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Review

A systematic literature review on factors of socio-environmental vulnerability associated with water-borne diseases

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Abstract

Introduction: Diarrhoeas, acute gastroenteritis with moderate dehydration, malaria and cholera are water-borne diseases with a high incidence in childhood and are one of the principal causes of morbidity and mortality in children under the age of 5 years, and predominantly so in developing countries. Various factors influence the population's vulnerability to these diseases. The objective of this work was to identify the factors of socio-environmental vulnerability associated with the occurrence of water-borne diseases (diarrhoeas, acute gastroenteritis with moderate dehydration, malaria and cholera).

Methodology: A systematic review of the literature was performed, with the databases PubMed, Scopus, B-On and Scielo to identify studies published between 2010 and 2021.

Results and Conclusions: The results showed that the most significant factors related to vulnerability to water-borne diseases have to do with sanitation and the availability of clean drinking water; however, temperature and precipitation were also found to exert considerable influence, together with the demographic factor.

Key words: socio-environmental vulnerability; water-borne diseases; cholera; malaria; diarrhoea; gastroenteritis.

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Introduction

The increasing intensity of situations of risk which people are exposed to, especially those with repercussions on human health, is a matter of concern for present-day societies [1,2]. Water-borne diseases may be considered as deficiencies or disturbances caused by the condition, quantity and quality of the water and their level of incidence depends on factors such as climate, demographics and sanitation [3,4]. These diseases mainly affect vulnerable populations that live in precarious conditions [5–7].

Drinking water of an adequate quality and in sufficient quantity, constitutes an essential element of life, in addition to its being a factor associated with the promotion of population health and the decrease in the incidence of a variety of diseases. The group of diseases that are commonly referred to as water-borne diseases are those where water acts as a vehicle for transporting pathogens and as a site where a parasite multiplies before infecting humans. This group of diseases include important illnesses, such as typhoid fever (enteric fever), rotavirus diarrhoea, malaria and pandemic cholera [8], and are the second highest cause of child mortality in the world, after respiratory infections [9–11]. In addition to their impact on children, water-borne diseases can also cause illness and death in adults. Griffiths reported that when cholera was reintroduced into South America the death toll among adults was significant [8].

Inadequate sanitation is considered to be responsible for 88% of deaths from diarrhoea in the world [7,12–14]. The occurrence of childhood diarrhoeal diseases is associated, in part, with socioeconomic conditions, coverage of basic sanitation services, and housing infrastructure and precarious health. In addition, the scarcity or the excess of precipitation can affect the availability and supply of drinkable water as well as exhaust the rainwater drainage systems, when they exist, in periods of heavy rains or flooding [15–18]. According to Mutono *et al*. [19], nearly 50% of the diarrheal cases reported globally are from Africa, with contaminated drinking water being the main source of transmission.

There is indeed a complex web of relationship between humans and water-borne diseases that highlight the need for an ecologic perspective in addressing this global problem. A disease may enter a population through water and then spread through other ways or may first spread by person-to-person contact and later enter water supplies through the fecal stream thus becoming waterborne [8].

Changes in temperature can also create conditions that may increase or decrease the number of cases of disease, given that extremes in temperature can slow down or accelerate the development and survival of vectors, and the extrinsic incubation period for certain carrier pathogens of the diseases can be altered [16,20–24].

Despite the substantial progress made in increasing access to clean drinking water and sanitation the lack of these basic services is still evident in some parts of the world. Given the burden of disease (on human health) attributable to water-borne diseases and the urgency in addressing this problem, tackling these diseases has been a priority stated by the millennium development goal and later reinforced by the target 3.3. of the Sustainable Development Goals (SDG). Moreover, considering population growth in the urban areas of developing countries, there is a strong concern of the United Nations towards the improvement of living conditions in those areas expressed in the SDG 11 to make cities and human settlements inclusive, safe, resilient and sustainable.

Thus, the objective of this work is to identify factors of socio-environmental vulnerability associated with the occurrence of water-borne diseases (diarrhoeas, acute gastroenteritis with moderate dehydration, malaria and cholera) in the urban environment. The results of this work will highlight current knowledge gaps in some African countries and contribute to inform regional authorities.

Methodology

In order to identify the socio-environmental factors of vulnerability associated with the occurrence of a selected group of water-borne diseases, a systematic review of the literature was carried out. Information was gathered from the databases PubMed, Scopus, B-On and Scielo, including items in English, Spanish and Portuguese. The texts selected were originally published in the form of articles, book chapters, theses, and reports.

