Funded by Wellcome

Standards for Official Statistics on Climate-Health Interactions (SOSCHI)

Airborne diseases (cerebrospinal meningitis): introduction

Alpha Phase document

Publication date: 12 November 2024

We welcome users' views and expertise on the alpha version of the statistical framework to further develop our work. Please email us at climate.health@ons.gov.uk.

Contents

Introduction to the SOSCHI project

The impacts on health of rising temperatures, wildfires, extreme weather events and other direct and indirect effects of climate change are a major global concern. The most significant hazards and their impacts differ between countries and regions, as do the possibilities and priorities for climate change adaptation. National and local governments and other stakeholders need to have regular, reliable and comparable data to monitor climate impacts and inform adaptation strategies, based on a transparent and globally generalisable statistical framework. The SOSCHI project, led by the UK Office for National Statistics and funded by the Wellcome, is developing a framework of indicators based on state-of-the-art statistical methods to measure climate-related health risks. To support global reporting and monitoring, we are also developing a knowledge-sharing platform, open-source tools, and R code. Our findings will also help highlight data gaps and help set the agenda for future improvement of data sources and methods.

Project partners

African Institute for Mathematical Sciences, Kigali, Rwanda
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Office for National Statistics, Newport, United Kingdom
Regional Institute for Population Studies, University of Ghana, Accra, Ghana
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The project is supported by Wellcome grant no. 224682/Z/21/Z

Document information

Document title	Standards for Official Statistics on Climate-Health Interactions (SOSCHI): Airborne disease (cerebrospinal meningitis): introduction
Document location	Zenodo: https://zenodo.org/communities/soschi
Date and version	12 November 2024 - published version 1.0
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DOI	10.5281/zenodo.14051848
Preferred citation	Twerefou DK, Wak G, Afful-Dadzie E. Standards for Official Statistics on Climate-Health Interactions (SOSCHI): Airborne disease (cerebrospinal meningitis): introduction. Zenodo; 2024. doi: 10.5281/zenodo.14051848.
Related topic documents	Methods: in progress Metadata: in progress
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Important notes

This document has been published as part of the alpha version of the SOSCHI statistical framework. Therefore, this should be read as a draft document, which does not necessarily represent the final state of the framework. We welcome users' views and expertise to further develop our work.

Please email us at climate.health@ons.gov.uk.

Abbreviations

C	CSM	Cerebrospinal Meningitis
F	FAO	Food and Agricultural Organization
G	GHS	Ghana Health Service
	GMeT	Ghana Meteorological Agency
	GWIS	Global Wildlife Information System
M	MoH	Ministry of Health
P	PM 2.5	Particulate Matter 2.5
W	WHO	World Health Organization

1. Acknowledgments

We are immensely grateful to individuals and institutions for their diverse contributions and guidance to the preparation of this document. We appreciate the Ghana Meteorological Agency (GMeT), Ghana Ministry of Health (MoH), Ghana Health Service (GHS) and the Tamale Reference Laboratory of the GHS for their support in providing access to climate and health data on Ghana**.**

We would also like to extend our profound appreciation to the Members of the Steering Committee including; Bernice Serwah Ofosu-Baadu (Ghana Statistical Service), Wisdom Atiwoto (MoH), Emmanuel Kyeremanteng (United Nations International Children's Emergency Fund, Ghana Office), Samuel Owusu Ansah (GMeT), Charlotte Norman (Ghana National Disaster Management Organization), Winfred A. Nelson (Ghana National Development Planning Commission), Antwi-Boasiako Amoah (Ghana Environmental Protection Agency) and William Barnes **(**UK Office for National Statistics**)** for their insightful contribution and guidance.

Our sincere thanks also go to the members of our Expert Advisory Group and Professor Andy Haines (Expert Advisory Group Chair) who provided broad expertise in climate and health which helped to inform the decisions made for this topic and the broader SOSCHI project.

