



Impact of Rainfall on The Distribution of Water-Borne Diseases: The Case of Viral Hepatitis

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ABSTRACT

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Waterborne diseases, including infection by viral hepatitis, represents a significant public health problem in many parts of the world, particularly in Morocco. They are sensitive to environmental conditions. Some or all are likely to be affected by climate change, which could alter their risk. The objective of this work is to study the impact of rainfall on the evolution of viral hepatitis in the prefecture of Meknes during the 2010-2014 period. The number of cases of water-borne viral hepatitis between 2010 and 2014 were obtained from prefectural epidemiology unit of Meknes, while the climatic variables were obtained from the meteorological station of the Agropolis agribusiness and research center of the region of Meknes. The epidemiological situation of viral hepatitis in the study area shows that the prefecture of Meknes was still affected by this epidemic during all the years of the study with a rate which reached 95 cases in 2012. In addition, this study shows that the years of heavy rainfall have seen a decrease in viral hepatitis cases. Climatic factors can therefore affect public health. In fact, heavy rainfall can reduce the risk of the appearance of diseases, in particular viral hepatitis, by reducing water pollution by dilution. Hence the need to encourage studies to improve knowledge and scientific evidence of the association between health and climate, and to integrate climatic factors into epidemic surveillance systems.

Keywords: Viral hepatitis, Rainfall, Water-borne diseases, Public health

Introduction

Hepatitis disease is a viral disease which causes inflammatory of the liver,¹ but it may result from a variety of causes such as the consumption of medications, drugs, toxins and alcohol, and the disease can also be due to the formation of antibodies directed against the liver tissue.^{2,3}

Almost all the cases of acute viral hepatitis are caused by one of five viral agents: Hepatitis A virus (HAV), hepatitis B virus (HBV), hepatitis C virus (HCV), hepatitis D virus, and hepatitis E virus (HEV).⁴

Hepatitis A is acquired by consuming food and water contaminated by the virus by the feces of an infected person. Hepatitis B and C are contagious and mainly spread by blood and blood product, and may also be transmitted by sexual contact.

Hepatitis D is contracted through direct contact with infected blood while Hepatitis E is a waterborne disease which is commonly found in areas with poor sanitation.

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Water-borne diseases, including viral hepatitis, remain important sources of mortality worldwide, but particularly in developing countries.

In Morocco, the epidemiology of viral hepatitis is not known with accuracy. No national serological study has been conducted to estimate the true magnitude of these infections in the general population. WHO estimates the prevalence of the hepatitis B virus at 2% in the general population, and 1.2% for hepatitis C virus.⁵

Changes in diseases associated with climate change make diseases a target for prevention. Climate change is likely to affect the quality of surface and groundwater by affecting weather conditions,⁶ such as temperature and rainfall, which may influence the incidence of waterborne diseases.^{7,8,9}

Previous research has studied the association between waterborne hepatitis and climatic conditions^{10,11}, while several epidemics of this type of hepatitis have been reported in the scientific literature^{12,13,14,15} after water-related weather events.^{7,10}

According to the present state of our knowledge, this is the first study that investigates the relationship between climatic factors, in particular rainfall, and viral hepatitis in Morocco.

The goal of this research is to investigate the association between annual rainfall and the number of waterborne viral hepatitis cases in the Meknes prefecture between 2010 and 2014.

Materials and Method

Study area

The prefecture of Meknes (34° north, 6° west) (Figure 1) is located in the Fez-Meknes region in central Morocco. Its legal population which

is mostly urban reached 835 695 inhabitants. It occupies a strategic geographical position because on the one hand, it is located between two sets of mountains: the Pre-Rif and the Middle Atlas West mountains, and on the other hand, thanks to the location of the city of Meknes, at the crossroads of major arteries of the Kingdom of Morocco (national and provincial roads, sections of freeway, and railroad linking Marrakech and Oujda which crosses the city of Meknes).¹⁶

Data acquisition

This study focused on the number of cases of viral hepatitis in the prefecture of Meknes over a period of 5 years (2010- 2014), and also on the correlation between rainfall and the number of cases of this disease. The epidemiological data were obtained from the prefectural epidemiology unit of Meknes while the annual rainfall data were obtained from a meteorological station of the Agropolis in Meknes.