Table 2. Distribution of the number of articles in each database.

Database	Articles (n)
PubMed	338
Scopus	30
Scielo	18
B-On	38
Total	**424**

Review protocol

A protocol for review was developed based on the previous works of this nature (the works of systematic review). Texts published between 2010 and 2021 were retrieved from the databases PubMed, Scopus, B-On and Scielo, employing a combination of the various terms that respond to our initial question (Table 1).

By using this protocol, it was assured that the articles selected complied with the following criteria: (1) were published between the years of 2010 and 2021; (2) addressed factors of socio-environmental vulnerability associated with the occurrence of the main water-borne diseases (diarrhoeas, acute gastroenteritis with moderate dehydration, malaria and cholera); (3) analyzed one of the four diseases or all of them together.

These expressions were combined for the realization of searches in the 4 online databases selected (PubMed, Scopus, B-On and Scielo). The research syntax is presented in Supplementary Table 1. The research was done by searching for combinations of the research terms in the title. The language selected was Portuguese in Scielo and B-On and English in Scopus and PubMed. Through this process, 424 articles (the majority from PubMed) were identified; from which 40 were selected after various exclusion criteria were applied (Table 2).

Exclusion criteria

All texts whose titles indicated research in the field of veterinary medicine (e.g., cattle, cows, pigs,

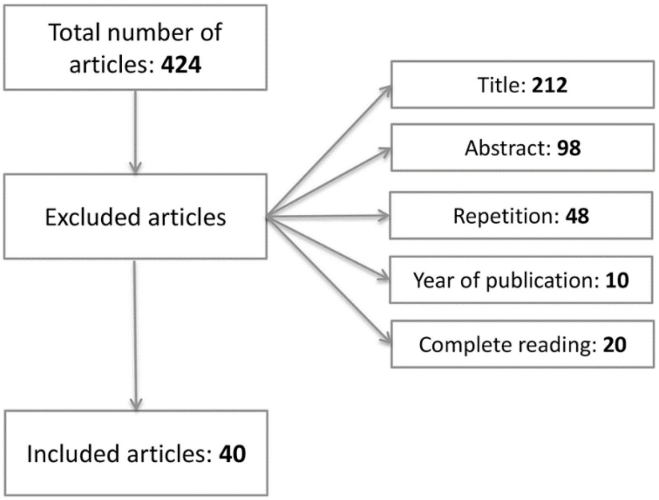
Table 1. Research terms used in the systematic review of literature on factors of socio-environmental vulnerability associated with the occurrence of water-borne diseases (diarrhoeas, acute gastroenteritis with moderate dehydration, malaria and cholera).

Question	Terms for water-borne diseases	Water quality and availability	Variables of analysis
What are the socio-environmental factors of vulnerabilities associated with the occurrence of water-borne diseases?	Diarrhoea Acute gastroenteritis Cholera Malaria	Drinking water Water availability Water diseases	Environment Socio-economic Development Risk factors Vulnerability Sanitation

chickens, dogs, sheep, cats) were excluded given that the object of this study is humans. Also excluded were titles that studied malaria or cholera during travels; clinical characteristics of malaria, cholera, gastroenteritis and diarrhoea; changes in risk factors; habitat of mosquito vectors; malaria, cholera, gastroenteritis and/or diarrhoea associated with other diseases; the role of the routes of navigation for malaria; forms and types of the four diseases; risk factors associated with ventilation; factors for the sulfoxide antibody; risk factors for urinary tract infection; vaccine against malaria; factors that affect the treatment of malaria; biofilms in the fight against malaria; and poor quality medications. The titles that addressed cholera, malaria, diarrhoea or gastroenteritis in a rural setting were excluded because this research aims to analyze factors of water-borne diseases in the urban environment. Thus, 212 works were excluded based on the title.

After reading and analysis of the abstract, 98 articles were excluded as they did not align with the objectives of the research. When repetitive articles were discovered (that is, available in more than one database or more than once in the same database), another 48 articles were excluded. After reading the text, another 20 articles were excluded as they did not align with the objective of the study (some articles analysed water-borne diseases as a secondary factor of hospitalization or the influence that water-borne diseases may have on other types of diseases). Consequently, a total of 388 articles were excluded, with 40 articles remaining (Figure 1).

