Standardized Breast Cancer Morbidity Ratio Mapping in Libya: A Geographic Statistical Analysis, 2015-2020

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Abstract: Cancer is a major public health problem in all over the world and including Libya. Over the ten years hugs advances have been made in the field of relative risk. In this research, relative risk estimation is the focus of our attention. Relative risk estimation is one of the most important issues in the study of geographical distributions of disease occurrence or disease mapping. For the case of breast cancer and its application in Libya, there are not many researches that use statistical methods to estimate the relative risk for disease mapping in Libya. Therefore, the aim of this study is to estimate the relative risk for breast cancer disease based on the most common statistic used in disease mapping "Standardized Morbidity Ratio (SMR)" and compare it with summary method during period from 2015 to 2020. The estimation of relative risk is applied to breast cancer data in Libya which will then be displayed in a map to represent the high and low risk areas of breast cancer occurrence. This research starts by providing a review of the SMR method, which we then apply to breast cancer data in Libya. We then make a comparison of the SMR method and summary method both results are displayed and compared using graphs, tables and maps. Results of the analysis shows that the SMR method gives a better relative risk estimates compared with using the summary method. Generally, Although SMR is not the best method to estimate risk; it can overcome the problems of mapping by using smoothing models. The drawbacks of this model have motivated many researchers to propose other alternative methods for estimating the relative risk.

Keywords: Breast Cancer, Standardized Morbidity Ration SMR, Disease Mapping, Relative Risk.

1. Introduction

Libya, a North African country, lies along the southern coast of the Mediterranean, approximately, between the latitudes 180 and 330 North and 90 and 250 East. Its total area is about 1,759,540 K2m, of which more than 90% desert with population is about 5,922000 (Figure 1).

Globally, cancer is the ever-increasing health problem and most common cause of medical deaths in the world. In this research, breast cancer was the center of our attention. Breast cancer is the most common form of malignant cancer in females, contributing to 23% of all types of cancer (Parkin and Fernandez,2006). In addition, there are huge studies showing that which cancer accounts for 10-18% of all cancer-related deaths and is the most common cause of cancer-related death in industrialized countries, and the third in developing countries [1]-[5].

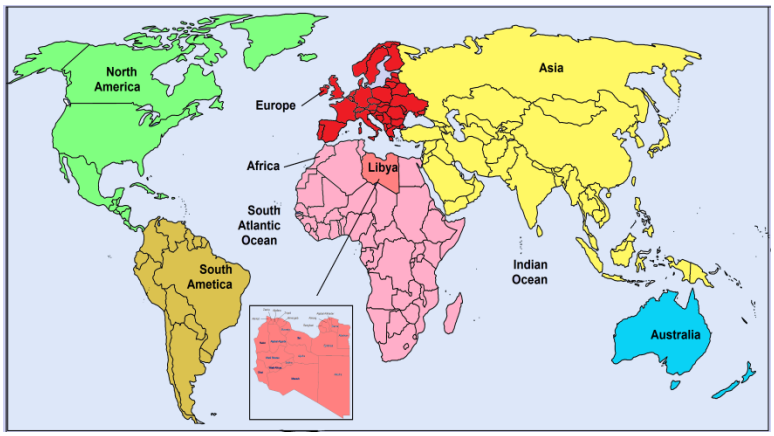

Figure 1: Libya in the world map

Breast cancer incidence is on the increase worldwide, but it varies from areas of low incidence (Japan and other Asian countries, and Latin American and African countries) to areas of high incidence (US, Western Europe, Northern Europe, and Australia). For example, in the US less than 0.9 new cases per 1000 women were reported in the 1990s, and more than 1.4 new cases per 1000 were reported in 2006 [1], [2], [5].

