Mapping Libya's prostate cancer based on the SMR method: A geographical analysis

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Abstract

Disease mapping has become an important method used in public health research and disease epidemiology. It is a spatial representation of epidemiology data. A very common disease mapping method is called Standardized Morbidity Ratio (SMR). Many researchers used this method to estimate the relative risk of the disease as a preliminary analysis. In this study, the SMR method displays the high and low risk areas of prostate cancer for all districts in Libya. SMR is the ratio of the observed to the expected number of prostate cancer cases and was applied to the observed prostate cancer data from Libya for the years 2010 and 2011. The results were presented in graphs and maps. The highest risk of prostate cancer (all type of cancers) is in the West of Libya probably due to the oil installations in this area such as Mellitah Oil and Gas B.v, the Azawia Oil Refining Company and Bouri Oil Field, as well as the electrical power stations. Susceptible people located in the Eastern part of the country have the lowest risk when compared to the overall population. In conclusion the results show that the use of the SMR method to estimate the relative risk in maps provides high-low risk appearances in maps compared to using the total number of cancer incidence alone. In other words, the SMR method can be considered a basic procedure because it takes into account the total human population for each district.

Keywords: disease mapping, Libya, prostate cancer, relative risk, spatial analysis, Standardized Morbidity Ratio

Introduction

Spatial epidemiology is defined as the study of the spatial occurrence of the disease in a spatial or geographical location. Spatial epidemiology deals with analysis and interpretation of the geographical distribution of particular diseases in the study. Disease mapping is a type of spatial epidemiology and a visual representation of epidemiology data spatially that provides a quick overview of the information for a certain region by using different colours or different shading. The aim of disease mapping is to estimate the relative risk and to describe the geographic variation of diseases risk as well as suggest possible risk factors that may explain variation. Other than that, maps produced from this relative risk estimation can be used as tools to identify unusually high risk areas so that appropriate actions may be taken such as to assess health inequalities to better allocate health care resources (Lawson *et al*., 2000; 2003).

Many publications explained the advantages of using disease maps (see, for example, Howe, 1971; Downing *et al*., 2008). These maps display the geographical distribution of diseases. The use of maps can reveal a lot of primary important information which could not be revealed from statistical tables or classical methods. Disease mapping has become an important tool in disease epidemiology and health service research. In the field of disease mapping, the standardized morbidity ratio (SMR) is the most common methods used to estimate the relative risk. The analysis of risk estimation initially based on

SMR is a good start for investigating the risk distribution of a disease. This method can be used to assess the status of an area with respect to disease incidence. This paper discusses about SMR method in order to estimate the relative risk for prostate cancer mapping. Firstly, the overview of the prostate cancer disease and its situation in Libya will be provided. This is followed by a review of the previous research on SMR method and their drawbacks. The SMR method will then be applied to prostate cancer incidence data and the result will reveal the high and low risk areas of prostate cancer occurrences in Libya.

Prostate cancer disease and its situation in Libya

Globally, cancer is an ever-increasing health problem and common cause of medical deaths in the world (WHO, 2003; 2014). Prostate cancer is the most common form of malignant cancer in males. In Libya, prostate cancer is the most common cancer for males with 19% of all male cancer patients (Cancer Office MOH, 2010). Therefore, this study is interested in investigating further about prostate cancer, and to find the high-low risk area of prostate cancer occurrence specifically for the country of Libya.

The 22 districts of Libya are Alnikat, Zawia, Aljafara, Tripoli, Almergaib, Mustrata, Sirt, Benghazi, Almarg, Aljabal Alakhader, Darna, Albatnan, Nalut, Aljabal Algarbi, Wadi Shatee, Aljufra, Ejdabiya, Ghat, Wadi Alhiya, Sabha, Morzuk, and Alkufra. Figure 1 shows the map of the name of 22 districts and number code for every district of Libya.