Figure 1. Process of selecting the articles.



Characterization of the selected articles

Out of the 40 articles selected for the study, 32 were published in English and 8 in Portuguese. 32 were case studies and 8 were systematic reviews of the literature. Among these articles, 17 were studies carried out in African countries (Nigeria 3, Ethiopia 3, and 1 each for Namibia, South Africa, Rwanda, Zambia, Kenya, Uganda, Senegal, Tanzania, Burkina Faso, and 1 each on Sub-Saharan Africa and Africa as a whole). The remaining 22 studies focused on Nicaragua, Yemen, Indonesia (2 studies), Turkey, Papua New Guinea, Lebanon, the Amazon, Brazil (7 studies), Asia, and 8 international literature reviews. As for the year of publication, 7 were published in 2021, 11 in 2020 (the largest number of publications), 4 in 2019, 3 in 2018, 3 in 2017, 1 in 2016, 1 each in 2015, 2014 and 2013, 3

Table 3. Studies retained from the systematic literature review

Number of articles selected	40	
Language used	32 English 8 Portuguese	
Type of study	Case studies = 32 Systematic review of the literature = 8	
Location of the study	**17 Africa:** 3 Nigeria; 3 Ethiopia; 1 Namibia; 1 South Africa; 1 Rwanda; 1 Zambia; 1 Kenya; 1 Uganda; *1 Sub-Saharan Africa;* 1 Senegal; 1 Tanzania; 1 Burkina Faso; 1 Africa (in its entirety)	**8 South and Central America:** 7 Brazil; 1 Nicaragua; **3 Southeast Asia and Oceania** 2 Indonesia; 1 Papua New Guinea; **3 Asia** 1 Turkey; 1 Lebanon; 1 Asia (in its entirety) **8 Generic** (various countries)
Year of publication	2021: 7 2020: 11 2019: 4 2018: 3 2017: 3 2016: 1 2015: 1 2014: 1 2013: 1 2012: 3 2011: 2 2010: 3	
Type of disease studied	Diarrhoea: 15 Malaria: 12 Cholera: 11 Gastroenteritis: 2	
Target age group of the study	0-2 years: 1 0-5 years: 10 0-15 years: 5 No specified age group: 24	

studies were published in 2012, 2 articles were published in 2011, and 3 articles were published in 2010. When categorized by the type of disease, 15 studies focused on diarrhoea, 12 dealt with malaria, 11 were about cholera, and 2 studies addressed gastroenteritis (some of the articles that analyzed diarrhoea also studied gastroenteritis). As for the age groups studied, 1 article studied children from 0-2 years of age, 10 studies covered the 0-5-year-old age group, 5 studies focused on 0-15-year-old age group, and 24 studies covered all age groups. The articles that did not have a predefined age range in their analysis, for the most part, dealt with malaria and cholera given that in studies on diarrhoea, the scenario is different; that is, the studies are primarily designed for children 5 years of age or younger (Table 3).

Results and discussion

Water-borne diseases are those that are caused by the presence of pathogenic microorganisms (bacteria, viruses and parasites) in water used for human consumption [5,21,25] and it has been confirmed that a significant part of the world's population lives in conditions of great socio-environmental vulnerability and thus are affected by diseases that can be avoided [20,26–28]. These diseases may be transmitted by two principal mechanisms: ingestion of water contaminated with pathogenic organisms or what is referred to as unhygienic water, and via vectors that are developed in water [10,12,14,29]. Asian, African and Latin American countries have shown an elevated incidence of water-borne diseases. Worldwide, it is estimated that 80% of the diseases and approximately 30% of deaths occur as a result of the poor quality of drinking water or from inadequate basic sanitation [7,9,13]. Inadequate sewage systems have contributed to the contamination of ground water and of agricultural lands and thus have had considerable impact on human health [1,6,27,30,31].

Factors of socio-environmental vulnerability associated with the occurrence of malaria

Malaria is an indirect water-borne disease. It is a disease transmitted by organisms/vectors that develop in the water, making this medium a breeding ground [32–34], and there are many factors, social as well as environmental, which aid in its propagation and transmission into and amongst the population (Table 4) [10,16,18,23,24].

