SELINUS UNIVERSITY
OF SCIENCES AND LITERATURE

Research and Clinical Considerations for Infectious Diseases and Public Health

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A DISSERTATION

Presented to the Department of Public Health and Infectious Diseases Program at Selinus University.

Faculty of Business and Media in fulfilment of the requirements for the degree of Doctor of Philosophy in Public Health and Infectious Diseases.

2023

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Abstract

The prevention and control of infectious diseases continues to be a major problem as the twenty-first century progresses. The most recent outbreak that so many can recall is Coronavirus disease 2019 (COVID-19), most known to scientists as SARS-CoV-2. The burden of unfamiliar diseases and emerging disabilities such as Long Covid. Death brought on by infectious diseases knows no bounds, and affects both developed and developing countries. This most recent outbreak, has highlighted unreservedly, the ability for economies, supply chains and communities to become destabilized. Knowledge of this creates new opportunities for government and science to research public health and infectious diseases.

This research paper will examine a composition of findings and research within the field of public health and infectious diseases. The aim of this research paper is to consolidate in one location, direct educational understandings of each topic, for the knowledge and advancement of the reader. This paper examines public health issues in the context of United Kingdom, Europe, the United States of America and in some cases the world at large.

Keywords:

Public Health, Infectious Diseases, Disease, Epidemiology, Outbreak, Globalisation, Studies, Covid-19, UK, Europe, USA.

Chapter 1: Introduction

This study will conduct a comparative examination of infectious disease epidemics over a six-month period with a focus on specific disease outbreaks and distinct geographic locations. Finding trends, patterns, and potential factors that influence how infectious diseases spread and have an impact in diverse geographical locations is the study's main objective. The research will employ a quantitative approach in order to assess epidemiological data from various sources and produce insightful results.

Background:

As a major cause of widespread morbidity and death, infectious diseases continue to be a major issue for worldwide public health. Infectious disease outbreaks are constantly emerging and re-emerging, underscoring the need for thorough understanding and efficient control techniques. This study aims to undertake a comparative examination of infectious disease outbreaks over a six-month period in various worldwide locations in order to highlight and hopefully solve this issue.

Epidemics of contagious diseases have recently demonstrated their ability to transcend boundaries and have a global impact. The complicated dynamics of disease transmission have been influenced by elements such increased international travel, urbanisation, and shifting climatic circumstances. Understanding the patterns, trends, and driving forces underlying these outbreaks is therefore crucial for developing evidence-based therapies and a worldwide preparation strategy.

There has been little comparative analysis of these outbreaks; even though there have been several researches conducted independently examining distinct infectious disease epidemics. This study tries to close this gap by methodically examining epidemics throughout a predetermined time span, including several places on various continents. This work intends to

provide significant knowledge to our understanding of infectious disease dynamics by highlighting similarities, differences, and potential causes of illness transmission.

The following issues are addressed by the study: What regional variations exist in the occurrence of infectious illness outbreaks? Are there any observable patterns or trends in the severity, demography, or spread of the diseases? What aspects of socioeconomics, the environment, and healthcare infrastructure could affect how these outbreaks affect various areas? By addressing these issues, the study hopes to offer a nuanced view on the complex nature of infectious disease epidemics and their effects on international health systems.

The results of this study will ultimately aid in the allocation of resources, the selection of public health initiatives, and cross-border cooperation to lessen the effects of infectious disease epidemics. The research is motivated by the conviction that a thorough knowledge of these outbreaks is essential for developing resilient health systems that can successfully meet the challenges posed by emerging infectious diseases in a world that is becoming more interconnected.

Research Objectives:

1. How do infectious disease outbreaks differ amongst various worldwide locations in terms of patterns, trends, and influencing factors?

2. What are the main parallels and discrepancies between the spread and effects of infectious diseases in various geographic locations?

3. How does the variety in infectious disease outbreaks across various continents relate to the demographic makeup of the afflicted populations?

4. What part do official reports, monitoring systems, and epidemiological databases play in revealing detailed information about the features of infectious disease epidemics around the globe?

5. How can Geographic Information Systems (GIS) be used to improve our comprehension of the geographic distribution and hotspots of infectious disease epidemics across several continents?

Significance of the Study:

In-depth understanding of the dynamics and effects of infectious disease epidemics across many worldwide locations will be provided through this research. The study attempts to identify patterns, trends, and significant factors that influence the spread, intensity, and effect of these outbreaks by comparative analysis. The findings of this study will be highly valuable in the following ways:

Providing an Enhanced Understanding: By identifying patterns, trends, and implications of infectious illnesses across many worldwide locations, this study will increase our understanding of how they manifest.

Making Informed Decisions: The knowledge gained will enable policymakers and health authorities to decide on interventions, resource allocation, and response tactics in an informed manner.

Global Coordination: The study's conclusions can encourage worldwide cooperation in response efforts by allowing nations to exchange efficient tactics and coordinate their initiatives.

Global Public Health Preparedness: this research paper will provide suggestions supported by evidence. This research will aim to improve worldwide public health readiness, supporting efficient management and epidemic control.

Tailored Policies: This papers' finding will help shape tailored policies and initiatives that take into account the unique traits of different locations and aim to increase their effectiveness.

In conclusion, this study will significantly advance our knowledge of infectious illnesses, facilitate informed decision-making, encourage international cooperation, improve public health preparedness, and guide the creation of efficient policies.

Chapter 2: Literature Review and Methodology

Literature Review

This research paper analyses infectious disease outbreaks through a comprehensive literature evaluation. It uses many data gathering and research methodologies to study infectious disease patterns, transmission dynamics, and treatment efficacy across different countries.

The study begins with descriptive statistics to quantify epidemic data such case counts and demographics. The data gathered is thoroughly evaluated.

Understanding global illness patterns requires comparing infectious disease outbreaks throughout time. The literature evaluation examines previous data gathering methods to help choose suitable data sources and analytical methodologies for a thorough study.

Epidemiological databases and monitoring systems help analyse disease pandemics. These repositories have data on reported cases, transmission rates, and demographics. Europe's infectious disease surveillance is provided by TESSy. Health bodies and international organisations provide authoritative reports on disease incidence, control, and public health measures.

Clinical trials and academic studies help compare epidemic treatment outcomes across locations and improve evidence-based tactics. Demographic and health data aid illness prevalence analysis. Spatial data and GIS technologies enable illness visualisation, hotspot detection, and geographical factor analysis.

This extensive literature analysis shows the variety of infectious disease epidemic data gathering methods. Epidemiological databases, authoritative reports, research studies, health surveys, and GIS-linked geographical data provide insights. These methods provide a complete knowledge of disease outbreaks, which supports evidence-based public health actions and global disease management plans.

Methodology

A comparative research strategy will be used in this study, which entails examining and contrasting data from several locations or nations over a predetermined period of time. The method makes it possible to spot patterns and distinctions among infectious disease outbreaks in diverse places.

Reputable sources included in the research include epidemiology databases, surveillance systems, national and international health authorities, and official publications. Information about infectious disease outbreaks, such as case numbers, death rates, and demographic details of the afflicted populations, will be available from these sources.

To achieve a complete depiction of worldwide infectious disease outbreaks, the research will choose a varied range of nations or areas from several continents.

This research paper will examine the infectious disease outbreaks across various locations by analysing several significant factors and indicators.

The analysis will cover several different disciplines. Some of the analysis may include: information unique to a disease, such as the number of cases, fatalities, rates of transmission,

and infection rates. Age ranges, and vulnerable groups make up the demographics, will also be included.

The paper will also examine the socioeconomic factors relating to the infectious diseases, such as the availability of medical facilities, access to them, and public health initiatives.

Lastly, the paper will also examine the authorities' reactions vaccination drives and quarantine regulations are among of the controls put in place to stop the spread.

Chapter 3: Data Analysis

Data analysis:

Data for this study will come from trustworthy sources such epidemiology databases, surveillance systems, national and international health authorities, and official publications. These sources include crucial data on infectious disease outbreaks, such as case numbers, fatality rates, and demographic details of the people impacted.

Data from infectious disease outbreaks that have most recently occurred in various geographic places will be included in the research. The analysis will be concentrated on outbreaks that have ample and trustworthy data, assuring the validity of the conclusions.

A wide range of places or nations will be picked from various continents in order to get a thorough depiction of worldwide infectious disease epidemics. This method makes it possible to spot patterns and trends in different geographic areas, which helps in comprehending the outbreaks' wider ramifications.

Chapter 4: Ethical Considerations

This research paper will abide by rules governing data privacy and ethical conduct. There will not be any direct engagement of human participants because the study includes the examination of secondary data.

Chapter 5: Results and Discussion

5.1: Public Health; Its Purpose, Concerns and Scope

An order to find an appropriate definition for what public health means, one must take into consideration that public health is an amalgamation of multiple societies' efforts and dedication to acknowledging that public health matters. The definition of infectious diseases is quite simple. Infectious diseases are 'illnesses caused by germs (such as bacteria, viruses, and fungi) that enter the body, multiply, and can cause an infection' (Who We Are | NCEZID | CDC, 2023).

Throughout many sanctioned reports on the health of a particular population, it had become an unwritten consensus that the research of public health tends to acknowledge and research the health disparities between differing communities.

The definition of public health that will be used to underscore this paper comes from Donald Acheson Report 1998.

Acheson (1998) defined public health as

'the art and science of preventing disease, prolonging life and promoting health through the organized efforts of society'.

In order to provide findings to what *public health* looked like in the United Kingdom, Acheson (1998) adopted a socio-economic model that traced the roots of ill health, it is determinants such as: income, employment and education alongside lifestyle and one's environment.

It is evident that public health is concerned with more than the eradication of disease as addressing public health issues, aids in a healthier society, which is ultimately a fundamental component of development. Both the United Nations Millennium Development Goals and Acheson's (1998) report acknowledge the biological, mental well-being and physical health of members of society, regardless of political views, gender, ethnicity, wealth and or sexual orientation. Public health has many elements of intersectionality, all of which are considered but not used in a discriminatory manner, to provide the best outcome and longevity.

The United Nations Millennium Development Goals along with the World Health Organisation each see the conclusion of public health as 'help for all'. Therefore, the field of public health has been adapted, developed, and applied the disciplines necessary to achieve optimal health, including the integration of psychological, biological, and social sciences.

5.2 The Function of Public Health Today

The U.S. Center for Disease Control and Prevention (CDC) is the government agency mandated to protect the health of American Citizens. The CDC conducts critical scientific research and provides/distributes health information to the public.

To successfully implement procedures and preventative measures to assist the health of the public, the CDC implemented their 'National Public Health Performance Standards Program', NPHPS, tasked with providing the necessary framework to assess the performance and ability of public health systems. As such the CDC/NPHPS detailed their guidelines as to what the functions of public health are. These are expressed in Image 1.1 below.

Image 1.1

Source: (CDC, 2023)

In order to effectively provide effective public health services, policies are implemented to encourage the reporting of highly transmissible diseases and any health threats to a community. Inequalities in health services that many believe may only affect poor, rural and minority groups, are sadly mistaken. Any group or community that cannot affectively access healthcare affect the wider society. Therefore, it is essential that the function of public health provides, manages, and produces cost effective health services that all its residents can access.

This becomes ever more paramount in relation to infectious diseases. Overlooking any community due to its restriction/lack of access to health care can result in creating a breeding ground for infectious diseases. Let us consider the research findings from the United States. Evidence of this can be seen in the data and findings obtained by DeSimone (2022) from COVID-19 outbreak. DeSimone (2022) articulates that 'Non-Hispanic Black or African American people and Hispanic people are about twice as likely to need to stay in the hospital due to COVID-19 than non-Hispanic white people.', arguing that 'members of racial and ethnic minority groups are more likely to face barriers to getting care.'. Image 1.2 below from the CDC expresses this similarly.

Image 1.2

Risk for COVID-19 Infection, Hospitalization, and Death By Race/Ethnicity

Updated May 25, 2023

Rate ratios compared to White, Non-Hispanic persons	American Indian or Alaska Native, Non-Hispanic persons	Asian, Non-Hispanic persons	Black or African American, Non-Hispanic persons	Hispanic or Latino persons
Cases[1]	1.6x	0.8x	1.1x	1.5x
Hospitalization[2]	2.4x	0.7x	2.0x	1.8x
Death[3, 4]	2.0x	0.7x	1.6x	1.7x

Source: (National Center for Immunization and Respiratory Diseases (U.S.) & United States. Advisory Committee on Immunization Practices, 2023)

Examining findings from the UK show a similar trend of ethnic minorities having higher risk levels of contracting the infectious disease of COVID-19. The Office for National Statistics found that:

> ‘ONS analysis continues to show that people from a Black ethnic background are at a greater risk of death involving COVID-19 than all other ethnic groups.
>
> Significant differences also remain for Bangladeshi, Pakistani and Indian men.’
>
> (White and Nafilyan, 2020).

The trend of individuals from ethnic backgrounds being at greater risk, is seen further in the long-term consequences of COVID-19. Black and Hispanic people in both the US and the UK are more likely to displays symptoms of long covid, than their white counterparts. Similarly, those who had contracted the virus in the early stages of the epidemic may not know they have the symptoms, and are often due to past and present societal/political traumas, less likely to seek medical intervention or care. Dhruv Khullar, assistant professor at Weill Cornell Medicine College in an interview with the British Medical Journal that ‘Overall, black and Hispanic patients had higher rates of long covid’ (Tanne, 2023).

Through effective public education, robust regulation, sound formulation of procedures and policies, public health care can take care of all ethnic group equally and effectively.

In the US factors outside of biological ill health contribute significantly to the death toll. Over 65% according to Schroeder (2007). Schroeder (2007) breaks it down to around 40% being behavioural, 15% being social circumstances, and around 5% being due to environmental factors.

In accordance with the above statistics, it is evidently paramount that any policies that are to be made should be made with sociological and behavioural awareness.

This would mean addressing past criminalities of governments that have created traumas and distrust within communities. Experiments such as the Tuskegee Experiment funded and sanctioned by the US Public Health Service in 1932 until 1972 have undoubtedly created apprehensiveness within black communities with regards to health care and vaccinations-vaccinations being the mode of healthcare and medicine for the recent COVID-pandemic.

Policies must focus on promoting positive and healthy practices/behaviours to conclude positive outcomes. Policies that stimulate the community to take positive actions, such as community gardening and sporting events, would undoubtedly address and reduce the figures mention by Schroeder (2007) above. Long term public health is difficulty to achieve without the support of community figures, and active participation.

All new public policies must undergo laborious evaluation before being scaled up to a national level. This is because there are often unforeseen circumstances or variables that are sometimes overlooked, even though the policy may seem direct and logical.

The development of new strategies of research has developed our understandings and findings within the varying fields of epidemiology, social and laboratory sciences, alongside biostatistical findings. The can be accredited to the development of artificial intelligence and computer data analysis. However, with new developments bring new challenges. The field of

analytical research on public data now requires new methodologies and approaches to reading such vast amounts of data, and sifting and sorting through what is relevant, and contextual.

Implementation science attempts to reduce the gap between the rapid conclusions of public health data, and the implementation of policies to match the data concluded.

5.3 Contemporary Health Issues: Water Contamination and Poverty

5.3.1 Water Contamination

Instances of poor health and fatalities resulting from the transmission of infectious diseases via water can arise from the ingestion of water that has been contaminated or from contact with pathogens present in water sources.

Several waterborne infectious diseases have been identified as significant contributors to mortality rates and poor health outcomes. Cholera, Typhoid fever, Hepatitis A, and Legionnaires' Disease are examples of infectious diseases that pose significant public health concerns.

It has been calculated that the annual health burden of human infectious diseases caused specifically by the discharge of waste water into the ocean is worth several billion dollars (Shuval, 2003).

844 billion people do not have access to clean drinking water, with approximately 2 billion drinking water that has been contaminated or contains faecal matter (Unicef Supply Division, 2023).

Water contamination can arise from a multitude of factors, encompassing insufficient wastewater treatment, industrial pollution, agricultural runoff, and deteriorating infrastructure. The existence of toxic substances in potable water has the potential to give rise to health complications, impacting individuals of all age groups, including both adults and children. Several primary pollutants and their associated health impacts encompass microorganisms, chemicals, heavy metals, and nitrates.

5.3.1a Combined Sewage (Sewer) Overflow

Combined sewer systems are a common form of wastewater management infrastructure that is frequently encountered in many urban countries. Nevertheless, in instances of intense precipitation, these systems may become inundated, leading to the occurrence of combined sewer overflow (CSO). The practise of combined sewer overflow results in the release of untreated wastewater, which includes both human and animal waste, directly into aquatic ecosystems.

Faecal contaminated water causes some of the most horrendous sickness, such as cholera, dysentery, diarrhoea, typhoid and in some cases polio. With this knowledge it is paramount that in order to keep the health of the public, waste water management system within countries must be constantly kept in check. Unfortunately, this has not been the case for the British public who have most recently experienced a waste/sewage system scandal. This is alarming, as millions of infectious microorganisms are present in every cubic metre of untreated wastewater dumped into the sea, (Shuval, 2003).

Members of the British Parliament in 2021 voted down amendments to the Environment Bill, now the Environment Act 2021 (*Environment act 2021,* 2021) that would place a legal duty on water companies preventing them from pumping waste into British seas and waterways. MPs such as Steve Brine, Ben Everitt, Michael Fabricant, Anne Marie Morris, and Sally-Ann Hart all featured comparable "explainers" regarding the vote on their websites. Their statements read:

> '"To eliminate storm overflows means transforming the entire Victorian sewage system to a whole new sewage system. It would be irresponsible for any government to spend an estimated preliminary cost of anywhere between £150bn to £650bn to transform the entire sewage system. This is a huge amount to spend in an ordinary time, let alone at a time of a continuing health pandemic' (Horton & Allegretti, 2021).

Members of the British government have in essence put the British public's health at risk, due to the illness that are known to be water borne. This is why it is paramount that policies regarding health are often voted on or made in the environments of those who know the severity of the consequences, or at the very least, advisors to such departments having voting rights. However, this is not the case, as most scientists and researchers are not Members of the British Government, or hold seats.

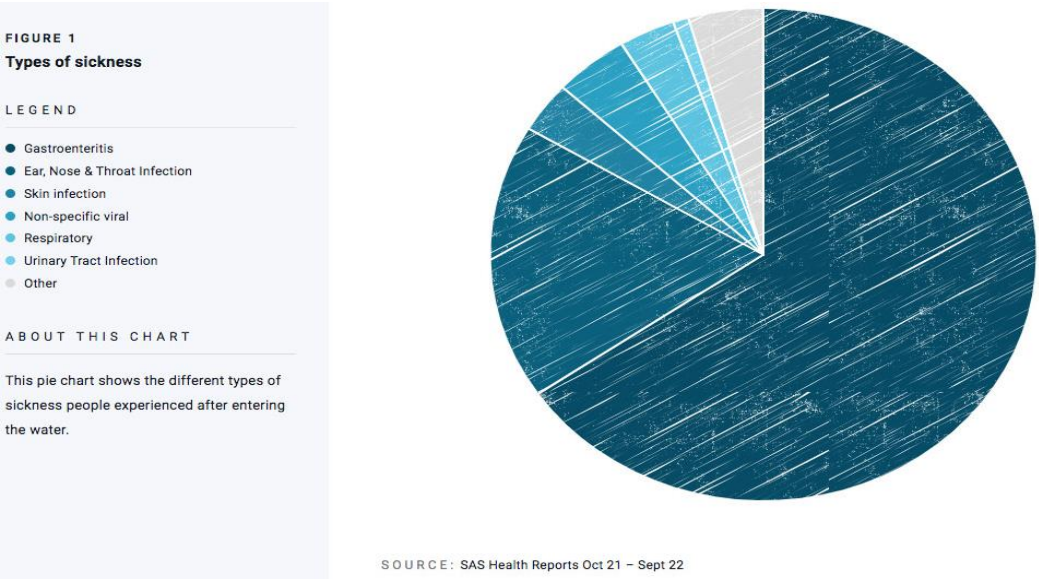
Public health policies are just as political as they are social. The chief policy advisor for the Angling Trust, of whom represents fishermen, anglers and advocates for the environment has stated '*our rivers are badly polluted and cannot wait for more plans and reports*' (Horton & Allegretti, 2021). The health of the British public relies on access to clean water, '*but, chemicals, sewage and manure continue to pour almost unabated into […] already polluted waterways'* (Salter cited in Horton & Allegretti, 2021).

According to Surfers Against Sewage (2021) '*Between 1st October 2021 and 30th September 2022, 720 water users reported getting ill after entering the water, […] more than double the amount of reports we received in 2020/21'*. Continuing to state that 'Our consumer survey undertaken in May 2022, showed more than half of people who have tried wild swimming or water sports in the UK have experienced sickness after swimming' (Surfers Against Sewage, 2021). In addition to sinus infections, skin rashes, and conjunctivitis, swimming in contaminated recreational waters has been linked to an increased risk of gastroenteritis.

Studies have revealed open-water swimmers suffer a significant risk of gastrointestinal sickness by entering the water, independent of the water's status as a bathing area. It is estimated that swimming in contaminated waters causes 120 million instances of gastrointestinal disorders yearly (Shuval 2003, Hall et al 2017, Harder-Lauridsen et al 2013).

Image 1.3 below shows a handful of sickness' people experienced after entering contaminated water. The pie chart segment in size correlates to the order of illnesses being mentioned, i.e., Gastroenteritis being first on the Identity list (Legend), and the largest segment of the Chart.

Image 1.3



Source: (Surfers Against Sewage, 2021)

The damage of raw sewage in British waterways continues. There has been evidence of the polio virus in Newham, London. The infection, which is known to have altered from the live vaccine brought back from abroad, can be extremely dangerous to human health and result in paralysis. Except for a few nations in Asia, the virus had almost completely disappeared worldwide since the development of the polio vaccine. However, 'between February and august 2022 the mutated virus has been found in London waste-water 116 times' (Gallagher, 2022), with advisements being given to parents to have their children Vaccinated against polio, via a booster shot.

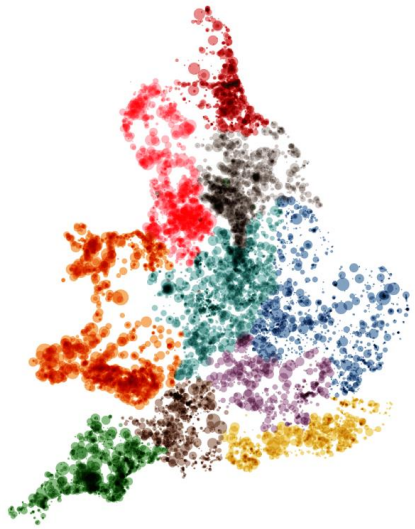
In practically every district in England and Wales, sewage overflows into rivers.

In England and Wales, Combined Sewage Overflows (CSO) release rainwater and toilet sewage into rivers, poisoning fish and other wildlife in the process and causing the rivers to dry up. Unfortunate, sometimes, downstream a variety of unclean sanitary goods may be found.

Due to the lack of Combined Sewage Overflows, very districts or towns number of people are left out.

In image 1.4 below, you will be able to view all the CSOs that overflowed in the United Kingdom in 2022. Each colour you will find, will represent a different Water Company, as they privately are responsible for disposing of the raw sewage they collect.

Image 1.4



Source: (Top of the Poops, 2023)

The sewage collection and management data provided by the water corporations themselves understate the scale of the issue. This as it relates to public health and consumption, is a problem. The data is often collected inefficiently and frequently without any monitoring at all. It appears that many data records are not linked to active permits, making it impossible to pinpoint their locations.

Although it may seem that a percent or the population is spared from contaminated water as they are not in contact with it, sadly, that is not the case. Due to their sensitivity to the water quality in their immediate environment, shellfish have the potential to pick up bacteria as they filter the water. This could lead to trace levels of the infectious disease, borne and transported by water, mentioned above. Therefore, babies, children and adults alike are not safe from the contaminated water. Data collection from Top of the Poops, analyses ‘at least 24,558 "sewage spills" into shellfish areas in 2022, lasting an almost unbelievable 161,044 hours’ (2023).

However, it appears wastewater management in the UK is set to improve with The Sewage Discharge Bill 2022, (*Sewage discharges bill - parliamentary bills - UK parliament,* 2022)

The Sewage Discharge Bill 2022 is a legislative proposal aiming at resolving the issue of untreated sewage discharges into UK aquatic bodies. We can grasp how the bill's core features, such as better surveillance, improved infrastructure, and higher public knowledge, can favourably benefit public health, sustainability in the environment, and community well-being.

The possibility for enhanced water quality, leading to better public health outcomes, is one of the key benefits of the Sewage Discharge Bill 2022. The bill emphasises greater sewage discharge monitoring and reporting regulations, ensuring that aquatic bodies are not affected by untreated sewage. This proactive strategy can lower the danger of waterborne infections, protecting the health and well-being of people who participate in recreational activities or drink and bathe in water sources.

The bill encourages water corporations to invest in infrastructure upgrades by introducing stronger restrictions and penalties for noncompliance. This can entail the development of new sewage treatment facilities as well as the use of modern treatment technology. Improved

infrastructure will reduce untreated sewage discharges, lowering the risk of exposure to hazardous germs and contaminants.

The Sewage Discharge Bill 2022 places an emphasis on environmental conservation by trying to lessen the adverse effect of untreated waste water on ecosystems and biodiversity. Untreated wastewater discharges can pollute water, harming aquatic life and upsetting sensitive ecosystems.

The bill encourages the use of environmentally conscious wastewater management practises, such as water reuse and recycling, as well as the use of natural-based treatment technologies. The bill helps conserve the biological equilibrium of water bodies and safeguards critical habitats by supporting ecologically beneficial techniques.

The emphasis on public education and participation is another key benefit of the Sewage Discharge Bill 2022. The bill encourages open reporting of sewage discharge data, ensuring that the general public has access to information on water quality and potential hazards. This knowledge enables people to make educated choices about their water-related activities, such as selecting safer recreational places or exercising caution while using drinking water sources.

Furthermore, the measure encourages public participation in wastewater management decision-making processes. This type of participation allows for input from the community, ensuring that local opinions are considered and fostering a sense of ownership and accountability for water resources.

The Sewage Discharge Bill 2022 provides various benefits to the British people. The bill intends to protect public health, maintain ecosystems, and encourage a sustainable approach to handling wastewater through improving water quality, environmental preservation, and increased public awareness and engagement.

5.3.1b Cholera

Microbiologically contaminated drinking water can spread diseases such diarrhoea, cholera, dysentery, typhoid, and polio, and is responsible for 485 000 diarrhoeal deaths per year. (WHO, 2022)

There are many ways in which cholera can be transmitted, such as poor water and sanitation infrastructure, human behaviour and hygiene practises, economic and social factors, travel, and migration. Here we will look at poor water and sanitation infrastructure.

Cholera is an acute diarrheal infection caused by the bacterium Vibrio cholerae. The disease is primarily transmitted through the consumption of contaminated water or food. Cholera is characterized by profuse watery diarrhoea, vomiting, and dehydration, and if left untreated, it can lead to severe electrolyte imbalances and death.

Cholera has a long history of causing epidemics and pandemics around the world. It was prevalent in Europe and the United States during the 19th century, leading to significant mortality and societal disruptions. However, advancements in sanitation, water treatment, and healthcare significantly reduced the occurrence and impact of cholera in developed countries.

With that, it is important to note, that there are still cholera outbreaks that affect developed countries, as at least 2 billion people worldwide consume feces-tainted water (WHO, 2022).

Cholera is mostly spread through contaminated water and food, with oral and faecal contact being the most prevalent form of transmission. Individuals who consume contaminated water become infected when water sources become polluted with human faeces containing V. cholerae. Inadequate sanitation infrastructure and practises contribute to water contamination, continuing the cholera transmission cycle.

According to the CDC 'Modern water and sewage treatment systems' have prevented the transmission of cholera through water (Cholera in the United States, 2019).

Inadequate water and sanitation infrastructure can contaminate water sources, elevating the risk of cholera transmission. Human waste can contaminate water supplies due to inadequate sewage infrastructure, a lack of efficient waste disposal, and poor sanitation practises. This pollution can occur as a result of either direct sewage discharge into bodies of water or sewage seepage into groundwater sources, rendering the water unsuitable for drinking.

Infected people experience acute watery diarrhoea, vomiting, and dehydration. Severe dehydration can result in electrolyte imbalances, organ failure, and death if not treated promptly and appropriately. Individuals affected with cholera have physical discomfort, are unable to work, and may suffer long-term health repercussions.

Cholera epidemics have the potential to devastate entire communities, especially those with limited access to healthcare and resources. The disease's rapid spread has the potential to overwhelm local healthcare systems and put a strain on available medical resources. As neighbourhoods focus on response to an outbreak and containment efforts, social and economic disruptions ensue, affecting production, education, and overall well-being.

The global situation has worsened since the first disease outbreak news on the global cholera scenario was reported on December 16, 2022, with additional countries reporting cases and outbreaks.

Since mid-2021, the world has been experiencing an acute outbreak of the 7th cholera pandemic, characterised by the number, size, and confluence of various epidemics, spread to formerly cholera-free areas, and alarmingly high mortality rates.

In 2021, 23 countries suffered cholera outbreaks, primarily in African and Eastern Mediterranean Regions. This continued into 2022, with 30 countries reporting cholera cases or outbreaks in five of the six WHO regions. 14 of those 'had not reported cholera in 2021, including non-endemic countries (Lebanon and Syria) or countries that had not reported cases' (*Cholera – Global situation*, 2023) in three years (Haiti and the Dominican Republic), while many of the remaining countries reported higher case numbers and case fatality ratios (CFR) than in previous years.

Unfortunately, at least 18 nations 'continue[d] to report cholera cases as of 1 February 2023' (Cholera – Global situation, 2023). This is because seasonality patterns indicate that many portions of the world are currently in low or interepidemic transmission periods, this figure could rise in the coming months.

Below (image 1.5) is a map of cholera outbreaks from the WHO, (Cholera – Global situation, 2023).

As of 1 February 2023, countries in white were not reporting continuing cholera outbreaks.

Image 1.5

The mortality connected with those outbreaks is especially concerning because many nations recorded greater CFR than in prior years. In 2021, the global average cholera CFR was 1.9% (2.9% in Africa), a considerable increase above tolerable (1%), and the highest recorded in almost a decade. Preliminary data for 2022 and 2023 indicate a similar trend.

The previous *Disease Outbreak News* highlighted probable epidemic causes and barriers affecting response actions. The simultaneous advancement of numerous cholera epidemics, exacerbated by climate change and compounded in countries suffering complex humanitarian crises with frail health systems, poses obstacles to outbreak response and risks spreading to neighbouring nations.

The overall capacity to respond to multiple and concurrent epidemics is strained due to a global paucity of resources, including the oral cholera vaccine, as well as overworked public health and medical workers coping with multiple disease outbreaks at the same time.

Based on the current scenario, including the growing number of outbreaks and their geographic spread, as well as a lack of vaccinations and other resources, WHO considers the risk to be very high at the global level.

Let us consider the research and findings, to do with current outbreaks and spreads and or longevities of cholera around the world.

In the WHO region of the Americas: The situation in the Port-au-Prince metropolitan area and the Ouest Department of Haiti is improving. A third of the confirmed cases recorded during the peak in October and November 2022 were reported by the department. Although the outbreak is currently under control, there are still suspected and confirmed cases of cholera being recorded in each of the nation's 10 departments. In addition, Santo Domingo, the capital of the adjoining Dominican Republic, is reporting imported cases and minimal local transmission.

The local population's mobility poses a persistent risk of national and worldwide expansion, although being constrained by the country's acute instability and a scarcity of fuel. It is conceivable for Haiti to sell more goods to other hemispheric nations and territories. The risk in Hispaniola is rated as Very High, while the regional risk is rated as Moderate, according to the 2 December 2022 AMRO quick risk assessment. The region is currently working to increase surveillance and laboratory capability. On the island of Hispaniola, there is a cholera vaccination campaign going on.

Luckily, in the WHO region of Europe Cholera is not an Endemic. Nevertheless, nations that share borders with Syria and Lebanon, where significant and continuous outbreaks have been documented, might face an increased likelihood of the introduction and subsequent spread of infections, particularly in specific contexts such as among refugees and displaced individuals (e.g., Turkey).

