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Importance of Water Supply System for Public Health

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Abstract

It is well known that polluted water is dangerous to health. Pollution of fresh water ecosystems is often the cause of diseases, and therefore a multidisciplinary approach involving hydrology, engineering, urban planning and public health is necessary for a good public health outcome. It has been recognized that a water supply system is connected with the improvement of public health of the population. Can diseases such as diarrhea in isolated rural areas or malaria in Africa be prevented through good water supply management? There is an opinion that water supply management is also public health management and that it is a very good tool in reducing and controlling diseases and will definitely play a big role in the future. Protected drinking water is essential for public health. The most common microorganisms associated with waterborne diseases are: Campylobacter, Legionella, Cryptosporidium, Norovirus, E. coli and Giardia. Legionella has been proven to be one of the most important causes of diseases associated with the water supply systems. Investing in water infrastructure is therefore investing in the safety of drinking water, which is the basis of public health, and its pollution can even lead to a potential epidemic caused by various microorganisms. The paper will present the most common diseases that can potentially be transmitted through the public water supply system, as well as the differences in the infrastructure in different parts of the world, which play a major role in public health of the population. The importance of a good water supply system and the environment in preventing diseases that are potentially spread by contaminated drinking water will be shown. Also, possible dangers of contamination of drinking water that the population uses on a daily basis will be pointed out.

Key words

Polluted water, Public health, Water supply system, Waterborne diseases

1. INTRODUCTION

We collect water for water supply from natural sources; we use it, and return wastewater back to nature. The characteristic feature of today's world is that the heavily polluted wastewater is increasing and the quality water supply is decreasing. In addition to high water pollution levels, losses occurring in the water supply system have a major impact on water supply. Such lost water does not reach the end consumers and is not even charged by the water supply company. All of this is due to the "water crisis", which means that a large part of the population on Earth has no access to drinking water or the basic hygienic living conditions [1].

One of the preconditions for a healthy life of people is access to drinking water through public water supply services and the drainage of contaminated wastewater through public drainage services. UN General Assembly Resolution 64/292 of 2010 affirmed the right to safe and clean drinking water and wastewater drainage as a human right essential for the full enjoyment of life and all human rights [2], [3], [4].

Since the creation of the human community there has been a need to provide conditions for supply of drinking water as well as for other human activities. At the same time, the question of disposal of used wastewater was also raised. These issues have been addressed by civilizations, from ancient times to present, and will continue to be addressed in the future, because these are issues without which there is no normal life on planet Earth [5]. Water is considered to be one of the basic components of life, and the entire history of mankind and civilization is largely related to it. Water is not only included in the composition of human organism and food, but it is also used to produce food and energy, and it is used in industry as a raw or auxiliary material. Due to its importance for humans, the supply of water to settlements and the population is nowadays considered to be one of the primary branches of water management. In the tendencies of concentration of settlements and consumers around water, and given the available water resources on Earth, the issue of water supply will become ever stricter in the future. The rule of water supply that every drop of water on the catchment is kept as long as possible for its wider use, is becoming more and more present in our practice. All the aforesaid affect the emergence of complex water supply and drainage systems [6].

It has already been noted that the investment in sanitary infrastructure and in its development has a significant impact on the reduction of population mortality [7], [8], [9], as authors [8], [9] researched and established in their papers. The area they studied and analysed was England, Wales, Switzerland, Finland and Sweden. The authors of the study [8] deal with the issues and research of the impact of the improvement of sanitary infrastructure on mortality in urban environments. Their special focus was to study the improvement of water supply and the development of efficient sewer systems. These improvements are likely to have the greatest health impact by reducing exposure to diseases transmitted by water and food [8].

Various studies have confirmed that good sanitation in a city has the major impact on public health [10]. The biggest reduction in mortality from waterborne infectious diseases was due to the establishment of improved sanitary conditions [11].

The paper [12] analyses the impact of works on water supply networks and sewer systems in German cities in the period from 1877 to 1913. The results of the research presented in the paper show that safe drinking water reduces mortality, but more importantly investment in sanitary infrastructure that contributes to the reduction of mortality. They also found that the limited impact of only safe-distribution of drinking water through water network on mortality reduction was limited. Greater influence is achieved by combining the construction of water and sewer systems - networks.