Climate change has raised concerns about the possible expansion of the area of incidence of some diseases transmitted by the way of vectors [18,22,24,26,33]. One of the greatest effects of this propagation can be observed in extreme events, which determine the strong fluctuations in the cycle of the diseases. This is an important component with respect to how these disease vectors are distributed over space and time, which serves not only to limit their propagation but also influence the dynamics of transmission [3,22,23,32,34].

Climate-based factors such as precipitation and temperature can hinder the rhythm of how malaria spreads; for example, warmer and drier years introduce a greater climate-based susceptibility in terms of the higher temperatures needed for a greater abundance of malaria vectors and parasites [10,18,20,24–26,33]. In contrast, other extremes of temperature can slow down or accelerate the development and survival of insect vectors as well as the extrinsic incubation period for certain pathogens [20,22–24,32,33]. With respect to precipitation, its seasonal nature is well-known for having an effect on the transmission of malaria, given that marsh mosquitos (*Anopheles*) depend on standing water for their breeding habitat [3,20,24,25,34]. The time when the rainy season occurs can have an influence on the presence of stagnant water, and the patterns of precipitation can also affect the population dynamics of mosquitos in water-sensitive environments, reducing the vulnerability of the human population to this disease to a certain extent [3,20,22,25,32].

Also amongst the environmental factors is altitude, which is considered to influence the distribution of the transmission of malaria, given that at higher altitudes the temperature is lower (not propitious for the development of the vector that causes the disease), thus limiting its transmission [10,23,24,33,34].

Demographics such as age, gender, and the person's state of health are also amongst the factors that influence the transmission of malaria as it also influences the vulnerability of individuals and the propagation of the disease. For example, people with immunosuppressive diseases are more susceptible to contracting the disease [16,20,22,23,32].

Socioeconomic and cultural conditions influence people's attitudes, including their behavior when ill, and aid in avoiding infections. The increased proliferation of malaria is directly related to high-population density environments and low buying power, represented by homes whose walls are unfinished, thus facilitating human contact with the vector [16,20,25,32,33].

A study carried out in Rwanda showed that the prevalence of malaria was higher amongst children who

lived in houses whose walls were built with poor and insecure materials [16,18]. Other sociocultural factors that can be mentioned as being a factor of vulnerability to malaria are the mobility of the urban population towards more rural environments and the fact that people travel at night. Studies done in Nigeria and Namibia [18,24] have shown that people are at a higher risk when they travel from urban areas to rural areas, given that the mosquito vectors are more present in the rural areas as well as the fact that this population has lower immunity to the disease. Also in this group of factors is not using any mosquito netting while sleeping and the carelessness in leaving the door open from 6:00pm to 5:00am, as these habits can increase one's vulnerability to malaria [22,24].

Table 4. Factors of socio-environmental vulnerability associated with the occurrence of water-borne diseases (diarrhoeas, acute gastroenteritis with moderate dehydration, malaria and cholera).