The occurrence of a significant earthquake in southern and central regions of Türkiye on 6 February 2023 has resulted in severe damage to infrastructure. Consequently, it is expected that there will be an increased susceptibility to cholera outbreaks in the country.

Furthermore, during the month of November in the year 2022, the nation of Israel officially notified the World Health Organisation (WHO) regarding the identification of toxigenic Vibrio cholerae O1 in environmental samples obtained from the Yarmuch stream after its ingress into Israeli territory.

Israel has implemented significant proactive measures aimed at preventing the introduction and transmission of cholera, leading to a low overall risk. The protracted conflict in Ukraine has the potential to exacerbate environmental and sanitary conditions, as well as undermine the health infrastructure in the region. However, it is worth noting that the occurrence of cholera is relatively less likely during the winter months.

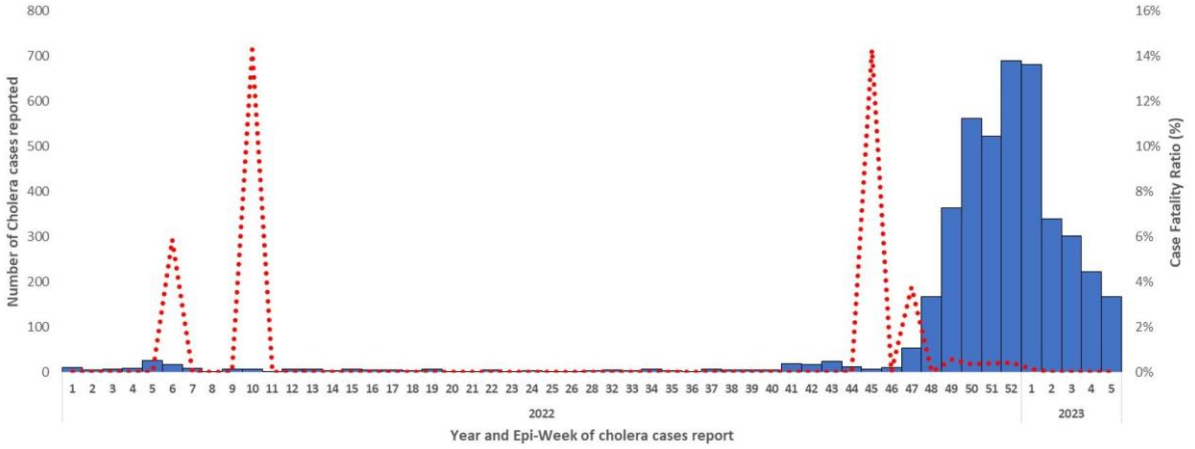
In November 2022, the World Health Organisation (WHO) European Region International Health Regulations (IHR) extended an invitation to Member States to promptly report any instances of cholera, whether imported or originating within their own territories, in order to facilitate comprehensive global surveillance of outbreaks. As of the date of 27 December 2022, the World Health Organisation (WHO) has received reports of 28 instances of cholera from eight Member States within the European Region. Out of these cases, 24 have been identified as being associated with individuals who had travelled to countries affected by cholera.

In the WHO region of Africa: In the last months of 2022, there was a rise in the number of internally displaced people (IDPs) to camps near Goma as a result of the ongoing fighting in the DRC's North Kivu province. The continuous cholera outbreak was made worse by the camps' lack of access to clean water and sanitary facilities. Additionally, the cholera situation in other eastern provinces is getting worse during the rainy season, raising the possibility of a regional outbreak.

The Governor of the province of North Kivu officially declared a cholera epidemic on 14 December 2022. This declaration was made after the identification of Vibrio cholerae in 140 out of the 247 samples obtained from individuals suspected to have contracted Nyiragongo HZ.

Image 1.6 below shows the number of suspected and confirmed cholera cases reported in the Karisimbi and Nyiragongo health zones.

Image 1.6



Source: (Cholera, no date)

As of February 4th, 2023, there have been a cumulative count of 4386 cases of cholera, out of which 1009 cases have been confirmed through laboratory testing. Additionally, there have been 16 reported deaths, resulting in a case fatality rate (CFR) of 0.4%.

Cholera has lately been confirmed to be spreading in Bujumbura, close to the border with the DRC's South Kivu region, along Lake Tanganyika's shoreline. While the number of cases reported in several nations that saw major outbreaks in 2022, including Cameroon and Nigeria, is gradually decreasing, the situation in Malawi, which reports more than 600 new cases per day, is still becoming worse in the early years of 2023.

Since March 2022, the country has been dealing with the deadliest cholera outbreak in its history, with a CFR that has consistently been high (>3%). Additionally, from mid-December 2022, adjoining Mozambique has had a substantial rise in cases and alarms, with instances recorded from five regions, including those bordering Malawi.

Further to this, Zambia informed WHO of the cholera epidemic in the Eastern province, which borders Malawi and Mozambique, on January 26, 2023. There is still a significant chance that the disease will spread to Tanzania and Zimbabwe, among other nations in the area. In addition, persistent cholera epidemics are being reported in three countries in the eastern part of Africa (Ethiopia, Kenya, and Somalia in the Eastern Mediterranean Region).

High levels of malnutrition enhance the probability of severe cholera outcomes in the area, and the ongoing drought is driving population movements that raise the danger of cholera spreading. Due to additional public health emergencies (COVID-19, mpox, malnutrition), there are numerous graded emergencies and stretched resource and human capability. There is limited access to the populace and restricted access to healthcare in many of the affected locations.

Climate change is causing drought and flooding in different parts of Africa, which is displacing more people and limiting their access to clean water. Multiple epidemics were reported to have high CFRs. In the Lake Chad basin, where there is a lack of response capability due to

insecurity, as well as Southern Africa, where the rainy/cyclone season is approaching, there is a significant danger of regional spread.

It is crucial to acknowledge that cholera epidemics can result in significant societal ramifications, as they undermine public confidence in water and sanitation infrastructure. Communities that encounter frequent outbreaks may develop a lack of confidence in their water sources, leading to reduced utilisation and increased dependence on public water supplies. This phenomenon has the potential to intensify the likelihood of cholera transmission through the perpetuation of a cycle characterised by inadequate water and sanitation practises.

Lack of adequate sanitation and water resources in the United States have a disproportionate impact on vulnerable populations. Socioeconomically marginalised populations, particularly those lacking adequate access to potable water and sanitation facilities, exhibit heightened susceptibility to cholera epidemics. Moreover, individuals experiencing homelessness, migrants, and those residing in overcrowded and unsanitary conditions exhibit heightened susceptibility to the transmission of cholera.

Enhancing water and sanitation infrastructure is of utmost importance in the prevention and management of cholera. One of the primary strategies includes:

The provision of safe drinking water plays a crucial role in mitigating the transmission of cholera. Significant reductions in the risk of contamination can be achieved through investments in water treatment facilities, water quality monitoring systems, and distribution networks. In addition to the measures above, the enhancement of water quality can be further facilitated through the implementation of water safety policies and the provision of support for household water treatment practises.

To conclude, the implementation of appropriate sanitation infrastructure, encompassing enhanced toilet facilities, sewage treatment systems, and efficient waste management practises, plays a pivotal role in mitigating water contamination. The promotion of appropriate sanitation practises, such as handwashing without the use of soap, plays a crucial role in mitigating the transmission of cholera.

Efforts aimed at promoting hygiene can significantly augment awareness regarding the prevention of cholera and the importance of cultivating proper cleanliness practises. It is imperative to prioritise the promotion of handwashing, safe food handling, and personal hygiene within these initiatives, with a particular focus on individuals who are more susceptible to adverse health outcomes.

The resolution of the problem pertaining to insufficient water and sanitation infrastructure calls for a collective effort involving governmental entities, public health organisations, and local communities. During cholera epidemics, the Centres for Disease Control and Prevention (CDC), the World Health Organisation (WHO), and other relevant agencies assume a significant role in offering technical proficiency, bolstering surveillance systems, and expediting response endeavours.

The persistence of cholera outbreaks is sustained by the presence of polluted water sources and insufficient sanitation infrastructure, resulting in adverse consequences for individuals, communities, and society. Minimising the risk of cholera and its adverse impacts on public

health can be achieved through the prioritisation of investments in water and sanitation infrastructure, the promotion of hygiene practises, and the facilitation of collaborative efforts.

5.3.1.c Typhoid Fever (Salmonella enterica serotype Typhi)

Europe (and the UK)

Typhoid Fever, also referred to as Salmonella enterica serotype Typhi, an infectious disease resulting from the bacterial pathogen Salmonella Typhi. Typhoid Fever is a significant global public health issue; however, its impact on public health in Europe is comparatively minimal owing to the presence of improved sanitation systems and the availability of clean water resources. However, it is important to note that sporadic instances and outbreaks may still manifest. Let us examine research cases from 2014-2018.

In 2018 for example, ‘30 EU/EEA countries reported a total of 1,118 cases of typhoid and paratyphoid fever’ (Typhoid and paratyphoid fever - annual Epidemiological Report for 2018 2023).

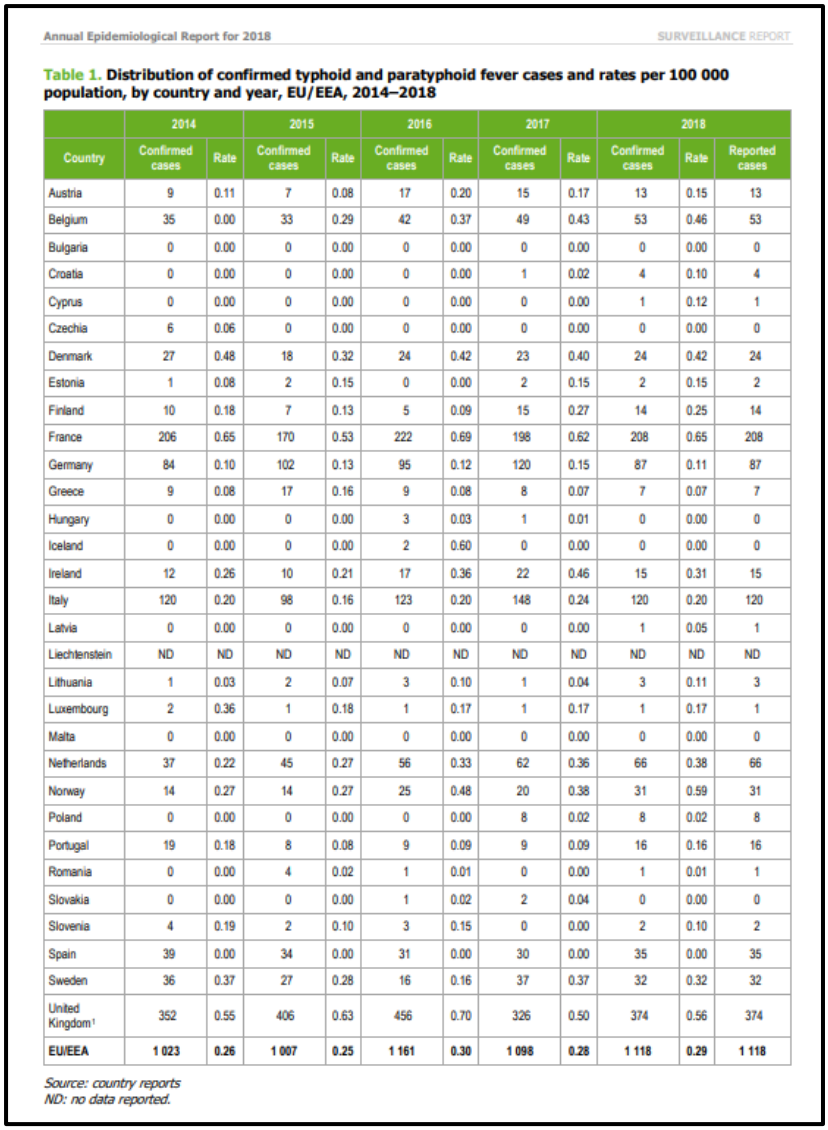
France, the United Kingdom (UK), and Norway exhibited the highest notification rates.

Out of the total 833 cases for which information was accessible, it was found that 90.8% of these cases were associated with travel.

Table 1.7 below expresses a distribution of confirmed cases and rates of typhoid and paratyphoid fever per 100,000 people, by country and year, EU/EEA, 2014–2018.

This report is based on information for 2018 that was collected from TESSy on September 17, 2019. TESSy is a system for gathering, analysing, and sharing information about communicable diseases.

Table 1.7



Annual Epidemiological Report for 2018 SURVEILLANCE REPORT

Table 1. Distribution of confirmed typhoid and paratyphoid fever cases and rates per 100 000 population, by country and year, EU/EEA, 2014–2018

	2014		2015		2016		2017		2018		
Country	Confirmed cases	Rate	Confirmed cases	Rate	Confirmed cases	Rate	Confirmed cases	Rate	Confirmed cases	Rate	Reported cases
Austria	9	0.11	7	0.08	17	0.20	15	0.17	13	0.15	13
Belgium	35	0.00	33	0.29	42	0.37	49	0.43	53	0.46	53
Bulgaria	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
Croatia	0	0.00	0	0.00	0	0.00	1	0.02	4	0.10	4
Cyprus	0	0.00	0	0.00	0	0.00	0	0.00	1	0.12	1
Czechia	6	0.06	0	0.00	0	0.00	0	0.00	0	0.00	0
Denmark	27	0.48	18	0.32	24	0.42	23	0.40	24	0.42	24
Estonia	1	0.08	2	0.15	0	0.00	2	0.15	2	0.15	2
Finland	10	0.18	7	0.13	5	0.09	15	0.27	14	0.25	14
France	206	0.65	170	0.53	222	0.69	198	0.62	208	0.65	208
Germany	84	0.10	102	0.13	95	0.12	120	0.15	87	0.11	87
Greece	9	0.08	17	0.16	9	0.08	8	0.07	7	0.07	7
Hungary	0	0.00	0	0.00	3	0.03	1	0.01	0	0.00	0
Iceland	0	0.00	0	0.00	2	0.60	0	0.00	0	0.00	0
Ireland	12	0.26	10	0.21	17	0.36	22	0.46	15	0.31	15
Italy	120	0.20	98	0.16	123	0.20	148	0.24	120	0.20	120
Latvia	0	0.00	0	0.00	0	0.00	0	0.00	1	0.05	1
Liechtenstein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lithuania	1	0.03	2	0.07	3	0.10	1	0.04	3	0.11	3
Luxembourg	2	0.36	1	0.18	1	0.17	1	0.17	1	0.17	1
Malta	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
Netherlands	37	0.22	45	0.27	56	0.33	62	0.36	66	0.38	66
Norway	14	0.27	14	0.27	25	0.48	20	0.38	31	0.59	31
Poland	0	0.00	0	0.00	0	0.00	8	0.02	8	0.02	8
Portugal	19	0.18	8	0.08	9	0.09	9	0.09	16	0.16	16
Romania	0	0.00	4	0.02	1	0.01	0	0.00	1	0.01	1
Slovakia	0	0.00	0	0.00	1	0.02	2	0.04	0	0.00	0
Slovenia	4	0.19	2	0.10	3	0.15	0	0.00	2	0.10	2
Spain	39	0.00	34	0.00	31	0.00	30	0.00	35	0.00	35
Sweden	36	0.37	27	0.28	16	0.16	37	0.37	32	0.32	32
United Kingdom[1]	352	0.55	406	0.63	456	0.70	326	0.50	374	0.56	374
EU/EEA	**1 023**	**0.26**	**1 007**	**0.25**	**1 161**	**0.30**	**1 098**	**0.28**	**1 118**	**0.29**	**1 118**

Source: country reports
ND: no data reported.

Source: (Typhoid and paratyphoid fever - annual Epidemiological Report for 2018 2023).

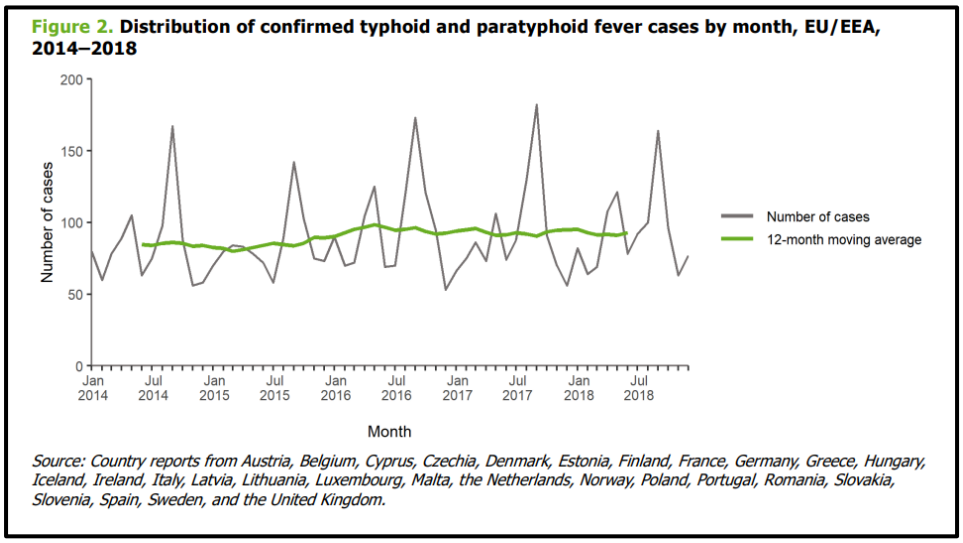
Typhoid Fever is predominantly transmitted via the consumption of food or water that has been contaminated with faecal matter containing the bacterium Salmonella Typhi. Bacterial contamination of water sources can occur as a result of insufficient sewage treatment, substandard sanitation practises, or the infiltration of sewage into drinking water supplies. Transmission can also transpire via direct contact with infected individuals who are excreting the bacteria in their faecal matter.

Typhoid Fever can have notable ramifications for public health in Europe, albeit to a lesser degree in comparison to regions characterised by limited access to clean water and sanitation. The disease predominantly impacts individuals who are travelling to regions where it is prevalent or individuals who are immigrants returning from those specific regions. This is evident as in '*2019, 10 countries reported travel-associated cases with an extremely drug-resistant Salmonella Typhi (S. Typhi). These were related to the typhoid fever outbreak ongoing in Pakistan since 2016*' (Typhoid and paratyphoid fever - annual Epidemiological Report for 2018 2023).

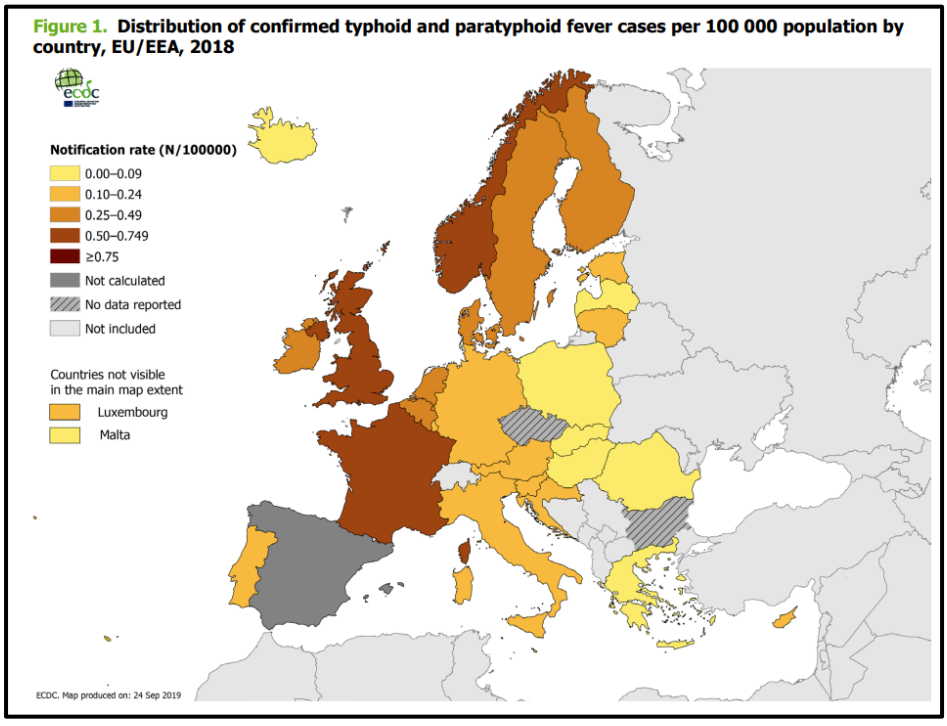
The cases observed within the European Union/European Economic Area (EU/EEA) exhibited distinct seasonal patterns, characterised by a prominent surge in September and a minor increase during late spring, which can be plausibly attributed to travel behaviours.

Such evidence is expressed in graph 1.8 and image 1.9 below, (Typhoid and paratyphoid fever - annual Epidemiological Report for 2018 2023).

Graph 1.8



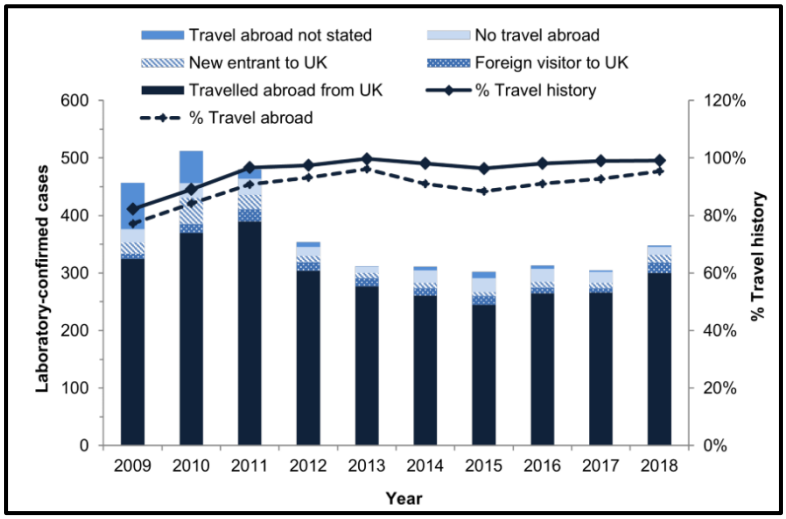
Inage 1.9



Individuals who have not received vaccinations are more susceptible to contracting infections, and in the absence of appropriate medical intervention, the illness can result in significant morbidity and mortality.

In the UK, 99% (345/348) of symptomatic S. Typhi and S. Paratyphi cases with laboratory confirmation in 2018 contained travel history data (i.e., whether the patient had travelled or not). Like 2017 (93%), 95% (332/345) of verified symptomatic cases with travel history data in 2018 reported illness onset within the recommended 28-day interval and were therefore believed to have been acquired overseas. Of these, 300/332 (91%) had left EWNI for a foreign country and were citizens of the UK. The remaining individuals were either new to EWNI (N=14) or foreign visitors (N=18). No overseas travel was documented in 13 cases (as opposed to 19 in 2017).

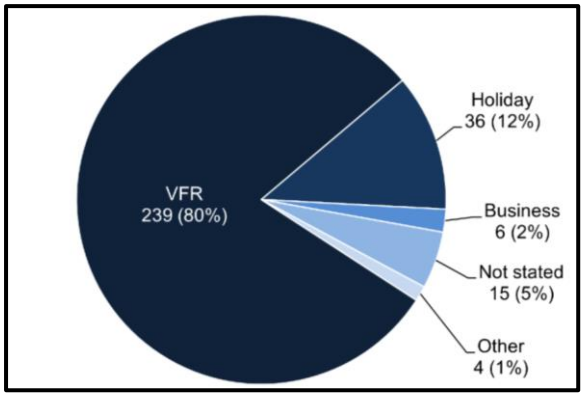
Image 2.0



Source: (Enteric fever (typhoid and paratyphoid) England, Wales and Northern Ireland: 2018 2023)

Image 2.1 is a pie chart that expresses the enteric fever cases with laboratory confirmation, of contracted fever, of those who travelled outside of England, Wales, and Northern Ireland in 2018 (N=300).

Image 2.1



Source: (Enteric fever (typhoid and paratyphoid) England, Wales and Northern Ireland: 2018 2023).

The onset of symptoms associated with Typhoid Fever typically occurs within a period of 6 to 30 days following exposure. These symptoms may encompass a persistent fever, abdominal discomfort, headache, irregular bowel movements (either constipation or diarrhoea), and a

general sense of unease or discomfort. In the absence of proper medical intervention, the infection has the potential to advance, resulting in significant complications such as intestinal perforation, gastrointestinal haemorrhage, and systemic infections impacting multiple organs.

The incidence of Typhoid Fever outbreaks in Europe is infrequent as a result of the implementation of effective public health interventions and the enhancement of water and sanitation infrastructure. In instances of outbreaks, it is imperative to promptly initiate a response. Outbreak investigations encompass the essential tasks of identifying the origin of contamination, implementing control measures to hinder subsequent transmission, and administering suitable medical interventions and vaccinations to individuals affected by the outbreak.

The provision of uncontaminated water and sufficient sanitation infrastructure plays a pivotal role in mitigating the transmission of Salmonella Typhi. The European region, characterised by its well-developed infrastructure, has made notable advancements in the provision of accessible clean water sources and efficient sewage treatment systems. These measures serve to mitigate the likelihood of contracting waterborne illnesses, such as Typhoid Fever.

Surveillance systems play a crucial role in the monitoring of Typhoid Fever cases and outbreaks, facilitating prompt identification and timely intervention. The expeditious reporting of suspected cases to public health authorities enables the timely implementation of control measures and the thorough investigation of potential sources of contamination. Effective surveillance and response necessitate efficient communication among healthcare providers, laboratories, and public health agencies.

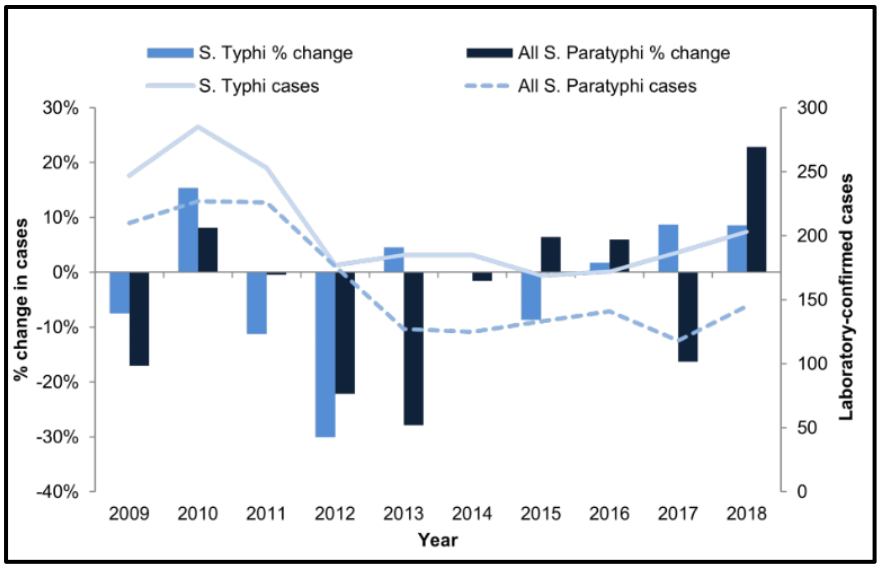
The UK Health Security Agency (UKHSA), formerly known as Public Health England, Salmonella Reference Service (SRS), located within the Gastrointestinal Bacteria Reference Unit (GBRU), is responsible for diagnosing confirmed symptoms cases of S. Typhi and S. Paratyphi in England, Wales, and Northern Ireland.

The UK Health Security Agency's Syndromic Surveillance System (UKHSA SRS) reported a total of 348 laboratory-confirmed symptomatic cases of S. Typhi and S. Paratyphi in the region of England, Wales, and Northern Ireland (EWNI) in the year 2018. This represents a 14% increase in comparison to the 305 cases that were reported in the previous year, 2017. This is presented in table 2.2, and image 2.3 below, (Enteric fever (typhoid and paratyphoid) England, Wales and Northern Ireland: 2018 2023).

Table 2.2

Year	S.Typhi	S. Paratyphi A	S. Paratyphi B	S. Paratyphi C	Mixed infection	Total	% S. Typhi
2009	247	185	25	-	-	457	54%
2010	285	211	16	-	-	512	56%
2011	253	219	7	-	1	480	53%
2012	177	162	12	2	1	354	50%
2013	185	121	6	-	-	312	59%
2014	185	114	10	1	1	311	60%
2015	169	107	26	-	-	302	56%
2016	172	133	8	-	-	313	55%
2017	187	103	15	-	-	305	61%
2018	203	126	19	-	-	348	58%

Image 2.3



When it comes to obtaining data in relation to distribution, the assignment of geographical areas was determined by the patient's postcode, with a small subset of cases where the patient's postcode was unavailable and the postcode of the sending laboratory was utilised instead. In 2018, London accounted for the highest percentage of English cases of S. Typhi and S. Paratyphi, with a proportion of 38%. This figure demonstrates a similarity to the preceding year, as the corresponding percentage in 2017 was 35%. Yorkshire and Humber exhibited the most substantial relative escalation in reported cases in 2018 when compared to 2017, without a discernible explanation for this upsurge. The number of reported cases in the South East, East Midlands, and North East regions exhibited a decrease in comparison to the figures recorded in 2017. Table 2.4 below expresses these findings, (Enteric fever (typhoid and paratyphoid) England, Wales and Northern Ireland: 2018 2023).

Table 2.4

Geographical area (UKHSA centre)	2018	2017	% change
London	127	102	+25%
South East	44	45	-2%
West Midlands	41	41	+0%
North West	35	26	+35%
Yorkshire and Humber	33	21	+57%
East of England	22	18	+22%
East Midlands	17	23	-26%
South West	14	11	+27%
North East	4	5	-20%
England total	**337**	**292**	**+15%**
Wales	9	10	-10%
Northern Ireland	2	3	-33%
EWNI total	**348**	**305**	**+14%**

Source: (Enteric fever (typhoid and paratyphoid) England, Wales and Northern Ireland: 2018 2023).

Lastly, it is important to note, that in 2018, a total of 13 cases of symptomatic enteric fever were confirmed. Among these cases, it was reported that the individuals did not engage in any travel activities within the 28 days preceding the onset of symptoms. Specifically, 6 cases were attributed to the bacterium Salmonella Typhi, 5 cases were caused by Salmonella Paratyphi B, and 2 cases were associated with Salmonella Paratyphi A.

Out of the total of 13 cases that were not associated with travel, it was determined that 3 cases were linked through both epidemiological and microbiological evidence, indicating a cluster. The individuals in question were determined to be associated with a cluster of 5 single nucleotide polymorphisms (SNPs). Among these cases, 2 individuals had contact with a chronic carrier, which refers to an individual who consistently sheds S. Typhi or S. Paratyphi bacteria for a duration of 12 months or longer. In the case of the third individual, no identifiable source of transmission was found. Out of the remaining 10 cases, for which there are no established epidemiological or microbiological connections to other cases, it was found that 3 cases had been in contact with a family member or friend who had recently travelled to a country with a high prevalence of the disease. The individuals in question exhibited symptoms prior to the onset of illness, suggesting a possible origin of transmission. A potential source for the remaining 7 cases was not identified, (*Typhoid and paratyphoid: Public health operational guidelines,* 2017).

The primary focus in both Europe and the UK, for the prevention of Typhoid Fever is centred on vaccination, with particular emphasis on individuals who are travelling to regions where the disease is endemic or those who are immigrants from such areas. The implementation of vaccination campaigns that specifically focus on populations at high risk, coupled with efforts to raise awareness regarding safe practises related to food and water, can effectively mitigate the transmission of the disease. Furthermore, the maintenance and enhancement of water and sanitation infrastructure play a crucial role in the long-term prevention efforts.

In conclusion, it can be observed that Typhoid Fever exerts a comparatively limited influence on the public health landscape in Europe. However, it is important to note that isolated instances

and instances of outbreaks can still manifest, primarily within the demographic of travellers or immigrants. The provision of clean water sources, effective sewage treatment, and vaccination programmes are crucial factors in mitigating the potential for disease transmission. In order to effectively mitigate the transmission of Salmonella Typhi and safeguard public health in Europe, it is imperative to maintain ongoing surveillance efforts, promptly respond to outbreaks, and prioritise public education.