2. Airborne disease (cerebrospinal meningitis) & climate change

2.1 Definition and scope

Climate change has profound impacts on health, particularly through extreme temperature variations. Both heatwaves and cold spells are becoming more intense and frequent due to global warming, leading to a range of health issues. Prolonged exposure to high temperatures can cause heat stress, heat exhaustion, and heat stroke[1,2], which are particularly dangerous for vulnerable populations such as the elderly, children, and those with preexisting health conditions[3]. Recent research[4] estimates that between 2000 and 2016, the number of people exposed to heatwaves increased by about 125 million, leading to a surge in heat-related illnesses and mortality. For example, in the United States of America, heat-related mortality increased from 297 in 2004 to 1,600 in 2021, indicating an average annual growth of about 27.5%[5].

Climate change can impact several airborne diseases such as tuberculosis, pneumonia[6], influenza, Cerebrospinal Meningitis (CSM), and valley fever (coccidioidomycosis)[7]. While airborne diseases such as tuberculosis, pneumonia, influenza, and valley fever are serious public health concerns, CSM warrants special attention in the context of climate change due to its unique relationship with environmental conditions like drought, dust, and temperature rise. The disease's epidemic nature, high mortality, and vulnerability of affected populations make it more susceptible to climate-driven spikes. Also, CSM causes significant long-term disability if not treated promptly and remains a public health emergency during outbreaks, especially in Africa's *Meningitis Belt*[7]. Consequently, the focus of this topic area is on CSM. In regions with low CSM cases, the methods developed for this topic could be used to estimate the impact of climate change on the health impacts of airborne diseases prevalent in those regions.

CSM is an infectious airborne disease, which is caused by the Neisseria meningitides bacterium[8] and transmitted from one person to another through droplets from the throat or respiratory secretion[9]. The bacteria causes inflammation of the protective membrane of the brain and spinal cord, known as meninges[10]. The inflammation obstructs the normal flow of blood and oxygen to the brain, which then leads to the disease[11]. The disease is predominant in the African Meningitis Belt, a region that consists of 26 countries and stretches from Senegal in West Africa to Ethiopia in the East[12].