Water-borne diseases	Factors	Effects/consequences
Cholera, Acute gastroenteritis and Diarrhoea	Demographics and health conditions	Globally, diarrhoeas are the second most common cause of death for children under the age of 5, and for the elderly (70+) [11,14,31,38,41].
		Children (0-5 years of age) are more susceptible when compared with other age ranges; [1,2,4,14,15,21,28,29,39,42].
		These diseases are also frequent in people who suffer from another serious illness [1,2,4,14,39,42].
	Lack of basic sanitation	Responsible for 88% of death from diarrhoeas worldwide [2,4,21,28].
		Associated with the occurrence of childhood diarrhoeal diseases [2,6,40,41].
		A direct risk factor for epidemics of cholera across large swaths worldwide [5,15,29,35,36].
		The incidence of these diseases is higher in areas with poor sanitation [37,39,42].
	Limitations to access to drinking water	Makes the prevention of these diseases impossible [30,37,38].
		Studies indicate that regions without access to drinking water are more likely to suffer from these diseases [17,30,37–39].
		Drinking water is of the utmost importance in the prevention of these diseases [17,30,37–39].
		Principal cause of the prevalence of gastroenteritis in the paediatric population [37,39].
	Hygiene	Not washing hands has also been linked to yearly outbreaks of these diseases in populations residing in settlements on the outskirts of cities [7,11,14].
		Environmental faecal contamination can also influence one's vulnerability to diarrhoeas [14].
		Taking a new-borne off of breast milk early increases the child's vulnerability with regard to contracting diarrhoeas [17].
	Precipitation	The incidence of these diseases is higher in months with higher rainfall indices perhaps due to human consumption of untreated water [9,12,13,15,38].
		High index of contamination of water near the surface by human waste and dead animals that drain after rainfall, which increases the number of people falling ill from these diseases [9,12,13,15,38].
		Scarce or excessive rainfall affects the availability and supply of drinking water, which can increase the number of people infected by these diseases [9,13,38].
	Temperature	Temperature (and precipitation) play an important role in how these diseases are spread, which can influence their spatial and seasonal distribution as well as the year-on-year variation and long-term trends [9,17,30,31,39].
Malaria	Demographic and health conditions	Patients with immunosuppressive diseases are more susceptible to contracting the disease [16,20,22,23,32].
		The increase in the proliferation of malaria is directly related to environments with high population density [16,20,32,33].
	Socioeconomic and behaviours	Populations with low purchasing power, represented by precarious housing, have greater contact with the malaria vector [20,22,24].
		People's behaviour and attitudes can contribute to avoiding infection and mainly their behaviour when ill [16,20,25,32,33].
		Journeys made by the urban population to more rural environments represent greater vulnerability given how mosquitos are more abundant in rural areas [18,24].
		Not using mosquito netting when sleeping and carelessness when leaving the door open from 6:00 pm to 5:00 am increase one's vulnerability to malaria [22,24].
	Political	More broad-reaching policies with respect to protective measures and healthcare for at-risk populations, such as those living in poor housing conditions, can reduce the number of people infected with malaria [10,16,20,22,24,26,33,34].
	Temperature	Temperature changes may delay or exacerbate the development and the survival of malaria vectors [10,18,20,24–26,33].
		Temperature (and rainfall) may influence the rhythm of malaria spreading [3,22,32,34].
		High temperatures are associated with higher number of malaria parasites [22,24,32,33].
	Precipitation	Due to its seasonality, it can affect the transmission of malaria because the vectors depend on standing water for their breeding habitat [3,20,24,25,34].
		Patterns of precipitation can also affect the population dynamics of mosquitos in environments bordering on water, reducing the human population's vulnerability to this disease [3,20,22,25,32].
	Altitude	Higher altitudes (where temperatures are lower) are not propitious for the development of the vector of the disease, limiting its transmission, in addition, in lower-lying regions, lesser possibility of forming a standing-water habitat for the disease vector to thrive [10,23,24,33,34].

Factors of socio-environmental vulnerability associated with the occurrence of diarrhoeas, cholera and acute gastroenteritis with moderate dehydration

Diarrhoeas, cholera and acute gastroenteritis with moderate dehydration are examples of water-borne diseases occurring from direct contact with water (transmission from ingestion) and/or food contaminated with faeces or vomit from an ill person or carrier of the disease [12–15,35,36]. These diseases are also transmissible via the faecal-oral route [6,7,29,31,35,37]. The principal socio-environmental factors of vulnerability to transmission are the lack of basic sanitation and the limitations to access to safe water [9,11,17,30,37–39].

Diarrhoeas are associated with inadequate sanitation, which is responsible for 88% of the deaths from diarrhoea in the world [2,4,21,28]. An assessment of the impacts of providing proper sanitation services indicates that if access to such services were universal, the number of episodes of diarrhoea, globally, would be reduced, on average, by 16.7%. If there were water treatment facilities at the locations where water is consumed, the reduction in the number of episodes would reach an average of 53% [5,12,29,36]. If the water supply consisted totally of running water, along with a connection within homes to the sewage network and partial treatment of wastewater, this would allow for an average reduction of 69% [2,6,40,41].

Personal hygiene, specifically with respect to keeping hands clean (principally), can contribute to the type and speed of the propagation of diarrhoeas in a given population. Studies performed in one South African and one Zambian city showed that children from families with good hygiene are less likely to become ill with diarrhoea than those from families with poor hygiene. Hygiene and hygienic practices, such as the purification of water including boiling and filtering water, can reduce the pathogenic load in said water if the process is carried out in a way that is consistent and correct and in accordance with standard practices [7,11,14].

The index of environmental faecal contamination can also influence a person's vulnerability to diarrhoeas (as much in the number of the population affected as in the prevalence of the disease). Thus, studies have shown that sanitation interventions to reduce diarrhoea will be more efficient in lowering levels of faecal contamination [14].