The results of the author's second paper [13] support other studies that highlighted the role of public health infrastructure, although it has been shown that the provision of clean drinking water alone has limited effects. In the absence of effective methods for the removal of urban waste, decontamination of water and disease vectors, they neutralise some of the benefits of water from the water supply (i.e. the construction of the water supply network) [13].

2. WATER SUPPLY SYSTEM

The practice of transporting water for human consumption has been around for several millennia. From the first pipes in Crete some 3500 years ago, to today's complex hydraulic models, the history of water distribution technology is quite a story [14].

Water supply and sewer system are the most important services and integral part of urban society and infrastructure. Water infrastructure cannot function well and efficiently without other urban infrastructure, in particular transport and electricity supply. Construction, operation and maintenance of urban infrastructure are a permanent and expensive process. Today, the management of urban water systems faces many problems such as:

1) The need for reliable sources of drinking water.

2) Significant flood damage as a result of the urbanisation of the catchment area and the possession of water inundation.

3) Deterioration of water quality, pollution and depletion of groundwater, and negative impact on residents including the coastal sea into which water is discharged from urban water systems.

4) Health problem caused by pollution of water resources and seas [15].

The most common and user-friendly access to water for human consumption and sanitation is ensured through public water supply and sanitation systems operated by public water service suppliers [16]. Water supply services are provided by means of a water supply system, and drainage services are provided by means of a public drainage system, i.e. a sewer system. Water supply system is a collection of buildings and devices for the supply and distribution of water from the site to the consumer. It covers all necessary system facilities: source, main supply pipeline, water improvement facilities, water supply, main supply pipeline and distribution network.

Fundamentally, a water supply system may be described as consisting of three basic components: the source of supply, the processing or treatment of the water, and the distribution of water to the users [17]. Typical elements of the water supply management system are presented in Table 1.

Table 1. Typical elements of the water supply management system (according to [18])

Component	Subcomponents
Water source	Lakes/Rivers
	Reservoir
	Ground water
Treatment plant	Filtration
	Coagulation
	Disinfection
Transmission and distribution	Pipe networks
	Service reservoirs
	Storage tanks
End users	Potable water

The basic roles of the water supply system, regardless of all possible variants and specificities, are:

- Ensuring quality water treatment from the environment to drinking water, the quality of which must comply with legal requirements, both in the processing phase and up to the consumption phase;

- Continuity in water supply 24 hours 365 days a year, all consumers;

- Necessary, sufficient amounts of water for all consumers in the defined area of the system [5].

Ensuring a sufficient quantity of quality water is primarily of great health importance in protecting against various diseases transmitted by water. Sufficient amounts of water in settlements make it possible to increase the general standard of living of man and to regulate his environment. Large quantities of water are needed to satisfy the growing needs of populated places. Water distributed to the public must have a drinking water standard in accordance with the law [15].

In 2020, an estimated 90% of the world population had access to at least basic drinking water services. Access was highest in Europe and North America and Australia and New Zealand, with 100% of both regions having access to at least basic drinking water services. In most regions of the world, 90% of the population has access to at least basic drinking water services. However, just 65% of the population in Sub-Saharan Africa and 57% of the population in Oceania had basic access in 2020 [19].