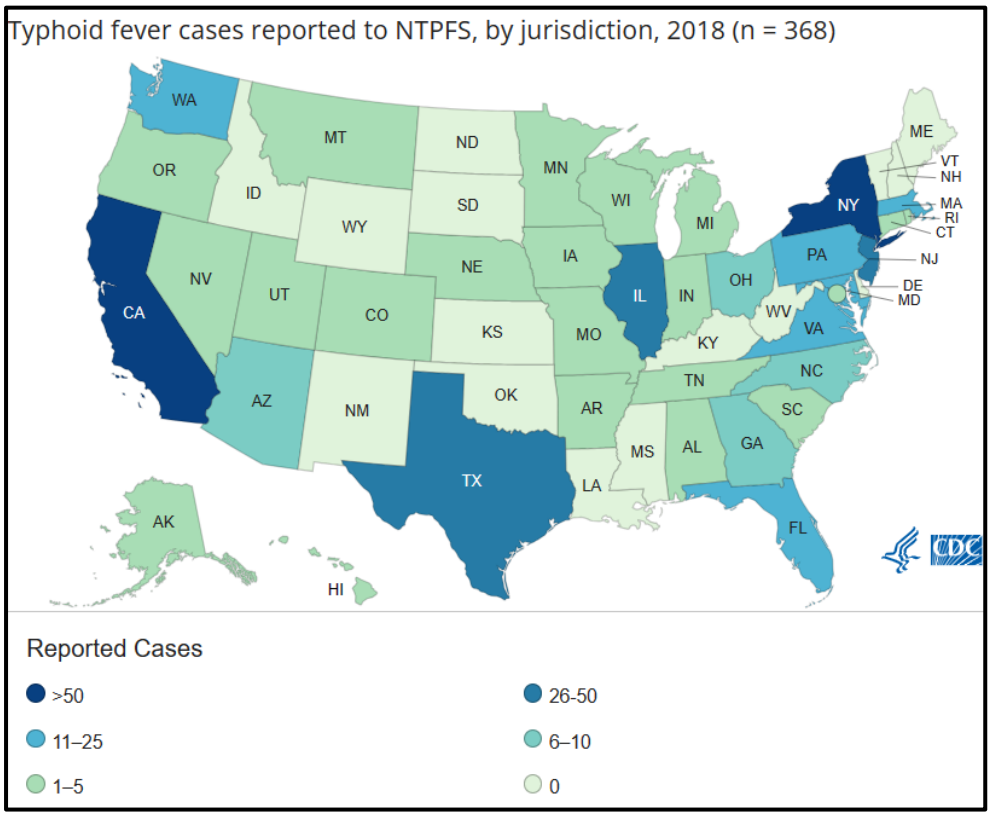
USA

In the United States, an annual incidence of approximately 350 cases of typhoid fever and 90 cases of paratyphoid fever has been reported. The cases do not encompass individuals who refrain from seeking medical attention, those who are not subjected to testing for either ailment, or those whose affliction is not officially documented and reported to the Centres for Disease Control and Prevention (CDC). According to the Centres for Disease Control and Prevention (CDC), the annual incidence of typhoid fever in the United States is estimated to be 5,700 cases, (*Information for healthcare professionals*, 2023), an increase on previous years. In 2018 for example, only '368 typhoid fever cases were reported by 36 jurisdictions' (*National typhoid and paratyphoid fever surveillance annual summary, 2018,* 2023).

Let us examine research between 2014 and 2018.

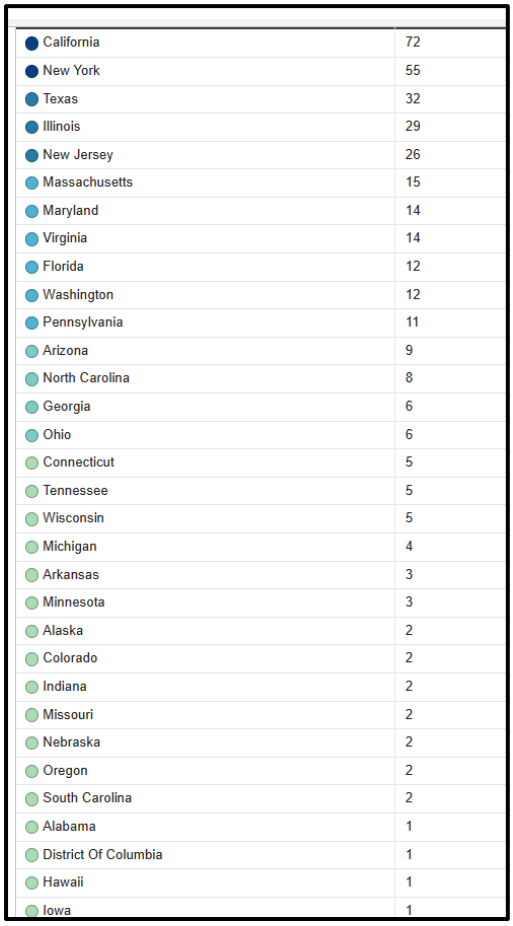
This is expressed in the map, image 2.5 below, with the expressed number of cases in some states, in image 2.6 below.

Image 2.5



Source: (*National typhoid and paratyphoid fever surveillance annual summary, 2018,* 2023).

Image 2.6



California	72
New York	55
Texas	32
Illinois	29
New Jersey	26
Massachusetts	15
Maryland	14
Virginia	14
Florida	12
Washington	12
Pennsylvania	11
Arizona	9
North Carolina	8
Georgia	6
Ohio	6
Connecticut	5
Tennessee	5
Wisconsin	5
Michigan	4
Arkansas	3
Minnesota	3
Alaska	2
Colorado	2
Indiana	2
Missouri	2
Nebraska	2
Oregon	2
South Carolina	2
Alabama	1
District Of Columbia	1
Hawaii	1
Iowa	1

Source: (*National typhoid and paratyphoid fever surveillance annual summary, 2018,* 2023).

The Centres for Disease Control and Prevention (CDC) has been engaged in the surveillance of typhoid fever since 1975. Standardised report forms are utilised by state and local health officials to document comprehensive epidemiological data pertaining to cases that have been confirmed through laboratory testing. This includes information on patient demographics, clinical characteristics, vaccination status for typhoid, and relevant travel history.

Out of the total of 345 individuals diagnosed with typhoid fever, it was reported that 294 individuals, accounting for 85% of the cases, had either travelled to or resided outside the United States within the 30-day period prior to the onset of their illness.

Of the patients who reported international travel, a majority of 92% of those with typhoid fever and 90% of those with paratyphoid fever reported travelling to a singular destination.

The primary motive for international travel among patients diagnosed with typhoid fever was visiting friends or relatives, accounting for 73% of cases. Similarly, for patients with paratyphoid fever, the most prevalent reason for international travel was visiting friends or relatives, constituting 70% of cases.

Similarly, ‘among the 87 paratyphoid fever patients whose travel histories were reported, 78 (90%) reported traveling or living outside the United States in the 30 days before illness’ (*National typhoid and paratyphoid fever surveillance annual summary, 2018,* 2023).

Table 2.7 below, express their number, and percentage of persons who contracted the fever, after visiting a single destination country.

Table 2.7

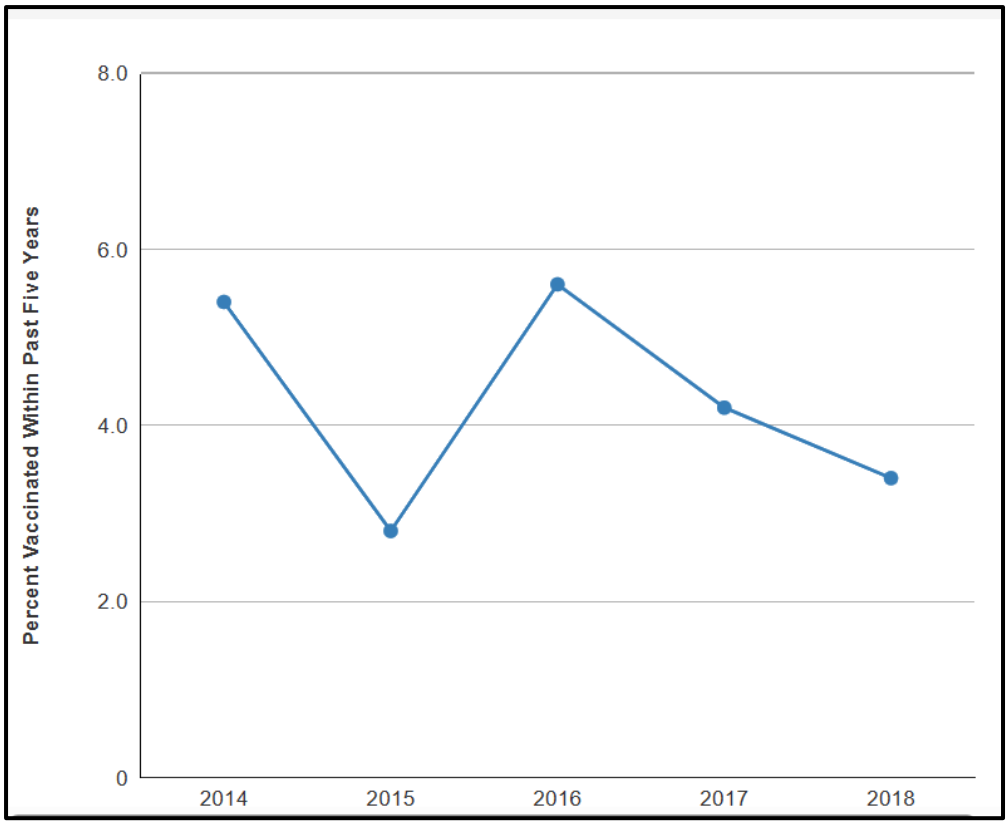
Travel Destination	No. (%)
India	146 (54)
Pakistan	37 (14)
Bangladesh	30 (11)
Mexico	13 (5)
El Salvador	10 (4)
Other[1]	34 (13)

[1]Guatemala (8), Nepal (5), Burundi (3), Iraq (3), Haiti (2), Nigeria (2), Uganda (2), Burma (1), Cambodia (1), Dominican Republic (1), Indonesia (1), Laos (1), Mali (1), Marshall Islands (1), Myanmar (1), Samoa (1)

Source: (*National typhoid and paratyphoid fever surveillance annual summary, 2018,* 2023).

The graph below (image 2.8) shows a graph of those who unfortunately contracted the disease, despite receiving the vaccine within the past five years. The graph does not include patients who's vaccination status was unknown or not reported.

Image 2.8



Source: (*National typhoid and paratyphoid fever surveillance annual summary, 2018,* 2023).

Most individuals who receive a diagnosis in the United States have a history of travel to regions where the prevalence of these diseases is highest.

The National Notifiable Diseases Surveillance System (NNDSS) is responsible for the collection and aggregation of data pertaining to infectious diseases that are considered nationally notifiable, such as typhoid fever. The reports from the National Notifiable Diseases Surveillance System (NNDSS) can be accessed on the official website of the Centres for Disease Control and Prevention (CDC) at www.cdc.gov/nndss/data-statistics.

The following diagram illustrates a comparative analysis of typhoid fever reports that were submitted to the National Typhoid Fever Surveillance System (NTPFS) and the National Notifiable Diseases Surveillance System (NNDSS) over the course of the previous five years.

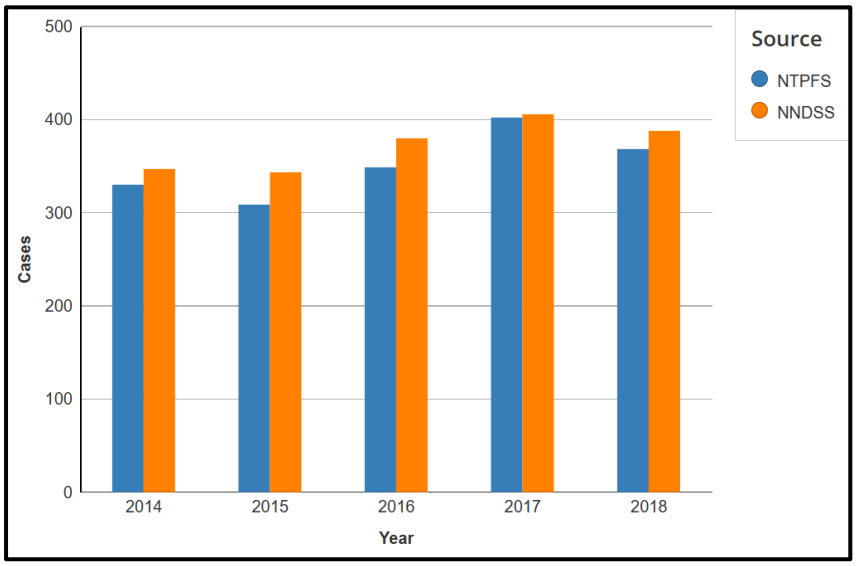
The reports that are submitted to the National Notifiable Diseases Surveillance System (NNDSS) have the potential to include cases that exhibit clinical compatibility and are epidemiologically connected to a confirmed case, even if they have not been confirmed through laboratory testing.

Comparisons for paratyphoid fever are unavailable because, despite being subject to national reporting requirements, it was categorised and reported as salmonellosis according to the established case definition during the specified time period.

Let us observe the number of typhoid fever cases reported to the NNDSS and to the NTPFS.

This is seen in table 2.8 below.

Table 2.8



Source: (*National typhoid and paratyphoid fever surveillance annual summary, 2018,* 2023).

Lastly, it is important to know, with regards to surveillance of the fever, The World Health Organisation (WHO) suggests that countries experiencing endemic typhoid fever should implement health facility-based surveillance, which includes laboratory confirmation, in order to assess the extent of the disease burden (Typhoid, 2018).

The primary objectives of the paper to be mentioned, were to monitor the patterns of antimicrobial resistance, enhance the prompt detection of outbreaks, and evaluate the impact of vaccines (*Typhoid vaccines: Who position paper - march 2018* 2018).

The diagnosis of typhoid fever relies on laboratory confirmation, specifically through blood culture, as the clinical symptoms of this disease often overlap with those of other acute febrile illnesses that are prevalent in regions where typhoid is endemic, such as malaria and dengue (*Typhoid vaccines: Who position paper - march 2018,* 2018). Nevertheless, the sensitivity of blood culture is relatively low, ranging from 40% to 60%. This sensitivity is further diminished by the widespread utilisation of antibiotics prior to diagnosis, the limited accessibility of blood culture at healthcare facilities, and the lack of systematic collection from patients with fever, (*Typhoid vaccines: Who position paper - march 2018* 2018), (*Typhoid,* 2018), (*Immunization vaccines and biologicals,* 2022)).

Hence, the count of laboratory-confirmed cases of S. Typhi merely constitutes a fraction of the true incidence of the disease. Annually, countries submit data on specific vaccine-preventable diseases to the World Health Organisation (WHO) and the United Nations Children's Fund (UNICEF) through the utilisation of the electronic Joint Reporting Form (eJRF). Between the years 2018 and 2021, a range of 59 to 62 countries documented instances of laboratory-confirmed cases of typhoid fever using the electronic Joint Reporting Form (eJRF). The number of reported cases experienced a notable rise over the span of three years, starting from around 8,800 cases in 2018, which marked the initial inclusion of typhoid fever surveillance in the electronic Journal Reporting Form (eJRF), and reaching a staggering 1 million cases in 2021.

The Centres for Disease Control and Prevention (CDC) assumes a pivotal role in the surveillance of diseases, responding to outbreaks, and furnishing resources to bolster public health endeavours.

In conclusion, it can be inferred that the likelihood of Typhoid Fever transmission through waterborne means in the United States is minimal. However, it is important to acknowledge that isolated instances and outbreaks may still arise, particularly in situations involving travel or the consumption of imported food that has been contaminated. The maintenance of access to uncontaminated water, well-developed sanitation infrastructure, and efficient surveillance systems continues to be imperative in the prevention and management of Typhoid Fever. In the United States, the mitigation of Salmonella enterica serotype Typhi's impact on public health necessitates the implementation of public health interventions, prompt diagnosis, and suitable treatment.

5.3.1d Hepatitis A

Europe

The primary mode of transmission for the hepatitis A virus is through the faecal-oral route, whereby an individual who is not infected consumes food or water that has been contaminated with the excrement of an infected individual. Within familial contexts, it is plausible for the transmission of infections to occur through the handling of food by an infected individual with unclean hands, thereby potentially affecting other family members. Waterborne outbreaks, although occurring rarely, are typically linked to water that has been contaminated by sewage or has not been adequately treated.

The transmission of the virus can occur through intimate physical contact, including oral-anal sex, with an individual who is infected. However, casual contact between individuals does not facilitate the spread of the virus.

Hepatitis A is a viral infection that predominantly impacts the hepatic organ. Although Europe has made notable advancements in decreasing the prevalence of Hepatitis A, the transmission of the virus through water continues to be a source of concern in specific areas, presenting significant public health obstacles.

The presence of Hepatitis A virus (HAV) can be observed in water sources that have been contaminated with faecal matter, particularly in regions where there is a lack of proper sanitation infrastructure. Waterborne transmission refers to the process by which individuals ingest water that has not been adequately treated or treated in an improper manner. Shellfish that has been harvested from waters contaminated with pollutants can also act as a potential source of infection.

Hepatitis A has the potential to impact individuals across all age groups, with the intensity of the illness exhibiting a range of manifestations. Although typically a condition that resolves on its own, it has the potential to result in substantial morbidity and mortality, particularly among elderly individuals and those with pre-existing liver conditions. The clinical manifestations of Hepatitis A encompass symptoms such as fatigue, nausea, abdominal pain, jaundice, and dark urine. In instances of significant severity, the manifestation of acute liver failure may arise, thereby requiring admittance to a medical facility and potentially necessitating the undertaking of a liver transplantation procedure.

There have been reports of hepatitis A outbreaks in various European countries that are associated with water contamination. The prompt and timely identification as well as surveillance of cases play a critical role in ensuring an efficient response to outbreaks. National public health agencies, such as the European Centre for Disease Prevention and Control (ECDC), have a crucial role in the surveillance and tracking of Hepatitis A, enabling prompt implementation of preventive measures.

Let us look at a few recent outbreak cases.

Italy is widely recognised as a region characterised by a notably low prevalence of the hepatitis A virus (HAV).

In Italy, the administration of the anti-HAV vaccine is presently limited to specific populations at risk, with the absence of a comprehensive nationwide immunisation initiative.

Research conducted by Zanella et al (2021), found that the enrolled population exhibited a seroprevalence of hepatitis A at a rate of 9.1%. A significant statistical disparity in the occurrence of anti-HAV was observed between individuals of Italian and non-Italian origin.

The study reported that approximately 50% of the population possessed anti-HAV antibodies, indicating prior vaccination, and no instances of hepatitis A infection were detected.

The results obtained from our investigation have substantiated the notion that Tuscany exhibits a low prevalence of hepatitis A virus (HAV) and have demonstrated a statistically significant elevation in the seroprevalence of hepatitis A among children and adolescents of foreign origin.

The higher prevalence of seropositive individuals compared to vaccinated individuals may be attributed to natural immunisation resulting from subclinical infections and/or potential underreporting by surveillance systems.

As of September 29, 2022, a total of 303 cases exhibiting HAV strains that are either identical or closely related have been detected in several European countries, namely Austria (7), Germany (8), Hungary (161), the Netherlands (8), Slovenia (35), Sweden (8), and the United Kingdom (76). Based on the existing epidemiological and microbiological evidence, it is indicated that there has been transmission of the disease from one human to another. Additionally, there is a possibility of transmission through food that has been contaminated.

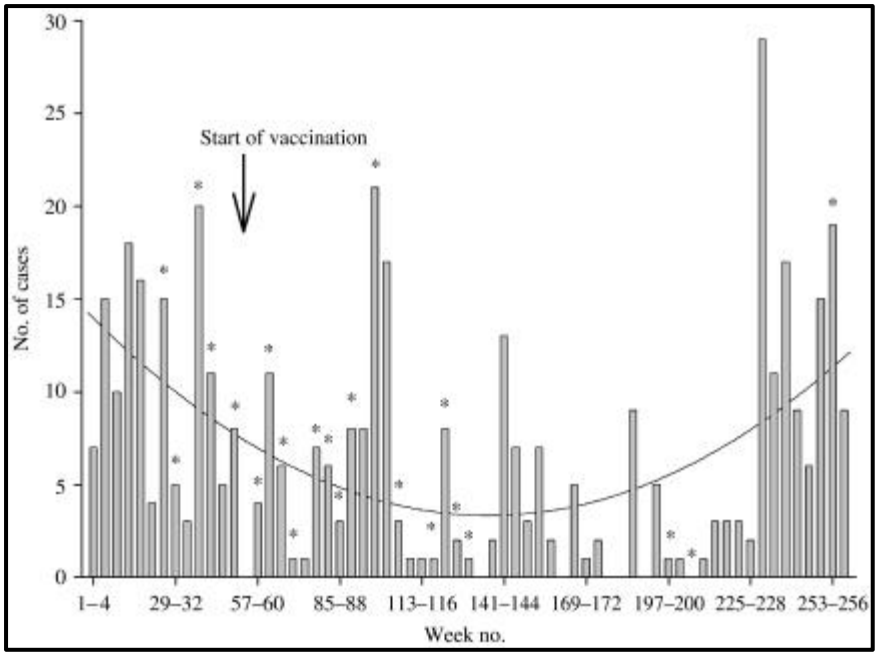
On the 15th of February 2022, Hungary documented an occurrence of HAV genotype IB, with the manifestation of the initial case's symptoms observed in early December 2021. As of the present time, a total of 161 cases (comprising 139 males and 22 females) have been officially confirmed with this strain at the National Hepatitis Reference Laboratory in Hungary. The incidence of reported hepatitis A cases has exhibited a downward trend on a weekly basis since June 2022. Several individuals who have contracted the infection have self-identified as males engaging in sexual activity with other males (MSM), indicating a potential avenue for transmission within sexual networks. Several individuals have been admitted to the hospital, (*Spread of hepatitis a virus strains of genotype IB in several EU countries and the United Kingdom,* 2022).

1. Research conducted by Pinto (2006) observed the presence of the Hepatitis A virus in urban sewage originating from two Mediterranean countries has been observed. Molecular techniques were employed to detect and classify various strains of the hepatitis A virus (HAV) in sewage samples, with the aim of assessing its prevalence in the cities of Cairo and Barcelona. The research findings demonstrated the presence of distinct patterns of hepatitis A endemicity within each urban area.

The study aimed to assess the impact of a child vaccination programme and the rise in the immigrant population on the prevalence of hepatitis A in Barcelona. The decline in clinical cases can be attributed to the impact of vaccination. However, it is likely that the substantial influx of immigrants in recent times has played a role in the resurgence of the disease during the final year of the study. This resurgence has manifested as localised outbreaks primarily affecting individuals who have not received vaccination.

The image below examines the incidence of Hepatitis A cases in Barcelona from 1998 to 2002. Hepatitis A is classified as a notifiable disease. The time period under consideration spans from weeks 1 to 52 in 1998, weeks 53 to 104 in 1999, weeks 105 to 156 in 2000, weeks 157 to 208 in 2001, and weeks 209 to 260 in 2002. The collection of raw sewage samples commenced during the 25th week, with a subsequent interruption observed between weeks 133 and 152. The presence of asterisks is indicative of the positive identification of Hepatitis A Virus (HAV) in untreated wastewater.

Image 2.9



A noticeable decline in the identification of sewage was observed after November 2000, which exhibited a parallel decrease in the incidence of hepatitis A cases in Barcelona following the implementation of a vaccination initiative. There has not been a severe outbreak, due to contaminated water since.

2. Research conducted by Giuseppina La Rosa et al (2014) observed the surveillance of the hepatitis A virus in urban sewage systems and its comparison with the reported cases during an outbreak in Italy in 2013.

The incidence of Hepatitis A cases in Italy has exhibited a downward trend over the course of the last two decades. Since the commencement of 2013, Italy has been confronted with a foodborne outbreak of hepatitis A, specifically genotype IA, which has resulted in the occurrence of numerous cases. The potential source of infection was identified as the consumption of frozen mixed berries. The objective of the study was to examine the transmission of hepatitis A virus (HAV) in Italy by analysing urban sewage samples collected from Wastewater Treatment Plants (WTPs). Subsequently, the environmental surveillance data was compared with the clinical surveillance data obtained during the epidemic.

The study encompassed a duration of 15 months, spanning from July 2012 to September 2013, which included both the outbreak period and the six months leading up to it. The environmental surveillance protocol involved the examination of urban sewage samples obtained from 19 water treatment plants (WTPs) located in seven regions of Italy that were significantly impacted by the epidemic. The detection and typing of HAV isolates were conducted through the utilisation of a nested reverse transcription polymerase chain reaction (RT-PCR) technique, which specifically targeted the VP1/2A junction. The sentinel surveillance system for acute viral hepatitis (SEIEVA) and the ministerial Central Task Force on Hepatitis A conducted parallel clinical surveillance. This was done in order to identify the origin of the outbreak and implement effective outbreak control measures.

The findings indicate that out of the 157 wastewater samples analysed, 38 samples (24.2%) tested positive for Hepatitis A virus (HAV). Specifically, 16 samples were collected in 2012

and 22 samples were collected in 2013. Multiple strains of Hepatitis A virus (HAV) were identified, including the IA variant which has been linked to the outbreak and was isolated from clinical cases during the same timeframe. The overwhelming majority of sequences were classified as genotype IB. It is noteworthy that despite the presence of these variants associated with strains previously implicated in Italian epidemics, recent clinical samples did not yield any positive detections, likely attributable to underreporting or asymptomatic transmission. In contrast, several sequences were detected in clinical samples that were absent in wastewaters.

The results of this study indicate that the proportion of sewage samples testing positive for Hepatitis A Virus (HAV) aligns with the categorization of Italy as a nation characterised by low to intermediate levels of endemicity. The integration of environmental and clinical surveillance enables a comprehensive assessment of the transmission patterns and genotypic diversity of the hepatitis A virus (HAV) within the population, facilitating a more nuanced comprehension of shifts in disease dynamics.

3. In July 2022, an alleged foodborne outbreak was identified, potentially originating from a restaurant located in Hungary. This incident resulted in the illness of 16 individuals who were diagnosed with HAV IB infection. Several patients reported ingesting chilled soup prepared using frozen berries. In the United Kingdom, the identification of a definitive source of infection remains elusive. However, preliminary epidemiological investigations suggest the potential involvement of foodborne infections alongside transmission occurring through interpersonal contact. Germany, the Netherlands, and Sweden have collectively documented a cumulative count of nine instances of individuals infected with strains that exhibit genetic sequences closely resembling those of the United Kingdom variant. The investigations conducted on these cases did not identify any discernible risk factors for infection, such as a history of travel or consumption of berries. Ongoing investigations are currently being conducted.

Hepatitis A virus (HAV) exhibits a high level of transmissibility through various means, including the consumption of contaminated water and food, as well as through the faecal-oral route among individuals in proximity, such as household members, sexual partners, and individuals in day-care centres or schools. The average incubation period for HAV is approximately four weeks, with a range of two to six weeks. The virus exhibits a notable degree of resilience towards various environmental conditions, as well as resistance to preservation techniques such as acidification or freezing. Hence, it is imperative to investigate potential instances of food-borne transmission when multiple cases are reported within a condensed timeframe.

The implementation of proper hand hygiene practises, such as the thorough washing of hands with soap following bathroom use, nappy changing and prior to food preparation or consumption, is a crucial factor in mitigating the transmission of hepatitis A. It is imperative to expand surveillance efforts in order to identify and examine isolated cases as well as clusters of instances that may potentially be linked to the transmission of foodborne illnesses. This should be done in close cooperation with food safety authorities.

The establishment of reliable access to uncontaminated water and sufficient sanitation infrastructure plays a crucial role in mitigating the risk of waterborne transmission of Hepatitis

A. The implementation of appropriate water treatment procedures, such as filtration, disinfection, and routine testing, is imperative for the elimination or inactivation of Hepatitis A Virus (HAV). Enhanced sanitation facilities and adherence to hygiene practises, such as the regular use of soap for handwashing, have the potential to further mitigate the likelihood of transmission.

Vaccination plays a crucial role in the prevention of Hepatitis A, particularly in areas where there is an elevated risk of transmission through contaminated water sources. Vaccination initiatives that specifically focus on populations at high risk, such as individuals travelling to regions with high prevalence of Hepatitis A, those with chronic liver disease, and certain occupational cohorts, have the potential to alleviate the impact of Hepatitis A. The implementation of routine childhood immunisation programmes has additionally played a role in the overall reduction of the disease in Europe.

The importance of effective risk communication cannot be overstated when it comes to increasing public awareness regarding the potential risks associated with the transmission of Hepatitis A through water. It is imperative for health authorities to disseminate unambiguous and precise information pertaining to preventive measures, encompassing the consumption of uncontaminated water, adherence to appropriate hygiene practises, and the significance of vaccination. Public education campaigns have the potential to empower individuals by encouraging them to adopt proactive measures in safeguarding their health.

The imperative for addressing waterborne transmission of Hepatitis A necessitates international collaboration due to its global prevalence. The exchange of surveillance data, implementation of best practises, and dissemination of scientific knowledge have the potential to bolster preparedness and response endeavours. Collaborative endeavours, exemplified by the Global Hepatitis Programme established by the World Health Organisation (WHO), serve to facilitate the dissemination of knowledge, and foster the development of capabilities in regions impacted by hepatitis.

USA

1. In 2022 a CDC research article identifies the infection caused by frozen organic strawberries in multiple states. There was a total of 19 reported cases, in 4 states, with 13 hospitalisations, and no deaths.

Four states—Arizona, California, Minnesota, and North Dakota—reported 19 hepatitis A cases linked to an outbreak.

Various illnesses began between March 28, 2022, and May 6, 2022.

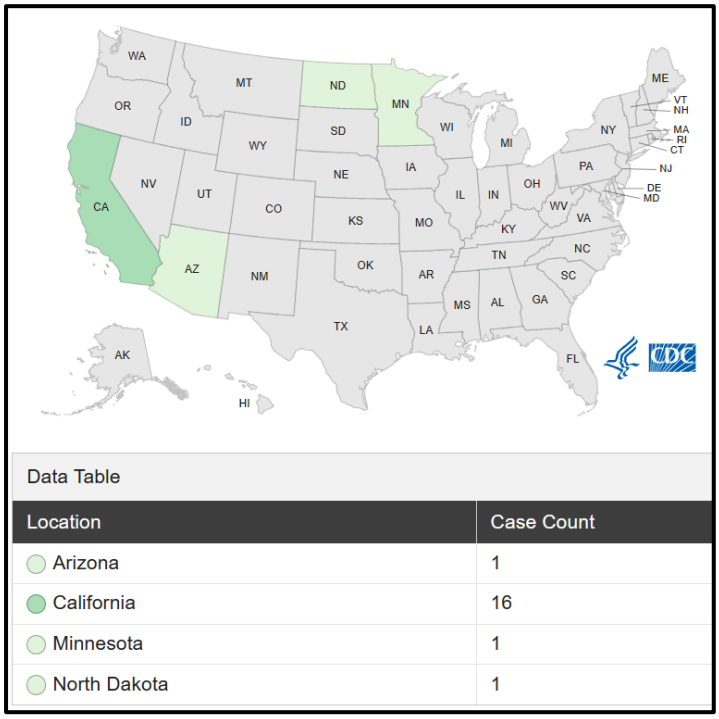
The Centres for Disease Control and Prevention (CDC), along with public health and regulatory officials in multiple states, collaborated with the U.S. Food and Drug Administration (FDA) to investigate a widespread occurrence of hepatitis A. This outbreak was found to be associated with the consumption of fresh organic strawberries that were imported.

The fresh organic strawberries in question were imported from Baja California, a state located in northern Mexico. They were marketed under the brand names FreshKampo and HEB, and were sourced from a shared supplier. These strawberries were acquired within the United States between the dates of March 5, 2022, and April 15, 2022. The traceback investigations revealed that individuals who were affected by the outbreak in California and Minnesota had acquired

FreshKampo brand fresh organic strawberries before experiencing symptoms of illness. The outbreak of hepatitis A was investigated by the Public Health Agency of Canada and the Canadian Food Inspection Agency. It was determined that the likely source of the outbreak was imported FreshKampo brand fresh organic strawberries.