In Arabic countries studies are not comprehensive. In Morocco, the most frequently occurring cancer in females is uterus cancer (35%) followed by breast cancer (22.3%) [6]. In Egypt, approximately 35% of all female cancer is breast cancer [4]. In particular, the cancer disease has spread dangerously in Libya. It is one of the leading causes of death, with nearly 4,000 new cases of cancer occurring in Libya every year [7]. In Libya, breast cancer is the commonest cancer in females in Libya it contributes to 33% of all female cancer patients, based on the Sabratha cancer Registry Database Report in 2008 [8]. According to Cancer Office MOH (2010), the survival rate of breast cancer cases is an important issue to help physicians improve quality of patient care.

Some studies have reported the survival rate of breast cancer in Libya. For example, there was a study completed in 2011, the five years survival rate was estimated at 87.6% of patients, they have compared Libyan's Breast Cancer data with corresponding data from patients from sub-Saharan Africa (Nigeria) and Europe (Finland) [9]. Evidence suggests a strong gradient in breast cancer rates Relatively large geographic distance in Libya, for example in the western part of Libya [10]. The purpose of this study is to investigate whether there are breast cancer incidences of statistical significance in Libya. In this study attempted definition of areas with high incidence of breast cancer using SMR method for every district in Libya.

2. MATERIALS AND METHODS

2.1. Description of mapping methods

Cancer maps are important tools in the public health research. Mapping can be viewed as a descriptive presentation of the cancer burden in some geographical areas and can help pointing out the areas where health policy should be improved. The maps can also be used for evaluating the performance of public health interventions. In any case, the maps must be designed to communicate effectively among the public, health researchers and decision makers[11]. The biggest challenge is to ensure the maps not being misinterpreted.

In this study, disease mapping is process of displaying the geographical variability of disease on maps using different colors, shading, etc. The idea is not new, but the advent of computers and computer graphics has made it simpler to apply and it is now widely used in descriptive epidemiology, for example, to display morbidity or mortality information for an area. Good maps of disease risk have been recognized as an important tool for disease control. Disease maps may be useful especially for government agencies to allocate resources of disease [12]. However, we proposed to start the analysis of risk estimation with common methods based on standardized mortality and morbidity ratios (SMR), to assess the status of an area with respect to disease incidence. Therefore, the initial aim of this research is to discuss SMR, which is the commonest method that can be used to estimate relative risk (RR) in disease mapping.

2.2. Standardized Mortality/Morbidity Ratio (SMR)

The SMR is the commonest method used by researchers in the choice of appropriate measures of relative risk in disease mapping. In broad epidemiological terms, SMR can be defined as either Standardized Mortality Ratio or Standardized Morbidity Ratio. Mortality refers to death while morbidity refers to incidence. In this research, SMR basically compares the observed

incidence with the expected incidence, which has been used traditionally for the analysis of counts within tracts as described by [13]. In disease mapping, suppose that the study area to be mapped is divided into P exclusive regions ($i = 1, 2 \dots P$). each region has its own observed number of cases $O_i$and expected number of cases E_i. Using O_i *and* E_i as obtained from the available data, we can calculate the relative risk θ_i for state i, which is the SMR defined as

$$\hat{\theta}_i = SMR_i = (O_i \,/\, E_i) \quad (1)$$

According to [14], equation (1) is used and discussion in their study on standardized morbidity ratio and its application to dengue disease mapping in Malaysia. Although the SMR has been used commonly as an index to measure relative risk, it has several disadvantages. Depending on [15], since it is based on a ratio estimator, the mean and variance of SMR are highly dependent upon Ei. The SMR is very large in areas where the expected numbers of cases are small, and small for areas where the expected numbers of cases are large. Furthermore, in areas where there are no observed count data or cases, the SMR is necessarily zero. This makes the interpretation of SMR difficult, and it should be done with caution. This view is discussed by [12], who points out that the SMR is a reliable measure of relative risk for large geographical regions such as countries or states but is unreliable for small areas such as counties.

