EDITORIAL

Considering the complexity of medical geology when evaluating relationships between geological risks and health outcomes

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ABSTRACT

Medical geology studies the connections between specific geological exposure and disease. characteristics and the development of a variety of health problems, such as long-term arsenic exposure Skin conditions and cancers can be caused by contaminants in drinking water. While these relationships exist, some examples are well characterized, while others lack understanding of the specific geological component triggering disease onset, necessitating further research. Objectives: The purpose of this paper is to highlight several important complexities in geological exposures and the development of related diseases that can complicate the linkage of exposure and health outcome data. Several approaches to dealing with these complexities are also proposed. Many diseases associated with geological hazards have long-term exposure and long latent periods.

When combined with long- or short-distance migrations over an individual's life, daily or weekly movement patterns, and small-scale spatial heterogeneity in geological characteristics, assigning exposure measurements to individuals becomes difficult. Supplementary methods, such as questionnaires, movement diaries, or GPS trackers, can aid medical geology studies by providing evidence for the most appropriate exposure measurement locations. Conclusions: Because of the complex and lengthy exposure-response pathways involved, as well as small-distance spatial heterogeneity in environmental components, interdisciplinary approaches to medical geology studies are required to provide robust evidence

Key Words: *Arsenic-contaminated water; Podoconiosis; Geological hazards*

INTRODUCTION

The geological features of the earth's surface can have a direct impact on human health through the ingestion, inhalation, or absorption of specific elements or compounds derived from naturally occurring materials [1,2]. However, the extent to which we understand the relationship between exposure and health outcomes varies significantly across geological hazards in the environment. For example, the link between arsenic-contaminated water and food supplies and the development of skin conditions and a variety of cancers is well established [3,4]. However, while a link has been established between specific soil types and the development of podoconiosis (non-infectious elephantiasis), the specific components within the soil that may trigger the onset of podoconiosis have yet to be identified [5]. When considering the gaps in our understanding of geological hazards, there are a number of critical issues that must be addressed in order to investigate the relationship between the environment and human health, most notably the compatibility between data collected to determine potential hazards in the environment and data collected to estimate disease occurrence. Using statistical methods to link epidemiological data with geological characterizations can improve understanding of the etiologies of environmental diseases, but this is not an easy link to make. Using a variety of medical geology examples, this paper aims to highlight several important complexities that must be considered in research examining the relationships between geological hazards and health outcomes. A variety of methodological approaches are discussed and evaluated in order to address these complexities in future research.

DISCUSSION

Characterizing geological variable heterogeneity

A geological survey's goal is to map variability across a specific domain

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(sample area), resulting in a distribution of a variable or variables in space and time. A robust sample plan for the survey will, in essence, reflect the purpose of the investigation, such as whether the map is to make local predictions across the domain, detect the presence/absence of specific components within the domain, or monitor whether the situation has changed over time (and space). When considering the vast number of exposure scenarios possible in the environment, within various environmental domains (e.g., air, soil/food, and water) and via various routes (ingestion, absorption, and inhalation), a broader perspective may be required to identify the study area's characteristics.

The traditional approach to map soil within a domain is to conduct a survey and collect soil samples for analysis, either in the field or in the laboratory, but sampling strategies are often defined by practical limitations such as funding constraints or logistical impracticalities. Geo-statistical modelling methods (with or without the use of covariates), such as Kriging (a method for spatial interpolation), can be applied to investigate spatial variation in observations across the domain of interest, and importantly, to make use of this variation (spatial autocorrelation) to provide accurate spatial predictions at unsampled locations. The distribution of soils will be determined by various environmental (e.g., parent rock type, climate, hydrology etc.) and anthropogenic (e.g., farming activities, pollution sources etc.) factors occurring at different spatial and temporal scales. In terms of spatial variation, targeted sampling is often compulsory due to the high cost of sample collection and analysis. If soil in the sampling area is highly variable (heterogeneous), the time needed to sample and costs of analyses will be high in order to obtain a sufficient spatial resolution to capture the variability [6].

