/index.php?option=com_phome). On the last website above the databases that were used were called Scopus and Web of Science.

We commenced in March 2014 and concluded in June 2015. For this study we used a combination of descriptors [drought and health] in the title and we did summary searches on Pubmed. We searched just on titles in the portals Prepara-

tion and Responses to Disasters BVS and Capes. The inclusion criteria were: (1) only articles, (2) articles in Portuguese, English and Spanish, (3) direct connection with the subject of health.

Exclusion criteria: (1) articles that did not **directly relate to health, such as biology, engineering, hydrology, botany and meteorology**, (2) **languages different to the designated ones**.

Results

In total we reviewed 586 articles in the different databases: 402 (Pubmed), 16 (the Preparation and Responses to Disasters portal) and 168 (the Capes portal). Of the above, 456 were excluded based on the aforementioned criteria, leaving 130 articles.

In the second part of the selection process, from the 130 articles, it was shown that 72 were duplicates from other databases and 6 were found to be unavailable. 52 were subsequently included in the revision (Figure 1) covering the first publication in September 1931 and the last in June 2015.

After reading the summary and the accompanying information, a more thorough and com-

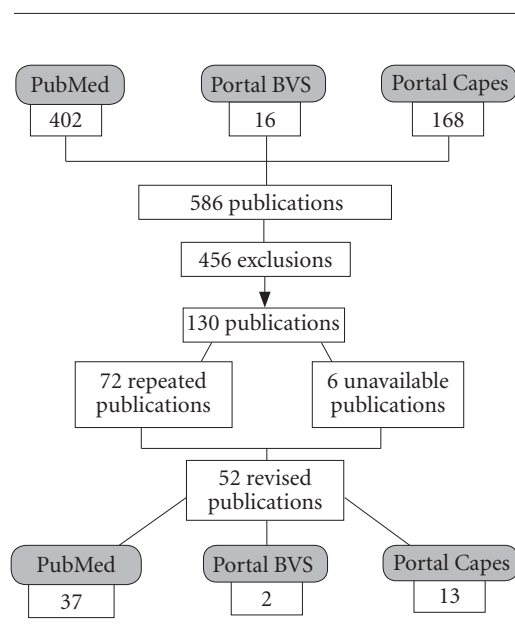


Figure 1. Revision of the articles in three databases.

Source: The authors of the paper.

Chart 1. Connections between services and products that have been compromised and the quality of the environment with the effects that droughts have on the health of humans.

Services, products and the quality of the environment	Effects on human beings	Original Article
Food quality that has been compromised and the quantity has been reduced	Malnutrition Nutritional Deficiencies	10, 18, 20, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40 18, 19, 21, 22, 27, 30, 31, 32, 34, 38
Water quality that has been compromised and the quantity has been reduced (sanitation e hygiene)	Transmittable diseases by vectors and other hosts Diseases related to inadequate sanitation Transmittable diseases related to contact with water Diseases related to hygiene Feco-oral transmittible diseases	10, 26, 27, 29, 30, 33, 35, 36, 37, 54, 55, 56, 57, 58, 59, 61 18, 62 46 32 18, 26, 27, 28, 29, 30, 31, 32, 33, 35, 37, 38, 40, 46, 62, 63
Alterations in the quality of the air	Acute and Chronic respiratory diseases	10, 27, 30, 35, 37, 46, 55, 64
Chronic transmittable diseases	Neoplasia	65
Economic and financial impacts	Mental Health (stress, anxiety, alcoholism e suicide) Migratory processes and the dissemination of diseases and epidemics	10, 16, 18, 34, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52 10, 18, 27, 30, 33, 35, 43
Research on health services	Alteration in the access and quality of health services	10, 35, 43, 68

plex review was done. In this second phase of the research it was possible to categorize, from the diseases that were connected with the drought occurrences, the risk factors for the diseases and the groups and services that were vulnerable due to the droughts, as seen in Chart 1. In terms of the diseases, an identification was made of: malnutrition and nutritional deficiencies, mental health disorders, diseases related to inadequate sanitation and the diseases transmitted by vectors/hosts, respiratory diseases and cancer. Apart from the above effects, themes related to vulnerability of health services impacting both quality and access, were identified.

Malnutrition and nutritional deficiency

Morbidity that was connected to the nutritional state of the population that was exposed to this type of natural disaster, was analyzed in a large number of publications, 24^{10,18-40}. From the above total, 11 analyzed the nutritional state of the population as a whole^{10,25-30,34,35,37,38}. In relation to the vulnerable groups, an identification was made of three groups: pregnant women^{20,32,33,36}, children between the ages of 0 to 5^{20,23,24,30,32,36,39,40} and people living in shelters and temporary makeshift accommodation^{26,27,30}.