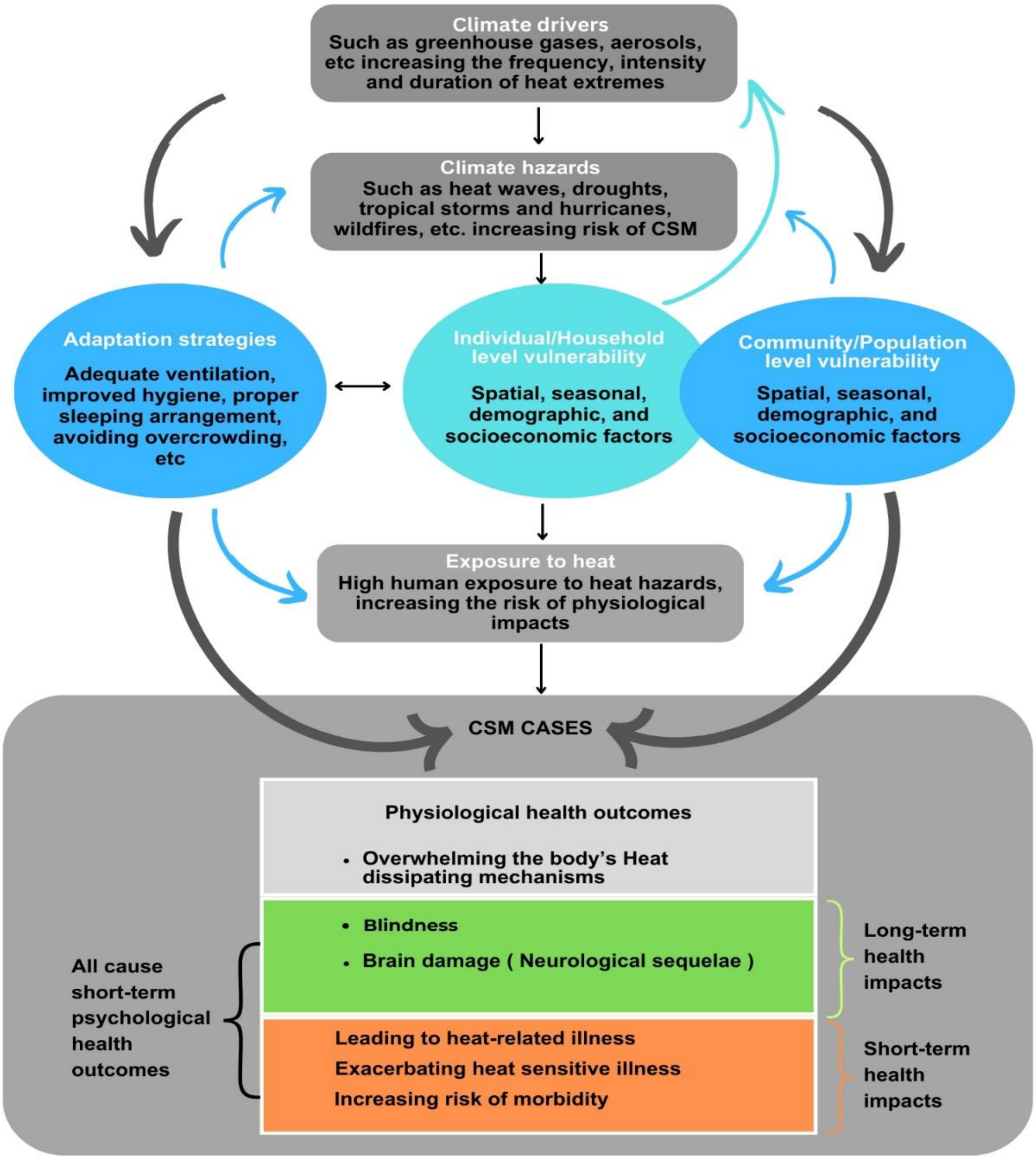
Analysis of the impact of climate change on CSM is imperative as it will help improve public health preparedness by enhancing early warning systems and guiding vaccine distribution, especially in resource-limited settings where CSM outbreaks can have devastating consequences. Accurate models incorporating climate variables can help anticipate changes in disease patterns, enabling timely intervention and resource allocation. It will also enable policymakers to know the changes in the distribution of climatic conditions that are potentially expanding or shifting the meningitis belt, as well as supporting the development of effective adaptation and mitigation strategies. This is also in tandem with the implementation of Sustainable Development Goals: Targets 13.1[13]; Paris Agreement: Article 7, 8, 13.8[14]; Sendai Framework: Targets A, B[15]; United Nations Global Set: Similar indicator - 45 Incidence of heat- and cold-related illnesses or excess mortality[16]; and the Lancet Countdown: Similar indicator – 1.1.5 heat-related mortality[17].

2.2 Impact pathway

A major risk factor of CSM is high temperatures and low humidity. The disease is predominant in the African Meningitis Belt, a region that consists of 26 countries and stretches from Senegal in West Africa to Ethiopia in the East[12]. The area along the belt is associated with relatively higher temperatures and low humidity compared with other areas in Africa. This, therefore, makes the areas within the belt endemic to CSM. By far, the highest incidence of global CSM occurs in Africa, with rates up to 1000 cases per 100,000 of the population (1%). Other regions of the world also experience CSM cases, but at low rates. For instance, in the Americas, reported incidence of CSM ranges between 0.3-4 cases per 100,000 of the population, while in the European region, an incident rate of between 0.2-14 per 100,000 of the population is recorded[18].

Existing studies[19-20] highlight many complex pathways by which temperature exposure interacts with temperature-sensitive physiological mechanisms that, in turn, affect health. **Error! Reference source not found.** describes a simplified high-level pathway of the impact of heat exposure on CSM and health.