Care taken when mothers are nursing can also influence whether a child becomes infected and develops diarrhoea. A study in Uganda concluded that children who were breastfed exclusively had an 85% chance of not contracting diarrhoea than children who were taken off breast milk early (before reaching the age of 1 year). Given the bad and unhygienic practices observed during the preparation of food for these babies, there was a higher probability that diarrhoea-causing germs would be spread to them [17].

In terms of demographics, diarrhoeas are more intense for certain age groups. For example, they are the second highest cause of death for children of age 5 years and under worldwide, and they show a greater incidence in older people, mainly those of age 70 years and over [11,14,31,38,41].

Cholera continues to be a significant threat to public health in developing countries where water and sanitation networks are in poor condition or lacking [9,12,13,30]. In addition, poor sanitation is a significant risk factor in terms of epidemics of cholera across large areas of the globe where more than 1 billion people do not have efficient and regular access to water [5,15,29,35,36].

The defects in the pattern of the supply of treated water, inadequacy of human waste disposal, housing shortages, poor hygiene, inadequate food, and disinformation also constitute powerful factors of vulnerability that expose the population to this disease [5,9,12,13,30]. A study carried out in Nigeria showed that cases of cholera decrease by a factor of 4.3 where there is partial access to quality drinking water sources and by 6.3 when there is total access to improved sources of drinking water, which is significantly better than those towns and villages without access to water ($p < 0.001$). In addition, towns and village without proper drinking water and sanitation are 6.7 times more likely to be hit by cholera. In contrast, towns and villages with total coverage of sanitation and water are 9.1 times ($p < 0.0001$) less likely to be affected with cholera [30].

Geographically speaking, cholera goes hand in hand with poverty and the absence of basic sanitation. It is not easy to prevent cholera from entering any environment, but the disease does not erupt in places with good infrastructure, particularly those with good quality water and basic sanitation [5,12,13,15,29].

Acute gastroenteritis is a water-borne disease caused by viruses, bacteria or parasites. The viruses most associated with the disease are the rotavirus and the Norwalk virus. Less frequently, this disease can be caused by astrovirus, calicivirus, adenovirus and parvovirus [1,14,31,39]. Viral gastroenteritis is transmitted via the faecal-oral route (person to person) or by ingesting contaminated food or water [14,42].

Similar to the other three diseases mentioned, (diarrhoeas, cholera and malaria), the factors of environmental sanitation and proper drinking water play an important role as to how vulnerable a person is to gastroenteritis. For example, on one hand, limited access to treated water constitutes one of the principal causes for the prevalence of gastroenteritis in the paediatric population, and on the other, incidence of the disease is higher in areas with unreliable and poor conditions of sanitation [37,39,42]. The availability of drinking water is a factor of utmost importance with respect to the prevention of this disease. In this regard, the lack of clean water emerges as one of the main factors that bring about the disease [17,30,37–39].

The demographic factor also influences the transmission of acute gastroenteritis, with studies pointing to children from 0-5 years of age as being the most susceptible to this water-borne disease when compared with other age groups [14,15,21,28,29]. Gastroenteritis is one of the main causes of morbidity and infant mortality in children under the age of 5 years, mostly in developing countries. In addition, it often affects older people and those with an accompanying serious illness. Worldwide, it is estimated that 1.5-2.5 million children die annually from gastroenteritis [1,2,4,14,39,42]. Climate-related factors influence the rates of water-borne diseases (diarrhoeas, cholera and acute gastroenteritis with moderate dehydration) through precipitation, given that they trend higher in months with greater indices of rainfall. The population may well be increasing its consumption of untreated water, which at this time is unsafe, as the water table lying close to the surface is prone to become contaminated by human waste and dead animals that drain and run off with the rainwater [9,12,13,15,38]. Climate also plays an important role in the transmission of these diseases as it can influence the spatial and seasonal distribution as well as the year-on-year variation and long-term trends [9,17,30,31,39].

Conclusions

The incidence of diarrhoeal diseases is associated, in part, with socioeconomic conditions such as the coverage of basic sanitation services, availability of drinking water, precarious housing infrastructures and poor health, and with demographic factors such as age (greatest incidence in children under 5 years of age and in older individuals or those with immunosuppressive diseases). Also associated with these factors is the cultural component, which dictates a person's behaviour when ill, mainly with respect to personal hygiene (washing one's hands). It was also observed that the time a child stops breastfeeding, and whether a child is given only breast milk, present a significant association with the occurrence of diarrhoea, given that when the younger child begins to eat other food, the risk of contracting diarrhoeas increases notably if there is insufficient attention paid to general food safety practices. This behaviour may or may not lead to a greater propagation of the disease, along with the practice of using mosquito netting and travelling from urban centres to rural locations at night. It was also noted that environmental factors can influence the occurrence of these diseases in that temperature and precipitation can play a role in their spatial and seasonal distribution and in the year-on-year variation and long-term trends.