In this research, the model was fitted to the data using full estimation within the WinBUGS software [13]. The WinBUGS code used for the Standardized Morbidity Ratio "SMR" model. The Win BUGS code in Figure 2 shows a type of software, which used to estimate the relative risk RR of breast incidence for the standardize Morbidity Ratio method, which it described above.

```
Model {
For (i in 1:M){
For (j in 1:T){
#Relative Risk-SMR
theta[i,j]<-y[i,j]/e[i,j]
}}}
```

Figure 2: Standardized Morbidity Ratio in WinBUGS Program

3. APPLICATION OF STANDARDIZED MORBIDITY RATIO TO BREAST CANCER DISEASE IN LIBYA

In this section, we will display the results of the applications of relative risk estimation methods, corresponding to the classical model based on the standardized morbidity ratio using observed breast cancer data of Libya. The data set are analyzed using Excel software, which is an electronic spreadsheet program that can be used for storing, organizing and manipulating data. All these results are then compared and presented in tables, graphs and maps, and the best fitted model for relative risk estimation for breast cancer disease mapping in Libya.

3.1 Data Collection, Libyan data

The precise number of cancer cases diagnosed each year in Libya is unknown since a complete cancer registry. As already mentioned earlier that breast cancer is ever increasing health problem and common cause of medical deaths in Libya, in order to manage this problem in Libya, Secretary of General Committee has decided to tackle this problem urgently. One of the initial steps for cancer control in Libya has been the formation of National Cancer Registry Program. He has decided to create the committee for preparing a draft of National Cancer

Registry Program vide letter no 63/2007 [16]- [17]. In pursuance of this order, the most important first step taken is the formation of cancer registries in Libya. This advancement is a big step to know about the magnitude of cancer and for implementation of an effective cancer control strategy in Libya. As a part of this program, whole of the country of Libya has been divided into five cancer registries (Figure 3) and (Table 1).

In this application, the information of the Libyan districts for the years 2015 to 2020 was analyzed. This data set gave the number of incidences per year by cancer site in the 22 local authority districts, which obtained from the patient records of those who were diagnosed in the Africa Oncology Institute (AOI), from January 1, 2015, to December 31, 2020. The area under study covered 22 major locations, namely Alnikat, Zawia, Aljafara, Tripoli, Almergaib, Musrata, Sirt, Benghazi, Almarg, Aljabal Alakhader, Darna, Albatnan, Nalut, Aljabal Algarbi, Wadi Shatee, Aljufra, Ejdabiya, Ghat, Wadi Alhiya, Sabha, Morzuk, and Alkufra. The districts consisted of urban, suburban and rural populations (as presented in Fig. 4).

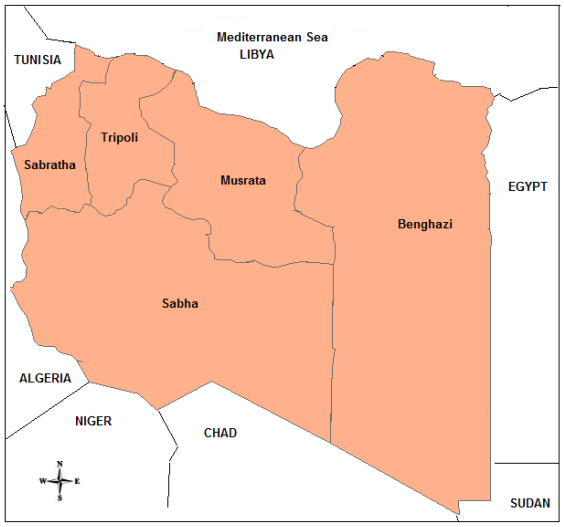

Figure 3: Cancer Centers in Libya

Table I. Libyan Cancer Registries initiated in 2007a

Location of cancer registry	Districts covered by the registry
1. Tripoli	Tripoli, Aljafara, Almergaib, Aljabal Algarbi
2. Benghazi	Benghazi, Albatnan, Darna, Aljabal Alakhader, Almarg, Ejdabiya. Alkufra
3. Sabha	Sabha, Morzuk, Wadi Alhiya, Wadi Shatee, Ghat
4. Musrata	Musrata, Sirt, Aljufra
5. Sabratha	Zawia, Alnikat, Nalut

*Presented in the National Cancer Registry program in 2007 [17].