Figure 1: Impact pathway between climate change and CSM



As indicated in Figure 1, drivers of climate change increase the frequency, intensity and duration of heat extremes, which in turn increases the risk of CSM. Conditions that facilitate the transmission of bacteria include higher temperatures; overcrowding in sleeping arrangements, marketplaces, funeral grounds, sporting grounds and classrooms; and poor ventilation, sanitation and nutrition[21]. High temperatures make the environment drier and reduce humidity levels, thereby facilitating the movement of the bacteria within the environment and from person to person. Also, higher ambient temperature leads to higher body temperature which also leads to the expansion of the cerebral membrane. This limits blood flow to the brain, thus causing meningitis.

The magnitude and pattern of risk associated with CSM is influenced by spatial, geographical, seasonal, demographic, socioeconomic and other factors, suggesting that population vulnerability may vary based on these characteristics. In terms of geographical factors, people living in areas that are located within the Meningitis Belt tend to have a higher risk compared to those who live in the periphery or outside the belt[21]. The occurrence of CSM is seasonal, where outbreaks occur during the hot dry season, coinciding between the period of December and March[22]. During this time, weather conditions are harsh, with dusty winds and high temperatures that promote the spread of the disease within the population[21]. Demographic characteristics, particularly age, are an important risk factor of CSM. Specifically, children under five years of age, teenagers, young adults (16-25 years), pregnant women and older adults (55+ years) are at higher risk of contracting the disease. Also, individuals with underlying medical conditions and weak immune systems, irrespective of age, are more susceptible to the disease[23]. In terms of sex, several studies have found no significant difference between males and females regarding the risk associated with CSM[24].

Adaptation refers to any form of adjustments in ecological, social, and economic systems in preparation for expected or actual climate stimuli and their effect, which moderates harm or exploits beneficial opportunities[25]. Anticipatory adaptation methods refer to actions taken in advance of climate change impacts, based on forecasts or risk assessments. Reactive adaptation methods refer to actions taken in response to the impacts of climate change after they have already occurred, to mitigate and adapt to the effects of high temperatures and other climate risks[9]. These adaptation measures can be undertaken at the community/ population level or at the household/ individual level.

At the community/ population level, an important anticipatory adaptation measure to mitigate against CSM is pre-season preparedness when the outbreak season is approaching. Some of these measures include health education on measures to avoid contracting the disease and vaccination against the disease. An important population-level anticipatory adaptation measure is efficient surveillance systems for early detection of the disease. This allows for appropriate measures to be put in place before the onset of the disease outbreak. At the population level, vulnerable people including children, young and older adults, pregnant women, individuals with underlying medical conditions and weak immune systems, should be provided with adequate protection before the outbreak season. Creation of open spaces within communities where people can relax is also an important adaptation measure to minimize the impact of CSM.

During the outbreak season, reactive adaptation measures to mitigate against CSM should include, avoiding overcrowding at gatherings such as stadia, funeral grounds, entertainment centres, classrooms, churches, and mosques. Continued health education during the outbreak is an important adaptation measure that needs to be carried out by the health system and other relevant institutions and agencies. As a long-term measure, community housing systems should encourage heat-absorbing buildings, with adequate ventilation that moderates indoor temperatures. Also, buildings should be spaced at a reasonable distance from each other. At the household level, because the disease is airborne and transmitted from one person to the other, avoiding overcrowding in houses is imperative as it facilitates the spread of the disease. At the same time, sleeping close to each other spreads the disease faster and should be avoided. Reducing body temperature requires frequent bathing and wearing light clothing. Good nutrition also provides some protective mechanisms against the acquisition of the disease. To accomplish these requires some level of socioeconomic status. Government, through its agencies, can support vulnerable and poor households and individuals to have the necessary protection.

3. Health impacts

The health impact of CSM is well-documented[10]. The disease can either be acute or chronic. In the acute form of CSM, onset is within hours of exposure and lasts for a few days[26,27]. On the other hand, chronic meningitis lasts for one month or more. Other related ill-health due to CSM includes high fever, vomiting, headaches, and a stiff neck.