In relation to nutritional deficiencies, the following deficiencies were identified: vitamin A^{19,27,30}, complex B (riboflavin and nicotinic acid^{21,31}) and chronic energy^{22,30}.

Mental Health

The effects on people's mental health and emotions was analyzed in 20 articles^{10,16,18,34,35,37,40-53}. The most amount of studies^{16,40,42,45-47,50-53} were done on elderly farmers and other elderly people that worked in agriculture. Their worries centered on what would happen in the future and thoughts of suicide. A small number of articles concerned teenagers, women and people from aboriginal descent. It was identified that the teenagers experienced social and economic isolation due to fears of the financial situation in their country and their own future. This was particularly the case because in periods with prolonged droughts they had to stop attending school or university and help their parents in relation to their family income^{48,49}. For women⁴¹, it was noted that they experienced more anxiety than men when in drought periods. This was because they had to increase their responsibilities in order to meet the basic needs of their families such as in obtaining water and food. This was particularly the case when husbands had to leave home in order to find a job to guarantee their family income. Lastly it analyzed the effects of the prolonged drought on the emotional well-being of the aboriginal communities in New South Wales which is one of the most populous states in Australia⁴³.

Diseases Transmitted by Vectors

17 articles analyzed diseases transmitted by vectors^{10,26,27,29,30,32,33,35,37,54-61}. When there are droughts it is often the case that water is stored or left in a stagnant state which becomes the ideal breeding ground for mosquitos^{32,33,58,61}. This is particularly the case for the *Aedes aegypti* mosquito which can transmit dengue fever^{29,37} and the Anopheles mosquito which transmits malaria^{26,27,30,60}. At the same time it was identified that a lack of surface water affects the behavior of mosquitos where they are forced to reproduce in marshland areas and in areas that have many bird species and other types of wild life. This convergence of mosquitos and birds allows the mosquito to act as vectors for these diseases to survive and can cause outbreaks of certain diseases which include: St. Louis Encephalitis⁶¹, Eastern Equine Encephalitis and West Nile Virus disease^{37,55,56,59,61}. Lastly, the focus of the article was on the main drought in Brazil that occurred in Ceará between 1877-1879 where millions of people died and others migrated to large capitals,

taking with them the Cutaneous Leishmaniasis (or Tegumentary Leishmaniasis) disease.

Diseases related to inadequate sanitation

In relation to diseases related to poor sanitation, 17 articles^{10,18,26-33,35,37,38,40,46,62,63} were identified which covered restrictions on the supply of water and the different ways of storing it (i.e wells, dams, water supply lorries, portable water, rivers and waters storage tanks). According to these articles, a lack of adequate hygienic conditions and poor water quality for human consumption^{18,62}, resulted in fecal-oral transmission of diseases (such as cholera^{26,30,37}, dysentery^{26,30,31}, typhoid fever^{28,29,31,33}, diarrhea^{18,26,27,29,31-33,35,37,40,46,62} and hepatitis A³³). In relation to a lack of hygiene, problems with conjunctivitis³² and skin diseases³² were noted. Also an identification was made of diseases transmitted through contact with water such as leptospirosis⁴⁶.

Respiratory diseases

Other effects related to droughts are respiratory diseases and this was analyzed in 8 publications^{10,27,30,35,37,46,55,64}. Smith et al.⁶⁴ used the Amazon region in Brazil to demonstrate forest fires caused by droughts could result in a rise in respiratory diseases in children.

Neoplasms

Only one article⁶⁵ analyzed cancer as possibly being related to droughts. This article associated esophagus cancer with areas that had droughts in China. It also noted that climatic factors as well as genetic and biological factors need to be considered when analyzing influences in people's lives and their health. That is why it is necessary to study the connection between climates and health.

Vulnerable Groups

Seventeen publications identified vulnerable groups with the effects of droughts on people's health^{16,20,23,24,39,40,42,44,45,47-53,66}. The groups were: elderly agricultural workers^{16,40,42,44,45,49-53,67}, teenagers^{48,49}, pregnant women²⁰, and children under the age of 5^{20,23,24,39}. The effects that received the most amount of attention were those related to: mental health, malnutrition and nutritional deficiencies. Aside from these groups and the effects, one article analyzed the subject of women in

their menopause who live in rural areas. Due to the financial pressures in drought stricken areas, these women had difficulties in accessing health services in order to obtain hormone replacement therapy⁶⁶. The situation was made worst due to the absence of emotional support which in turn led to depression.