ID	Districts
1	Alnikat
2	Zawia
3	Aljafara
4	Tripoli
5	Almergaib
6	Musrata
7	Sirt
8	Benghazi
9	Almarg
10	Aljabai Alakhader
11	Darna
12	Albatnan
13	Nalut
14	Aljabal Algarbi
15	Wadi Shatee
16	Aljufra
17	Ejdabiya
18	Ghat
19	Wadi Alhiya
20	Sabha
21	Morzuk
22	Alkufra

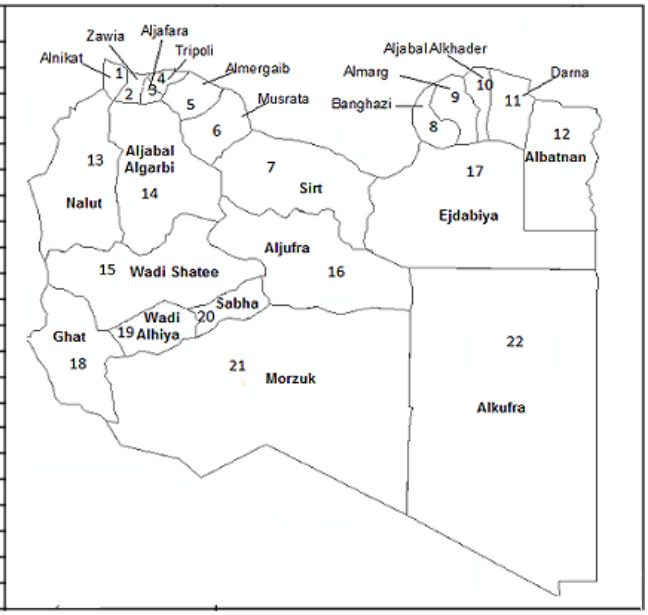

Figure 4: 22 Geographic boundaries and code of all districts in Libya (Source: [18])

3.2 The Results

The outcomes of total number of 1,080 case of breast cancer by years and districts are displayed in Figure 5 and Figure 6, respectively. Figure 4 presents the incidence of breast cancer cases in Libya during 6 years from 2015 to 2020. There were minor fluctuations of breast cancer cases between 2015 and 2017, during which period the worst outbreak occurred in 2018 with 246 cases, followed by 2019 with 219 cases, the number of cases decreased in 2020 with 162 cases. It can be seen from the bar graph in Figure 5 that Zawia district, which is located on the north-western of Libya near the capital Tripoli, recorded the highest number of cases at 246 followed by Tripoli, recorded the second higher number with 240 cases. The other two districts that recorded the highest number of cases were the district of Alnikat with 154 cases, and the southeastern state of Sabha with 88 cases. The total numbers of cases reported in other districts are in the range between 0 and 54 cases.

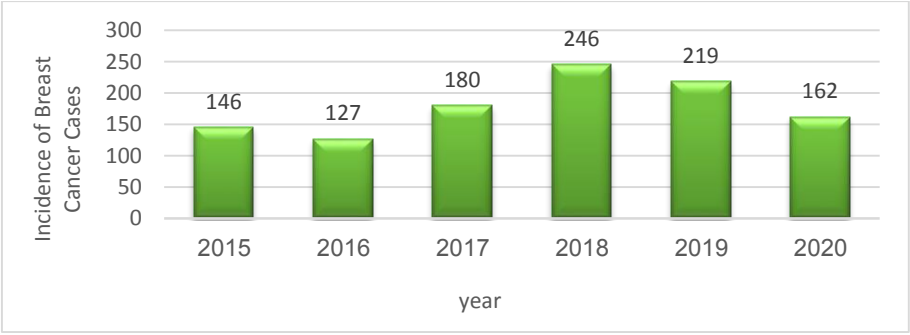

Figure 5: Total number of breast cancer cases from 2015 to 2020

The outcomes of relative risk estimation for the SMR model in all districts of Libya are displayed in Figure 7 and 8, respectively. It can be seen from both graphs that most districts have relative risk below one for all years. This means that the observed number of breast cancer cases is smaller than the expected number of dengue cases in those states. In contrast, there are eight districts that have SMR greater than one, which means that the observed number of cases is larger than the expected number of cases. In Figure 7, The districts that have SMR greater than one are the district of Zawia, Alnikat, Nalut, the capital Tripoli, Wadi Alhiya, Ghat, Murzok and Sirt, with corresponding SMR of 4.4666, 2.8148, 2.2801,