Statistical analysis

In order to facilitate the analysis of the epidemiological situation, the Excel 2013 software was used for the representation of the results in the form of graphs, and the QGIS software for the creation of the maps. For statistical analysis, the SPSS software was used.

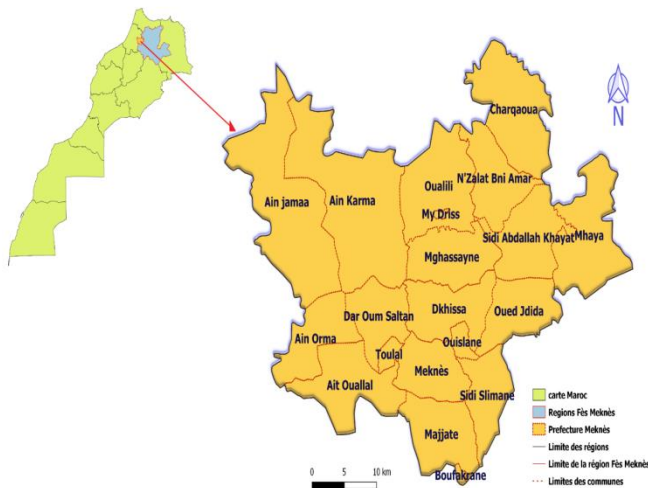


Figure 1: study area

Results and Discussion

Temporal distribution of waterborne viral hepatitis cases (2010-2014)

The Figure 2 represents the number of cases recorded during the 2010-2014 period.

It is noted that the prefecture of Meknes has always been affected by viral hepatitis with a rate that exceeds 45 cases. Moreover, most cases were recorded in 2012, i.e., 95 cases, followed by 81 cases recorded in 2013.

These results could be explained by the fact that the prefecture of Meknes is crossed by 3 wadis used for agriculture: Bouissshak to the West, Boufekrane in the middle, and Ouislane to the East (Figure 3). These wadis are characterized by a relatively low flow rate, which leads to a reliance of irrigation on other resources including raw or mixed wastewater.

This raw wastewater discharged or mixed (mixed with wadi water) is used for the irrigation of land located downstream of the places of discharge of domestic and industrial effluents, including effluents coming from market gardening and arboriculture.^{17, 18}

These waters ensure a profitable agricultural activity, but the pathogens and micropollutants conveyed can have an adverse effect on public health, which can affect both producers and consumers.^{19,20}

Consumption of food irrigated by wastewater poses health risks since it can be the vector of pathogens associated with excreta.^{21,22}

Impact of rainfall on the distribution of waterborne viral hepatitis

The association between the number of viral hepatitis cases and rainfall (Figure 4) shows that the years of heavy rainfall have experienced a

decrease of cases. This could be explained by the fact that rainfall and runoff play a role in decreasing water pollution through dilution. Indeed, the climatic profile of the city of Meknes shows an annual rainfall deficit greater than 988 mm, with monthly deficits ranging between 39 mm and 237 mm and occurring 8 months out of 12. The greatest deficits are observed from March to September, which causes a concentration of pathogens and chemical contaminants, having consequences for hygiene measures. Likewise, this deficit pushes farmers to reuse wastewater for irrigation during this period when river flows are low.^{23,24}