In terms of distinguishing elements amongst the factors determining vulnerability to these diseases, by country or by region, it was noted that they were indeed similar in most cases, namely those concerning diarrhoeas. However, in addition to sanitation and quality and availability of drinking water, issues of personal hygiene and questions referring to open defecation were raised. As for malaria, nearly all regions presented the same assumptions, pointing to precipitation, temperature, and housing structure as the principal factors determining vulnerability. However, studies in Africa also mentioned the use of mosquito netting, spraying, and travel at night (this last item was also addressed in Asian countries).

In the present review, there is no deeper discussion of the role of public policies in the fight against water-borne diseases based on the articles selected. Nevertheless, it is clear that they play a significant role in the efforts to control and combat these diseases, underscoring the need to prioritise basic sanitation as preventative and protective measures for health (especially children's health), particularly in those regions with the worst socioeconomic and environmental conditions.

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Annex – Supplementary Items

Supplementary Table 1. Research syntax**.**

PubMed
((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (malaria[Title])) AND (Environment[Title])) OR(((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (malaria[Title])) AND (Socio-economic development[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (malaria[Title])) AND (Water availability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (malaria[Title])) AND (Sanitation[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (malaria[Title])) AND (Risk factors[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (malaria[Title])) AND (Drinking water[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (malaria[Title])) AND (Vulnerability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (cholera[Title])) AND (Socio-economic development[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (cholera[Title])) AND (Environment[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (cholera[Title])) AND (Water availability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (cholera[Title])) AND (Sanitation[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (cholera[Title])) AND (Risk factors[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (cholera[Title])) AND (Drinking water[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (cholera[Title])) AND (Vulnerability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (diarrhoea[Title])) AND (Socio-economic development[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (diarrhoea[Title])) AND (Environment[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (diarrhoea[Title])) AND (Water availability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (diarrhoea[Title])) AND (Water availability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (diarrhoea[Title])) AND (Sanitation[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (diarrhoea[Title])) AND (Risk factors[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (diarrhoea[Title])) AND (Vulnerability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (acute gastroenteritis[Title])) AND (Socio-economic development[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (acute gastroenteritis[Title])) AND (Environment[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (acute gastroenteritis[Title])) AND (Water availability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (acute gastroenteritis[Title])) AND (Sanitation[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (acute gastroenteritis[Title])) AND (Risk factors[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (acute gastroenteritis[Title])) AND (Drinking water[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (acute gastroenteritis[Title])) AND (Vulnerability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (water diseases[Title])) AND (Socio-economic development[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (water diseases[Title])) AND (Environment[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (water diseases[Title])) AND (Water availability[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (water diseases[Title])) AND (Sanitation[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (water diseases[Title])) AND (Risk factors[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (water diseases[Title])) AND (Drinking water[Title])) OR ((((("2010"[Date - Publication] : "3000"[Date - Publication])) AND (water diseases[Title])) AND (Vulnerability[Title]))