1.1952,1.7352, 1.3708, 1.1508 and 1.10402, respectively. This means that the observed number of breast cancer cases is smaller than the expected number of dengue cases in those states. In contrast, there are eight districts that have SMR greater than one, which means that the observed number of cases is larger than the expected number of cases. The districts that have SMR greater than one are the district of Zawia, Alnikat, Nalut, the capital Tripoli, Wadi Alhiya, Ghat, Murzok and Sirt, with corresponding SMR of 4.4666, 2.8148, 2.2801, 1.1952,1.7352, 1.3708, 1.1508 and 1.10402, respectively. Among those districts that have SMR less than one, the state of Ejdabiy has the smallest SMR which is 0.1125.

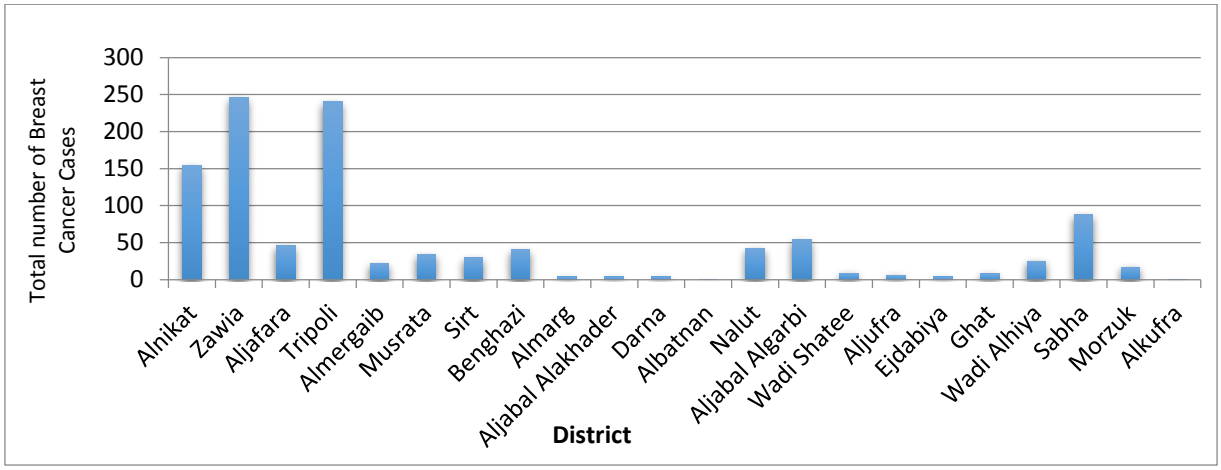

Figure 6: Total number of breast cancer cases for each district in Libya from 2015 to 2020

Also, it can be seen clearly from Figure 7 that the some districts have relative risk greater than one from most years, these districts are Zawia, Alnikat, Nalut, the capital Tripoli, Wadi Alhiya, Ghat, Murzok and Sabha, which indicate that susceptible people within these districts are more likely to catch breast cancer compared with people in the overall population. It was suggested that the high risk in these districts was related to the tendency to oily installations such as Mellitah Oil and Gas B.v, Azawia Oil Refining Company, Bouri Oil Field and Electrical power Stations.