Globally, about 3.29 million cases of CSM were recorded in 1990. The cases reduced to 2.51 million cases in 2019, out of which 1.28 million were children less than 5 years[28]. Global meningitis incidence rate in 1990 was 55.3 per 100,000 and by 2019 the rate had reduced to 35.4 per 100,000. By 2021, the incidence rate had further declined to 28.7 per 100,000[28]. With respect to the African Region, CSM incidence rate was highest in western Sub-Saharan Africa (most of which lies in the meningitis belt), with a rate of about 198.8 per 100,000 in 1990, which declined to 106 per 100,000 in 2019. The Eastern part of the sub-region (most of which lie within the meningitis belt), had the next highest rate, with 171.7 in 1990 per 100,000. This reduced to 95 per 100,000 in 2019[29]. Meanwhile, according to data from "Our World in Data", the incidence rate for meningitis for the whole of Africa was 244 per 100,000 in 1990, but reduced to a low of 90.3 per 100,000 in 2021[29].Within the meningitis belt, disease prevalence can reach 1000 cases per 100,000 population (1%)[29].

Regions outside of Africa also experience CSM cases, but at very low rates. For instance, in the Americas, incidence of CSM ranges from 0.3-4 cases per 100,000 population, while in Europe an incident rate of between 0.2-14 per 100,000 population is recorded[18].

CSM can be deadly if not treated on time[30]. Case fatality can reach as high as 70%[30]. Apart from death resulting from CSM, about 20% of individuals who survive the disease may suffer long-term health consequences, such as brain damage, sight problems, hearing loss, speech problems, and paralysis[31,32]. The health impact of CSM affects all ages, but children under the age of five years have the highest risk of contracting the disease[30].

4. Framework indicators

4.1 Headline outcome indicators

Within the timeline of this project, we have the scope to develop one headline indicator for this framework. This indicator has been selected because it can provide regular, reliable, and comparable data to monitor climate-related health impacts using state-of-the-art statistical methods. Within this topic, the priority indicator is:

- **A1**: Confirmed CSM morbidity cases attributed to high temperatures[i]

This indicator is monthly confirmed morbidity cases of CSM. The data in many cases would be at the national level and can be disaggregated into regional or sub-regional levels. This indicator was chosen because there is a direct positive correlation between CSM and non-optimal high temperature (exposure). Also, temperature data is collected in many countries. Other exposures such as wildfires and droughts also impacted CSM cases. However, it is very difficult to accurately measure these exposures.

4.2 Supplementary outcome indicators

In addition to the above headline indicator, a number of other health outcome indicators of CSM were identified during the refinement of this topic. We outline the potential and limitations of these indicators here. The development of these indicators is not within the scope of this framework.

- Confirmed CSM mortality cases attributed to high temperatures

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[i] Temporary indicator numbers have been assigned for reference during the development of the SOSCHI framework and will change in the final version.

- Confirmed CSM morbidity cases attributed to extreme weather events
- Confirmed CSM mortality cases attributed to extreme weather events

The two key exposures related to extreme weather events are wildfires and drought. Wildfires have become a significant and growing environmental concern worldwide, impacting ecosystems and human health. For example, in 2023, Canada experienced its worst wildfire, burning about 7.8 million hectares and releasing around 3 billion tons of carbon dioxide into the atmosphere. Similarly, Russia lost about 5.4 million hectares in 2021 to wildfires, resulting in significant pollution and billions of dollars in damages[33,34].

The relationship between wildfires and CSM is less direct, but impactful. Wildfires exacerbate air pollution by releasing fine Particulate Matter (PM2.5), which can irritate respiratory systems and increase the risk of bacterial infections. In regions prone to CSM outbreaks, like the African meningitis belt, climate change is making conditions drier, hotter, and dustier. This facilitates the spread of CSM. The dry and dusty Harmattan winds, which are becoming more intense due to climate shifts combined with poor sanitation and crowded living conditions, increase the risk of respiratory issues and make CSM outbreaks more likely in vulnerable populations. Overall, increasing wildfires are leading to ecosystem degradation, increased carbon emissions, and health risks like CSM due to worsening air quality and climatic shifts[34].