As of August 14, 2022, a cumulative count of 19 instances of hepatitis A linked to outbreaks has been documented across 4 states.

In image 3.0 below,



Data Table

Location	Case Count
Arizona	1
California	16
Minnesota	1
North Dakota	1

Source: (*Organic strawberries hepatitis A outbreak* 2022).

Based on epidemiologic and traceback evidence, it has been determined that the probable origin of this outbreak can be attributed to fresh organic strawberries that were imported from Baja California, Mexico. The FreshKampo and HEB products that may have been impacted are currently beyond their designated shelf life and are no longer accessible for acquisition within the United States. Individuals who have acquired FreshKampo or HEB fresh organic strawberries within the period of March 5, 2022, to April 15, 2022, and subsequently subjected them to freezing for future consumption are advised against consuming said strawberries. It is believed the products may have been distributed through various retailers, such as HEB, Kroger, Safeway, Sprouts Farmers Market, Trader Joe's, Walmart, Weis Markets, and WinCo Foods, among others.

The reclassification of a previously reported downstream recall (Urban Remedy Organic Revitalising Tea Tonic Strawberry Hibiscus Rose) has been observed as a market withdrawal. The investigation concluded that the product was not manufactured using strawberries that were implicated.

During the interview process, individuals who were experiencing illness were queried regarding their dietary intake and other potential exposures within the timeframe of 2 to 7 weeks prior to the onset of their symptoms. Out of the individuals who participated in the

interviews, a majority of 11 out of 16 respondents, accounting for approximately 69% of the sample, indicated that they consume fresh organic strawberries. The observed proportion exhibited a notable increase compared to the findings of a survey conducted among individuals without any health conditions, wherein 50% of respondents indicated consuming fresh strawberries within the week preceding their interview.

The Food and Drug Administration (FDA) has concluded its investigation into the process of traceback.

2. This year in 2023, there had been a multi-state outbreak in the US. The CDC research article identifies the infection caused by frozen organic strawberries in multiple states. There were a total of 9 reported cases, in 3 states, with 3 hospitalisations, and no deaths:

'*As of June 14, 2023, there have been: 9 outbreak-associated cases of hepatitis A reported from 3 states (California, Oregon, and Washington). Illnesses started on dates ranging from November 24, 2022, to April 12, 2023*.' (*Organic strawberries hepatitis A outbreak* 2023).

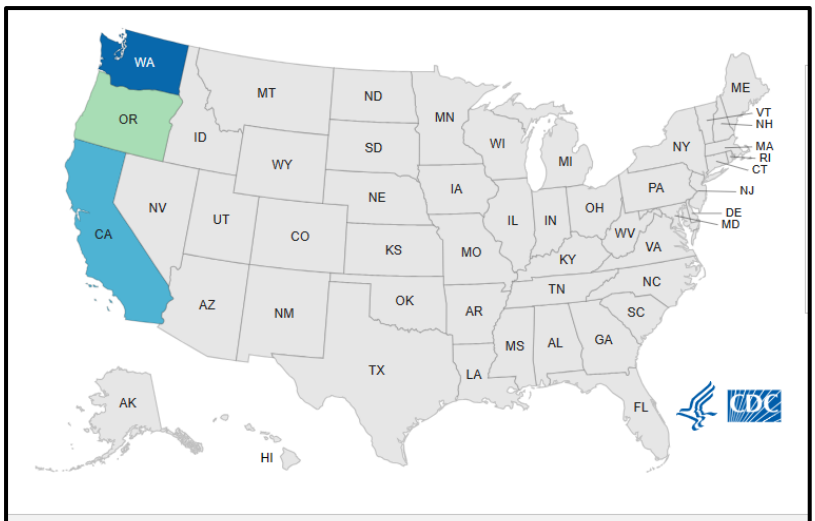
The outbreak of hepatitis A, which was associated with frozen organic strawberries imported from specific farms in Baja California, Mexico, and distributed by a shared supplier, was subject to investigation by the CDC, state public health and regulatory officials, and the U.S. Food and Drug Administration.

Frozen organic strawberries had the potential to be distributed to various retailers, being marketed under numerous brand labels. The traceback and epidemiological investigations indicate that individuals who were affected by the outbreak had acquired the identical retail brand of frozen organic strawberries before the onset of their illness.

The onset of illnesses occurred between the dates of November 24, 2022, and April 12, 2023. The age range of the individuals who are unwell spans from 38 to 64 years, with a median age of 56 years. According to the data, a significant proportion of individuals who are unwell, specifically 33%, are identified as female. Out of the total sample size of 9 individuals for whom data is accessible, it has been observed that 3 individuals, constituting approximately 33% of the sample, have been admitted to a hospital. There have been no reported fatalities.

He location of those infected can be seen in the map (image 3.1) below.

Image 3.1



Data Table

Location	Case Count
Washington	6
California	2
Oregon	1

Source: (States with hepatitis A outbreak in strawberries 2023 2023)

The outbreak can be attributed to frozen organic strawberries that were imported from specific farms in Baja California, Mexico in 2022, as indicated by epidemiological and traceback evidence. The strain of the hepatitis A virus responsible for the current outbreak exhibits genetic similarity to the strain that was associated with a foodborne hepatitis A outbreak in 2022. This previous outbreak was traced back to the consumption of fresh organic strawberries that were imported from Baja California, Mexico, and subsequently sold by multiple retailers.

During the interviews, individuals who were afflicted with illnesses provided responses pertaining to their dietary intake and other potential sources of exposure within the timeframe of 2 to 7 weeks prior to the onset of their symptoms. All individuals who were surveyed, a total of 9 out of 9 respondents, reported consuming frozen organic strawberries. The consumption rate of frozen organic strawberries among the surveyed population was found to be 100%. The observed proportion was found to be significantly greater than the results obtained from a survey conducted among individuals without any known health conditions, wherein 24% of respondents reported consuming frozen berries within the week preceding their interview.

Considering the inquiry, California Splendour, Inc., a company based in San Diego, California, has undertaken a voluntary recall of specific batches of 4-lb. bags of Kirkland Signature Frozen Organic Whole Strawberries. These products were retailed exclusively at Costco stores located in Los Angeles, California, Hawaii, and two business centres in San Diego, California. The subject of this recall encompasses the following lots: '140962-08, 142222-23, 142792-54, 142862-57, 142912-59, 142162-20, 142202-21, 142782-53, 142852-56, 142902-58, 142212-22, 142232-24, 142842-55'' (*Organic strawberries hepatitis A outbreak* 2023).

As a result of the investigation, the Scenic Fruit Company, located in Gresham, Oregon, has taken the voluntary initiative to recall its frozen organic strawberries. These strawberries were

distributed to various retailers, including Costco, Trader Joe's, Aldi, KeHE, Vital Choice Seafood, and PCC Community Markets, within specific states.

Importunely, it is important to also notice, that there is however, an ongoing outbreak.

This can be seen from data by the CDC in image 3.2 below.

Image 3.2

State-Reported Hepatitis A Outbreak Cases and Clinical Outcomes

State	Case Total	Hospitalizations n (%)	Deaths	Outbreak Start Date	Data Current Through
Total (37 states)	**44896**	**27428 (61%)**	**423**		
States with an ongoing outbreak (n=4)					
Indiana	2664	1506 (57%)	14	11/1/2017	4/4/2023
Maryland	444	314 (71%)	11	12/1/2019	7/1/2023
Missouri	1129	660 (58%)	5	9/1/2017	4/3/2023
Pennsylvania	1271	969 (76%)	19	1/1/2018	7/1/2023

Source: (*Outbreaks of hepatitis A across the U.S.* 2022)

3. Research conducted by Lo Castro et al (2014) monitored the virility of hepatitis A transmissions through environmental surveillance of water sources. The study aimed to examine the prevalence and distribution of hepatitis A (HAV) and E (HEV) viruses in both sewage and clinical samples collected from various regions of Argentina.

During the period spanning from 2016 to 2017, a total of 80 samples of raw sewage and 86 clinical samples, including stool and serum, were collected from individuals suspected to be infected with hepatitis A and hepatitis E. Both hepatitis A virus (HAV) and hepatitis E virus (HEV) were subjected to testing using both real-time polymerase chain reaction (PCR) and nested PCR methods. The positive samples underwent sequencing in order to determine their genotype and conduct phylogenetic analysis. In aggregate, hepatitis A virus (HAV) was detected in '39% of sewage samples and 61.1% of clinical samples' (ibid.). The presence of HEV was observed in '22.5% of sewage samples and 15.9% of clinical samples' (ibid.).

The presence of HAV was observed with greater frequency in sewage samples during the winter season, while clinical samples showed a higher incidence of HAV during the spring season. Conversely, HEV was found to be more prevalent in sewage samples during the summer season, while clinical samples exhibited a higher occurrence of HEV during the autumn season. All HAV isolates were classified as genotype IA, while the HEV isolates were classified as genotype 3, which are the most found genotypes in South America.

A notable occurrence of Hepatitis A virus (HAV) and Hepatitis E virus (HEV) was observed in both environmental and clinical samples collected in the region of Mendoza, Argentina.

In summary, a significant occurrence of Hepatitis A virus (HAV) and Hepatitis E virus (HEV) was detected in both untreated sewage and clinical specimens obtained from the period

spanning 2016 to 2017. Both the hepatitis A virus (HAV) and hepatitis E virus (HEV) were found to be present in all samples.

The changing of seasons is observed in both natural environments and clinical cases. These findings serve to underscore the significance of ongoing environmental surveillance to mitigate the transmission burden.

The results of this study provide further support for the significance of environmental monitoring and the adoption of health interventions in order to effectively manage the transmission of Hepatitis A Virus (HAV) and Hepatitis E Virus (HEV) within developing nations.

Although there has been a decline in the prevalence of Hepatitis A in water sources within the United States, it is important to note that outbreaks can still transpire, thereby posing a significant threat to public health. The timely identification of prompts, efficient monitoring, and swift execution of control strategies are imperative in mitigating the transmission of the virus. Water treatment, sanitation practises, vaccination strategies, and public education are crucial components in the prevention of waterborne transmission of Hepatitis A and the subsequent reduction of the disease's overall impact.

The World

Research conducted by Ahmad et al (2015) focused on investigating the molecular confirmation of enterovirus in sewage and drinking water samples collected from three cities in Pakistan.

A total of forty-two samples of sewage and drinking water were collected from three major cities in Pakistan. The samples were subjected to analysis in order to determine the presence of Enterovirus using a nested RT-PCR amplification method.

The findings of the study have unveiled a concerning situation in the densely populated regions of the three primary urban centres of Pakistan. Specifically, the analysis indicates that in Islamabad, Rawalpindi, and Lahore, the prevalence rates of enteroviruses in drinking water samples were recorded at 28%, 19%, and 21% respectively.

Further research conducted by Ahmad et al (2018) studied a total of 97 samples of drinking water, as well as river water contaminated with sewage and blood, were collected from high-risk communities in Pakistan during the period from June 2016 to June 2017. The concentration of the virus was achieved through the utilisation of membrane filters with a negative charge, while the identification of waterborne viruses was expedited by employing specific PCR primers.

Enteroviruses were detected in 40% of river water contaminated with sewage in Lahore, 28.57% in Islamabad, and 33.33% in Rawalpindi. Additionally, the presence of viral load was confirmed in 13.13% of drinking water in Lahore and 11.76% in Rawalpindi. The clinical samples also exhibited a significant prevalence of HAV, with rates of 12.5% and 21.05% observed.

In conclusion, the issue of waterborne transmission of Hepatitis A continues to be a matter of public health concern in Europe, the USA and the world at large, despite notable advancements in mitigating the occurrence of this disease. Ongoing investments in the development of

reliable water and sanitation infrastructure, coupled with focused vaccination strategies and efficient risk communication, are imperative in order to further mitigate the consequences of Hepatitis A on the well-being of the general population. By means of international collaboration and adopting a comprehensive approach, all countries globally can strive towards the objective of eradicating Hepatitis A as a public health menace.

5.3.1e Legionnaires' Disease

Europe

Legionnaires' disease is a highly consequential display of pneumonia, which arises due to the presence of the bacterium Legionella pneumophila. Infection from the bacteria can occur through the inhalation of aerosolized droplets. Legionella is frequently encountered in both natural and artificial water systems, including but not limited to hot water tanks, cooling towers, and plumbing systems. Legionnaires' disease presents a considerable public health issue in Europe, given its capacity to induce outbreaks and impact many susceptible demographics.

Legionella has the capacity to undergo multiplication and flourish in environments characterised by elevated water temperatures. Legionnaires' disease outbreaks frequently exhibit a correlation with water systems that have been compromised, notably within establishments such as hotels, hospitals, and residential structures. We will examine some cases with such causes later. Various sources contribute to the contamination of water, encompassing cooling towers, hot tubs, decorative fountains, and plumbing systems. The act of inhaling aerosolized droplets originating from these sources has the potential to result in infection.

Legionnaires' disease possesses the potential to exert a significant influence on the public health landscape in Europe. The illness commonly manifests as a severe form of pneumonia, characterised by symptoms such as elevated body temperature, persistent cough, difficulty breathing, and muscular discomfort.

accompanied by systemic symptoms such as fever, diarrhoea, myalgia, impaired renal and liver functions, and delirium, (Viasus et al., 2022). In instances of heightened severity, it has the potential to result in respiratory failure and, in extreme cases, fatality. Outbreaks have the potential to impose a substantial strain on healthcare systems and instigate feelings of panic and fear among communities.

Several demographic groups have an increased susceptibility to experiencing severe cases of Legionnaires' disease. These groups include older adults, individuals who smoke, individuals with compromised immune systems, and those with pre-existing health conditions. The European continent is currently experiencing a demographic shift characterised by an increasing proportion of elderly individuals, which consequently renders a significant portion of the population more vulnerable to the onset of severe illnesses. The allocation of additional resources and the implementation of specific preventive measures are necessary to address the needs of vulnerable populations.

Let us examine a few research cases.

Legionnaires' disease continues to be a relatively rare and primarily sporadic respiratory infection, with an overall notification rate of 2.2 cases per 100,000 population in the European Union/European Economic Area (EU/EEA) in 2019.

There exists variation in notification rates among EU/EEA countries, with Slovenia reporting the highest rate of 9.4 cases per 100,000 population.

The annual notification rate has witnessed an upward trend in recent years, with an increase from 1.4 cases per 100,000 population in 2015 to 2.2 cases per 100,000 population in 2019.

In 2019, there was a slight decline of less than 1% in the number of reported cases when compared to the figures from 2018.

In the year 2019, it was observed that a significant proportion of all notified cases, amounting to 71%, were attributed to four specific countries, namely France, Germany, Italy, and Spain.

The demographic group most impacted by the condition had a higher prevalence rate of 8.4 cases per 100,000 individuals, specifically among males aged 65 years and older., (*Legionnaires' disease - annual epidemiological report for 2020* 2022).

Based on information obtained from The European Surveillance System (TESSy) on January 12, 2021, this report, (*Legionnaires' disease - annual epidemiological report for 2020* 2022) uses data for the year 2019. TESSy is a system for gathering, analysing, and sharing information about communicable diseases.

ECDC posts a summary of the national surveillance systems and the methodologies used to create this report online. ECDC's online Surveillance Atlas of Infectious Diseases provides a portion of the data used in this research.

Over the past five years, there has been a significant increase in the notification rates confirming infection within the European Union/European Economic Area (EU/EEA), with figures nearly doubling from 1.4 in 2015 to 2.2 per 100,000 population. Four European countries, namely France, Germany, Italy, and Spain, were responsible for 71% of all reported cases, despite their collective population representing only around 50% of the total population of the European Union/European Economic Area (EU/EEA).

In 2019, '*28 countries reported 11 298 cases (Table 1), of which 10 636 (94%) were classified as confirmed. The number of notifications per 100 000 population remained stable at 2.2, being the highest notification rate ever observed for the EU/EEA'* (Legionnaires' disease - annual epidemiological report for 2020, 2022).

Table (image) 3.2 below expresses this data.

Table 3.2

Country	2015		2016		2017		2018		2019		
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	ASR
Austria	160	1.9	161	1.9	219	2.5	237	2.7	255	2.9	2.6
Belgium	118	1.1	157	1.4	235	2.1	270	2.4	224	2.0	1.8
Bulgaria	1	0.0	0	0.0	2	0.0	11	0.2	5	0.1	0.1
Croatia	48	1.1	31	0.7	33	0.8	43	1.0	-	-	-
Cyprus	2	0.2	3	0.4	1	0.1	5	0.6	4	0.5	0.5
Czechia	120	1.1	147	1.4	217	2.1	231	2.2	277	2.6	2.3
Denmark	185	3.3	170	3.0	278	4.8	264	4.6	270	4.7	4.2
Estonia	6	0.5	14	1.1	16	1.2	18	1.4	12	0.9	0.8
Finland	17	0.3	15	0.3	27	0.5	24	0.4	44	0.8	0.7
France	1389	2.1	1218	1.8	1630	2.4	2133	3.2	1816	2.7	2.5
Germany	842	1.0	974	1.2	1278	1.5	1446	1.7	1545	1.9	1.6
Greece	29	0.3	31	0.3	43	0.4	65	0.6	45	0.4	0.4
Hungary	58	0.6	66	0.7	62	0.6	74	0.8	113	1.2	1.1
Iceland	1	0.3	3	0.9	3	0.9	5	1.4	-	-	-
Ireland	11	0.2	10	0.2	25	0.5	25	0.5	21	0.4	0.5
Italy	1572	2.6	1733	2.9	2037	3.4	3018	5.0	3143	5.2	4.2
Latvia	22	1.1	24	1.2	31	1.6	37	1.9	42	2.2	2.1
Liechtenstein	.	.	.	.	.	.	.	.	.	.	.
Lithuania	7	0.2	11	0.4	14	0.5	21	0.7	17	0.6	0.6
Luxembourg	5	0.9	3	0.5	9	1.5	10	1.7	14	2.3	2.3
Malta	6	1.4	8	1.8	11	2.4	13	2.7	5	1.0	0.8
Netherlands	419	2.5	454	2.7	561	3.3	584	3.4	566	3.3	3.0
Norway	60	1.2	43	0.8	52	1.0	69	1.3	65	1.2	1.2
Poland	23	0.1	24	0.1	38	0.1	70	0.2	74	0.2	0.2
Portugal	145	1.4	197	1.9	232	2.3	211	2.1	201	2.0	1.7
Romania	3	0.0	2	0.0	19	0.1	62	0.3	19	0.1	0.1
Slovakia	14	0.3	14	0.3	14	0.3	54	1.0	85	1.6	1.6
Slovenia	106	5.1	93	4.5	117	5.7	160	7.7	195	9.4	8.3
Spain	1024	2.2	951	2.0	1363	2.9	1513	3.2	1542	3.3	2.9
Sweden	142	1.5	145	1.5	189	1.9	198	2.0	182	1.8	1.6
United Kingdom	412	0.6	383	0.6	504	0.8	532	0.8	517	0.8	0.7
EU-EEA	**6947**	**1.4**	**7085**	**1.4**	**9260**	**1.8**	**11403**	**2.2**	**11298**	**2.2**	**1.9**

Source: Country reports.
ASR: age-standardised rate.
.: no data reported.
-: no rate calculated.

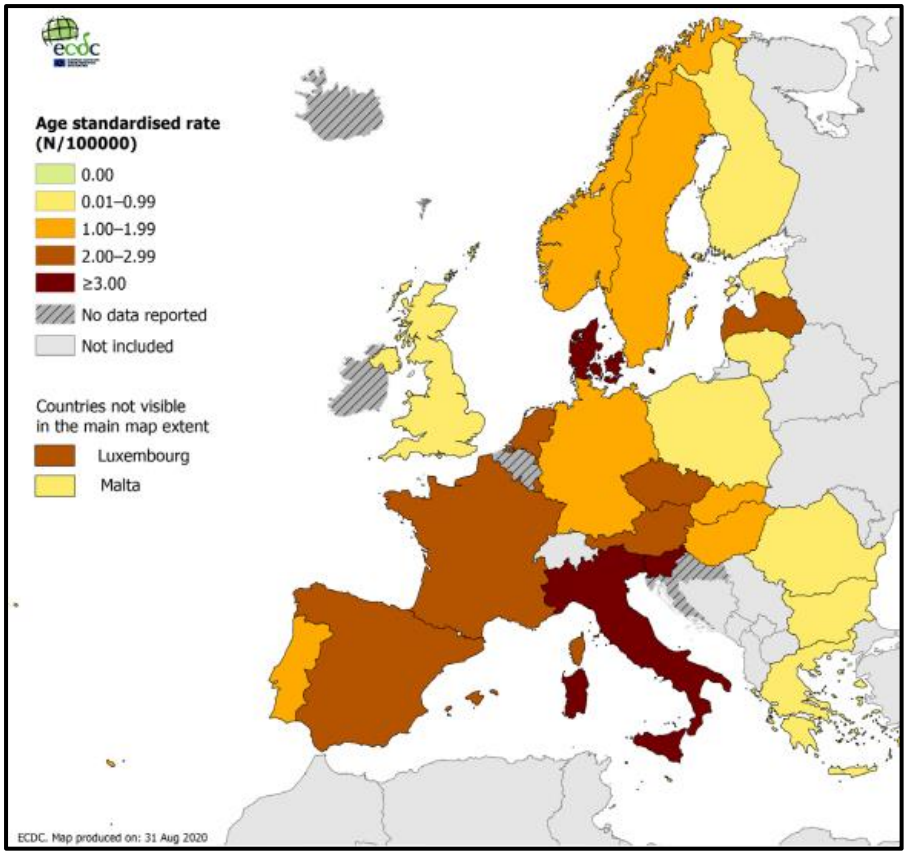
Source: Legionnaires' disease - annual epidemiological report for 2020, 2022).

Unfortunately, 'Of 8 458 cases with known outcome, 630 (7%) were reported to have been fatal' (ibid.).

Observing the data below however, the notification rates exhibited a wide range, varying from less than 1.0 cases per 100,000 population in ten countries (Bulgaria, Cyprus, the Baltic nation of Estonia Finland, Greece, Ireland, Lithuania, Poland, Romania, and the United Kingdom) to 3.0 cases per 100,000 population or higher in six countries (Denmark, France, Italy, the United Kingdom, the Netherlands, Slovenia, and Spain).

Image 3.3 below shows mapped data for 2019.

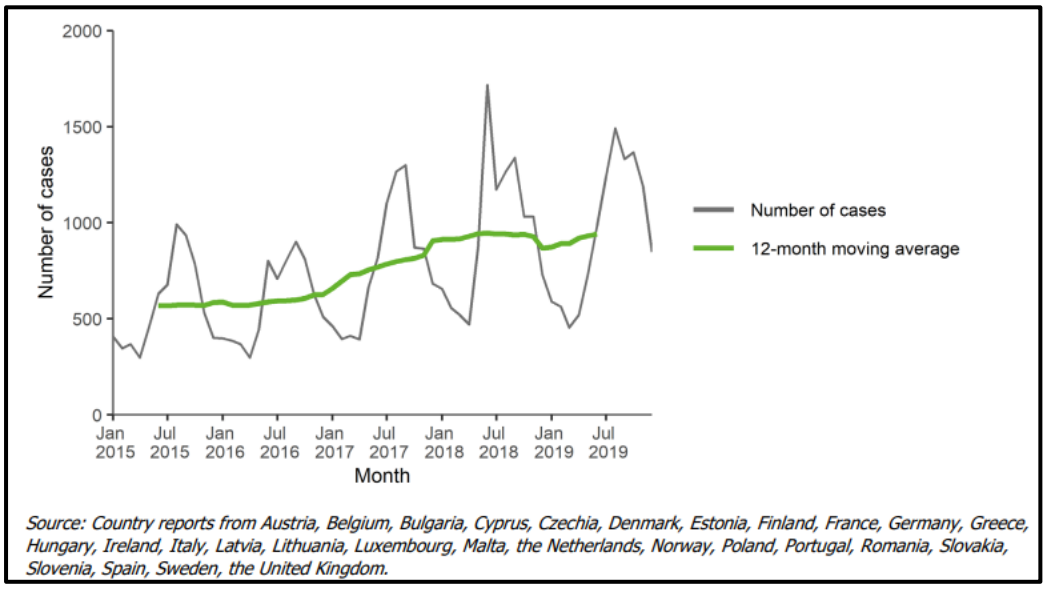
Image 3.3



Source: Legionnaires' disease - annual epidemiological report for 2020, 2022).

Between the years 2015 and 2019, there was a notable rise in reported cases, with an increase of 65% from 6,947 to 11,298. This data indicates a discernible upward trajectory in recent years. This is evident, and can be seen in image 3.4 below.

Image 3.4



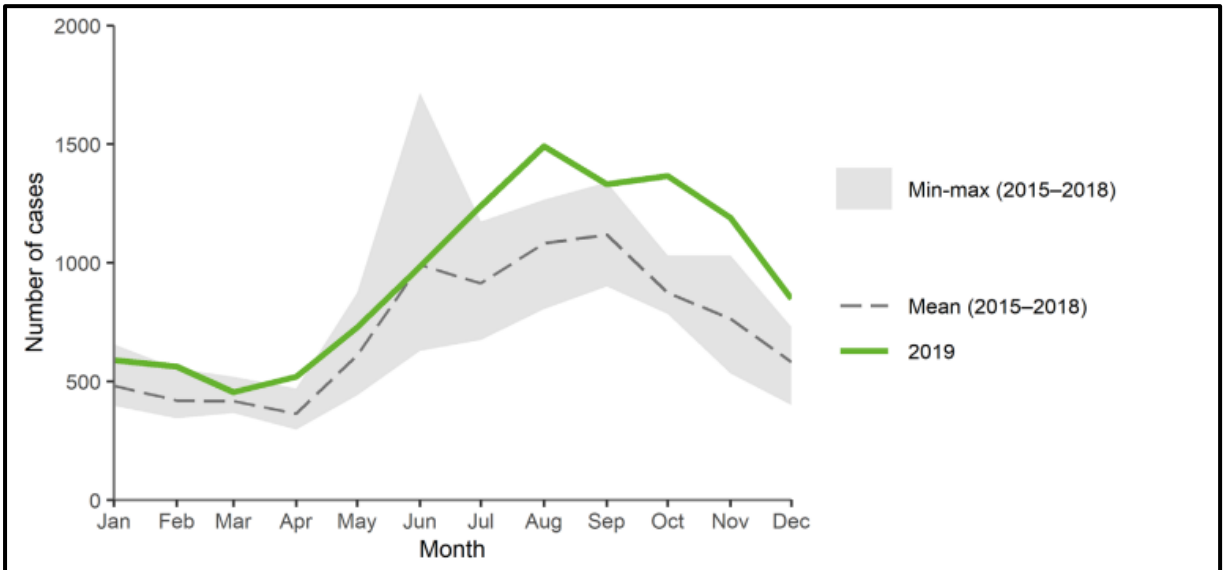
Source: Legionnaires' disease - annual epidemiological report for 2020, 2022).

The data regarding the distribution of reported cases by month indicates that a significant majority (57%) of cases were recorded between the months of June and October, which aligns with patterns observed in previous years. There was a noticeable rise in the number of cases in each month from July to December, when compared to the highest recorded figures in the preceding years (2015-2018).

The highest monthly number of recorded cases to date under EU/EEA surveillance occurred in June 2018, with a peak of 1,743 cases. This number was not surpassed in 2019. There were no reported instances of community outbreaks within any European Union/European Economic Area (EU/EEA) country that could account for the observed shift in the seasonal curve towards the later summer and autumn period.

This can be seen in the graph (image 3.5) below.

Image 3.5



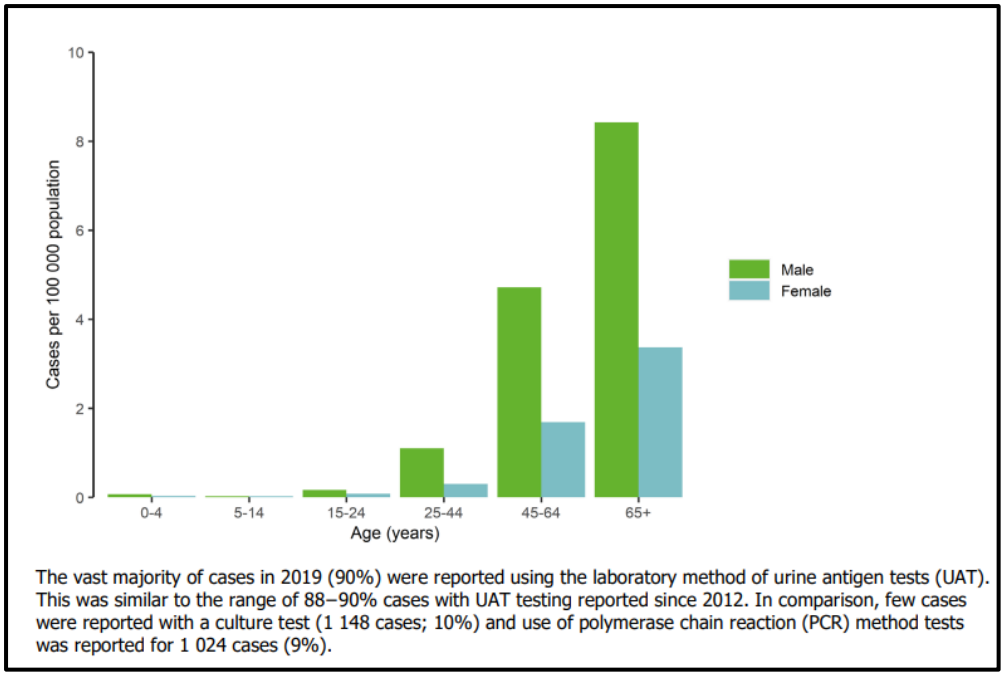
Source: Country reports from Austria, Belgium, Bulgaria, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, the United Kingdom

Source: (ibid.).

In the year 2019, individuals who were 45 years of age and above constituted a total of 10,236 out of 11,279 cases where the age was known, representing a proportion of 91%. The rate of notification demonstrated an upward trend in relation to age, starting from less than 0.1 cases per 100,000 individuals in those under 25 years old and reaching 5.6 cases per 100,000 individuals in individuals aged 65 years and older. This trend was more pronounced in males, with a rate of 8.4 cases per 100,000 individuals, compared to females who had a rate of 3.4 cases per 100,000 individuals. The male-to-female ratio remained consistent with the previous year, maintaining a ratio of 2.3 males for every female.

This can be observed in image 3.6 below.

Image 3.6



The vast majority of cases in 2019 (90%) were reported using the laboratory method of urine antigen tests (UAT). This was similar to the range of 88–90% cases with UAT testing reported since 2012. In comparison, few cases were reported with a culture test (1 148 cases; 10%) and use of polymerase chain reaction (PCR) method tests was reported for 1 024 cases (9%).

Source: (ibid.).

Legionnaires' disease continues to be a significant contributor to avoidable illness and death in Europe, with indications of a growing burden.

There has been a significant increase in the notification rates within the European Union/European Economic Area (EU/EEA) in recent years. Nevertheless, there is variation in rates across

1. In 2014 the ECDC conducted a rapid risk assessment, due to an outbreak in the Lisbon area, of Portugal.

On November 7, 2014, an outbreak of Legionnaires' disease was detected in three parishes of Vila Franca de Xira, located approximately 30km north of Lisbon, Portugal. The affected parishes were Póvoa de Santa Iria, Forte da Casa, and Vialonga. Vila Franca de Xira is not widely regarded as a popular tourist destination. On November 7th, the commencement of epidemiological and environmental investigations led to the initial identification of seventeen cases. As of November 13th, a total of 311 cases have been identified, with an additional eight cases reported in other regions, namely Norte, Centro, and Algarve. A total of seven individuals with pre-existing medical conditions have succumbed. All reported instances of infection occurred within the municipality of Vila Franca de Xira.

The commencement of the environmental inquiry on November 7th has yielded findings that indicate a potential origin of this outbreak. These findings are based on several factors, including the spatial distribution of the affected cases, analysis of environmental samples, examination of meteorological conditions such as temperature, humidity, and wind patterns during the relevant period and location, as well as the assessment of emissions from the cooling towers, which may have played a role in modulating the outbreak. On November 9, 2014, cooling towers located in the vicinity of Vila Franca de Xira were shut down as a preventive action.