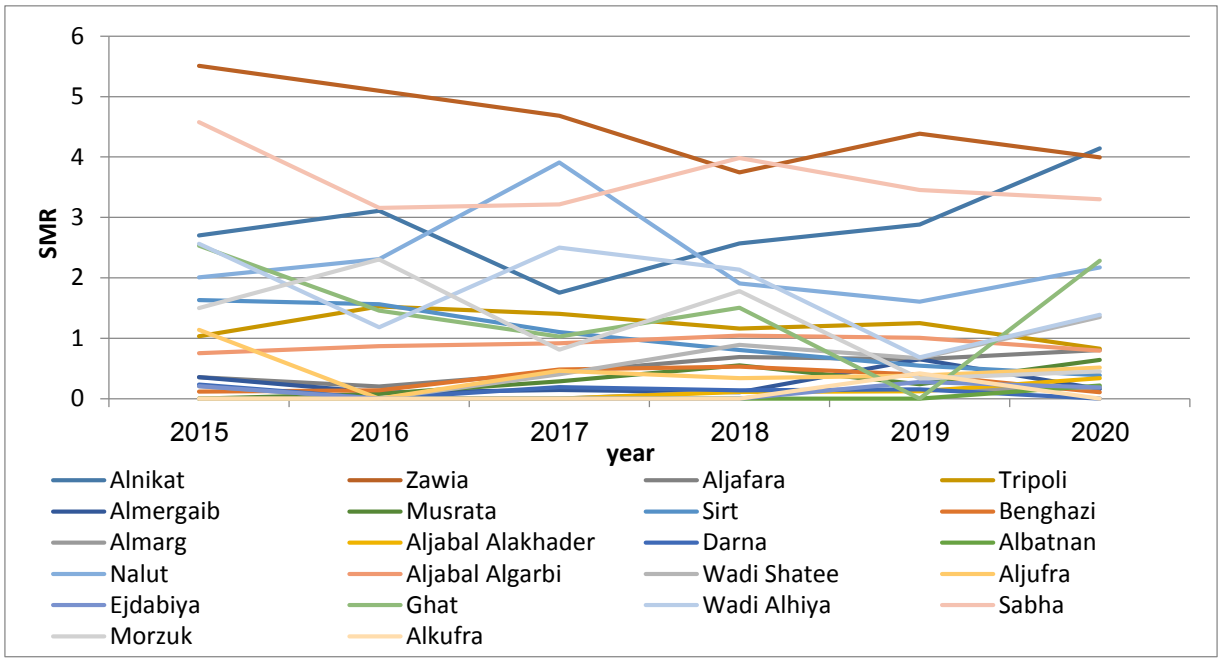

Figure 7: Time series plots of the estimated relative risk based on the SMR method for different districts in Libya

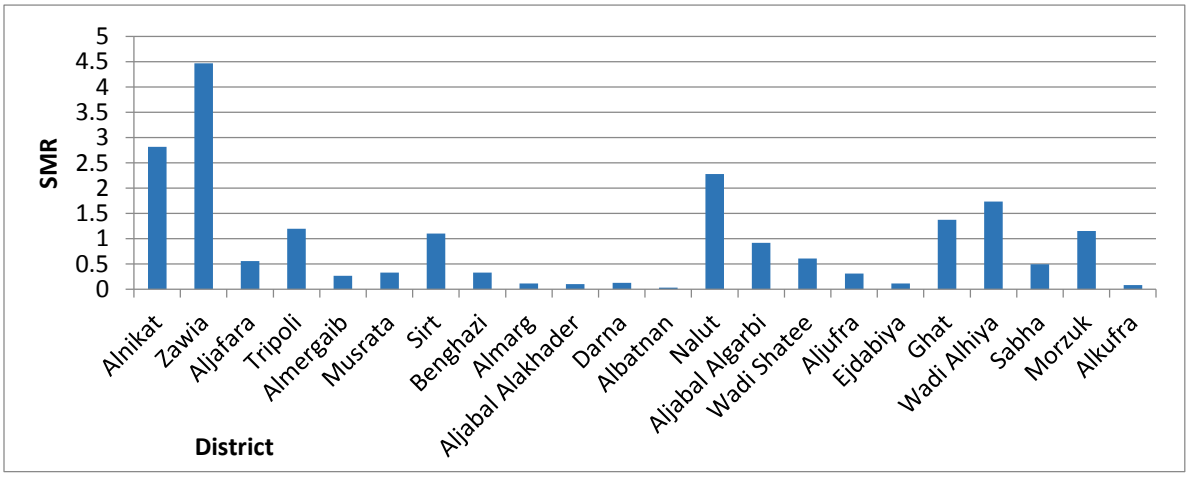

Figure 8: Bar graph for SMR from 2015 to 2020 for each district in Libya.