Estimated share of global population with access to at least basic drinking water services in 2020, by Sustainable Development Goal (SDG) region [19] is shown in the Figure 1.
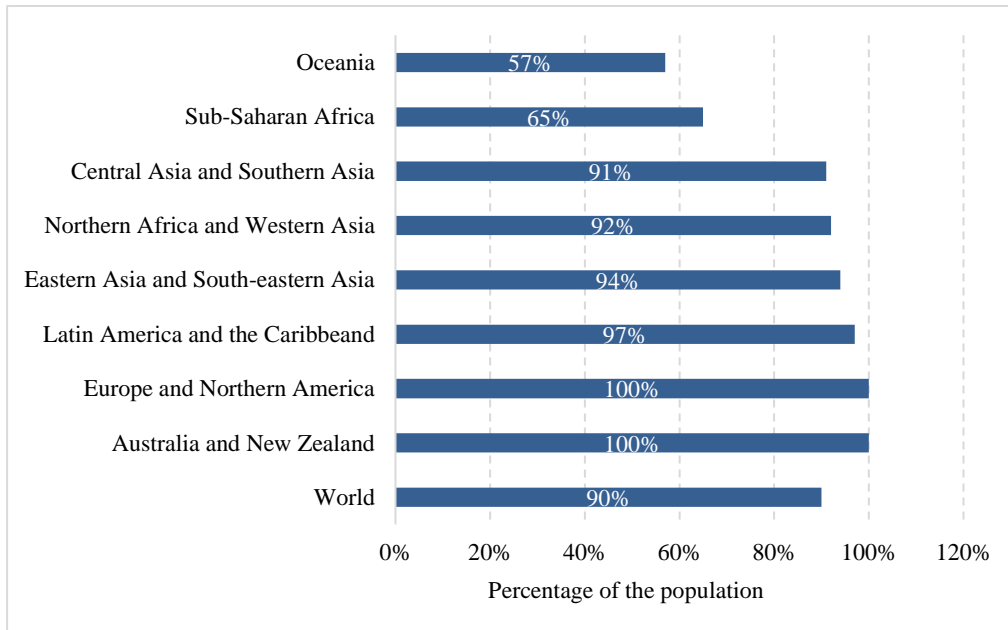
Figure 1. Estimated share of global population with access to at least basic drinking water services in 2020, by SDG region [20]

There are differences in distribution of drinking water in the world. Figure 2 shows the number of people across the world that do not have access to safe drinking water. Safely managed drinking water is defined as an "improved source located on premises, available when needed, and free from microbiological and priority chemical contamination" [21].
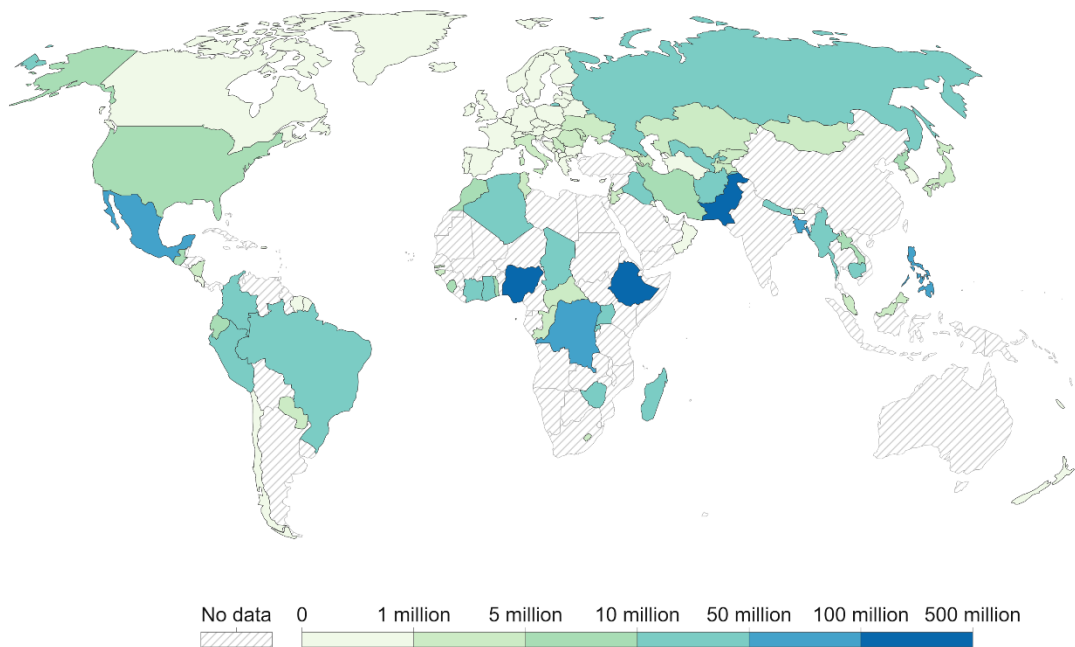

Figure 2. Number of people without access to safe drinking water, 2020 [21], [22]

3. WATERBORNE DISEASES

Clean water is the key factor for public health. Waterborne diseases are one of the most important diseases known as typhoid fever, rotavirus diarrhea, or pandemic cholera disease. Each of the listed in history was one of

the most important causes of death at the time. In 2006, the WHO showed that contaminated water and lack of basic sanitation led to at least 1.6 million deaths in children under 5 years of age in 2004 [23].