Scopus
TITLE ("Malaria sanitation" OR "Malaria risk factors" OR "Malaria drinking water" OR "Malaria water availability" OR "Malaria environment" OR "Malaria vulnerability" OR "Malaria socio-economic development" OR "Cholera socio-economic development" OR "Environmental cholera" OR "Cholera water availability" OR " Cholera sanitation" OR "Cholera risk factors" OR "Cholera drinking water" OR " Cholera vulnerability" OR "Diarrhea socio-economic development" OR "Environment diarrhea" OR "Diarrhea water availability" OR "Sanitation diarrhea" OR "Diarrhea risk factors" OR "Diarrhea drinking water" OR "Diarrhea vulnerability" OR "Acute gastroenteritis environment" OR "Acute gastroenteritis water availability" OR "Acute gastroenteritis sanitation" OR "Acute gastroenteritis risk factors" OR "Acute gastroenteritis drinking water" OR "Acute gastroenteritis vulnerability" OR "Acute gastroenteritis socio-economic development" OR "Environmental water diseases" OR "Water disease water availability" OR "Water diseases sanitation" OR "Water disease risk factors" OR "Water diseases drinking water" OR "Water disease vulnerability") AND PUBYEAR > 2010 AND PUBYEAR < 2021
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TI cólera + desenvolvimento socioeconómico OR TI cólera + ambiente OR TI cólera + disponibilidade hídrica OR TI cólera + saneamento OR TI cólera + fatores de risco OR TI cólera + água potável OR TI cólera + vulnerabilidade OR TI malária + desenvolvimento socioeconómico OR TI malária + ambiente OR TI malária + disponibilidade hídrica OR TI malária + saneamento OR TI malária + fatores de risco OR TI malária + água potável OR TI malária + vulnerabilidade OR TI diarreia + desenvolvimento socioeconómico OR TI diarreia + ambiente OR TI diarreia + disponibilidade hídrica ORTI diarreia + saneamento OR TI diarreia + fatores de risco OR TI diarreia + água potável OR TI diarreia + vulnerabilidade OR TI gastroenterite aguda + desenvolvimento socioeconómico OR TI gastroenterite aguda + ambiente OR TI gastroenterite aguda + disponibilidade hídrica OR TI gastroenterite aguda + saneamento OR TI gastroenterite aguda + fatores de risco OR TI gastroenterite aguda + água potável OR TI gastroenterite aguda + vulnerabilidade OR TI doenças hídricas + desenvolvimento socioeconómico OR TI doenças hídricas + ambiente OR TI doenças hídricas + disponibilidade hídrica OR TI doenças hídricas + saneamento OR TI doenças hídricas + fatores de risco OR TI doenças hídricas + água potável OR TI doenças hídricas + vulnerabilidade
Scielo
((ti:(cólera) AND ti:(desenvolvimento socioeconómico))) OR ((ti:(cólera) AND ti:(ambiente))) OR ((ti:(cólera) AND ti:(disponibilidade hídrica))) OR ((ti:(cólera) AND ti:(saneamento))) OR ((ti:(cólera) AND ti:(fatores de risco))) OR ((ti:(cólera) AND ti:(Água potável))) OR ((ti:(cólera) AND ti:(ambiente))) OR ((ti:(malária) AND ti:(desenvolvimento socioeconómico))) OR ((ti:(malária) AND ti:(ambiente))) OR ((ti:(malária) AND ti:(disponibilidade hídrica))) OR ((ti:(malária) AND ti:(saneamento))) OR ((ti:(malária) AND ti:(fatores de risco))) OR ((ti:(malária) AND ti:(água potável))) OR ((ti:(malária) AND ti:(ambiente))) OR ((ti:(diarreia) AND ti:(desenvolvimento socioeconómico))) OR ((ti:(diarreia) AND ti:(ambiente))) OR ((ti:(diarreia) AND ti:(disponibilidade hídrica))) OR ((ti:(diarreia) AND ti:(saneamento))) OR ((ti:(diarreia) AND ti:(fatores de risco))) OR ((ti:(diarreia) AND ti:(água potável))) OR ((ti:(diarreia) AND ti:(vulnerabilidade))) OR ((ti:(gastroenterite aguda) AND ti:(desenvolvimento socioeconómico))) OR ((ti:(gastroenterite aguda) AND ti:(vulnerabilidade))) OR ((ti:(gastroenterite aguda) AND ti:(disponibilidade hídrica))) OR ((ti:(gastroenterite aguda) AND ti:(saneamento))) OR ((ti:(gastroenterite aguda) AND ti:(fatores de risco))) OR ((ti:(gastroenterite aguda) AND ti:(água potável))) OR ((ti:(gastroenterite aguda) AND ti:(vulnerabilidade))) OR ((ti:(doenças hídricas) AND ti:(desenvolvimento socioeconómico))) OR ((ti:(doenças hídricas) AND ti:(ambiente))) OR ((ti:(doenças hídricas) AND ti:(disponibilidade hídrica))) OR ((ti:(doenças hídricas) AND ti:(saneamento))) OR ((ti:(doenças hídricas) AND ti:(fatores de risco))) OR ((ti:(doenças hídricas) AND ti:(água potável))) OR ((ti:(doenças hídricas) AND ti:(vulnerabilidade)))

Source: own elaboration.