Figure 1. *22 Map of Libya showing the Local Authority Districts with codes*

Figure 2 displays the total number of 105 cases of prostate cancer in Libya by months and districts. It presents the incidence of prostate cancer cases in Libya from 2010 to 2011. There were minor fluctuations of prostate cancer cases between 2010 and 2011, during which the worst outbreak occurred in 2010-2011 in Zawia, Alnikat (which are located at the north-west of Libya near the capital of Libya named "Tripoli") and Tripoli. These districts were located in the northern west part in the country. From 1 January 2010 to 31 December 2011, the total number of prostate cancer cases involving all districts in Libya is 105 cases. Nine districts were free from prostate cancer disease, which are Benghazi, Almarg, Darna, Albatnan, Aljufra, Ejdabiya, Ghat, Morzuk, and Alkufra.

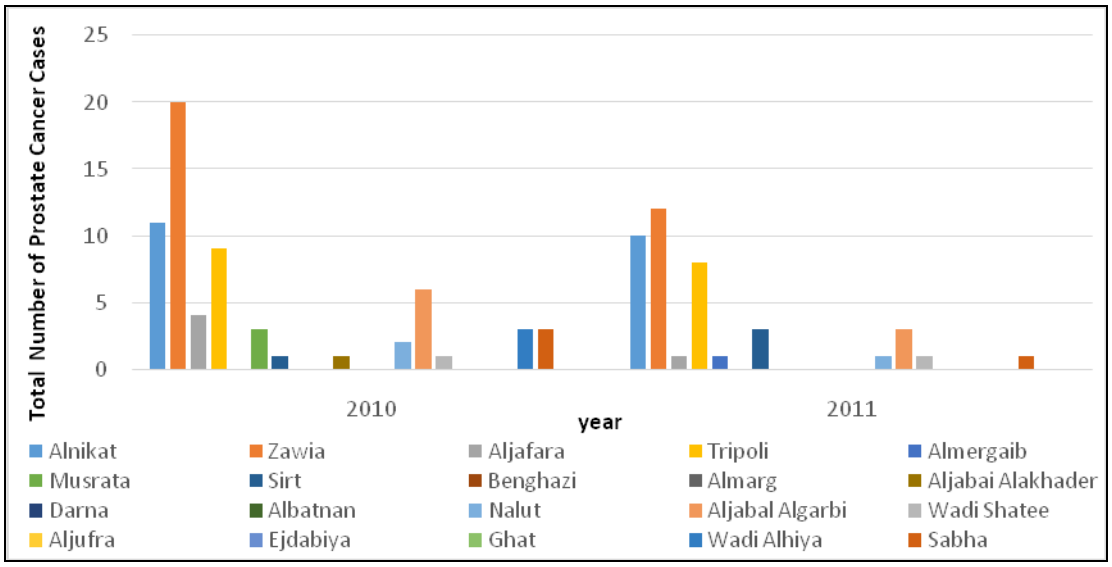

Figure 2. *22 total number of prostate cancer cases by districts for the years of 2010 and 2011*

The Standardized Morbidity Ratio (SMR)

In disease mapping, the most common method used to display the distribution of the disease on the map is by using the crude representation of the proportions of the observed numbers. However, there are several relative risk estimation methods that can be used to estimate the relative risk, which takes into account the background of the population. Lawson (2001) defined relative risk as a scale to measure the excess risk found in a particular area within the local population, which is exposed, or at risk. Samat and Percy (2008) discussed this SMR method in its application to dengue disease in Malaysia. Samat and Percy (2012) defined relative risk as the conditional probability that a person within the region contracts the disease divided by the conditional probability that a person in the population contracts the disease.