The causes of these diseases are different. And they are called pathogenic organisms. They include viruses, bacteria and protozoa [24]. The pathogen is every microorganism that causes the disease. Water contaminated by microorganisms may cause a disease either directly (e.g. drinking such water) or indirectly (consumption of vegetables washed in contaminated water).

Most pathogens causing waterborne diseases are primarily transmitted by faecal contamination. Thus, monitoring faecal pollution by bacteria in water is a necessary and relatively cheaper way of protecting the public health of the population from faecal - transmissible pathogens. Unfortunately, studies in the 1970s have shown that faecal indicators are not always affected by the concentration of pathogens. The scenario that occurred in Ontario is a good example, where the presence of E. coli did not mean the presence of the pathogenic E. coli O157:H7 [25].

The link between the disease and microorganisms was established back in the time of Robert Koch in the 1880s. In 1854, John Snow (Figure 3), the father of epidemiology, linked exposure to contaminated drinking water to cholera transmission, when an English water company supplied residents of London with contaminated drinking water [25], [26]. Insecure water supply, ineffective sanitation, and hygiene can be one of the major causes of diarrhea and the leading cause of death of about 1.58 million people each year. [25], [27].
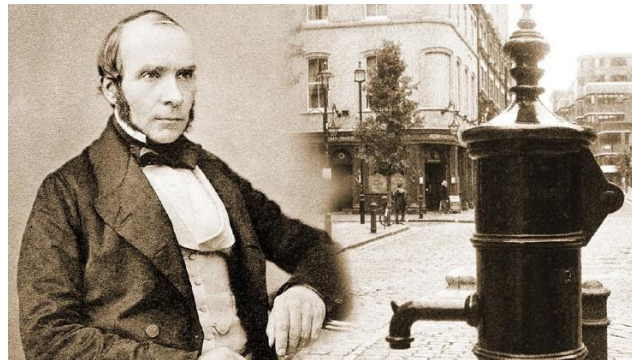

Figure 3. John Snow [28]

Table 2 shows the most common pathogens of waterborne diseases by category and name of microorganisms.

Table 2. Agents of Waterborne or Water-based Disease [24]

Category	Pathogens
Bacteria	*Vibrio cholerae*
	Salmonella spp.
	Shigella spp
	Campylobacter spp.
	Yersinia enterocolitica
	Legionella
	Helicobacter pylori
	Toxigenic *Escherichia coli*
Protozoa	*Giardia lamblia*
	Cryptosporidium parvum
	Entamoeba histolitica
	Isospora belli
	Toxoplasma gondii
	Naegleria fowleri
	Microsporidia
	Ballantidium coli
Viruses	Norovirus
	Sapprovirus
	Poliovirus
	Coxsackievirus
	Enteroviruses 69-91
	Adenovirus
	Hepatitis A
	Reovirus
	Rotavirus
	Coronavirus

Legionella is one of the most common causes of waterborne diseases. Legionella is the major cause of waterborne illness outbreaks in the USA [29], [30], [31]. Large *Legionella* outbreaks receive the most attention given their substantial health impact. However, it is estimated that less than 20% of all reported legionellosis cases are outbreak-related [30], [32], [33]. Worldwide, waterborne *Legionella pneumophila* is the most common cause of cases including outbreaks. *Legionella pneumophila* and related species are commonly found in lakes, rivers, creeks, hot springs and other bodies of water [34].

In Canada, reported rates of legionellosis in 2006–2020 (the latest year for which data have been published) were 0.37–1.75 per 100,000 population [30], [35]. Reported rates from the USA were 1.0–1.89 per 100,000 population in 2006-2016 [36], [37]. As legionellosis is underdiagnosed and underreported, the actual number of cases is expected to be much higher [38].

4. WATERBORNE DISEASES IN THE WORLD

Water pollution is a global problem, according to the World Health Organization (WHO), 2.1 million people do not have access to safe drinking water sources [39]. The WHO said the minimum water requirement per person for one day is about 7.5 to 10 litres [23].

As access to quantities of water increases, the public health risks decrease (see Table 3) [23], [40], [41]. When water is scarce, then people are forced to drink unsafe water, and water cannot be easily spared for hygiene or sanitation.