In conclusion, the occurrence of Legionnaires' disease in Portugal, which has resulted in 311 reported cases as of 13 November 2014, stands as one of the most significant outbreaks within the European Union. Vila Franca de Xira is not widely recognised as a popular tourist destination, and as of now, there have been no confirmed instances of its presence outside the borders of Portugal. Despite the significant scale of the outbreak, this occurrence can be regarded as the subject of discussion is a regional occurrence. All reported cases originated in Vila Franca de Xira, the location of the ongoing outbreak.

The cooling towers of significant industrial installations within the vicinity of Vila Franca de Xira had been shut down, and ongoing investigations were conducted to ascertain the origin of the outbreak.

(*Outbreak of legionnaires' disease in the Lisbon area*, Portugal 2014).

2. Research has previously been conducted by Krojgaard et al (2011), on a cluster of Legionnaires diseases in a block of flats in Denmark. They found, that between December 2008 and January 2009, two individuals were afflicted with Legionnaires' disease within a recently constructed residential complex located in a suburban area of Copenhagen, Denmark. (Cluster of legionnaires disease in a newly built block of flats, Denmark, December 2008 - January 2009 2011).

The diagnostic methods employed in this cluster involved the utilisation of polymerase chain reaction and culture techniques to identify cases of Legionnaires' disease. The isolates obtained from both patients yielded positive results for Legionella pneumophila serogroup 1 subgroup Philadelphia sequence type 1. Furthermore, the identical strain was identified in hot water samples collected from the residential vicinity, suggesting that the hot water supply system was the probable origin of the infection. The presence of Legionella was not identified in the cold-water sample.

Two interventions were implemented in order to mitigate the colonisation of Legionella in the piping and storage tanks. The impact of these interventions was assessed by examining water samples collected from different locations within the residential building. The second intervention demonstrated a significant impact on the colonisation of Legionella. This cluster analysis highlights various risk factors associated with the proliferation of Legionella in hot water systems. These factors include: (i) the presence of stagnant water during the construction and installation of piping, which persists until residents occupy the building, (ii) the combination of stagnant water and low temperatures ranging from room temperature to approximately 38°C in shower hoses, and (iii) deficiencies in the operation and implementation of control measures for the hot water.

The analysis of the B-samples, which were obtained by flushing the tap in the apartment of Case 2, indicated that the temperature of the hot water was below the recommended minimum of 50 ºC. Specifically, after 15 minutes of flushing, the temperature was measured to be 46 ºC. Additionally, the culture analysis revealed a concentration of 5.5 x 104 Legionella CFU/L, which is above the acceptable limit. This can be seen in image 3.7 below.

Image 3.7

TABLE 1

Effect of heat treatments on the number and species, serogroups, strains of *Legionella*, data collected from seven different apartments, Copenhagen, Denmark, January – September 2009

Timing of the sampling	Sampling site	Type of sample[a]	Number of samples	Number of positive samples	Temperature of water tested (°C)	*Legionella* concentration CFU/litre CFU/L Median		Type of *Legionella* identified
Before the first intervention (9/1/09)	Shower hose	A	1	1	not measured	> 6 *10^5	–	*L. pneumophila* serogroup 1 subgroup Philadelphia. Sg 3
	Tap	A	1	1	not measured	1,4 *10^5	–	*L. pneumophila* serogroup 1 subgroup Philadelphia. Sg 3
	Tap (hot water)	B	1	1	46	5,5*10^4	–	*L. pneumophila* serogroup 1 subgroup Philadelphia
	Kitchen tap (hot water)	B	1	1	56	2,0*10^2	–	Sg 3
After the first intervention	Shower hose	A	5	5	not measured	8,0*10^2– 1,6*10^6	266000	Sg 1. *L. pneumophila* serogroup 1 subgroup Philadelphia. Sg 3. Sg 2-14. Sg 4 subgroup Portland.
	Shower hose 38 °C[b]	B	4	4		2,0*10^2 –1,2 *10^4	9000	Sg 1. *L. pneumophila* serogroup 1 subgroup Philadelphia. Sg 3. Sg 2-14
	Bathroom tap (hot water)	A	5	5	not measured	5,0*10^3 –1,2*10^5	20000	Sg 1. *L. pneumophila* serogroup 1 subgroup Philadelphia. Sg 3. Sg 2-14
	Bathroom tap (hot water)	B	5	5	51.5–56	4,5*1+ ^{2}–1,2*10 ^{4}	800	*L. pneumophila* serogroup 1 subgroup Philadelphia. Sg 3. Sg 2-14.
	Kitchen tap (hot water)	A	5	5	not measured	7*10 ^{2}–3,3*10 ^{5}	31000	*L. pneumophila* serogroup 1 subgroup Philadelphia. Sg 3. Sg 2-14
	Kitchen tap (hot water)	B	5	5	52–57	5 *10^1–5*10^3	800	Sg 3. Sg 2-14
	Bathroom tap (cold water)	B	4	0	8.5–16	BD	BD	–
After the second intervention	Shower hose	A	7	1	not measured	BD–5*10^3	BD	spp. *L. anisa*
	Shower hose 38 °C[b]	B	7	3		BD–1*10^2	BD	*L. anisa*
	Bathroom tap (hot water)	A	7	0	not measured	BD	BD	–
	Bathroom tap (hot water)	B	7	0	55.3–64	BD	BD	–
	Kitchen tap (hot water)	A	7	3	not measured	BD–1*10^3	BD	spp. *L. anisa*
	Kitchen tap (hot water)	B	7	0	56.7–64	BD	BD	–
	Bathroom tap (cold water)	B	3	0	7.3–16.7	BD	BD	–
Seven months after the second intervention	Shower hose	A	3	1	not measured	BD – 5*10 ^{1}	BD	Sg 3. Sg 2-14
	Shower hose 38 °C[b]	B	3	2		BD –1*10 ^{2}	5	spp.
	Bathroom tap (hot water)	A	3	2	not measured	BD – 2*10 ^{1}	5	*L. pneumophila* serogroup 1 subgroup Philadelphia. Sg 3. Sg 2-14
	Bathroom tap (hot water)	B	3	0	53–54	BD	BD	–
	Kitchen tap (hot water)	A	3	1	not measured	BD – 5*10^1	BD	Sg 3. Sg 2-14
	Kitchen tap (hot water)	B	3	1	54	BD – 5	BD	Sg 3

BD: below detection by culture; CFU: colony-forming unit; Sg: serogroup.

[a] A-samples are the first litre of water from the tap or shower hose (first flush); B-samples are one-litre samples collected after flushing to reach constant water temperature (warm or cold) was reached.

[b] Samples of taps are collected after flushing until constant temperature. B-samples from shower hoses were collected when the thermostats were mixing cold and warm water to 38 °C. If B-samples are not referred to in the text as being from shower hoses, B-samples are from samples collected at constant temperature from taps.

Source: (ibid)

The temperature of the hot water in the building was not maintained within the suitable range for the proliferation of Legionella bacteria. Two interventions were implemented to eliminate the presence of Legionella contamination. However, it was observed that only the second intervention, which involved heating the water in the boilers to 70 ºC for 24 hours followed by maintaining a temperature of 65 ºC for three weeks, along with an overall increase in temperature throughout the warm water system, proved to be effective. This contrasted with the first intervention, and resulted in only minimal regrowth of Legionella after a period of seven months.

The persistence of EU/EEA countries in this matter likely indicates a potential underestimation of the prevalence of this disease in several Member States. An ongoing focus remains on providing support to countries with significantly low rates of notification in enhancing the process of diagnosing and reporting cases of Legionnaires' disease to relevant public health authorities.

Public health authorities in EU/EEA countries are consistently identifying and investigating outbreaks of Legionnaires' disease, which vary in terms of their size and origin. Given the significant mortality rates linked to diseases and the considerable difficulties in promptly identifying and managing environmental origins, it remains crucial to maintain vigilance through surveillance in order to detect clusters and outbreaks.

The primary focus in the prevention of Legionnaires' disease revolves around the effective management of water systems to regulate the proliferation and dissemination of Legionella bacteria. The implementation of routine monitoring and maintenance protocols for water systems, encompassing activities such as cleaning and disinfection, is imperative in order to mitigate the potential hazards associated with contamination. Ensuring the appropriate design

and functioning of cooling towers, hot water systems, and other water sources are crucial preventive measures.

The identification of TALD clusters via the ELDSNet surveillance scheme prompts investigations and proactive measures at lodging facilities by participating nations. The ongoing identification of clusters predominantly through this collaborative surveillance scheme underscores its significance in safeguarding public health.

In 2019, the European Centre for Disease Prevention and Control (ECDC) initiated an annual External Quality Assessment (EQA) programme focused on enhancing surveillance and outbreak investigation capabilities in European nations. This programme specifically targets the analysis of clinical and environmental samples pertaining to Legionella spp. The initial publication regarding the results of the External Quality Assessment (EQA) programme in laboratories from European Union/European Economic Area (EU/EEA) countries for the November 2019 distribution was released in 2020 [6].

Implementing routine monitoring for the presence of Legionella bacteria and implementing effective control measures in engineered water systems can potentially mitigate the occurrence of Legionnaires' disease in various settings, such as tourist accommodation sites, hospitals, long-term healthcare facilities, and other environments where there is a significant population at higher risk of exposure.

The expeditious identification and prompt reaction are imperative in the management of outbreaks of Legionnaires' disease. Public health authorities in Europe have a crucial role in the monitoring, investigation, and implementation of measures to address outbreaks. It is imperative to promptly report suspected cases, conduct laboratory testing, and carry out epidemiological investigations in order to ascertain the origin of infection and enforce suitable control measures.

Europe has enacted a range of regulations and guidelines aimed at the prevention and management of Legionnaires' disease. The guidelines encompass precise protocols for the management of cooling towers, hot and cold-water systems, and spas. Adherence to these regulations, in conjunction with routine inspections and monitoring, serves to guarantee the security of water systems and mitigates the potential for Legionella contamination.

USA

The occurrence of Legionnaires' disease outbreaks in the United States is a matter of concern owing to their capacity to impact numerous individuals and communities.

1. Flint, Michigan. The aetiology of the Legionnaires' disease outbreak in Genesee County, MI during 2014-2015. Flint, the city with the highest population in Genesee County, experienced an outbreak that occurred concurrently with the deterioration of its water infrastructure and the subsequent crisis known as the Flint water crisis. The evaluation of the statistical relationship between free chlorine residual and the risk of Legionnaires' disease was made possible by the exceptional disruption in water quality observed in Flint's drinking water distribution system. This disruption, which was unprecedented, occurred within a full-scale drinking water system. The outbreak in the City of Flint is attributed to changes in water quality, specifically alterations in free

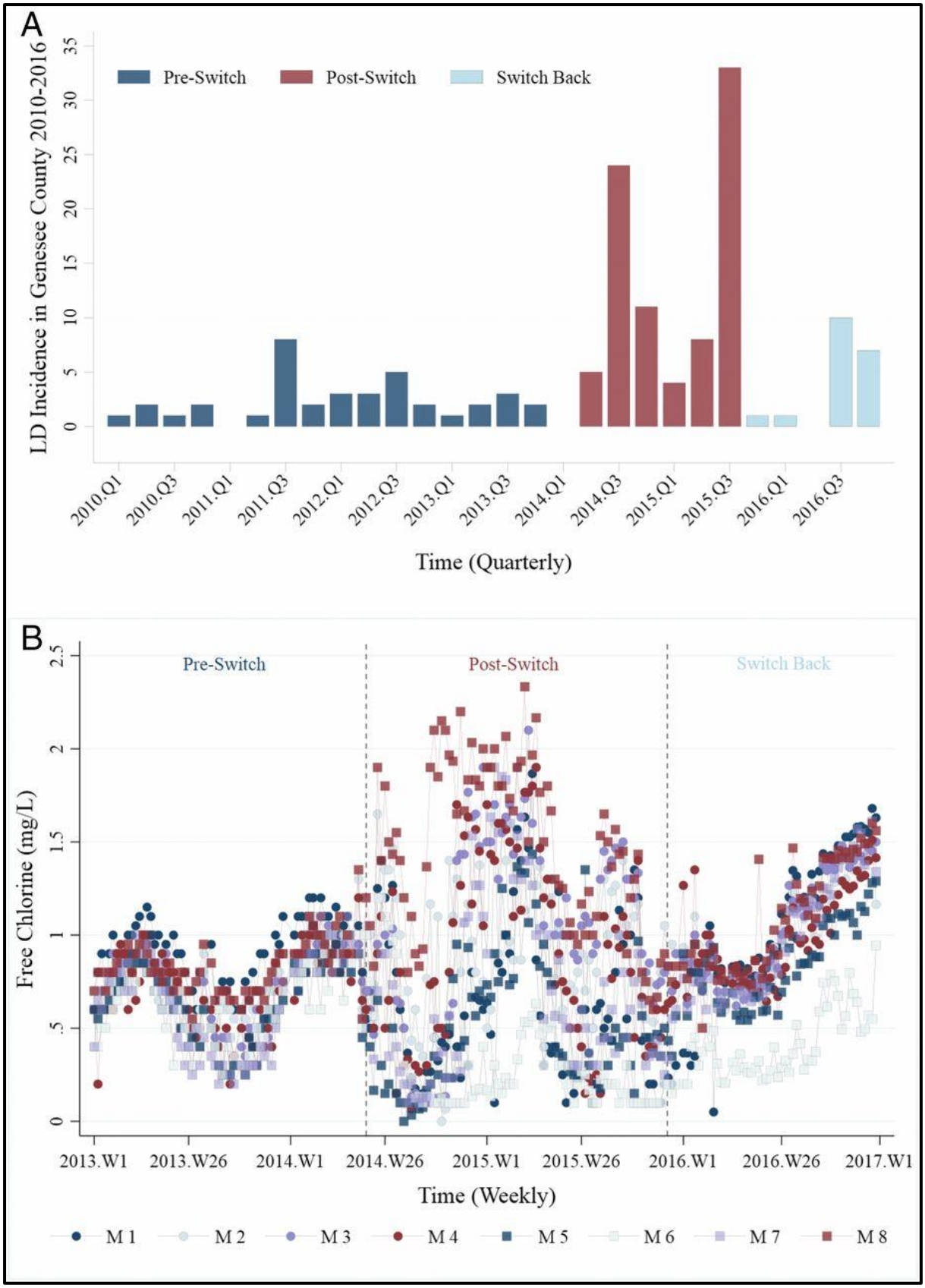
chlorine residual, as indicated by the integration of multiple datasets and the findings of various causal inference tests.

The occurrence of the Legionnaires' disease (LD) outbreak in Genesee County, MI during the period of 2014-2015, as well as its subsequent resolution in 2016, coincided with alterations in the origin of the drinking water supply to Flint's municipal water system. After the transition from Detroit's water supply to Flint River water, there was a significant increase in the likelihood of a resident of Flint developing Legionnaires' disease, with odds increasing by a factor of 6.3 (95% CI: 2.5, 14.0).

During the period of crisis, the decline in the concentration of free chlorine in the water supplied to the residents of Flint resulted in an elevated susceptibility to contracting Legionnaires' disease. The odds of a Legionnaires' disease (LD) case occurring in a Flint neighbourhood '*increased by a factor of 2.9 (95% CI: 1.4, 6.3)'* (Zahran S. et al, 2018) or 3.9 (95% CI: 1.8, 8.7) when the average weekly chlorine level in a census tract was below 0.5 mg/L or below 0.2 mg/L, respectively. During the transition period, there was a notable correlation between the decrease in free chlorine levels and the increased likelihood of a Flint neighbourhood experiencing a case of Legionnaires' disease (LD). This relationship was quantified by determining that for every 1 mg/L decrease in free chlorine, the risk of LD in the neighbourhood increased by 80%. This conclusion was drawn based on the extensive range of chlorine levels observed during the switch. The incidence of LD in neighbouring communities exhibited a positive correlation with the influx of commuters into the city of Flint.

Image 3.8 below depicts the increase in LD cases as occurring concurrently with a change in water source and greater fluctuation in the Flint water distribution system. The purpose of this study is to examine the quarterly incidence of learning disabilities (LD) in Genesee County, Michigan, from the years 2010 to 2016. The number of cases of Learning Disabilities (LD) in Genesee County, as recorded in the Michigan Disease and Surveillance System, is reported on a quarterly basis. Grey bars represent the pre-switch era, maroon bars represent the post-switch period, and navy bars represent the switch back period. (B) Free chlorine levels at eight monitoring sites in Flint's water distribution system from 2013 to 2016. Free chlorine (mg/L as Cl2) was measured weekly at eight locations in Flint during the three water regime phases mentioned above (vertical lines) and the times and dates (year/week) displayed.

Image 3.8



Source: (ibid.).

To conclude, the evidence presented, including various causal inference tests, integration of multiple datasets, and repeated validation of hypotheses, supports the conclusion that the

outbreak of Legionnaires' disease in Genesee County during 2014 and 2015 can be attributed to the persistent and widespread inability to maintain sufficient levels of free chlorine residuals in Flint's municipal water system. The likelihood of a census tract in Flint reporting a case of LD experienced a 7.3-fold increase following the transition to the Flint River as the water source.

2. New York City, New York. The primary aim of this study is to investigate the prevalence and impact of infections attributed to Legionella, which have been identified as the predominant source of waterborne disease outbreaks within the United States. (Weiss et al., 2017)

In the summer of 2015, a comprehensive investigation was conducted to examine a significant outbreak of Legionnaires' disease in New York City. The primary objectives of this study were to analyse the characteristics of the affected patients, identify potential risk factors associated with mortality, and assess the various environmental exposures that may have contributed to the outbreak.

The cases in this study were classified as individuals who were diagnosed with pneumonia and had laboratory confirmation of Legionella infection during the period of July 2 to August 3, 2015. Additionally, these individuals had a documented history of either residing in or visiting one of the various neighbourhoods located in the South Bronx region of New York City. In this study, we present a comprehensive analysis of the epidemiological, environmental, and laboratory investigations conducted to ascertain the origin of the outbreak.

The findings of the study revealed a total of 138 individuals who were diagnosed with Legionnaires' disease that was directly linked to the outbreak. Among these patients, a distressing 16 cases resulted in mortality. The median age of the patients in the study was 55 years. A cohort of 107 individuals exhibited a chronic health condition, comprising 43 cases of diabetes, 40 cases of alcoholism, and 24 cases of HIV infection. A total of 55 cooling towers were subjected to testing for the presence of Legionella bacteria. Among these, it was found that 2 cooling towers exhibited a strain that was indistinguishable, using pulsed-field gel electrophoresis, from 26 isolates obtained from patients. The outbreak was determined to have originated from a single cooling tower based on evidence from both whole-genome sequencing and epidemiological analysis.

In conclusion, A significant occurrence of Legionnaires' disease, resulting from the operation of a cooling tower, transpired within a community characterised by a high prevalence of individuals with compromised health conditions. The occurrence of the outbreak served as a catalyst for the implementation of a novel municipal ordinance pertaining to the functioning and upkeep of cooling towers. Continuous monitoring and assessment of cooling tower process controls will ascertain the extent to which the implementation of the new legislation contributes to the reduction of Legionnaires' disease cases in New York City.

3. In 2019, the Office of the Auditor General USA, conducted a *Performance Audit Of Legionnaires' Disease At The Quincy Veterans' Home,* (E S legionnaires' disease at the Quincy Veterans' home - illinois 2019).

According to the audit report, it was discovered that alongside the 57 reported cases of legionella at the Quincy Veterans' Home in 2015, a significant number of residents and staff

members fell ill during the initial outbreak of the legionella bacteria. Specifically, a total of 220 individuals, comprising both residents and staff, experienced sickness during the months of August and September in 2015.

Despite the confirmation of a second instance of Legionnaires' disease at the Home on August 21, 2015, there was a lack of comprehensive notification or specific protocols communicated to the nursing staff to ensure the safety of residents and employees. It was not until August 27, 2015, that guidelines for water restrictions were finally provided.

The on-site visit to Quincy Veterans' Home by the Illinois Department of Public Health (IDPH) did not occur until the afternoon of Monday, August 24th. The event occurred approximately 67 hours after the confirmation of the second case, which took place in the late afternoon on August 21st. The site visit was primarily centred on a single building that housed the two confirmed cases.

On the 26th of August, five days after the identification of the initial outbreak, officials from the Illinois Department of Public Health (IDPH) convened a meeting with officials from Quincy Veterans' Home. During this meeting, it was determined that the outbreak may be linked to the central hot water tank. It had been ascertained that hot water tank number 2 was rendered inoperable from July 2015 as a result of a valve malfunction, and remained unheated until its reinstatement on August 6, 2015.

To conclude, it is understood that due to this issue, the legionella outbreak occurred.

In conclusion, the importance of increasing public awareness regarding Legionnaires' disease cannot be overstated, as it plays a pivotal role in both prevention and early detection of the illness. Disseminating information regarding risk factors, symptoms, and preventive measures to the general public, healthcare professionals, and building managers has the potential to facilitate timely identification and implementation of appropriate interventions. This measure has the potential to decrease the incidence of cases and alleviate the consequences of outbreaks.

The presence of Legionnaires' disease in water sources presents a substantial public health issue. The dissemination of Legionella via water sources that have been contaminated can result in the occurrence of outbreaks and the development of severe illness, particularly within populations that are more susceptible to the infection. In order to mitigate the impact of Legionnaires' disease on public health, it is crucial to prioritise swift detection, implement appropriate response measures, and employ preventive strategies, such as effective management of water systems.

5.3.1f PFAS

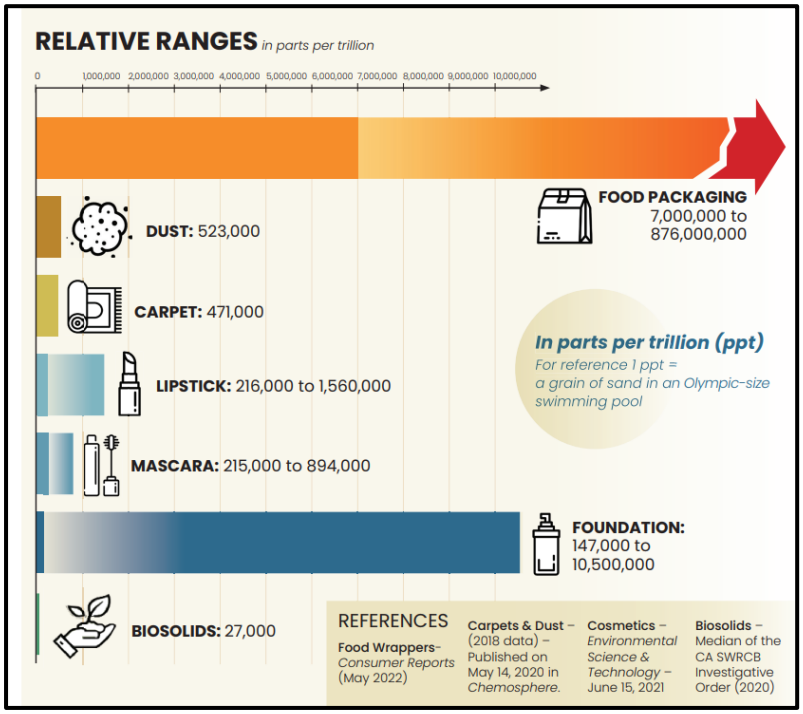
Public health is similarly, impacted by various waterborne diseases that result from the presence of toxic pollutants.

Numerous health issues have been related to two PFAS. PFOA has been linked to thyroid disease, ulcerative colitis, kidney and testicular cancer, excessive cholesterol, and pregnancy-induced hypertension. PFOS has been linked to disorders of the thyroid, liver, kidney, and thyroid development as well as reproduction. The immunotoxicity of PFAS has also been linked to exposure at lower concentrations.

Due to their water and stain resistance, PFAS are a class of synthetic compounds that are frequently employed in industrial and commercial applications. They have been utilised in a variety of applications, including waterproof fabrics, non-stick cookware, and firefighting foams. Because PFAS are persistent in the environment and have the potential to build up in human bodies over time, they are a cause for concern.

Image 3.9 below presents some of the ways PFAS presents.

Image 3.9:



Source: *Bar Chart pfas 2022 - madison sewer district pfas initiative*. Available at: https://madsewerpfasinitiative.org/wp-content/uploads/2022/10/CASA-PFAS-Infographic-2022.pdf (Accessed: 08 July 2023).

The Nordic Council of Ministers calculates that the annual direct healthcare expenses associated with PFAS exposure in Europe alone range from €52 to €84 billion. The numbers are even more astounding when you factor in the costs associated with "remediation," or taking PFAS out of the environment (The top 12 PFAS producers in the world and the staggering societal costs of PFAS pollution, 2023).

PFAS research is conducted by Carmen Messerlian, a professor of reproductive environmental epidemiology at Harvard's TH Chan School of Public Health, states: '*Once they get into your body, they stick around for a really, really long time*' (cited in McFall-Johnsen & Tyson, 2023).

A way to determine how long they persist, is by using principle known as *half-life*.

The half-life of a chemical in humans, is the length of time it takes for your body to eliminate half of the specific substance from your bloodstream. This could be through by urinating or absorbing it into other tissues.

A substance's half-life can differ significantly from person to person; however, averages have been determined through investigations.

Although PFAS may not directly cause infectious diseases, they do have an impact on several health conditions, such as impaired Immunological function, vulnerability to chronic illness, developmental effects, and damage of the gut bacteria.

1. Impaired immunological function. According to studies, PFAS exposure can impair immune function, leaving people more vulnerable to illnesses. There is mounting evidence that PFAS can have an impact on the immune system by impairing its capacity to produce antibodies that are essential in the battle against infectious diseases.

Scientists are beginning to wonder whether communities that experience greater exposures to PFAS, perhaps through contamination of water supplies or other sources, may be more susceptible to COVID-19 and other infectious diseases considering the present COVID-19 epidemic and the numerous threats populations face.

Children in the US between the ages of 12 and 19 who had greater levels of PFOS also had lower levels of antibodies against the mumps and rubella, according to a study (Stein, 2016). Similarly, researchers in Norway discovered that at age three, children born to mothers who had greater amounts of PFAS at the time of their delivery had more colds and gastrointestinal episodes. The children also showed decreased levels of rubella antibodies. (Granum, 2013).

Another shocking fact, is that only two years after having their DTaP vaccination at age five, children with greater blood levels of PFAS had lower levels of diphtheria and tetanus antibodies, according to studies conducted in the Faroe Islands (Grandjean 2012).

2. Increased vulnerability to chronic illnesses: Exposure to PFAS has been linked to a higher chance of acquiring long-term ailments such some cancers, thyroid problems, and liver damage. An individual's vulnerability to infections may be indirectly impacted by certain circumstances.

There may be a link between PFAS exposure and some cancers, such as kidney, testicular, prostate, and ovarian cancer, according to several research. For instance, a study by Hu (2018) examined reviewed data from over 35,000 people exposed to PFAS-contaminated drinking water in the United States and discovered a link between PFAS exposure and kidney and testicular cancer mortality rates in Environmental Health Perspectives (2018).

According to further research, exposure to PFAS may cause liver damage, including changes in liver function, an increase in liver enzymes, and non-alcoholic fatty liver disease (NAFLD). A 2017 study that was published in Environmental Health Perspectives discovered a link between PFAS exposure and NAFLD in a sample of teenagers, (Salihovic, 2018).

In further studies by Lui et al (2022) express that in the Chinese adult general population, the research discovered negative correlations between PFAS substitutes and mixtures and liver function. Our findings provide additional epidemiological proof of PFAS's possible subclinical hepatotoxicity.

3. Penultimately, developmental effects. Studies have revealed that PFAS exposure may harm neurodevelopment, especially children's cognitive development. A 2019 study in the Journal of the American Medical Association (JAMA) Paediatrics identified a link between child PFAS exposure and impaired cognitive function (Hoffman et al, 2010).

Lastly, with regards to thyroid dysfunction, changes in thyroid hormone levels and an increased risk of hypothyroidism, may be linked to PFAS exposure. A 2017 study that was published in Environmental Health Perspectives discovered a link between adult subjects' exposure to PFAS and lowered thyroid function, (Taylor et al., 2013).

4. Damage of gut microbiota: The gut microbiota, is essential for maintaining a strong immune system, and may change as a result of PFAS exposure. Infection susceptibility may rise and immune function may be affected by imbalances in the gut microbiota. These are the conclusions from current research.

Maintaining gut health depends on the integrity of the gut barrier, which stops dangerous substances from entering the bloodstream. Exposure to PFAS may impair the function of the intestinal barrier, according to research by Moroishi et al, (2023), as exposure to PFAS developed increased intestinal permeability, a sign of a dysfunctional gut barrier.

Another way in which PFAS has been concluded to damage gut bacteria, is by altering the makeup and operation of the gut microbiota. It is believed that PFAS may be a factor in the development of metabolic diseases such obesity and insulin resistance. A 2022 study by Latcu et al examined the relationship between, intestinal microbiota, and metabolic indicators in kids. It was discovered that disrupted gut microbiota composition and elevated insulin resistance indicators are often found in tandem. It can therefore be theorised, that damage to the gut microbiome from PFAS, may consequently cause insulin resistance, and gut related complications.

It is crucial to remember that although these studies show potential links between PFAS exposure and chronic disorders, more study is necessary to demonstrate causal links and comprehend the underlying mechanisms. Nevertheless, the conclusions of all the above papers and research, emphasise the significance of reducing PFAS exposure and putting precautionary measures in place to safeguard public health.

With the above knowledge it is fundamental that new public polices address the dangers of contaminated water from PFAS. The dangers are generational.

One would be please to discover that scientists have been working to identify viable remedies as part of efforts to create efficient techniques for eliminating PFAS from water sources. Emerging PFAS removal technology include:

AOPs, or advanced oxidation processes, utilise chemical reactions to break down PFAS chemicals. These procedures can convert PFAS into less hazardous compounds using methods including ozonation, ultraviolet (UV) radiation or advanced electrochemical oxidation.

Through adsorptions activated carbon, specialised resins, and altered clays are a few examples of adsorption materials that have showed promise in the removal of PFAS from water. Through adsorption, these substances can capture PFAS molecules, significantly lowering their quantity in water.

Regulations have been put in place in the US to handle PFAS due to the possible dangers connected with exposure to these chemicals. Regarding PFAS pollution, several states have created their own rules and laws, and the EPA (US Environmental Protection Agency) has issued health recommendations for specific PFAS compounds found in drinking water.

The EPA plan to ‘propos[e] the first-ever national drinking water standard to limit six per- and polyfluoroalkyl substances (PFAS) – the latest action to combat PFAS pollution.’(EPA, 2023).

By the end of the year; 2023; the EPA hopes to have the plan finished, (EPA, 2023).

This would place the PFAS class of chemicals in the ranks of regulated contaminants, among well-known harmful substances like lead, arsenic, and nitrate. It would also establish a federal maximum on the quantity of those PFAS allowed in drinking water. As part of efforts to safeguard public health, more research is being done on the potential impacts of PFAS on human health.

Finally, scientists and researchers are constantly exploring novel methods to remove PFAS from water sources. Many Americans have high levels of PFAS chemicals in their blood, which is indicative of their pervasive environmental presence and historical applications.

5.3.1g Nitrates

While new pollutants such pharmaceuticals, pesticides, per- and polyfluoroalkyl substances (PFASs), and microplastics raise public concern, arsenic, fluoride, and nitrate provide the greatest chemical threats to human health in drinking water, (WHO, 2022).

Nitrate Contamination and Its Health Consequences:

Consuming nitrate-contaminated water causes health hazards, especially for vulnerable populations such as infants, pregnant women, and those with impaired immune systems. The main issue with nitrate exposure is its conversion to nitrite in the body, which can be harmful. Nitrite can bind to haemoglobin in the blood, limiting its ability to carry oxygen, resulting in methemoglobinemia, sometimes known as "blue baby syndrome." In babies, this can result in oxygen deprivation, with potentially lethal consequences.