In disease mapping, we assume that the study area to be mapped is divided into n mutually exclusive regions ($i=1,2,...,n$). Each region has its own observed number of cases O_i; and expected number of cases E_i, based on an assumption of homogeneity in its simplest form. Using O_i and E_i as obtained from the available data, we can calculate one of the most common indices to estimate the relative risk Θi for district i, by using the following equation.

$$\hat{SMR}_i = \hat{\theta}_i = \frac{O_i}{E_i} \qquad i = 1,2,\ldots,n \quad (1)$$

The variance of the SMR is given by:

$$Var(\hat{SMR}_i) = Var(\hat{\theta}_i) = Var\left(\frac{O_i}{E_i}\right) = \frac{Var(O_i)}{E_i^2} = \frac{\theta_i E_i}{E_i^2} = \frac{\theta_i}{E_i} \quad (2)$$

In this research, the expected number of the disease Ei is calculated as

$$E_i = N_i \left(\sum_{i=1}^{n} O_i \Big/ N \right) \qquad i = 1,2,\ldots,n \quad (3)$$

where *Ni* is the population of district/area i and the summations are for *i=1,2,...,n*. Here the standardization is done based on the total population at risk, assuming everybody is equally at risk. Consequently, the estimated relative risk may be defined by

$$\hat{SMR}_i = \hat{\theta}_i = \frac{(O_i / N_i)}{\left(\sum_{i=1}^{n} O_i / \sum_{i=1}^{n} N_i\right)} = \frac{(O_i / N_i)}{\left(\sum_{i=1}^{n} O_i / N\right)} \quad (4)$$

According to Lawson (2001) and Lawson *et al*. (2000), although SMR is commonly used to estimate the true relative risk, there are problems associated with its use. SMR is based on a ratio estimator; the mean and variance of SMR are very highly dependent on expected count E_i. Furthermore, if there are areas with no observed count data, mathematically the SMR is necessarily zero.

Materials application of Standardized Morbidity Ratio to prostate cancer data in Libya

This section displays the results of the applications of relative risk estimation methods, corresponding to the classical model based on the SMR using observed prostate cancer data of Libya. All maps were produced with ArcGIS software. Results will be compared and presented in tables, graphs, and maps.

A. The data set and motivation

The African Oncology Institute (AOI) Shabratha recently published annual reports of morbidity in Libya, which include Population and morbidity information (Sabratha Cancer Registry, 2012). In this study, all observed cancer incidence and population data in Libya were provided by the department of Statistic at the African Oncology Institute (AOI) Sabratha for 2010 to 2011 (Libyan National Statistics Figures, 2011; Sabratha Cancer Registry, 2008).

This data set gives the number of incidence per year in the 22 local authority districts in Libya. The data of cancer extracted by AOI was the main source of information for this study and the initial motivation to attempt to find the best statistical models to estimate prostate cancer disease in Libya. The benefits of the annual report which is issued by the AOI every year has helped to identify differences in morbidity of disease occurrence from different causes at the public level in Libya. Other advantage was to indicate regions with high risk which need more study and appropriate action to reduce them.

B. The results

In this study, the SMR method will be applied to data of prostate cancer disease in Libya to identify the distribution of high and low risk area of prostate disease.

Figure 3 displays the time series plots for the number of prostate cancer cases for each district in Libya from 2010 to 2011. Alnikat shows the high number of cases at the beginning but slowly decreased over the month. Zawia has the highest number of prostate cancer cases with six cases during July. Figure 4 shows the SMR estimation for each district in Libya from 2010 to 2011. The highest SMR is at Wadi Alhiya in August. Wadi Alhiya showed a small number of prostate cancer cases. This is followed by Alnilkat with SMR equal to 9.87 in September and November. Zawai had high number of relative risk during July with SMR equal to 9.05. By using the SMR method, the relative risk is estimated to have the highest value of SMR with a value equal to 18.7405. These results are probably due to the number of population that we consider in the calculation of expected cases for Wadi Alhiya.

From Figure 4, most districts have a relative risk (SMR) below one for most epidemiology months. Based on the definition of relative risk, a value of relative risk is less than one that means that

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susceptible people within this district are generally less likely to contract prostate cancer compared with people in the overall population. Otherwise, Alnikat, Zawia, and Wadi Alhiya have relative risks greater than one for most epidemiology months. People in these districts are more likely to contract prostate cancer compared to the people living elsewhere in Libya.