Table 3. World Health Organization summary of water access, adequacy and level of health concern [23], [40], [41]

Service level	Access measure	Needs met	Health concern
No access <5L/c/day	>1 km; 30 minutes	Consumption not assured; hygiene not possible	Very high
Basic-often<20 L/c/day	100-1000 meters; 5-20 min	Consumption should be assured; hand washing and basic food hygiene; laundry/ bathing no	High
Intermediate~50 L/c/day	Within 100 m, 5 minutes, or by single tap	Consumption, ditto basic personal and food hygiene, laundry/bathing	Low
Optimal >100L/c/day	Supplied by multiple taps	Consumption and hygiene-all needs met	Very low

L/c/day – liters per capita per day

By comparison, in wealthy countries, residents use 200-300 litres per day for drinking, sanitation, cooking, hygiene, not to mention the unnecessary and uncontrolled use of drinking water to wash cars or clean (watering) the garden or watering grass surfaces [23].

Diarrhea, which is closely associated with contaminated drinking water, coupled with poor sanitation, causes many cases of disease. Diarrheal disease is very high, accounting for 1.7 to 5 billion cases per year worldwide. Specifically, diarrheal diseases are associated with an estimated 1.3 million deaths annually, with most occurring in resource-limited countries. Very young children are the most vulnerable, the incidence of severe gastroenteritis being highest in the first 2 years of life. Indeed, up to 25% of deaths in young children in Africa and south-east Asia are attributable to acute gastroenteritis [42], [43]. Waterborne diseases can range from light, self-limiting diseases to serious diseases such as typhoid fever and cholera. Serious cases end in death unless treated.

In Sub-Saharan Africa significant progress has been made in reducing the risk for children under the age of five, but progress is slower for newborns. The region accounts for 38% of global neonatal deaths and has the highest infant mortality rate (34 deaths per 1,000 live births in 2011). There are many causes of such a high mortality rate, but poor hygiene during childbirth could account for up to 15% of neonatal deaths [44], [45]. Lack of access to water and sanitation is linked to neonatal infection and maternal mortality. It is estimated that clean

childbirth practices could avert 6 to 9% of the 1.16 million annual newborn deaths in countries in Sub-Saharan Africa [44], [46].

Many women giving home birth do not have access to clean water and sanitation (less than 10% according to a study examining data from 22 Western and Central African countries) [44], [47]. Even women who attend a health care facility may not be guaranteed acceptable hygiene standards. A WHO survey of health care facilities in a selection of low- and middle-income African states revealed that 42% did not have an improved water source within 500 metres of the facility, 16% did not have improved sanitary facilities and more than 45% lacked adequate handwashing facilities [48].