Aside from methemoglobinemia, nitrate contamination has been linked to several additional health problems, including:

a. Cancer Risk: Some research has revealed a link between long-term nitrate consumption and various cancers, including gastric cancer, colorectal cancer, and bladder cancer. Nitrate can undergo chemical interactions in the body, resulting in the formation of carcinogenic chemicals known as nitrosamines, which may lead to the development of cancer.

b. High nitrate levels in drinking water have been linked to negative reproductive effects such as spontaneous abortions, birth abnormalities, and decreased fertility.

c. Endocrine Disruption: Nitrate exposure has been linked to endocrine disruption, which can impact hormone control and reproductive health.

d. Thyroid Function: According to some study, nitrate exposure may interfere with thyroid function, potentially leading to thyroid problems.

Nitrate Contamination Sources:

Agriculture and, to a lesser extent, sewage systems and industrial discharges are the principal causes of nitrate contamination in water. Nitrogen-containing fertilisers are extensively used in agriculture to increase crop productivity. These fertilisers can contribute to nitrate leaching into groundwater or surface water if they are applied excessively or incorrectly. Another substantial cause of nitrate contamination is animal waste, particularly from extensive livestock farming. Nitrogen molecules found in manure and urine can infiltrate water bodies via runoff or infiltration.

In addition to agriculture sources, poorly maintained sewage systems and septic tanks, particularly in rural areas, can contribute to nitrate contamination. If not properly managed, pollution from chemical manufacturing, livestock/agricultural practices or food processing plants can introduce nitrates into water bodies (Burt et al., 2011) (Nitrates, 2023).

European and American Regulations and Mitigation Efforts:

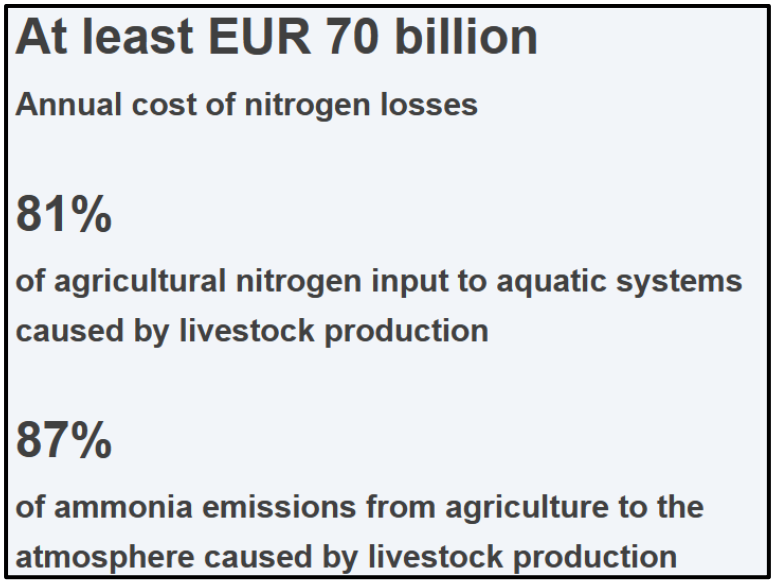
To combat nitrate contamination in drinking water, both Europe and the United States have developed regulatory measures and initiatives. Here are some major initiatives in each region:

a. European Union:

Water safety regulations and standards are created in Europe at both the European Union (EU) and individual member state levels. The EU Drinking Water Directive (DWD) or Nitrates Directive (ND) establishes quality requirements and maximum allowable amounts for a variety of chemicals, including nitrates. The guideline limits nitrates in drinking water to 50 milligrammes per litre (mg/L).

The Nitrates Directive compels EU Member States to monitor water quality and identify sites that drain into dirty or potentially polluted waters. These are waters that are eutrophic as a result of agricultural activity or may contain nitrate concentrations of greater than 50 mg/l. These are known as Nitrate Vulnerable Zones (NVZs).

Image 4.0



Source: (Nitrates, 2023).

The Directive seeks to reduce the contamination of water caused by agricultural nitrates, by monitoring nitrate concentrations in water bodies, defining nitrate susceptible zones, developing rules of acceptable agricultural practises, and implementing steps to avoid and decrease nitrate-related water pollution.

The law duly focusses on combating nitrates from agricultural sources from polluting ground and surface waters and encouraging the use of healthy farming practises. The Nitrates Directive is one of the primary rules protecting waters from agricultural pressures and is a vital aspect of the overall Water Framework Directive.

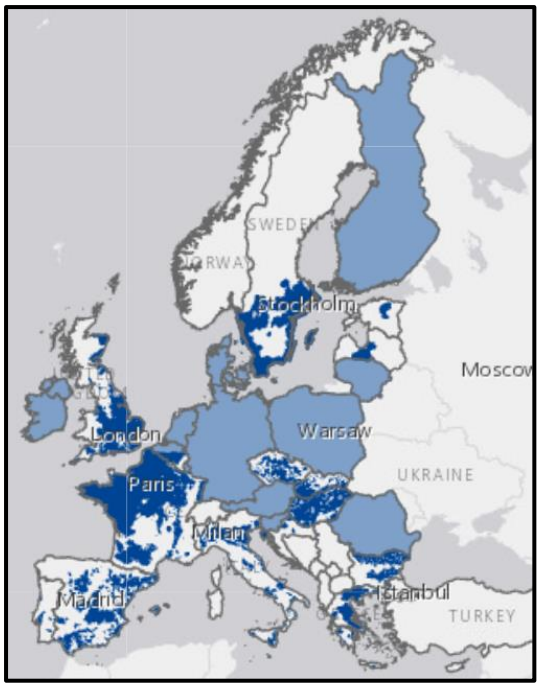
In implementing the Nitrates Directive to protect the public health, all EU countries must:

Designate Nitrate Vulnerable Zones (NVZs), which are regions of land that drain into polluted or potentially polluted waters and contribute to nitrate pollution; or EU Member States can choose to apply measures (see below) to the entire territory (rather than designating NVZs).

The map below in image 4.1 and 4.2 display the current status of NVZs as well as complete territory designations with Europe and the UK, (2016-2019).

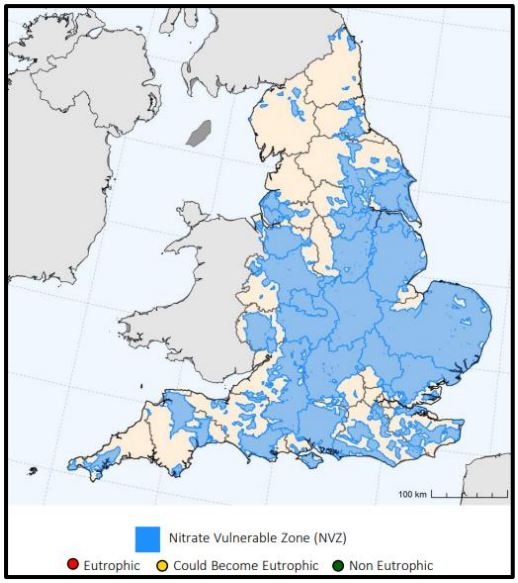
The dark blue areas in image 4.1 are designated NVZ areas.

Image 4.1



Source: *ArcGIS Web Application* (no date) *water.jrc.ec.europa.eu*. Available at: https://water.jrc.ec.europa.eu/portal/apps/webappviewer/index.html?id=b33a220c1b284583851e93a245da02ef.

4.2



Source: Nitrates Directive Reporting 7: *Groundwater (no date).* Available at: https://water.jrc.ec.europa.eu/arcgis/rest/services/nid/msNidReporting7/MapServer/2/1370/attachments/254 (Accessed: 4 July 2023).

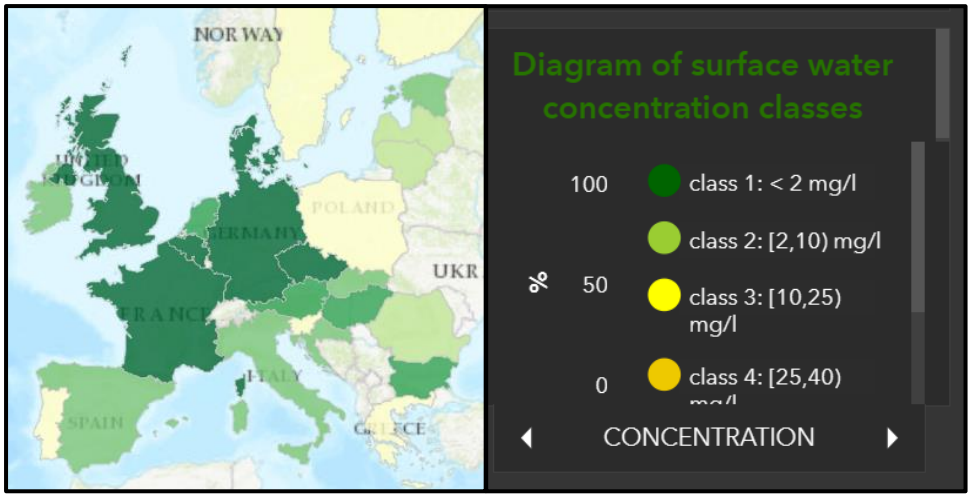
Similarly, members must, establish voluntary Good Agricultural Practise Codes.

This includes measures limiting the times when nitrogen fertilisers can be used on land to target application to times '*when crops require nitrogen and prevent nutrient losses'* (Nitrates, 2023) to waters.

Alongside, methods limiting fertiliser application conditions '(*on steeply sloping ground, frozen or snow-covered ground, near water courses, etc.)* (ibid.) *to prevent nitrate losses'* through leaching and run-off. And lastly, a minimum storage capacity for livestock manure is required, as are crop rotations, soil winter cover, 'and catch crops to prevent nitrate leaching and run-off' (ibid.) during wet seasons.

The map below (image 4.3) depicts the administrative hierarchy of surface water monitoring stations with concentrations more than 10 mg/l. Stations are displayed at a regional geographic scale based on class concentrations. The key explaining the concentration of nitrate with each country is present also.

Image 4.3



Source: ArcGIS Dashboards (no date) *water.jrc.ec.europa.eu*. Available at: https://water.jrc.ec.europa.eu/portal/apps/dashboards/cb6034c2a75e4df282f8a62f90c16caa (Accessed: 3 July 2023).

Thirdly members are required to identify waters at risk of pollution, and or polluted water.

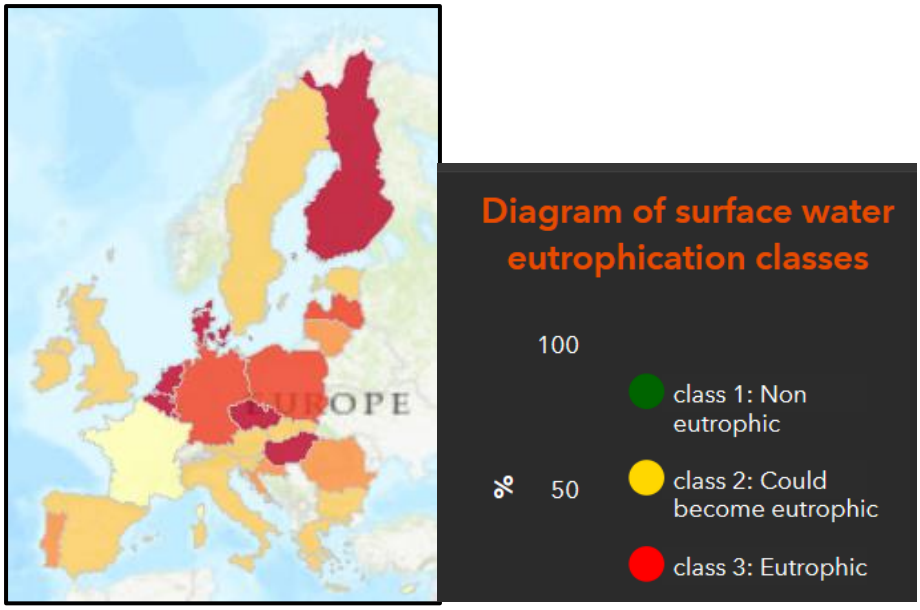
Industries and businesses within agriculture must notify their respective government of polluted water or waters at risk of pollution surface freshwaters. More specifically, those used or intended for drinking water abstraction, containing, or potentially containing (if no action is taken to reverse the trend) creating a concentration of more than 50 mg/l nitrates in the groundwater.

Member must pay close attention to freshwater bodies, estuaries, coastal waters, and marine waters discovered to be eutrophic or at risk of becoming such (if no effort is made to reverse the trend).

Eutrophication is ‘harmful algal blooms, dead zones, and fish kills are the results of a process called eutrophication—which begins with the increased load of nutrients to estuaries and coastal waters’ (NOAA, 2021).

Below is image 4.4 depicts the administrative structure of eutrophic surface water monitoring stations (GISCO-EUROSTAT). Stations are displayed at a regional geographic scale by eutrophication class. Image 4.5 depicts the key to read the map in image 4.4.

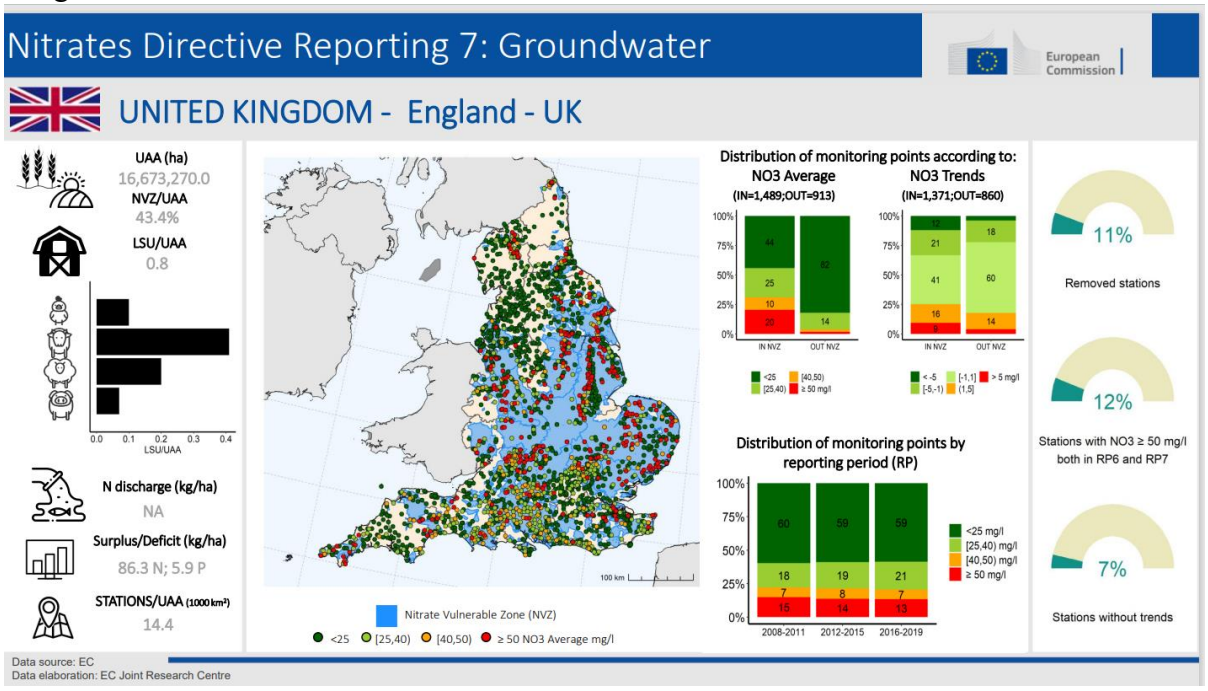
Image 4.4 and 4.5



Source: ArcGIS Dashboards (no date) *water.jrc.ec.europa.eu*. Available at: https://water.jrc.ec.europa.eu/portal/apps/dashboards/cb6034c2a75e4df282f8a62f90c16caa (Accessed: 4 July 2023).

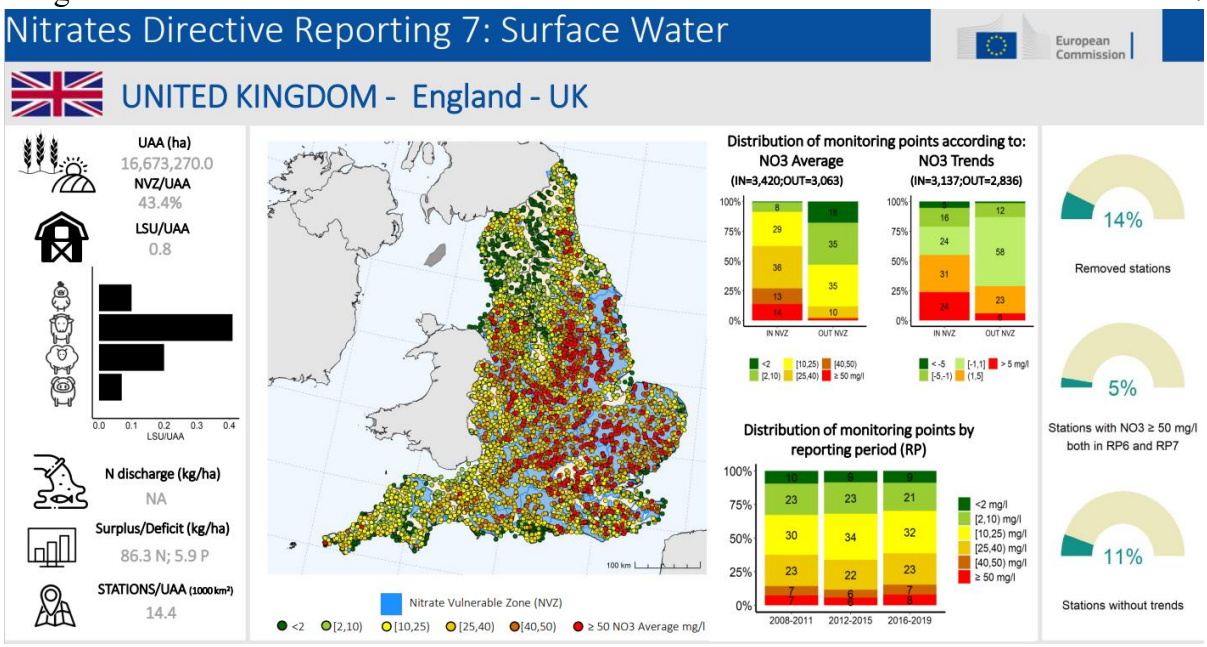
Below in images 4.6 and 4.7 are further images from the European Commission expressing the nitrate concentration in both ground water and surface water for further reading.

Image 4.6



Source: Nitrates Directive Reporting 7: *Groundwater (no date).* Available at: https://water.jrc.ec.europa.eu/arcgis/rest/services/nid/msNidReporting7/MapServer/2/1370/attachments/254 (Accessed: 4 July 2023).

Image 4.7



Source: Nitrates Directive Reporting 7: *Groundwater (no date).* Available at: https://water.jrc.ec.europa.eu/arcgis/rest/services/nid/msNidReporting7/MapServer/2/1370/attachments/254 (Accessed: 4 July 2023).

Now, in relation to nitrate pollution in United States of America:

The Environmental Protection Agency (EPA) oversees drinking water quality in the United States through the Safe Drinking Water Act (SDWA) 1996. Maximum contamination limits (MCLs) for several compounds, including nitrates, are established by the SDWA. Nitrates have an MCL of 10 mg/L, which is much lower than the European limit.

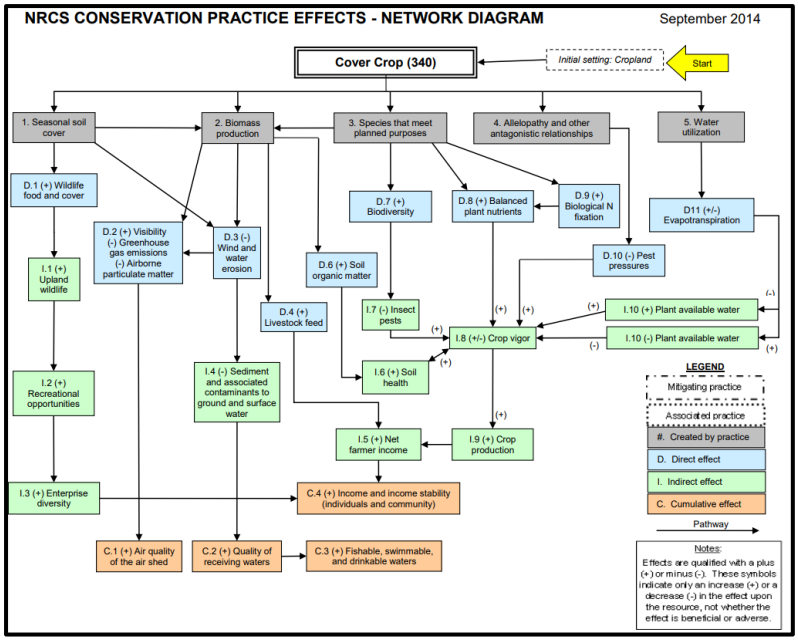
Among some of the attempts in the United States to prevent nitrate contamination are:

Encouraging Best Management Practises: Promoting agricultural best management practises such as precision fertiliser use, cover cropping, and nitrogen runoff management strategies.

Nutrient Best management practices are referred to as the 4Rs. Right rate, Right time, Right source, and Right placement—the first line of defence—should be employed on all cropping systems. Additional best management practises (BMPs) should be implemented to control nutrients as they migrate from the application area to the water resource. When these BMPs are combined, they constitute a system for avoiding, controlling, and trapping nutrients.

Animal manure and chemical fertilisers include nitrogen and phosphorus, which are required for crop growth. However, if these nutrients are not effectively utilised by plants, they might be lost from farm fields and have a harmful impact on the quality of air and downstream water. The image below, image 4.8 expresses this.

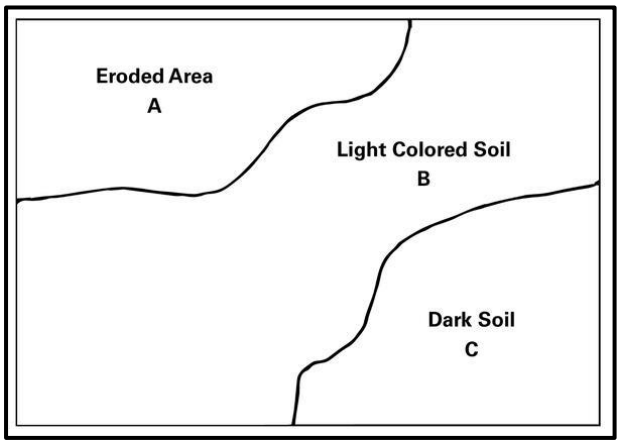
Image 4.8



Source: NRCS CONSERVATION PRACTICE EFFECTS -NETWORK DIAGRAM (2014). Available at: https://www.nrcs.usda.gov/sites/default/files/2022-09/Cover_Crop_340_Network_Diagram.pdf (Accessed: 2 July 2023).

1. Right Rate: A soil test result reveals the quantity of nutrients (excluding nitrogen) that the soil can give and advises the amount, if any, that must be obtained from other sources in order to grow the suggested crop. Soil testing is only as good as the quality of the sampling, so collect samples at random to the correct depth. Image 4.9 is an image of a field. Tests should be taken from each area that has a different type of soil.

Image 4.9:



Source: *(Careful Soil Sampling—The Key to Reliable Soil Test Information | NC State Extension Publications, 2017)*

To ensure adequate nutrients, soil should be tested every two to three years. Many North Carolina soils have been so highly fertilised that they don't require any more phosphorus. If the pH is too low, soil test recommendations include the amount and type of lime to apply. All requirements should be strictly followed because a nutrient shortfall or an unsuitable soil pH

will limit crop responsiveness to the other nutrients. A valid soil test for nitrogen has not been produced in North Carolina, however nitrogen application rates are accessible from the North Carolina Realistic Yield database.

2. Right Sources: Nitrogen and Phosphorus. It is critical that nitrogen remain in the root zone long enough for the growing crop to use it. Although soil can hold ammonium nitrogen, it is generally nitrified (converted from ammonium to nitrate) extremely quickly (three to five days) under North Carolina temperatures. Nitrification is a natural process in which soil microorganisms convert ammonium to nitrate. The rate of nitrification is determined by soil temperature, moisture, pH, and aeration.

Although there are other sources, such as urea and organic sources, most farmers use liquid nitrogen as urea ammonium nitrate. Nitrogen found structurally in manures and other organic materials is less susceptible to short-term loss by leaching since it is only available through decomposition. Because it is produced and sold in North Carolina, most farmers use diammonium phosphate fertiliser, which contains a tiny amount of nitrogen along with the phosphorus.

3. Right Placement: Apply Nitrogen and Phosphorus Correctly. Nitrogen and phosphorus are less likely to be lost due to erosion or runoff if they are banded or integrated directly into the soil. Incorporation, on the other hand, disturbs the soil, which encourages soil erosion. Although surface nitrogen and phosphorus delivery without incorporation is the least desired fertiliser application method, it is frequently employed for pastures, lawns, turf, other perennial crops, and conservation-tilled fields because it is the simplest and least disruptive way. Because nitrogen tends to move down into the soil as rainwater infiltrates, the application method (surface applied or banded) has little effect on nitrogen leaching losses.

However, nitrogen and phosphorus applied to the soil surface are more likely to be carried away by runoff and are less likely to get attached to soil particles or taken up by plant roots. As a result, even if conservation tillage is used, nitrogen and phosphorus should be integrated into the soil before crops are planted/established or banded. When surface application is unavoidable, use as little phosphorous as possible.

Allow no fertiliser to be administered outside of crop zones. The spinner spreader is the most inefficient and widely used way of disseminating fertiliser. Because of their tapering shape, these spreaders administer fertiliser unevenly. Field edges either receive insufficient nutrients or nutrients are provided outside the field boundaries. Use spinner spreaders only where there are vegetative field borders to catch misapplied nutrients. Full-width or boom spreaders (including gravity-flow boxes, auger booms, drag-chain booms, pneumatic booms and spray booms) are significantly superior to spinner spreaders in terms of delivering fertiliser extremely evenly within field limits. These spreaders' principal constraints are their higher initial cost and more difficult operation. All fertiliser spreaders should be calibrated to ensure proper application rate and pattern.

Fertigation (the application of nitrogen or other nutrients in irrigation water) offers both advantages and downsides. The key advantage is that the fertiliser can be administered in small

amounts that are tailored to the demands of the plants. Drip-tube irrigation allows for precise placement, although sprinkler irrigation has the same restrictions as spinner spreaders. Nutrients should not be applied via spray irrigation unless vegetative buffers are present.

4. Right Timing. When Nitrogen and Phosphorus are required, apply them. Because nitrogen is supplied in huge volumes to many crops and is very mobile, time of application is more essential with nitrogen than with any other nutrient. Phosphorus is stable in soil and can be applied when it is most convenient.

Nitrogen should ideally be supplied frequently in modest amounts appropriate to the plants' urgent demands. This is usually only possible with fertigation or with high-value crops. For most crops, nitrogen should be applied in split applications that correspond as closely as possible to the crop's uptake pattern. Corn, for example, requires relatively little nitrogen early in the growth cycle, but this requirement grows significantly when the plant begins to elongate. As a result, the majority of the nitrogen needed by maize should be applied as a sidedressing after the plants have established. Nitrogen fertiliser in the autumn for crops grown in the spring is never suggested in North Carolina. Improper fertiliser or animal manure application or location can cause water contamination and poor crop development.

Other forms of preventing nitrates from ntering safe drinking water, take the forms of:

- Implementing Conservation Programmes: Implementing conservation programmes such as the Conservation Reserve Programme (CRP) and the Environmental Quality Incentives Programme (EQIP) to assist farmers in using nutrient-saving practises.
- Utilising Water Treatment: Nitrate removal from drinking water using treatment methods such as the use of reverse osmosis, ionic exchange, and biological denitrification.
- And lastly, by engaging in continuous monitoring and study to analyse nitrate levels in the water supply and identify issue areas.

These however, will not be explored further in this research paper.

The presence of nitrates in drinking water poses significant chemical risks to public health in Europe and the United States. Excessive nitrate exposure can result in methemoglobinemia, an increased risk of cancer, reproductive issues, endocrine disruption, and thyroid dysfunction. Agriculture, sewage systems, and industrial emissions are the primary sources of nitrate contamination.

To address this issue, both Europe and the United States have enacted legislation and implemented nitrate pollution mitigation strategies. These include encouraging best farming practises, establishing buffer zones, implementing water treatment technologies, and monitoring nitrate levels in water sources. To protect public health from the chemical dangers of nitrate contamination while preserving pure drinking water, continuous efforts in regulation, higher education, and research are essential.

In summary, the issue of water contamination presents a substantial threat to the well-being of the general population, stemming from a variety of factors including industrial pollution, agricultural runoff, insufficient wastewater treatment, and deteriorating infrastructure. The existence of deleterious substances in potable water can have adverse consequences on individuals across all age cohorts, encompassing both adults and children.

The occurrence of microorganisms in water, including bacteria and parasites, can result in the transmission of waterborne diseases, giving rise to a spectrum of illnesses that range from gastrointestinal infections to more serious ailments. Chemical contaminants and heavy metals, such as per- and polyfluoroalkyl substances (PFAS), present supplementary health hazards, potentially leading to enduring impacts on diverse organ systems. The potential adverse effects of nitrates, commonly present in agricultural fertilisers, on infants and pregnant women, including the development of methemoglobinemia and other complications, warrant significant concern.

Comprehensive water quality management strategies are imperative in order to effectively address these contaminants and their corresponding health impacts. This encompasses the implementation of efficient monitoring systems, enhancement of wastewater treatment processes, enforcement of more stringent regulations and standards for industrial and agricultural practises, and allocation of resources towards infrastructure upgrades. The provision of safe and clean drinking water necessitates the involvement of government agencies, water utilities, environmental organisations, and the public through collaborative efforts

By examining the diverse origins of water pollution and implementing proactive strategies, we can strive towards guaranteeing universal access to potable water that is free from impurities, thus alleviating the detrimental health consequences linked to waterborne pollutants and infectious diseases.

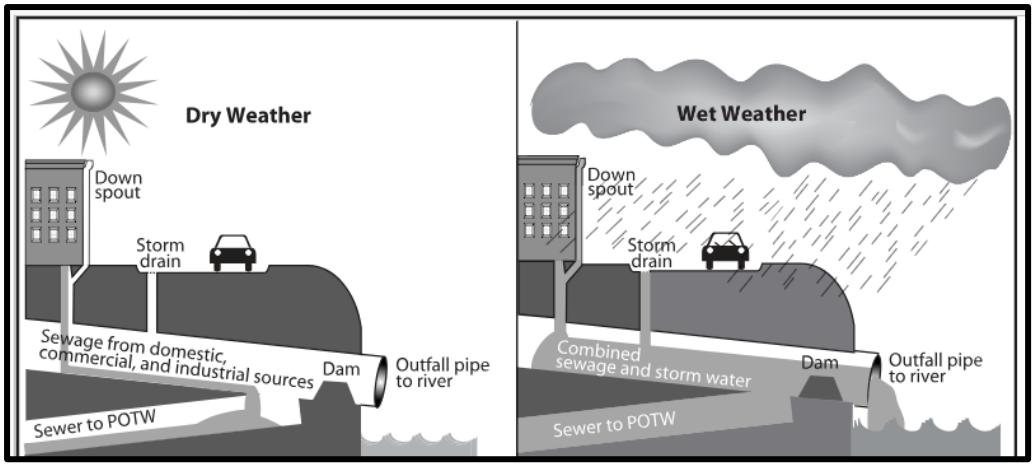
Lastly it is important to note, that access to clean water is a human right, defended by the United Nations, the EU council, and the British Constitution. Every country acknowledges access to clean water is not a privilege but a right. However, access to clean water is not always an option, and in some cases, deliberate neglect of position, and lack of effective funding in the right areas facilities this problem. If policies were made to assist public health such as: allocating funding to update sewage management systems, fining and imprisoning companies and persons who deliberately contaminate water ways, there can then, in the case of the UK, potentially be a remedy to the current plight that they are facing.

5.3.2 Water Infrastructure Collapse

Water contamination is a major global concern with serious consequences for human health. Water contamination is caused by a variety of sources, including but not excluded to insufficient wastewater treatment.

This poses substantial public health hazards. Through an analysis of the mechanisms by which diseases are transmitted, the identification of the specific pathogens involved, and an assessment of the potential health consequences, a clearer understanding of the significance of addressing issues related to combined sewer overflows (CSOs) can be achieved. Image 5.0 below, is a depiction of a CSO, and POTW means publicly owned treatment works.