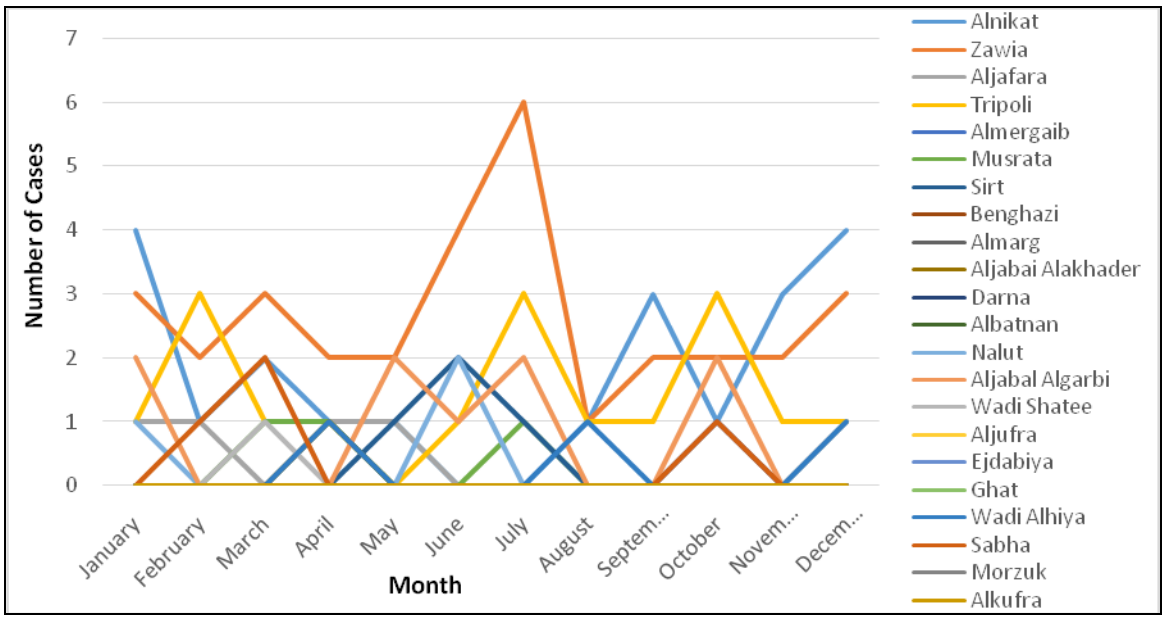

Figure 3. *Time Series Plots for the Number of Prostate Cancer Cases in Libya from 2010to 2011*