Identifying health outcome heterogeneity

Epidemiological data can be classified as either primary (created for the specific research purpose for which they are being used) or secondary (created for a purpose other than the one for which they are being used, such as routine surveillance systems or previous epidemiological studies) [7,8]. Both the underlying population distribution and, consequently, the distribution of health outcomes are spatially heterogeneous, as are potential geological hazards. When considering the health effects of geological exposures, it is clear that spatial heterogeneity must be considered; thus, epidemiological data should have spatial attributes [9,10].

Routine surveillance data will frequently include information on the administrative area in which individuals live, allowing for aggregated analysis. Cases are assigned to specific administrative areas, and maps are displayed. of case counts, or in conjunction with population data (e.g., census data) information), prevalence, or incidence [11,12]. The use of cross-sectional or cohort studies in which health outcomes are examined are evaluated in individuals (rather than aggregates of individuals), allows for more precise geographical locations to be attached, as Geographic coordinates for individuals' homes or alternative locations can be recorded [9], limiting exposure with time.

The relationship between geological hazards and health outcomes

The discovery of unexpected health outcomes (often indicated by unusually high incidence) in a population, suspected to be caused by exposure to a naturally occurring hazard, may trigger a geo-epidemiological investigation study. As a result, gathering epidemiological data is usually the first step response, followed by the gathering of geological data to supplement this dataset The area of interest must be considered from the start as there is a little point in assessing health outcomes in an area from the start where the presumed geological character does not change As a result, the research area should strive to include a variety of values for the variables that can be measured to determine the potential risk, as well as The potential mechanism of exposure is one of the most important issues to consider. (For example, the environmental media in which the hazard exists and the path of the hazard) exposure) and how individual exposure varies within the population (e.g. genetic proclivity, age, behavior), both of which can be used to determine the hazard's dose-response relationship to establish a correlation between potential geological hazards and health outcomes, the two data sources (epidemiological and geological surveys) must be linked to allow statistical analysis. analysis. There are several approaches to this. Where aggregated health is concerned Data on outcomes are available within administrative units, and data will be linked. as in an ecological study, at the population level.

This approach requires the environmental component(s) thought to be contributing to the disease to be collectively characterized within administrative areas, for example by calculating mean values for each area. Examining correlations in this way can be less demanding than for individual level studies [13]. However, within administrative units (often defined by political boundaries) the components within the environment contributing to the disease are likely to be highly variable and correlations detected at population level may not exist at individual level. Thus, these studies are useful for hypothesis generation for further study and can provide a useful means for the initial assessment of potential causative agents, but are prone to bias and the "ecological fallacy" [14].

Individual-level epidemiological studies provide more detailed evidence of the relationships between environmental exposure and health outcomes, though obtaining suitable data is typically more time consuming and costly. Individuals' health outcomes and exposures can be collected using survey methods (e.g., case-control, cohort, or similar study), but assigning quantitative measures of exposure to the environmental component to individuals is difficult. Ecological exposure data (for example, mean values within an individual's area of residence) can be linked to individual level health outcome data, though this may not adequately capture environmental component heterogeneity or individual level exposures. Estimating exposure to the environmental component for each individual (e.g. at their home) allows us to directly link exposure and outcome information at an individual level, but is more challenging logistically and incurs greater financial costs [15]. In addition, individual exposure estimates may be based on subjective information (e.g. questionnaire responses), potentially introducing measurement bias. Where it is not possible to take a physical measurement of hazard exposure for each individual included in the study, geo-statistical methods may be beneficial. Geo-statistical model-based predictions, such as Kriging, can be used to produce spatially continuous estimates of a value of interest (e.g. concentrations of the environmental component associated with the disease) based on an even coverage of data from the sample area: the spatially continuous estimates can then be used to provide exposure estimates for individuals based on their spatial locations

CONCLUSION

There are several complex and lengthy exposure-response pathways involved Environmental components exhibit small-distance spatial heterogeneity and a variety of other issues, interdisciplinary approaches to Medical geology studies are required to provide strong evidence. Geological and epidemiological methods must be linked, as well as spatial data always address the component. These approaches could be supplemented using quantitative and qualitative methods such as questionnaires approaches based on a diary or calendar, or GPS tracking to capture spatial data and variations in exposure caused by movement patterns or migration. The most appropriate approach is to take an individual level approach to ensure that environmental exposures are accurately represented, health outcomes and the connections between them Furthermore, laboratory studies should be used to confirm the nature of geological associations of components and disease development wherever possible.

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