Migratory Processes

Historically prolonged droughts contributed to the mass movement of populations to urban centers because people were not able to sustain their families in these rural areas^{10,18,27,30,33,35,43}. This was due to: a reduction in the production of food, loss of harvest, death of animals and loss or absence of work and income.

Health services

In relation to health services, three articles analyzed the connection between these services and the theme of droughts^{10,35,43,68}. The focus was on aboriginal Australians that were considered a vulnerable group as they could not get access to some services or even health care professionals from their own background. In times of droughts their situation worsened as it directly affected the group's health⁴³.

Discussion

In Figure 2 we systemized the implications of droughts on people's health and during drought occurrences there were changes in morbidity and mortality rates in the affected regions. Some effects on health can be felt in the short term, however, some impacts are indirect and have long

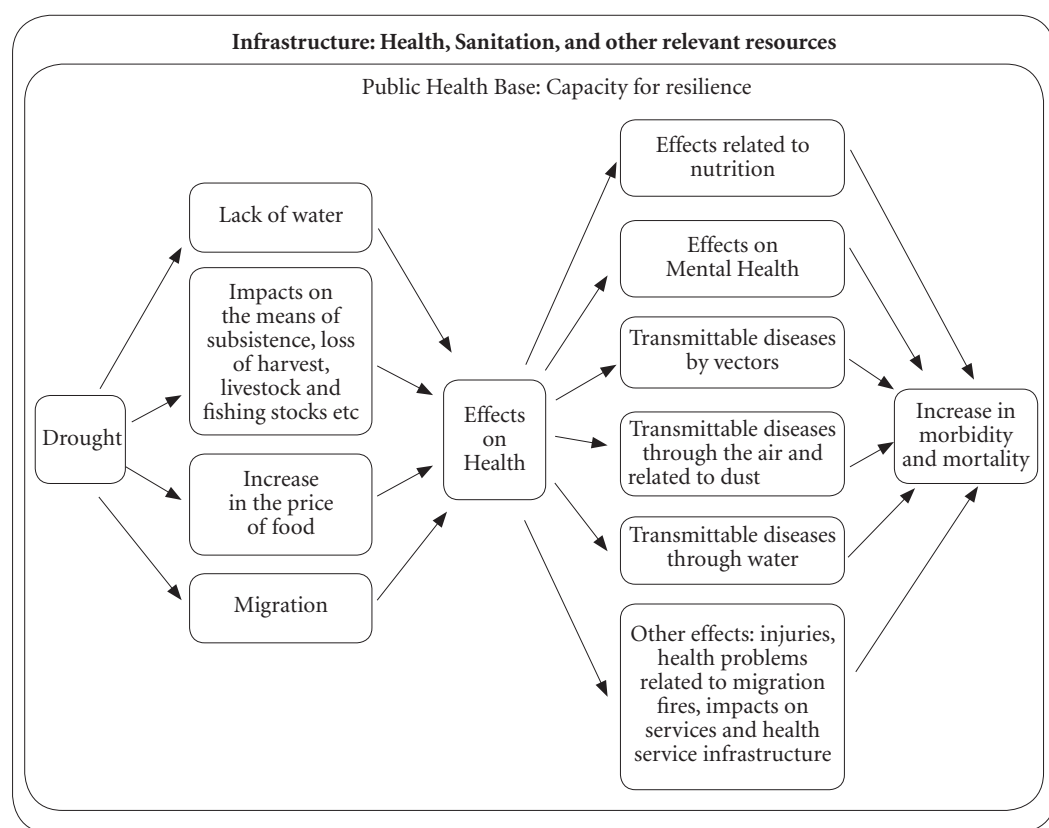


Figure 2. Droughts and their effects on living conditions and health.

Fonte: Próprios autores.

term effects such as, for example, malnutrition that can last for months or years during drought periods. The sum of these impacts and effects of drought occurrences on people's health, compounds people's social and economic situations and environments. For example existing health problems are made worse and are compounded by any poor socioeconomic conditions or malnutrition. This is also the case in relation to access to sanitation services and health care which creates new scenarios and socio-environmental vulnerabilities^{67,69,70}.

Prolonged droughts can affect agricultural, livestock and fishing activities either partially or completely. This in turn affects food consumption. Food can be compromised in respect of its quality and quantity owing to: the scarcity and or the contamination of the water, a lack of sanitation, or an increase in demographic density (due to population displacement). Another factor refers to economic losses due to total or partial loss of sources of income and work, which affects people's purchasing power for food. This has direct results on the nutritional states of individuals. A poor nutritional state can lead to a weakened immune system and a tendency to fall ill easily^{67,69-73}.