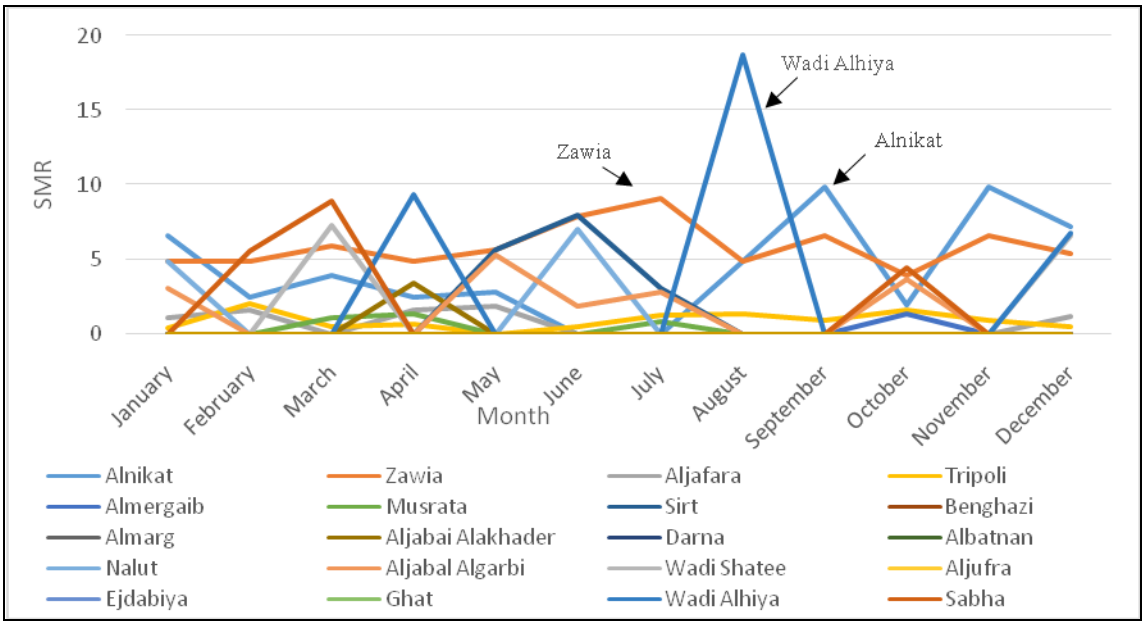

Figure 4. *Time Series Plots for the SMR of Prostate Cancer Cases in Libya from 2010 to 2011*

Disease maps for prostate cancer in Libya

Disease maps are used to represent the high-low risk area of prostate cancer for all districts in Libya. For the purpose of interpretation in this application, thematic maps with multiple colours are used to display and differentiate between the high and low risk areas. In disease mapping, there is no definitive way to choose the interval levels of risk, so each district is assigned one of five different levels of relative risk which are very low (the lighter regions), low, medium, high, and very high risks (the darker regions), with respective intervals of [0,1), [1,2), [2,3), [3,4) and [4, ∞) respectively for summary map which is based on number of cases, and [0.0,0.5), [0.5,1.0), [1.0,1.5), [1.5,2.0) and [2, ∞) respectively for SMR map.

Figure 5 shows the thematic risk maps for prostate cancer disease based on number of cases and SMR method. These maps show the result for the month of January during the spanning years 2010/2011 for each district in Libya. Figure 5 (A) shows a summary map of the total numbers of prostate cancer cases reported for each district in Libya. This map is used to summarise and display the data and do not give much information. Very high numbers of cases mean that these districts have very high numbers of prostate cancer occurrences compared to other districts, without considering another factor such as human population. Alnikat is a very high risk area, followed by Zawai and Aljabal Algarbi. There are three districts with medium risk are Aljafara, the capital of city Tripoli, and Nalut. Sixteen other districts are at very low risk. Figure 5 (B) represents the risk map for prostate cancer disease based on the SMR method. This figure depicts that there are four districts with very high risk, which are Alnikat, Zawai, Nalut, and Aljabal Algarbi. This is followed by the district of Aljafara with medium risk. Other districts represent very low risk areas.

