Applicant: [Applicant name redacted]
Proposed PhD Project Proposal: Climate change and health in Brazil: Investigating the impacts of extreme rainfall and drought
Route: 1+4

Route Of Choice

I am applying for the 1+4 pathway with an MSc in Health Data Science at LSHTM. The master's course will build on my [deleted] degree, healthcare experience and knowledge of health data management, including the use of [database name deleted] for analysis of medical data and development of technical reports. It will also extend the statistical skills and epidemiology knowledge I gained through my [programme deleted] at [institution deleted]. More importantly, the MSc offers the formal training I require on big data and statistical modelling to adapt and develop research models for the PhD project.

Introduction

Anthropogenic climate change is a pressing global challenge with far-reaching implications for human health. The impact of climate change on human health is multifaceted, encompassing both direct and indirect causal pathways, and often disproportionately affecting populations experiencing social disadvantages. Extreme climatic events, such as extreme rainfall or droughts, have been identified as significant contributors to the health burden associated with climate change. These events can lead to a range of climate-sensitive diseases. Reviews suggest that drought events are associated with the increase of cardiovascular and upper respiratory diseases, diarrheal illness, mental health and malnutrition. Floods have been related to a 50% increase in mortality in the first-year post-flood, and an increased risk of food- and water-borne diseases outbreaks, such as dysentery and cholera.

The relationship between extreme precipitation events and human health is a complex and critical area of study, particularly in low- and middle-income countries where vulnerable populations, with a lower baseline health status, are at heightened risk[2] due to their lack of resources to adapt to weather extremes.

Understanding the specific health-related impacts of extreme precipitation events, such as extreme rainfall, drought and flooding, within these contexts is essential for informing targeted public health interventions and policies[3], such as investment in robust health monitoring and surveillance or WASH awareness-raising campaigns. Moreover, the influence of socioeconomic factors on the association between extreme precipitation events and health outcomes necessitates comprehensive research to address the underlying health disparities[4].

By focusing on Brazil, the study will take advantage of a large sample size, with a powerful source of sociodemographic information linked to nationwide mortality data. It will address the urgent need to fill critical gaps in our understanding of the impact of extreme precipitation events, ultimately contributing to the broader global efforts to address the health impacts of climate change, particularly on vulnerable population.

Methods

The methodology for this research will involve a mixed-method approach and can be structured into three phases.

Phase I: Evidence synthesis

Conceptual models are developed in epidemiology to try and understand how variables interact with each other, as well as to explain key concepts and presumed relationships.

Therefore, this phase will aim to create a conceptual framework that descriptively links climate change-related precipitation hazards, adaptation responses, mitigation and health outcomes while meticulously accounting for socioeconomic factors. This will involve a rigorous search strategy, inclusion and exclusion criteria, and quality assessment of the identified studies.
Databases, such as Medline (Ovid), will be searched using MeSH terms to comprehensively examine existing literature. The study will focus on all-cause- and cause-specific mortality as the outcome measures for climate change impacts since mortality is an indication of risk and severity of the exposure**.** It will also concentrate on literature examining populations in low and middle-income countries.

The quality of the evidence will be assessed using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach. The statistical analysis will include meta-analyses if feasible, to quantitatively synthesise the findings from the selected studies. For each relationship between climate precipitation hazards and mortality, the Harvard Cancer Risk Index (also applicable to non-cancer outcomes) will be used to determine the strength of the association between variables based on the range of Relative Risk or Odds Ratio reported in the reviews or individual studies. The strength of association will provide a robust evidence base for use in mediation analysis.

Phase II: Epidemiological analysis

The study will utilize ecological precipitation data from the CIDACS Climate and Environmental Platform (CIDACS-Clima) and individual-level socioeconomic and health data from the CIDACS 100 Million Brazilian Cohort to achieve its objectives in phase II and III.

CIDACS cohort data will be linked to the Mortality Information System (SIM) dataset to evaluate the mortality outcomes according to the International Classification of Diseases – ICD-10. Cause-specific mortality outcomes will be selected based on a) findings from the Evidence Synthesis in phase I; b) the availability and reliability of data in SIM; and c) relevance to social policies to be analysed in phase III. In addition, I will evaluate the linkage quality of the linked data between the cohort baseline and mortality to identify potential sources of bias.