Image 5.0



Source: (EPA, 2004).

Combined sewage overflow (CSO) has the potential to contribute to the spread of infectious diseases through various mechanisms. To begin with, the discharge of contaminated wastewater during combined sewer overflow (CSO) events has the potential to pollute recreational water bodies, including rivers and lakes, thereby elevating the likelihood of waterborne illnesses. Pathogenic microorganisms, including bacteria (such as Escherichia coli and Salmonella spp.), viruses (such as norovirus and hepatitis A virus), and parasites (such as Cryptosporidium and Giardia), can endure and persist in the surrounding environment. Consequently, these microorganisms pose a significant risk to individuals who partake in water-based recreational activities or consume water that has been contaminated.

Moreover, the infiltration of CSO has the potential to contaminate groundwater sources, leading to subsequent contamination of wells. This phenomenon has the potential to facilitate the transmission of waterborne pathogens to communities that depend on groundwater as their primary source of drinking water, thereby increasing the likelihood of waterborne disease outbreaks.

The presence of pathogens in combined sewer overflow (CSO) systems is a significant concern in the field of environmental health.

The phenomenon of combined sewer overflow entails the presence of a wide range of microbial pathogens that originate from both human and animal waste. Numerous studies have extensively documented the existence of pathogenic microorganisms, including bacteria, viruses, and parasites, within combined sewer overflow (CSO) samples.

The bacterial pathogens frequently detected in combined sewer overflows (CSOs) encompass Escherichia coli, Salmonella spp., Campylobacter spp., and Vibrio cholerae. The bacteria have the potential to induce gastrointestinal disorders, encompassing both mild cases of diarrhoea and more severe infections. Furthermore, the introduction of antibiotic-resistant bacteria into the environment by CSO can exacerbate the escalating global health issue of antimicrobial resistance.

Various viral pathogens, including norovirus, hepatitis A virus, and rotavirus, have been identified in combined sewer overflow (CSO) samples. These viral pathogens have the capacity to induce gastroenteritis and possess the potential to instigate widespread epidemics within communities that encounter water sources contaminated by these viruses.

Protozoan parasites, such as Cryptosporidium and Giardia, are a matter of significant concern due to their ability to withstand commonly employed disinfection methods in water treatment. The parasites can persist in the surrounding environment and induce gastrointestinal ailments, resulting in manifestations such as diarrhoea, abdominal cramps, and nausea.

The exposure to water contaminated with combined sewer overflow (CSO) can result in notable health consequences for individuals. Waterborne diseases that are linked to combined sewer overflows (CSOs) encompass gastrointestinal infections, respiratory ailments, and skin infections.

The ingestion of water contaminated with combined sewer overflow (CSO) is primarily associated with gastrointestinal infections, which represent the most prevalent health consequence. Common symptoms associated with this condition may encompass diarrhoea, vomiting, abdominal pain, and fever. Severe instances have the potential to result in dehydration and the need for hospitalisation, particularly among susceptible demographics such as children, older adults, and individuals with weakened immune systems.

Respiratory ailments may also arise as a result of the inhalation of aerosolized droplets that contain pathogens while engaging in recreational activities within water bodies that have been contaminated. Legionella pneumophila, the bacterium accountable for the onset of Legionnaires' disease, has been identified in combined sewer overflow (CSO) systems, posing a significant risk of causing severe respiratory infections, particularly among individuals with preexisting health conditions.

Skin infections can potentially occur as a result of direct exposure to water contaminated with combined sewer overflow (CSO), especially in individuals who have open wounds or cuts. Pathogenic microorganisms such as Staphylococcus aureus and Streptococcus pyogenes have the potential to induce various skin infections, notably cellulitis and abscesses.

The presence of communicable illnesses associated with combined sewer overflow (CSO) can result in heightened strain on healthcare systems, financial implications, and diminished well-being for those impacted. Vulnerable populations, such as those residing in low-income communities, may experience a disproportionate impact as a result of insufficient access to clean water and healthcare resources.

The implementation of mitigation strategies is crucial in addressing and reducing the adverse impacts of various phenomena or events. These strategies are designed to minimise the extent of illness within a population.

In order to address the potential hazards linked to infectious diseases related to Combined Sewer Overflows (CSOs), it is imperative to adopt a comprehensive strategy. The enhancement and enlargement of sewer infrastructure, including the establishment of distinct stormwater and wastewater systems, can effectively mitigate combined sewer overflow (CSO) incidents and decrease the discharge of untreated wastewater into aquatic environments.

Enhancing water treatment procedures is of utmost importance in effectively eliminating or rendering pathogens inert in wastewater, thereby reducing the potential for disease transmission. Advanced disinfection techniques, such as the utilisation of advanced oxidation processes and ultraviolet (UV) radiation, can be implemented to effectively combat a wider spectrum of pathogens.

Public education and awareness campaigns are of utmost importance in the promotion of appropriate hygiene practises and dissemination of information to communities regarding the potential hazards linked to water contaminated by combined sewer overflow (CSO). This encompasses the promotion of individuals refraining from engaging in recreational activities within or near water bodies affected by combined sewer overflows (CSOs), the advocacy for practising proper hand hygiene, and the provision of recommendations regarding suitable water treatment approaches for populations at higher risk.

The occurrence of combined sewer overflow presents a substantial public health hazard, as it contributes to the dissemination of infectious diseases via the contamination of water sources. Various types of pathogens, such as bacteria, viruses, and parasites, can be found in combined sewer overflow (CSO) and have the potential to induce a variety of illnesses, with gastrointestinal infections being the prevailing outcome. In order to mitigate these risks, it is imperative to adopt a comprehensive strategy that includes the implementation of infrastructure upgrades, improvements in water treatment processes, and the implementation of public awareness campaigns. Through the implementation of comprehensive mitigation strategies, it is possible to effectively reduce the occurrence of infectious diseases associated with Combined Sewer Overflows (CSOs). This not only safeguards public health but also guarantees the availability of safe water resources for communities.

5.3.3. Consequences and Implications of Wastewater Management Failure

Wastewater management systems that fail can harm public health, the environment, and ecosystems.

When wastewater is improperly handled or discharged into waterways, water contamination is a major issue. Water supplies can get contaminated with pathogens, pollutants, and other impurities. When polluted water is swallowed or touched, microbiological pathogens like bacteria, viruses, and parasites raise the risk of waterborne illnesses. As mentioned in this research report, untreated wastewater can swiftly spread diseases like cholera, typhoid fever, and hepatitis A.

Untreated wastewater also harms the ecosystem. Wastewater with high organic matter and nutrient levels like nitrogen and phosphorus can cause eutrophication. Eutrophication overgrows algae and aquatic plants, depleting water body oxygen. Oxygen depletion kills fish and disrupts ecosystems (UNEP, 2016). Nutrient accumulation can also cause toxic algal blooms, which release toxins that affect humans and animals (Paerl et al., 2016).

Wastewater management system failures also endanger public health. Untreated wastewater and contaminated water can cause health problems. Waterborne infections can spread, causing illness, hospitalisations, and deaths. Children, the elderly, and those with compromised immune systems are especially at risk. In Yemen, insufficient wastewater treatment caused a cholera outbreak that harmed thousands (Camacho et al., 2020).

Wastewater management reduces these concerns. Biological treatment, disinfection, and sophisticated technology can reduce wastewater pathogens and pollutants. To prevent system failures and assure safe wastewater discharge, infrastructure and wastewater treatment facilities must be upgraded.

Public awareness and education initiatives promote water conservation, hygiene, and wastewater management. Promoting awareness of untreated wastewater concerns and community-wide solutions can help prevent waterborne illness outbreaks and safeguard public health.

Finally, wastewater management system failure tends to have serious repercussions. Water contamination, waterborne infections, environmental harm, and public health threats are major effects. These dangers demand comprehensive treatment, infrastructure, and public awareness strategies. Wastewater management protects water resources, public health, and community sustainability.

5.3.4 Poverty: The impact on the Spread of Infectious Diseases

Though technology and emerging technology is at the forefront of assisting public health policy, the largest underlying issue it is yet to help eradicate is poverty.

Poverty, is the largest underlying factor that jeopardises public health at large- in every continent and country on the planet.

In order to understand poverty, one must first understand how it is measured. On the world stage, poverty is measured by the International Poverty Line.

The poverty line is defined as the ‘proportion of the population below the international poverty line’ (*SDG indicator metadata – UNSD,* 2023).

An extensive definition put forward by the World Health Organisation is thus:

> ‘[the] poverty line is compared with consumption or income per person (including consumption of their own production and income in kind), and it reflects the minimum level necessary to meet basic needs. This poverty line has fixed purchasing power across countries or areas; hence, it is often called the "international poverty line”’ (Population below the International Poverty Line, 2023).

In 2015, the poverty line sat at USD $1.90, according to the World Bank. A staggering 900 million, 10% of people were living on less that. The last time the international poverty line was updated was in 2008, where the guideline sat a USD $1.25. This data alone shows that despite progress being made in nearly 8 years, ‘poverty persists at unacceptable levels’ (World Bank Group, 2019).

Meta-data released by the United Nations in march of this year (2023) identify that the World Bank adopted USD $2.15 as the new benchmark of which to mark the poverty line, based on 2017 international prices, (*SDG indicator metadata – UNSD,* 2023).

Worldwide there are widening poverty and wealth margins. Poverty causes a variety of health problems leading to poor health. The variety of illnesses knows no bounds, ranging from infectious parasitic diseases, respiratory illness, maternal and perinatal conditions to name the more obscure, aside from malnutrition, and gastric related ailments.

The presence of poverty exerts a substantial influence on the dissemination and consequences of infectious diseases within the socioeconomic context. The presence of limited resource availability, insufficient healthcare infrastructure, and underlying social determinants of health contribute to the facilitation and perpetuation of infectious disease transmission. Gaining a

comprehensive understanding of the correlation between poverty and infectious diseases is of paramount importance in order to effectively implement interventions and mitigate the impact of these diseases.

One of the consequences of poverty is the restricted availability of healthcare services, encompassing preventive measures, diagnostics, and treatment options. Individuals experiencing poverty may exhibit a tendency to postpone the pursuit of medical attention, encounter limited availability of vaccines and medications, and encounter obstacles in accessing sufficient healthcare infrastructure. The lack of sufficient healthcare resources poses a significant obstacle to effective disease surveillance, early detection, and timely interventions, thereby exacerbating the rates of disease transmission.

1. In the context of infectious disease outbreaks, Quinn and Kumar (2014) emphasise the significant challenge of health inequality, emphasising its impact on global health security. The article explains how vulnerable people are disproportionately impacted by differences in access to healthcare, social determinants, and underlying health issues during infectious disease outbreaks. These disparities can increase disease transmission, thwart efficient response initiatives, and raise morbidity and mortality rates in underserved communities.

   The authors emphasise the significance of incorporating social justice and health equity principles into public health policies and actions to promote more efficient disease management and epidemic readiness in the future. In order to attain global health security and lessen the effects of infectious disease outbreaks on vulnerable communities, their analysis highlights the crucial necessity for coordinated efforts, international cooperation, and community participation.

The presence of poverty is often accompanied by overcrowded living conditions also, characterised by the existence of slums or informal settlements, wherein individuals face a scarcity of sufficient space, proper sanitation, and adequate hygiene facilities. The phenomenon of overcrowding plays a significant role in expediting the transmission of various infectious diseases, such as respiratory illnesses (e.g., tuberculosis), gastrointestinal infections (e.g., diarrheal diseases), and vector-borne diseases (e.g., dengue fever). The risk of transmission is heightened by the proximity and shared resources.

1. Infectious illnesses and housing maintenance are both investigated by Ali et al. (2018) in their study of Indigenous Australian households. The study, which mostly focuses on isolated Indigenous communities, finds that poor housing conditions, including subpar infrastructure, overcrowding, and insufficient water and sanitation facilities, are major factors in the incidence of infectious diseases in these populations.

   The findings highlight the urgent need for better housing conditions to lower illness load and improve Indigenous populations' general health. To achieve health equity and better health outcomes for these vulnerable populations, it is critical to address housing disparities and undertake targeted public health interventions. In order to solve the complex issues associated to housing and infectious diseases in Indigenous Australian homes, collaboration between policymakers, public health agencies, and Indigenous community leaders is crucial.

The condition of poverty also frequently gives rise to insufficient nutrition, resulting in a compromised immune system and heightened vulnerability to infectious diseases. The condition of malnutrition, particularly in the paediatric population, has a detrimental impact on immune system functioning, rendering individuals more susceptible to various infections, including respiratory tract infections and diarrheal diseases. A compromised immune system is a contributing factor to the heightened severity of diseases and unfavourable health outcomes.

1. Schneider's study from 2021 examines how dietary status affects historical infectious disease morbidity, primarily using data from the London Foundling Hospital from 1892 to 1909. The study investigates the connection between undernourishment and the prevalence of infectious diseases in this particular community. The results show evidence of a substantial relationship between poor nutritional status and elevated rates of infectious illness morbidity among patients at the hospital throughout the specified period.

In order to lessen the impact of infectious diseases, this study emphasises the significance of addressing dietary inadequacies in at-risk populations. In both historical and modern contexts, public health policies can improve overall health outcomes and lower infectious disease morbidity by enhancing nutritional interventions and ensuring adequate dietary consumption.

Insufficient Provision of Potable Water and Sanitation: The condition of poverty is closely linked to restricted availability of safe potable water and adequate sanitation infrastructure. The transmission of waterborne diseases such as cholera, typhoid fever, and hepatitis A is facilitated by the presence of contaminated water sources and insufficient sanitation measures. The transmission of infectious diseases within impoverished communities can be facilitated by the lack of adherence to proper hygiene practises, including handwashing and appropriate waste disposal.

1. Ritchie and Roser (2021) talk on how important clean water and sanitary conditions are for advancing public health. Their article emphasises the important role that access to clean water and adequate sanitation facilities have in reducing waterborne illnesses and enhancing general health. The authors stress that underprivileged communities are disproportionately affected by a lack of access to clean water and sanitary facilities, which increases the risk of infectious diseases and avoidable deaths.

Their research discusses the ongoing difficulties, particularly in low-income areas, while also giving data and evidence on the global progress made in meeting clean water and sanitation goals. In order to enhance global health outcomes and guarantee equitable access to these vital resources, the research emphasises the need of investing in water and sanitation infrastructure as a critical pillar of public health interventions.

Insufficient Education and Awareness: The presence of poverty frequently restricts individuals' ability to obtain education, leading to a diminished level of health literacy and awareness pertaining to preventive measures against infectious diseases. The limited understanding of disease transmission, preventive behaviours, and the significance of immunisation poses a

barrier to the implementation of protective measures within economically disadvantaged communities. Education and awareness initiatives play a crucial role in empowering individuals and fostering behavioural modifications.

1. The study by Wang et al. (2018) investigates the effects of health education on students' knowledge of and attitudes towards infectious diseases in Gansu Province, China. The purpose of the study is to evaluate how well health education interventions have improved students' knowledge of infectious diseases and encouraged healthy behaviours.

The authors provided health education programmes to the intervention group and performed a survey among a sample of students using a quantitative research approach. The intervention and control groups' knowledge and behavioural practises were compared in the study.

The results showed that students' understanding of infectious diseases had greatly increased as a result of health education. Additionally, the intervention group showed improvements in health-related habits like handwashing, maintaining personal cleanliness, and following safety precautions.

The research's favourable effects on students' knowledge and attitudes towards infectious diseases are highlighted as a conclusion. In order to improve illness prevention and control measures, the study emphasises the necessity of putting in place efficient health education interventions, especially among young populations in China.

2. In research conducted titled "eHealth Literacy, Awareness of Pandemic Infectious Diseases, and Healthy Lifestyle in Middle School Students," Choi et al. (2021) investigated the connections between middle school students' eHealth literacy, awareness of pandemic infectious diseases, and healthy lifestyle. The researchers evaluated middle school students' eHealth literacy, awareness of infectious pandemic diseases, and adherence to a healthy lifestyle by examining data from a sample of the students.

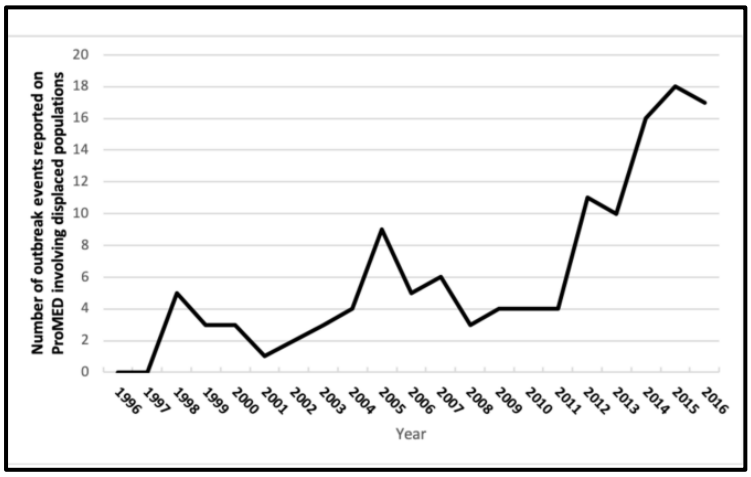
The study discovered a link between students' understanding of pandemic infectious illnesses and better levels of eHealth literacy. Additionally, adopting healthy lifestyle habits was more likely among people with higher eHealth literacy. The results show how crucial it is to improve young people's eHealth literacy in order to raise awareness of infectious diseases and encourage healthier lifestyles.

The phenomenon of migration and displacement, primarily motivated by poverty, plays a significant role in the proliferation of infectious diseases. Migrants and displaced populations frequently reside in densely populated and unhygienic environments, characterised by restricted availability of healthcare services. The phenomenon of forced migration resulting from poverty-related causes has the potential to disrupt disease surveillance efforts, place significant strain on healthcare systems, and elevate the likelihood of disease transmission within the communities hosting the displaced individuals.

1. Using ProMED reports from 1996 to 2016, Desai et al. (2020) examined infectious disease epidemics among people who had been forcibly relocated. ProMED is an online

reporting platform that tracks and shares data on infectious disease outbreaks around the world. To comprehend the incidence, varieties, and traits of outbreaks impacting displaced communities, the researchers looked at the data. Image 5.1 and 5.2 depict this.

Image 5.1



Source: (Desai et al., 2020).

Image 5.2

Source: (ibid.).

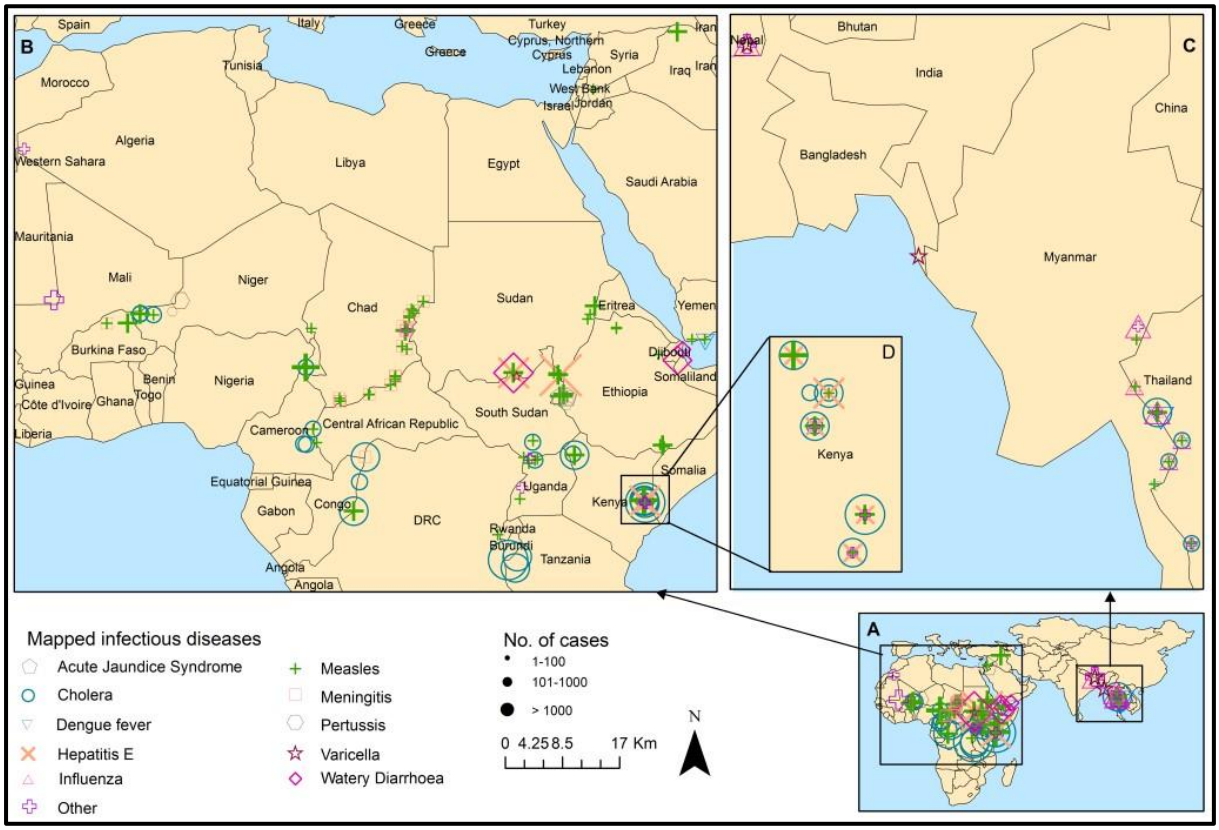
The study discovered that during the study period, infectious illness outbreaks were a prominent worry among people who had been forcibly evacuated. Numerous infectious diseases were reported, and outbreaks were common. The investigation brought attention to how susceptible displaced populations are to infectious diseases because of the cramped, resource-constrained living circumstances in camps and other makeshift communities.

The results highlight the significance of tracking and addressing infectious disease outbreaks in populations that have been dispersed. Early diagnosis and intervention can be aided by prompt reporting through programmes like ProMED, reducing the impact of outbreaks on vulnerable communities. During infectious disease epidemics, forcibly displaced people have special challenges that might be addressed by public health methods and interventions.

2. The paper "Infectious Disease Epidemics in Refugee Camps: A Retrospective Analysis of UNHCR Data 2009-2017" offers a thorough examination of infectious disease outbreaks in refugee camps. In order to determine the frequency and consequences of infectious diseases among people who have been displaced from 2009 to 2017, Sahloul et al (2019) used data from the UNHCR.

Retrospective analysis demonstrates that infectious disease epidemics pose serious health hazards to vulnerable populations in refugee camps and are a major source of concern. Acute respiratory infections, diarrhoea, and measles are among the common illnesses recorded in the camps; cholera and malaria have also been reported in some areas. Living conditions that are too congested, the lack of access to sanitary facilities and clean water, starvation, and insufficient healthcare funding are all factors that contribute to epidemics. Image 5.3 below, is an image of the 'Worldwide case count of infectious diseases distribution by refugee camp, 2009-2017' Sahloul et al (2019).

Image 5.3



In order to control infectious disease outbreaks in refugee settings, the study emphasises the significance of timely and efficient surveillance, prevention, and response techniques. It emphasises the requirement for more international cooperation, humanitarian assistance, and better healthcare facilities to lessen the effects of infectious diseases on people that have been displaced.

3. Lastly, Connolly and Heymann (2002) talk on the complex connection between infectious diseases and war. They emphasise how the breakdown of healthcare institutions, population dislocation, and poor sanitation are only a few examples of how conflict exacerbates the spread of infectious illnesses. The authors stress that a state of

war makes it easier for diseases to spread, which raises the rates of morbidity and mortality. They also contend that preventing infectious diseases during armed conflict is essential for the wellbeing of the afflicted populace as well as for the establishment of stability and peace.

In the research paper, the significance of public health initiatives in conflict settings is emphasised. These interventions include disease surveillance, immunisation programmes, and the provision of clean water and sanitation facilities. To effectively address the health issues brought on by war, the authors promote cooperation between humanitarian organisations, armed forces, and public health organisations.

In conclusion, Connolly and Heymann (2002) highlighted the urgent need for comprehensive public health interventions during times of conflict by illuminating the considerable impact of war on infectious diseases. The importance of public health initiatives in reducing the health effects of conflict and fostering stability in afflicted areas is highlighted in this article.

The social determinants of health encompass a range of factors that are influenced by poverty, such as education, employment, housing, and access to clean water and sanitation. These determinants exert an influence on health outcomes and contribute to the creation of conditions that facilitate the transmission of infectious diseases. The mitigation of infectious diseases necessitates a critical focus on addressing social determinants that are associated with poverty.

It can be observed that poverty plays a substantial role in the proliferation of infectious diseases. This is primarily due to the restricted availability of healthcare services, the promotion of densely populated living environments, the facilitation of malnutrition and compromised immune systems, as well as the impediment of educational opportunities and awareness. Mitigating poverty-related determinants and enhancing the healthcare infrastructure, sanitation facilities, hygiene behaviours, and educational opportunities can contribute to the alleviation of the prevalence and impact of infectious diseases. In order to effectively address poverty and minimise the consequences of infectious diseases, it is imperative to adopt comprehensive strategies that encompass multi-sectoral collaboration, targeted interventions, and policy modifications.

UK

The relationship between poverty and infectious diseases is deeply interconnected, as poverty serves as both a catalyst and a consequence of the transmission of infectious diseases. Socioeconomic inequalities in the United Kingdom (UK) have the potential to amplify the risk of infection transmission, impede access to healthcare services, and hinder efforts aimed at controlling diseases. Let us briefly observe four illustrative instances, that are substantiated by data obtained from the Office for National Statistics (ONS).

The correlation between tuberculosis (TB) and homelessness

Tuberculosis continues to pose a considerable public health burden in the United Kingdom, wherein specific susceptible populations, such as individuals experiencing homelessness, encounter an elevated susceptibility to contracting the disease. The issue of homelessness, which exhibits a strong correlation with poverty, frequently results in living conditions characterised by overcrowding and unsanitary environments. Consequently, these circumstances significantly elevate the probability of tuberculosis transmission. According to

the Office for National Statistics (ONS, 2021), there is a notable disparity in tuberculosis (TB) incidence rates between homeless individuals and the general population. The mitigation of homelessness and the enhancement of housing conditions are pivotal measures in the reduction of tuberculosis transmission and the management of its dissemination within underprivileged communities.

2. The Impact of COVID-19 on Socioeconomic Disparities

The COVID-19 pandemic has highlighted the correlation between poverty and the transmission of infectious diseases. Numerous studies have consistently demonstrated that individuals hailing from socioeconomically disadvantaged backgrounds face an elevated susceptibility to contracting COVID-19 and experiencing more severe consequences as a result. The Office for National Statistics (ONS) has presented data that indicates an inequitable distribution of COVID-19 cases, hospitalisations, and fatalities in socioeconomically disadvantaged regions throughout the United Kingdom (ONS, 2021). Disparities in health outcomes can be attributed to various factors, including but not limited to overcrowded housing, restricted healthcare accessibility, and a higher incidence of underlying health conditions within impoverished communities.

3. The Relationship Between Socioeconomic Status and Sexually Transmitted Infections (STIs)

Poverty and socioeconomic factors exert an influence on the prevalence and transmission of sexually transmitted infections (STIs). Individuals of lower socioeconomic status may encounter obstacles in their ability to access sexual health services, resulting in delayed identification and intervention. According to the Office for National Statistics (ONS, 2021), there exists a positive correlation between the prevalence of sexually transmitted infection (STI) diagnoses and the level of deprivation in various regions of the United Kingdom. It is imperative to prioritise the reduction of health disparities and enhancement of accessibility to sexual health services as crucial measures in effectively managing the transmission of sexually transmitted infections (STIs) within marginalised populations.

The Impact of Vector-Borne Diseases on Urban Poverty

Urban poverty can exert an influence on vector-borne diseases, including but not limited to Lyme disease and West Nile virus. The presence of disease-carrying vectors may be heightened in deprived urban areas due to substandard living conditions and restricted availability of green spaces. The data provided by the Office for National Statistics (ONS, 2021) reveals notable disparities in the incidence rates of Lyme disease. Specifically, areas characterised by higher levels of deprivation exhibit elevated rates of this disease. The implementation of efficient vector control measures, active community engagement, and urban planning strategies that specifically target environmental factors associated with poverty can have a substantial impact on mitigating the prevalence of vector-borne diseases.

Similarly, in 2013, the British Red Cross initiated a programme aimed at distributing food parcels to economically disadvantaged families within the United Kingdom. The intervention implemented by the charitable organisation sought to mitigate the escalating crisis of food poverty within the nation, wherein numerous households are confronted with economic difficulties that prevent them from procuring essential provisions. The Red Cross and the Co-Op supermarket intended to engage in a collaborative effort to distribute food parcels to

individuals facing food insecurity. This development occurs in the context of a notable increase in the population's dependence on food banks and charitable institutions for vital provisions, thereby shedding light on the growing predicament of poverty in the United Kingdom. The collaboration between the British Red Cross and the Co-op exemplifies a joint endeavour aimed at mitigating the immediate consequences of food insecurity on disadvantaged families, while simultaneously raising awareness about the wider societal predicament of poverty, necessitating additional systemic remedies and assistance. (Sky News, 2016).

The complex association between poverty and the transmission of infectious diseases in the United Kingdom necessitates the implementation of specific interventions that target socioeconomic inequalities. These interventions are crucial in effectively reducing disease transmission and enhancing public health outcomes.

Europe

Many of the abovementioned mechanisms of spread, for infectious disease caused by poverty, occur in Europe also.

European poverty promotes infectious disease transmission and hinders prevention and control. Europe has generally excellent living standards, yet poverty still remains, especially in vulnerable people (European Commission, 2019).

Poverty in Europe limits access to healthcare and preventive services, delaying infectious disease detection and treatment. Financial constraints may delay medical care, increasing transmission rates. Poverty often causes overcrowding and poor living conditions, making it easier for illnesses to spread.

Poverty-related malnutrition weakens the immune system, rendering people more susceptible to pathogenic pathogens (European Commission, 2017). Poor sanitation and water availability can spread waterborne and foodborne infections, worsening infectious disease burdens in disadvantaged areas.

Poverty may also reduce understanding of infectious disease prevention and compliance with public health standards and vaccination programmes. Social and economic inequities can also prevent vulnerable communities from accessing vaccination programmes and public health initiatives, lowering immunisation rates.

Targeted measures are needed to alleviate poverty and infectious disease spread. Europe can reduce infectious illness spread through lowering poverty and boosting access to healthcare, sanitation, and education. Protecting vulnerable people from infectious diseases requires strengthening social safety nets, poverty alleviation programmes, and universal healthcare.

USA

Many of the abovementioned mechanisms of spread, for infectious disease caused by poverty, occur in the US also.

Infectious diseases can spread due to US poverty. Poverty persists in the world's wealthiest nation, especially among certain populations and geographic locations (U.S. Census Bureau, 2021).

Poverty in the US hinders access to healthcare, delaying infectious illness diagnosis and treatment. Poverty can affect access to healthcare, health insurance, and medical costs. Thus, they may not receive timely medical care, increasing transmission risk and infection severity.

Poverty can spread infectious diseases. Infections can spread more easily in overcrowded, inadequate homes.

Poverty and food instability weaken immune systems and make people more susceptible to infections. Waterborne and foodborne infections are also increased by poor water and sanitation.

Educational gaps can also transmit infectious diseases. Poverty may limit health education and illness preventive information, resulting in poor vaccination and public health guidelines adherence.

Poverty and infectious diseases necessitate comprehensive interventions. Expanding affordable healthcare and preventive services is essential for early diagnosis and treatment. Poverty reduction and social safety nets can improve healthcare access and results.

Educating vulnerable groups about infectious disease prevention empowers them to protect themselves and others. Infrastructure and public health projects in underprivileged areas can improve living conditions and minimise disease transmission.

The US can improve health and resilience by recognising and tackling poverty's impact on infectious disease spread.

Chapter 6: Principals of Infectious Disease Control.