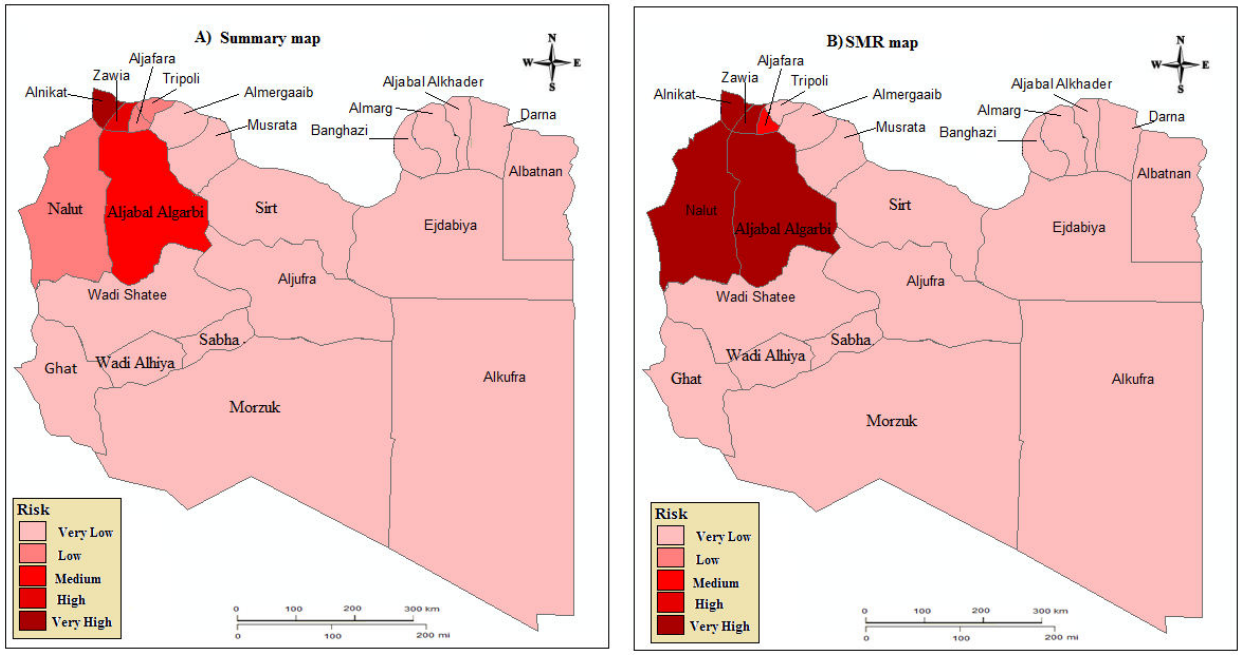

Figure 5. *Risk map for prostate cancer based on number of cases (A) and risk map of estimated relative risk for prostate cancer disease based on the SMR method (B)*

Conclusion and future work

This study estimates the relative risk of prostate cancer occurrences in 22 districts in Libya using the SMR method. It identified the high and low risk areas of cancer occurrences in Libya by displaying the

risks using an SMR map and compared it with the summary map. The results showed that manufacturing or producing reliable maps for a certain disease must take into account the modeling in order to estimate the risk for most geographical areas of the map. Based on the results, the use of different methods for estimating the risk will give several appearances of prostate cancer risk in mapping. This will give inaccurate interpretations to describe the geographical distribution of risk. Results show that the use of the SMR method to estimate the relative risk in maps provides high-low risk appearances in maps compared to using the total number of cancer incidence alone. In other words, these results propose that the SMR method can be considered a basic procedure because it takes into account the total human population for each district.

The highest risk of prostate cancer (all type of cancers) is in the West of Libya probably due to the oil installations in this area such as Mellitah Oil and Gas B.v, the Azawia Oil Refining Company and Bouri Oil Field, as well as the electrical power stations (Malak, 2013). Susceptible people within districts located in the Eastern part of the country have the lowest risk of all models when compared to the overall population.

Future research can investigate alternative methods to estimate the relative risk for prostate cancer disease to overcome the problems and disadvantages of using SMR. The methodology that is used in this study will provide and supply the appropriate methods in the analysis of geographical disparities in cancer morbidity and incidence that has been revealed in cancer registry data. Based on these maps, which must be considered as tools to form hypotheses leading to the next step of study, for example, development of analysis methods and the current models that may be considered as attempts to develop future analysis and could be used as a tool for identifying districts that need closer scrutiny or further attention in terms of government policy and financial support for monitoring and controlling prostate cancer. In order to inform and help the Libyan government strategy for controlling cancer in general, future work based on this research must be done to improve the current models used to produce the maps of disease. From the future work, it is expected that an improved statistical method of prostate cancer disease mapping and a map of prostate disease for the districts of Libya would be obtained.

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