Considering the huge variation in precipitation levels across regions/biomes in Brazil, and that each location has its own set of mortality data, the dataset will need to be clustered to account for the hierarchical structure of the data**.**

Analysis of association

To assess the exposure-outcome association between extreme precipitation events and mortality patterns, I consider a distributed lag model to be appropriate, based on the method developed by Baek[5]. This model will explore the dynamic nature of the relationship between extreme precipitation levels (exposure) on mortality (outcome) over time at the regional level, while accounting for potential confounders such as age, gender, and socioeconomic status (e.g., educational level). For example, the shortage of clean water during extreme drought may result in a reduction in water availability for drinking needs resulting in increased exposure to enteric pathogens causing an increase in child mortality. For this study, I propose focusing on extreme drought (SPEI ≤ -1.6), which will be measured using the Standardized Precipitation Evapotranspiration Index (SPEI), using timescales of 6- and 12-months from the period starting 2011, at spatial resolution of 0.1^{o} (10 x 10km). The precipitation data will be extracted from the ERA5-Land and Brazilian Daily Weather Gridded

databases. These assumptions will be tested as different categories of drought severity, timescales and geographic resolutions may be more appropriate.

Mediation analysis

To explore the mediating role of socioeconomic factors in the association between extreme precipitation events and mortality, mediation analysis will be conducted. This will involve testing the indirect effects of extreme precipitation events on mortality through potential socioeconomic mediators (confounders), using established mediation analysis techniques such as the Baron and Kenny method or structural equation modelling. For example, examining further the significance of extreme drought on different high-risk subgroups, such as pregnant women.

Phase III: Policy evaluation

The study will also incorporate a policy evaluation component to assess the impact of the Cisternas (Wells) social protection policy on all-cause and cause-specific mortality during and after extreme precipitation events. This would involve a quasi-experimental design to compare mortality outcomes in areas with and without the implementation of the policy. This will provide insights into the effectiveness of the policy in mitigating health impacts and of climate change adaptation in protecting human health from the negative consequences of extreme precipitation events.

The design of the method for this phase may require adjustment in consideration of the following:

- Regional differences in precipitation levels across Brazil, where the policy was implemented or not, may make comparison unreliable between regions.
- Whether a baseline of CIDACS data created before the implementation of Cisternas exists to enable before-and-after comparison within regions.

In addition, Brazil's Cisterna program is only offered to semiarid regions and therefore may not generalise well to the full Brazilian study cohort. As a result, other social programs are worth considering, such as the Programa Bolsa Família, a conditional cash transfer program, which is a larger and broader socioeconomic programme.

Previous Experience and Future Work

Through my experience working as [prior employment deleted], I have knowledge of the Brazilian public health system (SUS), engagement with low-income communities experiencing infectious disease and chronic illness, and access and use of [deleted]. This provides a useful perspective on health issues and public health systems in Brazil. In addition, my [deleted] background will help when linking the cause of mortality with precipitation changes as well as controlling for confounders.

Currently, I am engaged in [deleted] at [deleted], which provides me with the confidence to conduct systematic reviews and assess the quality of a body of evidence, specifically using the GRADE approach which will be used in phase I of this study.

The statistical analysis for this study phases II and III will be conducted using appropriate software, such as R or STATA, and will adhere to best practices in statistical methodology to ensure the robustness and validity of the study findings. I am interested in these techniques and have been undertaking self-paced online learning in R Studio. Furthermore, the MSc in

Health Data offers the formal training I require on technical aspects (programming, machine learning) to complete the project.

Finally, I am deeply committed to working on meaningful and impactful research into the risks associated with climate change on public health. In five years', I see myself working as [delete] with the goal of [delete]. I wish to become a strong voice to fight against the current climate crisis, change policies and practices and co-develop solutions to help vulnerable communities adapt to climate and health challenges. I would also advocate for the integration of the planetary health curriculum into medical studies.

References

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3. Wang P, Asare E, Pitzer VE, Dubrow R, Chen K. Associations between long-term drought and diarrhea among children under five in low- and middle-income countries. *Nat Commun*. 2022;13(1):3661. doi:10.1038/s41467-022-31291-7
4. Hartinger SM, Yglesias-González M, Blanco-Villafuerte L, et al. The 2022 South America report of The Lancet Countdown on health and climate change: trust the science. Now that we know, we must act. *Lancet Reg Health - Am*. 2023;20:100470. doi:10.1016/j.lana.2023.100470
5. Baek J, Sánchez BN, Berrocal VJ, Sanchez-Vaznaugh EV. Distributed Lag Models: Examining Associations Between the Built Environment and Health. *Epidemiology*. 2016;27(1):116-124.

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