Diarrhea is particularly dangerous for children and it is the fourth cause of death of children under the age of 5 in poorly developed parts of the world. Effective treatment of drinking water, however, can kill or inactivate the more than 20 waterborne pathogens. Several of these pathogens are already antibiotic resistant and have taken first place on the WHO global pathogen list. So, clean safe water is the first line of defence against serious diseases that will soon become incurable due to antibiotic resistance. Safe water is also needed to prevent diseases that can arise from inhaling contaminated water droplets, or aerosols, associated with air conditioning systems, spas and devices or systems that produce mists or sprays. These include outbreaks caused by the bacteria Legionella, which can be the most significant waterborne pathogen in high-income countries. Safe and sufficient drinking water is also key to maintaining the health of people who are vulnerable to opportunistic infections (e.g., people living with HIV/AIDS) [49]. It is also estimated that 1.8 million people globally are at risk of potential COVID-19 infection through faecal contamination of drinking water [50]. Death rates are much higher in low-income countries [21]. Figure 4 shows estimated annual number of deaths attributed to unsafe water sources per 100,000 people.
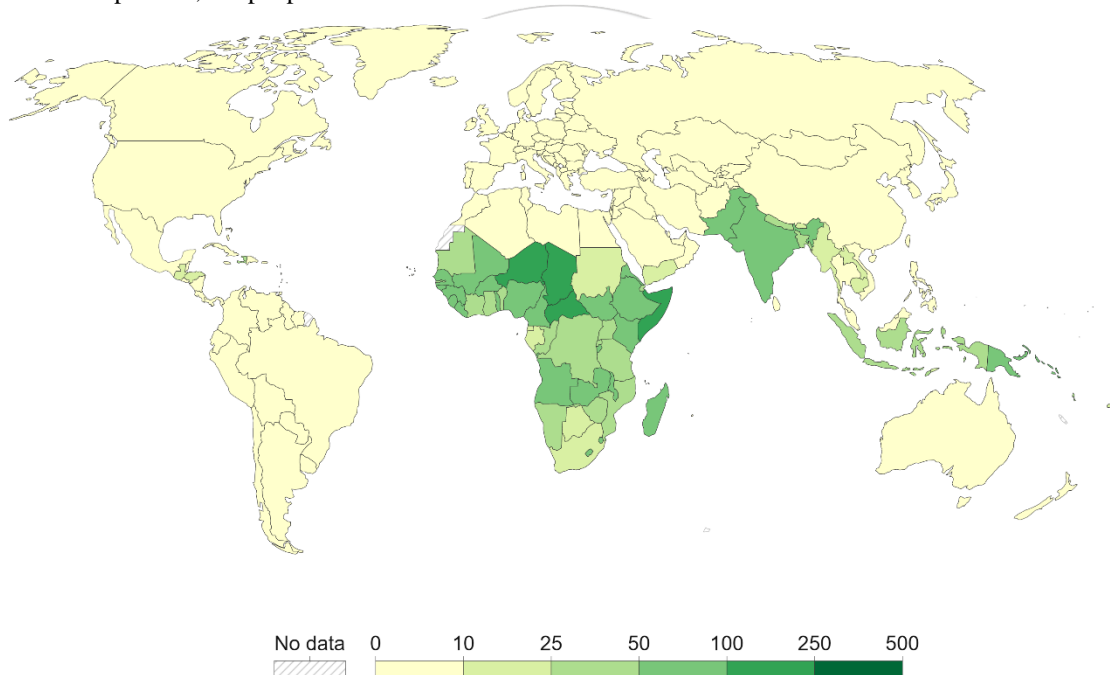

Figure 4. Death rate from unsafe water sources, 2019 [21], [51]

Figure 4 shows large differences in death rates between countries: rates are high in lower-income countries, particularly across Sub-Saharan Africa and Asia. Rates here are often greater than 50 deaths per 100,000 – in the Central African Republic and Chad this was over 100 per 100,000 [21].

5. CONCLUSIONS

Water is essential for people's life and health. Proper sanitation, including proper wastewater management, is essential to ensure human health, a healthy ecosystem, and economic and environmental benefits. Due to its importance for people, the supply of water to settlements and the population is nowadays considered one of the primary branches of water management. Water is distributed to end consumers through the water supply system. The most important roles of the water supply system are ensuring quality water processing from the environment to drinking water, the quality of which must comply with legal regulations, continuous water supply 24 hours a day for all 365 days of the year and sufficient quantities of water for all consumers on the system space. Sufficient quantities of quality and proper drinking water in settlements provide a prerequisite for the protection of the health of residents. This prevents people from becoming infected with diseases transmitted by water.

There is a different availability of drinking water in the world. Thus, in 2020, it is estimated that 90% of the world's population had access to at least basic drinking water services. The biggest access was in Europe, North America, Australia and New Zealand. However, in sub-Saharan Africa only 65% of the population have access and 57% of the population in Oceania. Without water, there is no life, and the health of the body depends largely on the state of the water we bring into it. In case of water contamination from water supply, the intake of such contaminated water into the body can cause disease for a large number of people and animals and can thus lead to a pandemic in a very short period of time. The intake of contaminated water can infect us with various diseases such as: dysentery, typhoid belly, cholera, rotavirus diarrhea, infectious hepatitis, etc. Some of the most common causes of waterborne diseases are bacteria, protozoa, and viruses. Diarrhea, which is closely associated with contaminated drinking water, coupled with poor sanitation, causes many cases of disease. By ensuring sufficient quantities of quality drinking water, it is possible to prevent different diseases transmitted by water, maintain proper health - hygiene conditions and reduce the risk of death associated with inadequate hygiene conditions (due to insufficient quantities of water and its poor quality). Water is the most important and the most used natural resource on Earth, so its health is essential, as well as proper and careful water management.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

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