On the one hand it was clear that the lack of food protection and nutrition are some of the effects caused by droughts. It was also identified that there were mental health effects for the exposed Australians. Based on the observations of some authors^{67,69,74}, droughts can affect the mental health of individuals causing: stress, suicides, anxiety, increases in alcohol consumption and depression. The above is also caused by: loses in agricultural productivity (including productivity from livestock) and falls in land values. The pressure increases with financial difficulties. There is a loss of social and family support and the environment becomes vulnerable.

Beside from the quantity of water that is reduced, the quality of the water can end up being affected by different factors such as: long periods of droughts where the temperature is high, contamination of the soil by cyanobacterias, the accumulation of toxic products and chemicals in the soil and animal feces. These factors can adversely affect the water for human consumption, the soil, and hygiene practices. With reference to the availability of water, the reduction in water levels in the supply system, coupled with the scarcity of rain means that there is a need for other water supplies. This is the case even though the water is not fit for human consumption^{67,69,75}.

It should be reiterated that diseases transmitted by vectors do not stopped being related to a lack in the supply of water or the storage of water in an inappropriate way. It is also connected to infectious diseases. According to the literature^{67,69}, droughts cause environmental problems and harm the health of the population. This type of natural disaster alters the cycles for vectors, hosts, and reservoirs which can contain diseases and has environmental impacts mainly related to water.

Droughts that last for long periods have negative impacts on air quality owing to: the amount of particles suspended in the air (pollen, fluorocarbons), the low air humidity, the dry air, and the formation of aerosols and dust particles. The air also ends up being contaminated due to forest fires and toxins that accumulate in the soil^{67,69}.

With reference to populations, certain people that fall into certain age groups and sexes are considered to be more vulnerable when droughts occur such as: children, the elderly, women and people with special needs. The following factors for the above groups can contribute towards making their situation of vulnerability worst: the extent of their cognitive and physical development (for children and the elderly), their motor skills (for people with special needs) their socioeconomic status and access to basic health resources^{69,76,77}. The root of their vulnerability lies in the social, economic and cultural processes of the territories in which they live⁶⁶.

In relation to populations, droughts tend to force people to migrate with the hope of better conditions for their families particularly through obtaining jobs, better incomes, food and water^{11,67,69,78}. Nevertheless it should be pointed out that due to migration there is tendency for transmittable diseases to be spread which can cause more health problems in other areas.

Droughts not only affect the health of the population and access to services, it can also cause disruptions to health services due to medical instruments and equipment becoming contaminated owing to poor hygiene⁶⁸. Other effects include: loss of vaccines and medications, lack of hygienic water for human consumption and an inability for health care professionals to do their jobs. This makes some areas even more vulnerable^{67,69}.

In Chart 1 we have systemized the articles we analyzed using mechanisms related to risk factors (compromised services, products or environmental quality) and their effects on health. We noted that for both health services and sanitation, both

had been compromised, having direct and indirect effects. A lack of water not only has hygiene effects with the consequences being diseases, but people start to store water in different areas which can lead to other diseases such as dengue fever. In Sao Paulo, for example, comparing the first bimester for 2014 with 2015 (the period when there was a water crisis) the number of dengue fever cases jumped from 11,876 to 94,623 (an increase of 697%)⁷⁹. The lose of plantations and animals or jobs in affected areas, apart from having direct economic and financial impacts, can also result in the following: an increase in food prices and available water that can be bought. This in turn affects people's mental health and the nutrition of the family. The environmental quality of the water, the air and other consequences can occur. These can be overlaid with other consequences.

In Figure 3 we organized and demonstrated the interactions between the diseases highlighted in the articles. We focused on effects and we grouped together vulnerable groups with the process of migration of populations and health services which is not in the diagram. One of the important aspects of Figure 3 is that it not only shows us the interactions between the diseases in the articles, it gives us the elements to identi-

fy overlaps with risks and diseases that droughts produce in relation to the health conditions for populations.

The Brazilian Atlas for Natural Disasters⁸⁰, that covers recently registered data on natural events in the country (from 1991 to 2010) showed that out of 31,913 natural events and 96,368, 789 of those that affected the country in 20 years, droughts and similar natural phenomena accounted for 53% and 49% respectively⁸⁰. For mortality (n = 3.414) and morbidity (n = 486.638) droughts and similar natural phenomena account for 7.5% and 33.5% of the total. This reflects a tendency of their being a reduction in deaths by this type of natural disaster. Out of the more that 6 million people that have been directly affected (including disappearances, being displaced, being made homeless and with the majority forced to abandon their homes and run the risk of exposure to diseases) 21% were affected because of this type of disaster. Also out of the 1.2 million people forced to migrate, 65% did so due to issues related to droughts or similar occurrences. With this data, even though it does not show the total effects of droughts, it does show the magnitude and complexity of these types of disasters. They can cause risks of diseases which

