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Assessing factors affecting flood-induced public health risks in Kassala State of Sudan

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ABSTRACT

Objective: The objective of this study is to prioritize the effective intervention measures for reducing the risk of waterborne and vector-borne diseases in the context of flooding in Kassala State.
Method: This study uses the Analytic Hierarchy Process (AHP) based on the judgments and opinions of experts with different relevant backgrounds and serving on federal and state levels.
Results: The main health risks related to flood are identified as vector and water borne diseases. Exposure to vectors and availability of emergency health care service are the main factors that directly affect the public health risks in Kassala State. On the other hand, inaccessibility, damaged and non-functioning health facilities are the main indirect factors.
Conclusion: AHP is a useful and cost effective method to assess, prioritize and plan for health risk interventions. Addressing the root causes through integrated risk, multi-hazard management is essential to reduce the health risks. The main areas of intervention are; access to basic service, safety of the health centers, and environmental health management.

1. Introduction

Almost all types of disasters result in health consequences mainly through; disruption of water and sewage system, poor living conditions and personal hygiene, people displacement, and interruption of routine health care service [1]. Flood related health risks are categorized into short term like; injuries and disrupted health services, midterm like; water contamination, and communicable diseases, and long term consequences like; disability, and mental illnesses [2]. In favorable environment, flood can be complicated by outbreaks of both water-borne and vector-borne diseases [3]. Applicable both for large and small scale floods, the common consequent diseases are; cholera, other diarrheal diseases, malaria, hemorrhagic fevers [4,5]. The factors which are associated with increased risk of diseases are; gender, age group, source of drinking water, type and severity of flood [6].

To control the public health consequences of flood, it is important to consider mapping of potential flood risks, vulnerability capacity analysis of the community, and ensuring strong and effective coordinating mechanisms [7]. Besides, simple and low cost measures to improve the water quality and sanitation practices have been shown to be effective [8,9]. The integrated multi-sector approach is preferable over the short term crisis management to ensure sustainable and efficient prevention strategies [10,11]. Such a situation needs a prioritization tool and decision-making method to incorporate expert's opinions and avoid subjectivity.

AHP is defined as a theory of measurement through pair wise comparisons that relies on the judgments of experts to derive priority scale [12]. AHP has been widely used and accepted method for analyzing, prioritizing of problems and decision making in different applications and fields [13]. Its applicability is mainly due to its ability to translate tangible and intangible concepts into comparable numbers and ratios. It suits any governmental and nongovernmental projects where there is a need for making a decision in the context of competing factors and different views among groups' members [14]. AHP facilitates decision making based on subjective judgments using locally available information [15]. Applying the same concept of AHP, but with different scales and techniques, many other processes and tools, such as HMD by Kocaoglu, have been developed to assist group decision making and consider interpersonal inconsistencies [16–18].

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As the process is based on the judgments of experts to deal with problems' subjectivity it is expected that the results would show some degree of inconsistency simulating the real life situation [19]. AHP can test and accept those inconsistent judgments [20]. Another concern is the group heterogeneity which has to be accepted within narrow margins or otherwise to conduct consensus building to narrow the gaps among the group members [21].

Among the proven areas of success for the AHP are the selection of alternatives, resource allocation, forecasting, total quality management, engineering applications and environmental risk [22,23,14]. Health care, like other fields has utilized the AHP process for identifying priorities, evaluation and taking decisions. The application ranges from patient–physician relationship to health system research [24–26] and has showed flexibility and practicality [27]. The Madigan Army Medical Center of Tacoma, Washington, used AHP to select the members to be dispatched depending on the type of disaster. However it mainly addresses the direct injuries rather than the public health risks [22].

A few research papers that used AHP in the context of disaster could be retrieved from literature searches and almost none could be found in the context of public health risk related to natural disasters. One study in Malaysia applied the AHP in decision making for selection of evacuation centers. It recommended to use the multi-criteria analysis methods as a supportive decision making process and not to rely solely on them [28]. Others have developed new approaches based on the classical AHP method to manage natural hazards [29]. Some have complemented the AHP and other tools like Triangular Fuzzy Number (TFN) to analyze the flood risk and rank risk factors ranking. The method has shown the advantage [30].

AHP was used to investigate and rank of environmental impacts of dust storm. The results revealed that dust has its greatest effects on health [31]. Fard and colleagues used AHP to develop GIS based risk map in Iran [32].