The occurrence of droughts is becoming frequent and severe across different regions, having a significant impact on ecosystems, agriculture and human health[35,36]. Droughts affect more than 55 million people each year globally and climate change will exacerbate the frequency of droughts in all regions[35,36]. Largely as a result of poor adaptive capacity, Africa is particularly vulnerable, with regions like the Sahel frequently experiencing severe droughts, which affect both water availability and food security[37].

Like wildfires, the impact of drought on CSM is not direct but has the potential to exacerbate public health crises, including CSM. This is especially the case in the *Meningitis Belt* of sub-Saharan Africa, where conditions associated with droughts are linked to increased transmission of the disease. Dusty and dry air that irritates the mucosal surfaces of the respiratory system, together with water shortages during droughts, may lead to overcrowded conditions and poor sanitation, which can further spread diseases like meningitis[37].

4.3 Other relevant measures

Here we signpost other relevant measures that could be considered as part of future analysis within this topic. The development of these indicators is not within the scope of this framework. These include measurements of exposure and adaption and are outlined below:

- Person days exposed to high temperatures
- Health surveillance
- Early warning systems at national, regional and sub-regional levels
- Health sector response plans at national, regional and sub-regional levels
- Vaccination against CSM
- Intake of nutritious diet (which builds immunity to fight CSM)
- Green spaces available

The development of these exposure and adaptation-related indicators is imperative as exposure to CSM can result in a range of effects, from acute and severe illness to long-term neurological and physical damage. Though timely intervention can improve outcomes, the risk of severe complications remains high, posing a significant challenge to the public health system. Adaptation to CSM through vaccination, education and behavioral changes is crucial for reducing the prevalence of CSM.

5. Proposed beta phase developments

The beta phase will see the development of the headline indicator described above, focusing on data requirements, methods, and limitations. Specifically, there will be further methods development of the recommended indicator on confirmed CSM morbidity cases attributed to non-optimal high temperatures. This will include optional meta-analysis and calculation of attributable numbers and rates. Data templates and code will also be completed.

6. Comparison to existing frameworks and statistics

A literature review of climate-health-related frameworks and statistics identified indicators relevant to this topic area. These have been presented in Table 1.

Table 1: Indicators linked to CSM identified from existing climate-health related frameworks and statistics

Indicator	Measures	Source
Incidence Rates: The number of new CSM cases per 100,000 population within a given time period	Outcome	World Health Organization (WHO)

Mortality Rates: The number of deaths caused by CSM per 100,000 population	Outcome	WHO
Case Fatality Ratio: The percentage of individuals diagnosed with CSM who die from the disease	Outcome	WHO
Vaccination Coverage: The percentage of the population covered by CSM vaccines	Outcome	WHO
Burned Area: The total area (in hectares or square kilometers) affected by wildfires	Outcome	Global Wildfire Information System (GWIS)
Fire Incidents: The number of individual wildfire events recorded over a specific time period		GWIS
Population Exposure: The number of people living in areas affected by or at risk of wildfires	Exposure	GWIS
Drought Intensity and Duration: The length and severity of a drought event in specific regions	Exposure	World Meteorological Organization
Socioeconomic Drought Impact: Indicators measuring the effect of drought on agricultural productivity, food prices, and water supply	Exposure	Food and Agriculture Organization (FAO)
Drought Vulnerability and Exposure: An indicator of the number of people or assets at risk due to drought	Exposure/ Vulnerability	FAO

7. Further reading

- Wellcome. The human cost of climate change: Health is needed for accelerated and equitable climate actions [Internet]. Available from: https://cms.wellcome.org/sites/default/files/2023-11/cop-28-human-cost-of-climate-change-report.pdf
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