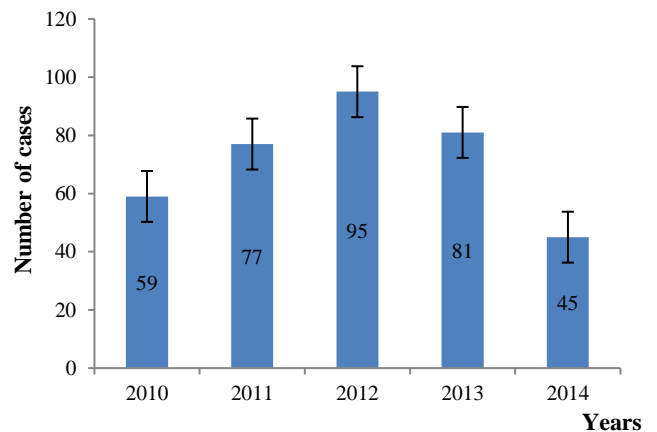


Figure 2: Temporal distribution of water-borne viral hepatitis

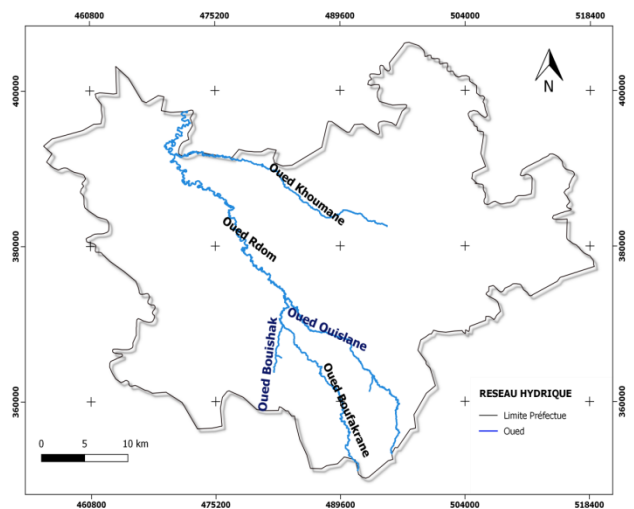


Figure 3: Prefecture water network

Statistical analysis showed an association between rainfall and the number of hepatitis cases with p -value < 0.005 (Table 1).

Annual rainfall is therefore negatively correlated with an increase in water-borne diseases such as viral hepatitis, which justifies the results of this study.

In other words, the years of heavy rain and snow were associated with a higher risk of hepatitis due to dilution of the waters of these wadis used in irrigation, hence the need to strengthen partnerships between health and climate experts, to improve the scientific evidence of the link between health and climate factors.²⁵

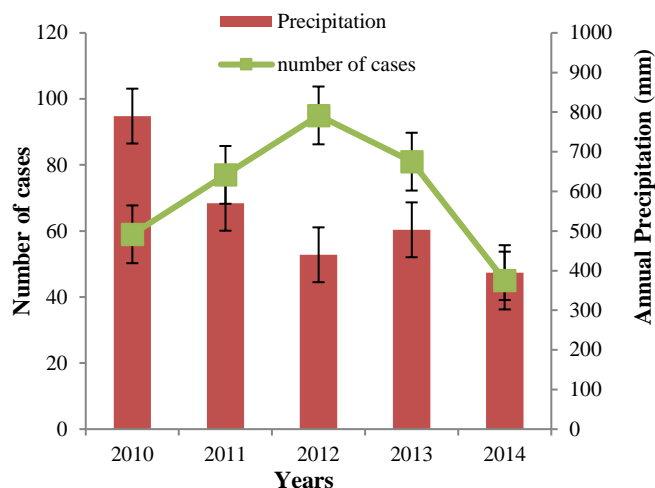
The results obtained corroborate the work of Bai *et al.* who showed that periods of low rainfall can lead to an increased risk of waterborne diseases.²⁶

Other studies have shown that rainfall is positively correlated with viral hepatitis and that heavy rainfall and snowfall present an elevated risk of waterborne diseases.^{7,8}

However, Chen *et al* found no association between rainfall and viral hepatitis.¹⁰

Table 1: Test-student

Variables	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Number of cases	8.160	4	.001	71.40000	47.1065	95.6935
Rainfall	71.699	4	.000	18.09400	17.3933	18.7947

**Figure 4:** Correlation between the number of hepatitis cases and rainfall

Conclusion

The result of the study revealed that the rainfall can affect public health, especially when wastewater is reused without prior treatment. Therefore, awareness-raising and information campaigns should be strengthened concerning the reuse of wastewater in irrigation, and studies should be encouraged to improve knowledge and scientific evidence of the association between health and climate.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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