In the realm of global public health, infectious diseases present formidable obstacles, exerting their impact on populations across the globe. The management and mitigation of infectious diseases necessitate a comprehensive approach that encompasses a range of strategies and interventions. Let us observe a comprehensive examination of the fundamental principles governing the control of infectious diseases. Through an analysis of the fundamental principles that govern the prevention and control of infectious diseases, such as surveillance, vaccination, infection prevention and control strategies, and public health interventions, a deeper comprehension of the significance of these principles in curtailing the transmission of infectious diseases and safeguarding public health can be attained.

Surveillance

The implementation of surveillance mechanisms holds a pivotal position in the realm of infectious disease control. The process encompasses the methodical gathering, examination, interpretation, and distribution of data pertaining to the incidence of diseases. The availability of surveillance data that is both timely and accurate plays a crucial role in facilitating the prompt identification of outbreaks, the analysis of emerging trends, and the evaluation of the impact of diseases on a population. Multiple surveillance systems, such as notifiable disease reporting, syndromic surveillance, and laboratory-based surveillance, play a significant role in disease monitoring. The utilisation of surveillance data plays a crucial role in informing public health interventions, facilitating evidence-based decision-making, and guiding the allocation of resources (World Health Organisation [WHO], 2012). Two notable examples of effective surveillance programmes are the Global Influenza Surveillance and Response System (GISRS) and the Global Polio Eradication Initiative (GPEI).

Vaccination

Vaccination serves as a fundamental pillar in the management and prevention of infectious diseases. Vaccines elicit an immune response that enables the immune system to identify and react to pathogens, thus averting infection or mitigating the intensity of the associated illness. The attainment of a high level of vaccination coverage is of utmost importance in order to attain herd immunity, safeguard vulnerable populations, and disrupt the transmission of diseases. Vaccination programmes adhere to the fundamental principles of vaccine effectiveness, safety, availability, and recommended immunisation schedules as prescribed by national immunisation programmes and international organisations such as the World Health Organisation (WHO). The implementation of effective vaccination initiatives, specifically aimed at eradicating polio, measles, and human papillomavirus (HPV), has resulted in a substantial decrease in the prevalence and impact of infectious diseases on a worldwide scale (Orenstein et al., 2017).

The implementation of infection prevention and control measures is crucial in maintaining a safe and healthy environment.

The implementation of infection prevention and control (IPC) measures is imperative in healthcare settings and other environments that are susceptible to disease transmission. Infection prevention and control (IPC) practises are designed to disrupt the transmission of infections by implementing various strategies, including but not limited to, maintaining proper hand hygiene, adhering to respiratory hygiene measures, and employing personal protective equipment (PPE) in a manner consistent with established guidelines. The importance of

adhering to standard precautions, which encompass safe injection practises, appropriate disinfection, and sterilisation of medical equipment, cannot be overstated in the prevention of healthcare-associated infections. Enhanced precautions, including contact, droplet, and airborne precautions, are implemented in the management of specific pathogens or diseases that possess distinct modes of transmission. The implementation of effective infection prevention and control (IPC) measures has demonstrated significant efficacy in managing and containing outbreaks of highly contagious diseases such as Ebola and severe acute respiratory syndrome (SARS) (World Health Organisation [WHO], 2019).

Public health interventions refer to strategies and actions implemented by public health authorities to promote and protect the health of populations. These interventions aim to prevent disease, promote healthy behaviours, and

Public health interventions encompass a diverse array of strategies that are designed to effectively prevent and manage the spread of infectious diseases within various communities. The interventions encompassed in this context encompass health promotion campaigns, public health education initiatives, community engagement efforts, and targeted interventions specifically tailored for populations at high risk. The field of health communication assumes a crucial function in the dissemination of precise information, the rectification of misconceptions, and the encouragement of behavioural modifications. Effective public health interventions include vector control measures, such as the utilisation of insecticide-treated bed nets for the prevention of malaria, as well as the implementation of environmental management strategies aimed at controlling mosquito breeding sites. Furthermore, it is imperative to implement outbreak response strategies such as the identification of cases, tracing of contacts, implementation of quarantine measures, and isolation protocols in order to effectively contain and manage outbreaks of infectious diseases (Centres for Disease Control and Prevention [CDC], 2019).

To conclude, the management of infectious diseases necessitates a multifaceted and ever-evolving framework. Effective infectious disease control strategies are built upon the fundamental principles of surveillance, vaccination, infection prevention and control measures, and public health interventions. The availability of up-to-date surveillance data plays a crucial role in offering valuable insights into patterns of diseases and informing decision-making in the field of public health. Vaccination programmes play a crucial role in safeguarding both individuals and communities by effectively mitigating the transmission of diseases and alleviating the overall impact of infectious ailments. The implementation of infection prevention and control measures holds significant importance within healthcare settings as it serves to mitigate the occurrence of healthcare-associated infections and restrict the transmission of diseases. Public health interventions encompass a diverse array of strategies that are designed to advance the promotion of health, the prevention of disease, and the effective management of outbreaks. Through the incorporation and amalgamation of these principles within all-encompassing programmes aimed at controlling infectious diseases, we are able to alleviate the repercussions of such diseases, safeguard populations, and foster global health.

Many of the principals for infectious disease control aforementioned, is also implemented with the UK, Europe, and USA. Let us observe them.

UK

The control and prevention of infectious diseases in the United Kingdom are guided by a set of fundamental principles. These principles serve as a framework for public health strategies and interventions that are designed to mitigate the transmission of infections and safeguard the well-being of the population. The United Kingdom has implemented several principles, which are as follows:

The National Health Service (NHS) and Public Health England (PHE) are two prominent entities within the healthcare system of the United Kingdom. The National Health Service (NHS), being the publicly funded healthcare system, assumes a pivotal role in the management and containment of infectious diseases. The organisation offers healthcare services, conducts surveillance, and manages outbreaks. Public Health England (PHE) is the governmental organisation tasked with the executive responsibility of safeguarding and enhancing the health and overall well-being of the population, encompassing the control and management of infectious diseases. The Public Health Agency (PHE) is responsible for the coordination of surveillance systems, provision of scientific expertise, and facilitation of the development of public health policies.

The implementation of comprehensive surveillance systems plays a pivotal role in the monitoring of infectious diseases within the United Kingdom. The United Kingdom possesses comprehensive national surveillance programmes, exemplified by the Health Protection Surveillance Centre and the National Institute for Health Protection (formerly known as Public Health England's Centre for Infectious Disease Surveillance and Control). These systems are designed to gather and analyse data pertaining to the occurrence, frequency, and patterns of diseases in order to detect and manage outbreaks, provide guidance for public health interventions, and evaluate the efficacy of preventive measures.

Immunisation Programmes: The United Kingdom possesses a robust immunisation programme that adheres to national guidelines and recommendations put forth by the Joint Committee on Vaccination and Immunisation (JCVI). The primary objective of the programme is to attain a substantial level of vaccination across the population, thereby safeguarding both individuals and communities against diseases that can be prevented through vaccination. These diseases encompass influenza, measles, mumps, rubella, and most recently, COVID-19. Vaccination campaigns are designed to cater to diverse age cohorts, vulnerable populations, and evolving public health challenges.

Infection Prevention and Control (IPC) measures are systematically implemented within healthcare settings to effectively mitigate the occurrence of healthcare-associated infections and minimise the spread of infectious diseases. In the United Kingdom, adherence to evidence-based infection prevention and control (IPC) guidelines is observed, as prescribed by esteemed organisations such as Public Health England (PHE) and the National Institute for Health and Care Excellence (NICE). The guidelines encompass various aspects of healthcare practises, including hand hygiene, proper utilisation of personal protective equipment (PPE), protocols for cleaning and disinfection, safe administration of injections, and the effective management of healthcare-associated infections.

The United Kingdom has implemented robust mechanisms for the detection and management of outbreaks, as well as the tracing of contacts. Public health agencies, such as Public Health England (PHE) and local health departments, engage in expedited inquiries to ascertain the origin of outbreaks, execute measures to manage their spread, and track individuals who have

come into contact with affected individuals in order to promptly intervene. The NHS Test and Trace programme was implemented during the COVID-19 pandemic with the aim of identifying and isolating individuals who have contracted COVID-19, as well as their close contacts. This initiative was put in place to effectively manage and mitigate the transmission of the virus.

Health education and communication strategies are utilised to enhance public awareness, foster the adoption of healthy behaviours, and disseminate precise information pertaining to infectious diseases. The objective of these endeavours is to enhance the agency of individuals and communities in adopting proactive measures, accessing healthcare when required, and adhering to public health directives in times of outbreaks. The implementation of effective communication strategies necessitates the collaborative efforts of public health agencies, healthcare providers, and community organisations in order to guarantee the precise and prompt dissemination of information.

The United Kingdom (UK) employs a comprehensive framework of principles to govern the management and mitigation of infectious diseases. These factors encompass the functioning of the National Health Service (NHS) and Public Health England (PHE), the establishment of resilient surveillance systems, the execution of comprehensive immunisation initiatives, the adherence to infection prevention and control protocols, the prompt response to outbreaks and contact tracing, and the implementation of effective health education and communication strategies. The United Kingdom endeavours to safeguard public health, minimise disease transmission, and protect the population from the burden of infectious diseases by adhering to these principles and continually adapting to emerging threats posed by infectious diseases.

Europe

Europe has made notable advancements in the implementation of infectious disease control principles. Let us observe a comprehensive examination of what has been implemented in Europe, with a particular emphasis on the region's unwavering dedication to safeguarding public health. Through an analysis of the surveillance systems, vaccination strategies, infection prevention and control measures, and public health interventions implemented in European countries, valuable insights can be gleaned regarding the efficacy of these principles in curtailing the transmission of infectious diseases.

Surveillance systems refer to technological setups that enable the monitoring, observation, and recording of activities, events, or individuals within a given

European nations have implemented comprehensive surveillance systems to effectively observe and address the occurrence of infectious diseases. The European Centre for Disease Prevention and Control (ECDC) assumes a crucial function in the coordination of surveillance endeavours throughout Europe. The Early Warning and Response System (EWRS) facilitates the prompt dissemination of information, exchange of data, and harmonisation of public health interventions within the European Union (EU) member states. Furthermore, Eurosurveillance, a scholarly journal that undergoes peer review, serves as a platform for the widespread distribution of surveillance data and fosters cooperation among European nations (European Centre for Disease Prevention and Control [ECDC], 2019). These systems facilitate the identification of outbreaks, surveillance of disease patterns, and dissemination of specific interventions aimed at managing the transmission of infectious diseases in Europe.

Strategies for Vaccination

Vaccination is regarded as a fundamental cornerstone of infectious disease control in Europe. European Union (EU) member states adopt and execute national immunisation programmes in accordance with guidance provided by the European Centre for Disease Prevention and Control (ECDC) and the World Health Organisation (WHO). The establishment of vaccination coverage targets is aimed at attaining herd immunity and mitigating the impact of vaccine-preventable diseases. The European Vaccine Action Plan (EVAP) seeks to eradicate measles and rubella through the implementation of strategies such as expanding vaccination coverage and improving surveillance, as outlined by the World Health Organisation (WHO, 2014). According to the European Centre for Disease Prevention and Control (ECDC, 2021), numerous European countries have effectively executed vaccination campaigns targeting influenza, pneumococcal diseases, and human papillomavirus (HPV), resulting in significant reductions in disease prevalence.

The implementation of infection prevention and control measures is crucial in maintaining a safe and healthy environment.

European nations place a high emphasis on the implementation of infection prevention and control (IPC) strategies in order to effectively mitigate the spread of communicable diseases. Hand hygiene, respiratory etiquette, and proper utilisation of personal protective equipment (PPE) are highlighted as crucial aspects in healthcare settings, as emphasised by national and regional guidelines. Hospitals employ rigorous infection prevention and control (IPC) protocols, which encompass various strategies aimed at mitigating healthcare-associated infections and effectively managing highly contagious diseases. European nations played a crucial role in the implementation of infection prevention and control (IPC) measures amid the COVID-19 pandemic. These measures encompassed the promotion of physical distancing, adherence to mask-wearing protocols, and the adoption of comprehensive testing strategies (European Centre for Disease Prevention and Control [ECDC], 2020).

Public health interventions refer to strategies and actions implemented by public health authorities to promote and protect the health of populations. These interventions aim to prevent disease, promote healthy behaviours, and

European nations actively implement a range of public health interventions in order to effectively manage and mitigate the spread of infectious diseases. Health promotion campaigns and public health education initiatives have the primary objective of enhancing public awareness, fostering modifications in behaviour, and effectively disseminating precise information to the general population. Rapid implementation of outbreak response measures, including the identification of cases, contact tracing, and quarantine, is crucial for effectively managing and containing the transmission of infectious diseases. Europe has exhibited effective community involvement in addressing public health crises, as evidenced by its response to Ebola outbreaks and the ongoing COVID-19 pandemic (World Health Organisation [WHO], 2021).

European nations demonstrate a robust dedication to the implementation of infectious disease control principles. The implementation of robust surveillance systems, comprehensive vaccination strategies, effective infection prevention and control measures, and targeted public

health interventions collectively play a significant role in mitigating the transmission of infectious diseases and safeguarding the well-being of the general population in Europe.

USA

In the United States, the control of infectious diseases is guided by a comprehensive framework encompassing various principles and strategies. Let us observe the framework implemented in infectious disease control in the USA. By examining the principles of disease surveillance, vaccination, infection prevention and control, and public health interventions, we can better understand the approach taken by the United States in mitigating the spread of infectious diseases and safeguarding public health.

Disease Surveillance

The United States employs robust disease surveillance systems to monitor and track infectious diseases. The Centers for Disease Control and Prevention (CDC) coordinates national surveillance efforts, working closely with state and local health departments. Notifiable disease reporting is a fundamental aspect of disease surveillance, requiring healthcare providers and laboratories to report specified infectious diseases to public health authorities. The National Notifiable Diseases Surveillance System (NNDSS) serves as a centralized database for collecting and analyzing surveillance data. Additionally, the CDC operates various surveillance programs, such as the National Healthcare Safety Network (NHSN) for healthcare-associated infections and the National Syndromic Surveillance Program for monitoring emergency department visits and detecting disease outbreaks (CDC, 2019a).

Vaccination Programs

Vaccination plays a crucial role in infectious disease control in the USA. The National Immunization Program, coordinated by the CDC, provides guidance on recommended immunizations for different age groups. Vaccination coverage is monitored through the National Immunization Surveys, which assess vaccine uptake and identify areas of improvement. The Vaccines for Children (VFC) program ensures that eligible children receive vaccines regardless of their ability to pay. Additionally, state-level immunization registries help healthcare providers track immunization records and monitor vaccine coverage rates. The Advisory Committee on Immunization Practices (ACIP) provides evidence-based recommendations on vaccine use, safety, and schedules (CDC, 2019b).

Infection Prevention and Control

In healthcare settings, infection prevention and control measures are essential for preventing healthcare-associated infections and controlling the spread of infectious diseases. The CDC provides guidelines and recommendations for infection control practices, including hand hygiene, personal protective equipment (PPE) use, safe injection practices, and environmental cleaning. The National Healthcare Safety Network (NHSN) supports healthcare facilities in monitoring and reporting healthcare-associated infections. The CDC's Healthcare Infection Control Practices Advisory Committee (HICPAC) offers expert guidance on infection prevention strategies (CDC, 2021).

Public Health Interventions

Public health interventions are a crucial component of infectious disease control in the USA. The CDC and state health departments collaborate to implement interventions during outbreaks or epidemics. These interventions may include case investigation, contact tracing, isolation and quarantine measures, and public health education campaigns. Community engagement plays a vital role in promoting behavioural changes, such as mask-wearing, social distancing, and adherence to public health guidelines. The Strategic National Stockpile (SNS) serves as a national repository of medical supplies and pharmaceuticals for emergency response purposes (CDC, 2020).

To conclude, in the USA, infectious disease control relies on a framework encompassing principles of disease surveillance, vaccination programs, infection prevention and control, and public health interventions. These principles are implemented through collaborative efforts between federal, state, and local health authorities, aiming to minimize the impact of infectious diseases and protect public health.

Chapter 7: Outbreak Investigation: A Comparative Analysis in the UK, Europe, and the USA

Outbreak investigations are of paramount importance in the identification of etiological factors, containment of transmission, and mitigation of future recurrences of infectious diseases. Here I am going to undertake a comparative analysis of outbreak investigations conducted in the United Kingdom (UK), Europe, and the United States of America (USA). Through an analysis of the methodologies, conceptual frameworks, and significant determinants that shape outbreak investigations in various regions, we can acquire valuable perspectives on the commonalities, disparities, and overall efficacy in addressing outbreaks of infectious diseases.

Let us first observe the outbreak situation in the United Kingdom.

In the United Kingdom, the process of investigating outbreaks entails a collaborative endeavour among various entities, with Public Health England (PHE) taking the lead role. The Health Protection Team (HPT) at Public Health England (PHE) collaborates extensively with regional health authorities, healthcare providers, and laboratories to identify, evaluate, and manage instances of disease outbreaks. After the identification of an outbreak, a systematic methodology is implemented, encompassing the establishment of a case definition, the gathering of data, and the conduct of epidemiological analysis. The Health Protection Report (HPR) serves as a reliable source of information for healthcare professionals and the general public, offering periodic updates on ongoing outbreak investigations (Public Health England, 2017).

Outbreak investigations in the United Kingdom place significant emphasis on fostering collaboration, wherein multidisciplinary teams are engaged in the execution of epidemiological studies, microbiological testing, and environmental assessments. Rapid response units are promptly deployed to investigate and effectively handle outbreaks, thereby ensuring timely interventions aimed at controlling the transmission of diseases. Prominent instances encompass the reaction to the 2009 H1N1 influenza pandemic and the continuous monitoring and examination of foodborne outbreaks via the Foodborne Disease National Surveillance System (FDNSS) (Hawker et al., 2012; Public Health England, 2016).

Investigation of Outbreaks in Europe

In the European context, the facilitation of outbreak investigations is carried out by the European Centre for Disease Prevention and Control (ECDC) in conjunction with national public health agencies. The European Centre for Disease Prevention and Control (ECDC) offers assistance and direction to Member States in the identification, evaluation, and management of disease outbreaks. According to the European Centre for Disease Prevention and Control (2019), the European Early Warning and Response System (EWRS) facilitates the expeditious dissemination of information pertaining to both potential and ongoing outbreaks.

The Epidemic Intelligence Information System for Food- and Waterborne Diseases (EPIS-FWD) is an operational system within the European Union (EU) that aims to facilitate timely identification and reaction to outbreaks related to foodborne and waterborne diseases. According to the European Centre for Disease Prevention and Control (2021), this system facilitates and improves cross-border collaboration and the exchange of information among Member States.

In Europe, outbreak investigations adhere to a standardised methodology that encompasses the utilisation of case definitions, laboratory confirmation, and epidemiological analyses. The European Centre for Disease Prevention and Control (ECDC) offers technical assistance, training programmes, and outbreak-specific recommendations to national authorities. European networks, such as the European Foodborne Outbreak Reporting System (EFORS) and the European Surveillance System (TESSy), play a crucial role in promoting data sharing and enabling synchronised responses to outbreaks (ECDE, n.d.).

An analysis of epidemic investigation within the United States.

Outbreak investigations in the United States entail a cooperative endeavour among federal, state, and local health agencies, with the Centres for Disease Control and Prevention (CDC) assuming a predominant leadership role. The Epidemic Intelligence Service (EIS) of the Centres for Disease Control and Prevention (CDC) fulfils a crucial function in the examination of outbreaks and the provision of epidemiological proficiency. The primary responsibility for detecting, reporting, and responding to outbreaks lies with state and local health departments, as outlined by the Centres for Disease Control and Prevention (2020).

In the United States, outbreak investigations adhere to a standardised methodology that encompasses several key components, namely the establishment of a case definition, the identification of cases, and the gathering of relevant data. The National Outbreak Reporting System (NORS), established by the Centres for Disease Control and Prevention (CDC), functions as a centralised mechanism for the reporting and surveillance of outbreaks throughout the United States. The PulseNet system, which is a nationwide laboratory network, facilitates the prompt identification and surveillance of foodborne disease outbreaks by employing molecular subtyping techniques to analyse pathogens (Centres for Disease Control and Prevention, 2021).

The outbreak investigations conducted by the United States of America (USA) are frequently distinguished by their emphasis on surveillance systems and sophisticated laboratory capabilities. The Centres for Disease Control and Prevention (CDC) employs various integrated systems, including the National Notifiable Diseases Surveillance System (NNDSS) and the National Healthcare Safety Network (NHSN), to enable the timely monitoring, early identification, and effective response to disease outbreaks (Centres for Disease Control and Prevention, 2019a; Centres for Disease Control and Prevention, 2019b).

A Comparative Analysis and Identification of Key Factors

Outbreak investigations conducted in the United Kingdom, Europe, and the United States of America exhibit numerous shared characteristics, encompassing standardised methodologies, extensive stakeholder collaboration, and reliance on surveillance systems to facilitate timely identification. Epidemiological analysis, laboratory testing, and environmental assessments are essential components in all geographical areas. Nevertheless, there may be variations in essential elements such as governance structures, mechanisms for information sharing, and the allocation of resources.

In the United Kingdom, the governance structure of Public Health England (PHE) enables a synchronised approach to managing outbreaks, whereas the healthcare delivery system in the

United States is characterised by a decentralised framework, requiring collaboration among federal, state, and local authorities. In the European context, the engagement of the European Centre for Disease Prevention and Control (ECDC) and the frameworks established by the European Union (EU) serve to promote harmonisation and coordination among the various Member States.

Various mechanisms for sharing information, such as the Health Protection Report (HPR) in the United Kingdom, the Early Warning and Response System (EWRS) in Europe, and the National Outbreak Reporting System (NORS) in the United States, facilitate the prompt distribution of outbreak-related information. Nevertheless, variations may be present regarding the extent, availability, and level of detail of the disseminated information.

The allocation of resources for outbreak investigations exhibits variability across different regions as a result of disparities in healthcare systems, funding mechanisms, and infrastructure. The effectiveness and timeliness of outbreak investigations are enhanced by the presence of specialised units, such as the Epidemic Intelligence Service (EIS) in the United States and rapid response units in the United Kingdom.

To the conclude, the approach to outbreak investigations in the UK, Europe, and the USA demonstrates similarities, characterised by the utilisation of standardised methods and the establishment of collaborative efforts among diverse stakeholders. Although there are variations in governance structures, information sharing mechanisms, and resource allocation across different regions, there is a common emphasis on the importance of early detection, coordinated response, and prevention of infectious disease outbreaks.

Chapter 8: Outbreak Investigation and the COVID-19 Pandemic: Comparative Analysis in the UK, Europe, and the USA

The COVID-19 pandemic currently underway has brought attention to the significant importance of outbreak investigations in comprehending and addressing infectious disease outbreaks. Here I shall undertake a comparative analysis of outbreak investigations conducted during the COVID-19 pandemic in the United Kingdom (UK), Europe, and the United States of America (USA). Through an analysis of the methodologies, conceptual frameworks, and significant determinants that shape outbreak investigations within different regions, valuable insights can be obtained regarding their efficacy in the identification, containment, and mitigation of the transmission of the Covid-19 virus.

Here we shall observe the outbreak that occurred in the United Kingdom.

In the United Kingdom, the management of outbreak investigations during the COVID-19 pandemic has predominantly been spearheaded by Public Health England (PHE), in conjunction with regional health departments and the National Health Service (NHS). The prompt emphasis has been placed on expeditious identification and reaction, as evidenced by the implementation of the NHS Test and Trace system, which aims to promptly identify and isolate individuals affected by COVID-19 while also tracing their contacts. Public Health England (PHE) has been instrumental in the implementation of epidemiological surveillance, case investigation, and contact tracing endeavours (Public Health England, 2020a).

In the United Kingdom, outbreak investigations have employed a comprehensive approach that incorporates case-based surveillance, extensive testing, and genomic sequencing to effectively monitor the transmission of Covid-19 and detect emerging variants. The COVID-19 Genomics UK Consortium (COG-UK, n.d.) has played a crucial role in the process of sequencing viral genomes for the purpose of monitoring transmission chains and providing valuable insights for public health interventions (Public Health England, 2021a).

The utilisation of public health messaging and communication strategies has played a crucial role in the conduct of outbreak investigations within the United Kingdom. The primary objective of regular briefings conducted by government and public health officials, including the Chief Medical Officer and the Chief Scientific Adviser, is to disseminate current information, alleviate public apprehensions, and encourage compliance with preventive measures (Public Health England, 2020b).

Investigation of Outbreaks in Europe

During the COVID-19 pandemic, the European Centre for Disease Prevention and Control (ECDC) has played a crucial role in coordinating outbreak investigations in Europe, working closely with national public health agencies. According to the European Centre for Disease Prevention and Control (ECDC, 2020), the provision of guidance on case definitions, testing strategies, and risk assessment tools by the ECDC aims to assist Member States in their efforts to respond to outbreaks.

European nations have employed diverse strategies for investigating outbreaks, encompassing extensive testing, contact tracing, and quarantine protocols. Digital tools and mobile applications, such as the "Corona-Warn-App" in Germany, have been implemented to augment the velocity and efficacy of contact tracing endeavours (Wymant et al., 2021).

The European Commission (2021) has highlighted the significance of the European Union's collaborative procurement of COVID-19 vaccines and the implementation of the Digital Green Certificate in facilitating safe travel within the EU. These measures have played a crucial role in the control and mitigation of the outbreak.

An analysis of outbreak investigation in the United States.

During the COVID-19 pandemic in the United States, the Centres for Disease Control and Prevention (CDC) have taken charge of outbreak investigations, in conjunction with state and local health departments. The Centres for Disease Control and Prevention (CDC) has made significant contributions to outbreak investigations and response efforts through their extensive knowledge in the fields of epidemiology, surveillance, and laboratory testing (Centres for Disease Control and Prevention, 2020a).

The primary emphasis of outbreak investigations in the United States has been on comprehensive testing, contact tracing, and the establishment of surveillance systems. According to the Centres for Disease Control and Prevention (CDC, 2021a), the COVID-19 Data Tracker offers up-to-date information on the number of cases, testing rates, and hospitalisations. This resource allows decision-makers to closely monitor the progression of the outbreak and efficiently distribute resources.

The United States has placed significant importance on the development and dissemination of COVID-19 vaccines as a crucial aspect of managing the outbreak. The Advisory Committee on Immunisation Practises (ACIP) of the Centres for Disease Control and Prevention (CDC) offers guidance regarding the prioritisation and distribution strategies for vaccines, thereby facilitating a well-coordinated and fair vaccination campaign (Centres for Disease Control and Prevention, 2021b).

A Comparative Analysis and Identification of Key Factors

The outbreak investigations conducted in the United Kingdom, Europe, and the United States during the COVID-19 pandemic have revealed both commonalities and distinctions. Common elements encompass the utilisation of case surveillance, testing strategies, contact tracing, and public health communication. All regions have placed emphasis on the prompt identification of cases, implementation of isolation protocols, and enforcement of quarantine measures in order to mitigate the transmission of the virus.

The COVID-19 context is characterised by several key factors that exert influence on outbreak investigations. These factors encompass governance structures, mechanisms for information sharing, and the allocation of resources. The presence of contrasting governance structures, characterised by the UK's centralised approach and the USA's utilisation of a federal system, has resulted in divergent approaches to decision-making and response strategies. The utilisation of information sharing mechanisms, such as periodic public briefings and digital dashboards, has played a pivotal role in ensuring the public remains well-informed and actively involved across various geographical areas.

The allocation of resources has been a crucial factor in the conduct of outbreak investigations, considering the diverse levels of healthcare infrastructure, laboratory capabilities, and vaccine distribution systems across the United Kingdom, Europe, and the United States of America.

Several factors have exerted an influence on the testing capabilities, efficiency of contact tracing, and strategies for vaccine rollout.

The COVID-19 pandemic has witnessed outbreak investigations in the United Kingdom, Europe, and the United States, revealing notable parallels in fundamental approaches such as testing, contact tracing, and public health communication. Although there are variations in governance structures, information sharing mechanisms, and resource allocation, all regions have prioritised the prompt identification, containment, and prevention of Covid-19 transmission.

Chapter 9: Conclusion

9.1 The Future of Public Health and Infectious Diseases: A Path Forward

The discipline of public health is in a constant state of evolution as it endeavours to confront the intricate challenges presented by infectious diseases. As society continues to confront the ongoing COVID-19 pandemic and extract valuable insights from previous outbreaks, it is imperative to contemplate the trajectory of public health and proactively anticipate forthcoming transformations.

Advancements in surveillance and data analytics have emerged as significant developments in contemporary society. These technological advancements have revolutionised the way information is collected, processed, and analysed, enabling organisations and governments to enhance their monitoring capabilities and gain valuable insights from vast amounts of data.

The field of public health is expected to experience notable progress in the coming years, particularly in the areas of surveillance systems and data analytics. The enhanced accessibility of digital technologies will contribute to the improved efficacy of real-time disease monitoring, facilitating the timely identification of outbreaks and the implementation of more precise response strategies. The incorporation of diverse data sources, such as electronic health records, wearable devices, social media, and environmental data, will augment the capacity to identify patterns and forecast the dissemination of diseases. The utilisation of artificial intelligence and machine learning algorithms will have a significant impact on the analysis of extensive datasets, the identification of patterns, and the provision of practical insights to inform decision-making in the field of public health.

The One Health approach, which acknowledges the interdependence of human, animal, and environmental health, is expected to gain increased prominence in the coming years. This approach places significant emphasis on fostering interdisciplinary collaboration among professionals in the fields of public health, veterinary medicine, ecology, and other pertinent stakeholders. The One Health approach facilitates the recognition and management of emerging infectious diseases at the interface of animals, humans, and the environment by embracing a comprehensive viewpoint. The establishment of this collaboration will play a pivotal role in mitigating the occurrence of zoonotic disease spillover, tackling the issue of antimicrobial resistance, and executing efficient strategies for ecosystem management.

Not least forgetting, vaccinations are expected to maintain their crucial significance in shaping the trajectory of public health and combatting infectious diseases in the foreseeable future. The advancement of innovative vaccine technologies, such as mRNA vaccines and vector-based platforms, has the potential to significantly transform the process of vaccine development and distribution. These technologies exhibit potential in facilitating quicker responses to emerging pathogens and the development of universal vaccines capable of targeting multiple strains. Furthermore, the improvement of vaccine distribution systems, effective cold chain management, and the implementation of strategies to address vaccine hesitancy are expected to contribute to the enhancement of global immunisation coverage.

Similarly, the significance of global pandemic preparedness and response has been highlighted by the COVID-19 pandemic. In the forthcoming era, the field of public health will place significant emphasis on the development and implementation of resilient surveillance systems, timely alert systems, and efficient global collaboration. It is imperative to emphasise the

significance of collaborative endeavours aimed at bolstering health systems, enhancing laboratory capacity, and fortifying emergency response frameworks. Public health agencies are expected to allocate resources towards proactive research, the accumulation of vaccine reserves, and the advancement of antiviral therapeutics in order to effectively, and promptly address forthcoming pandemics. Furthermore, the establishment of strategic alliances with industry, academia, and community organisations will serve to augment the adaptability and robustness of public health systems.

The concept of health equity and its relationship with social determinants of health has garnered significant attention in academic discourse. The notion of health equity refers to the absence of disparities in health outcomes among different population groups, particularly those that are socially disadvantaged.

The future of public health will be significantly influenced by the imperative of addressing health equity and the impact of social determinants on health outcomes. The prioritisation of initiatives aimed at mitigating health disparities, enhancing health literacy, and guaranteeing equitable access to high-quality healthcare services across all populations will be emphasised. The acknowledgment of systemic disparities and the incorporation of social justice principles into public health policies and interventions will inform the process of decision-making. The promotion of community engagement and empowerment will be prioritised, with a specific emphasis on employing participatory methodologies that actively involve marginalised communities in the design and implementation of public health interventions.

To conclude, the potential for significant advancements in the field of public health and infectious diseases is highly promising. By leveraging advancements in surveillance techniques, fostering interdisciplinary collaboration, harnessing vaccine technologies, enhancing pandemic preparedness, promoting health equity, and addressing social determinants, it is possible to envision a future in which the impact of infectious diseases is minimised and the overall global health and well-being are protected.

Declaration of interests

I declare no competing interests.

Data sharing

No raw data was collected as part of this study.

Acknowledgements

None.

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