The process is based on structuring of a hierarchy of at least three levels that represent the goal or problem, criteria and alternatives. Each criterion is compared to others in a matrix by giving an absolute value corresponding to its importance. The values in each cell of the matrix can be an integer or a fraction and the corresponding cells will have the reciprocal values. Next is the calculation of the Eigenvalue by squaring the matrix values, calculating the sum of values in each column of pairwise comparison matrix, and dividing each element by its column total to give the normalized pairwise comparison matrix. Following is the averaging of elements in each row to estimate their relative priorities [13].

Like other models, AHP needs to be evaluated to guarantee the validity of their assumptions and their long-term successful application in practice. AHP can be tested for prediction, coherence, consistency and scope [33]. The AHP can be validated at different levels ranging from priority vectors derived from pair wise comparison matrices to the synthesized priorities for a hierarchical model, to the matching of overall results to the actual life examples [34]. As a decision making process, validation is challenged by the qualitative nature of the data. Another challenge is the changing of results with time and environment as because of the subjectivity in experts' opinions, however that should not limit the use of the process [35]. Another effective validating method is to retest the outcome of the process through involving large group of experts [36]. However no consensus on one validation measure [37]. The AHP process can be validated in many ways depending on the purpose and type of data. For AHP that is used for prediction the validation could be done through comparing the output of the process with the future real life situation. For AHP used for decision-making, best alternatives have to be chosen to achieve the objective [38].

When quantitative data is used, AHP can be validated statistically through, for example, factor analysis. While for qualitative data, as the case in this study, the consistency index and ratio can be used for validation. The preferable way to ensure the validity of AHP is to use group judgments and decisions to encounter the subjectivity [33].

The study area is under the annual risk of flooding with poor health indicators and weak infrastructures and vulnerable community that is at risk of frequent disease outbreaks. Such a condition requires the development of evidence based preparedness and intervention plans. Those plans are difficult to develop based on the weak information system, insufficient quantitative data, and low technical capacity. This justifies the need for addressing the opinion of experts with different backgrounds who are familiar with the local conditions. The most suitable tool is the AHP to formulate their judgments and use them at the tactical level with the possibility of developing strategic intervention priorities and plans.

Hence, the objective of this study is to prioritize the effective intervention measures for reducing the risk of waterborne and vector-borne diseases in the context of flooding in Kassala State using the AHP model.

2. Study area

Kassala state is in the Eastern Sudan with an area of 42,282 and total population of 1,710,000. The average family size is 6.2 persons with a significant number of female-headed households in rural areas as male urban migration increases. Women make up 48.4% of the population of Kassala State, out of which 35% are reported extremely poor. The study area is part of Gash Delta where agriculture is the main economic activity.

The state economy largely depends on traditional, natural resource related activities. This makes it vulnerable to the extreme environmental conditions and armed conflict in the region. Agricultural sector constitutes 80% of the economic activity in the state. Kassala is rich in animal resources with over 5 million animals, 4,500,000 acres cultivated land equivalent to 40.5% of the state's total land, and 6,000,000 acres of natural pastures. Some of the important social development indicators in Kassala State, are, urban population 19.3%, pastoral people 25%, coverage with electricity 22%, illiteracy rate (age 15+) 56%, primary school enrollment rate is 23.9%, [39].

Kassala state is under the annual risk of flooding with 5 years frequency for significant damaging events. The main source of the flood hazard is the Gash River that overflows during the rainy season from May to October. Flooding occurs suddenly within two to four hours after the water reaches the Sudan–Eritrea borders [40]. Water has high velocity and carries tons of mud flashing across the area with one to three feet height. Physical access to primary health care centers in the study area is affected by the isolation of the health centers and houses by flood water [41]. The 2003 flood was as the worst disaster event in Sudan history. About 300,000 people directly affected and more than 30,000 families displaced. The main hospital in Kassala was damaged and putout of function. All health centers experienced various degrees of damage [42].

The state frequently faces the risk of Malaria outbreaks, Dengue fever, and Diarrhea, associated with high vectors' density [43]. Kassala has the highest malnutrition rates (GAM 29%) in the country, infant mortality rate (56/1000 MMR) and maternal mortality ratio (140/10,000 live births) [44].

3. Data and method

The secondary data used in this research were collected using a form to extract data from records about the rate of Malaria and Diarrhea cases in the state and rainfall data. The primary data about the importance of factors/variables was obtained though questionnaire based interviews with the participating experts.