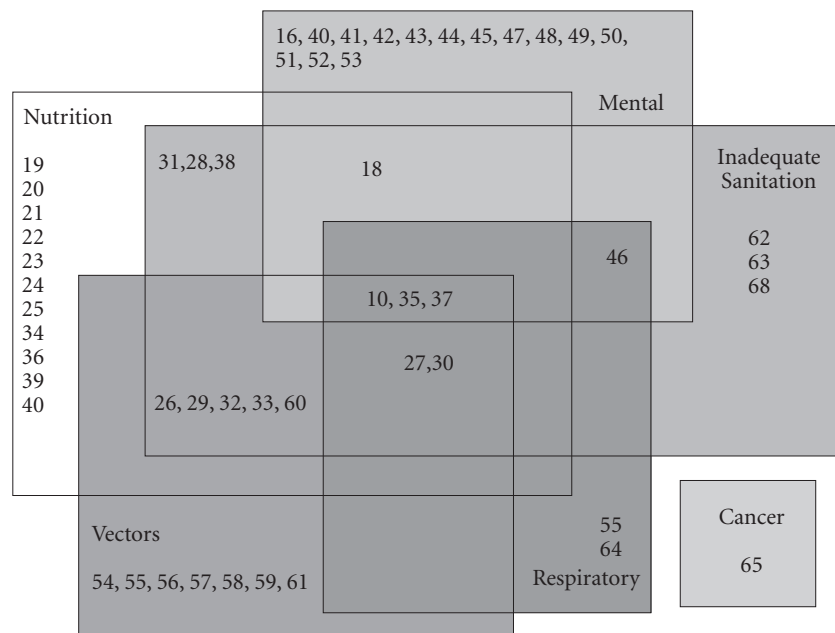


Figure 3. Diagram showing the interaction between the articles.

Source: The authors of this paper.

we endeavored to systemize in this article showing overlaps, even though there were no monitoring systems and structures in place to prevent these diseases. Nor were there provision in place to provide care so that populations could recover from the aforementioned diseases.

Final considerations

The first recorded drought in the country lasted for 4 years, between 1552 and 1555. After this period the number of droughts over the years increased. In the 19th century there were 12 drought episodes. Then in the 20th century there were 19 drought occurrences which in total summed up to 36 years of droughts⁸¹. In spite of millions of Brazilians having been affected by droughts in the past, others recently and still other that will be affected in the future on a more frequent basis, the only study that exists that associates life conditions and health with droughts was done by Arthur Nevia and Belisario Penna 100 years ago. This means that more in depth and current studies are needed.

This year Brazil experienced a continuation of one of the most severe droughts in the last 50 years in relation to meteorological, water and agricultural aspects of the country. The worst part

of the drought was between 2012 and 2014. In spite of this its impact on living conditions it was less severe than some of the great droughts of recent times such as the one that occurred between 1998 and 1999. A number of emergency public policies to reduce their impacts were implemented which included: the use of water delivery trucks, the construction of cisterns and wells, selling corn for animal flocks and opening lines of credits. We grouped together all of these policies and programs which included: drought relief aid for agricultural families, pensions for farm workers, and a number of financial benefits for families that allowed them to buy food and water. With all of the above health measures and strategies, the idea is to reduce infant mortality rates. There are no doubts that these policies have lessened the negative impacts of droughts but they have not totally immunized the population from risks and diseases. Many of these are often both complex and not directly visible.

If there are more in depth and wider reaching studies on the effects of droughts on living conditions, this will go a long way in breaking the common cycle of impacts that have become the norm when droughts occurs which is: a resultant rise in poverty, the suffering and agony of populations in the social ambit, and problems in semi-arid parts of Brazil.

Collaborations

TA Alpino, ARM Sena e CM Freitas equally participated in the idea, methodology, research and final draft of this paper.

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onde se lê:

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p. 814

onde se lê:

Fonte: Próprios autores.

leia-se:

Fonte: Stanke et al.¹⁰.

onde se lê:

Na Figura 2 sistematizamos

leia-se:

Na Figura 2, Stanke et al.¹⁰ sistematizaram

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p. 2879:

where it reads:

Luiz Sena Guimarães ¹

it should read:

André Luiz Sena Guimarães ¹

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Where it reads:

Source: The authors of the paper.

It should read:

Source: Stanke et al.¹⁰.

Where it reads:

In Figure 2 we systemized

It should read:

In Figure 2 Stanke et al.¹⁰ systemized.