3.3 Maps of the Relative Risk Estimates for Breast Cancer Disease Mapping in the 22 Districts in Libya

In this section, disease maps are used a means of graphical statistical results for relative risk estimation based on SMR and, we compared it with summary map of the number of breast cancer cases reported for each district in Libya, discussed in previous section. For the purpose of interpretation in this application, thematic maps with multiple colours are used in this analysis in order to display and differentiate between the high and low risk area. In disease mapping, there isn't definitive way to choosing 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 [0.0,0.5), [0.5,1.0), [1.0,1.5), [1.5,2.0) and [2, ∞) respectively.

Figure 9 shows summary maps of the numbers of breast cancer cases reported for each district in Libya. These maps have been produced based on the number of breast cancer cases reported in each district. These maps are used to summarize and display the data and do not give much information. Very high numbers of cases mean that these districts have very high numbers of breast cancer cases reported compared to others. In contrast, the opposite is true for the very low numbers. However, Figure 9 shows SMR maps in the 22 administrative districts in Libya during the years from 2015 to 2020.Such these maps will help us to give a clear presentation about high districts of breast cancer occurrences.

The maps illustrated in Figure 9 and Figure 10 below show huge differences in terms of high and low breast cancer occurrence areas for the districts in Libya using two different methods, particularly in the north-west and south-west of the country. The most important difference is that the summary maps showed that there was no districts with high levels of breast cancer disease, while SMR maps showed it clear that there are districts with high levels of breast cancer disease for every years, for example, the summary map in Figure 9, in 2015 shows that there is no district with high risk, that is mean that every district has very low risk, while the other method "the SMR map" in Figure 10 shows that that six districts with very high risk are Zawia Alnikat, Nalut, Ghat , Sabha and Wadi Alhiya. This is followed by the district of Sirt and Morzuk with high risk and the districts of Tripoli and Aljufra with medium risk. District with low risk is only Aljabal Algarbi, while eleven other districts have very low district; they are Aljafara, Almergaib, Musrata, Wabi Shatee, Banghazi, Almarg, Aljabal Alakhader, Darna, Ejdabiya, Albatnan and Alkufra. However, for Figure 9 other huge changes can be seen in the districts of Alnikat, Zawia, Nalut and Sabha, they have very high risk and high risk at every year.

Comparisons between the summary maps and SMR maps during the period from 2015 to 2020, demonstrate huge obvious differences in terms of the estimated risks produced by both methods considered. Generally, this comparison shows the importance of using the right method to display the risk areas in maps. Although SMR is not the best method to estimate risk, it can overcome the problems by using smoothing models.

4. Discussion

Map based on SMR by administrative division can clearly show the geographical distribution of health affairs. The present study aimed to detect the high morbidity or incidence rate area through the use of breast cancer data for each district in Libya and it has showed the that different methods used to calculate risk provided different appearances of breast cancer risk in mapping and might give inaccurate interpretations of risk. These findings suggest that SMR methods can be used as a basic procedure for estimating relative risk instead of using the number of breast cancer cases alone.

In conclusion, we reported on some districts in Libya that have high risk of breast cancer. This study methodology will be helpful in the analysis of geographical disparities in cancer morbidity and incidence revealed in cancer registry data. These maps should be regarded as tools for forming hypotheses leading to the next step of the study, for example, attempting to start with investigating and developing further analysis to improve upon current models to inform and direct government strategy for monitoring and controlling breast cancer.

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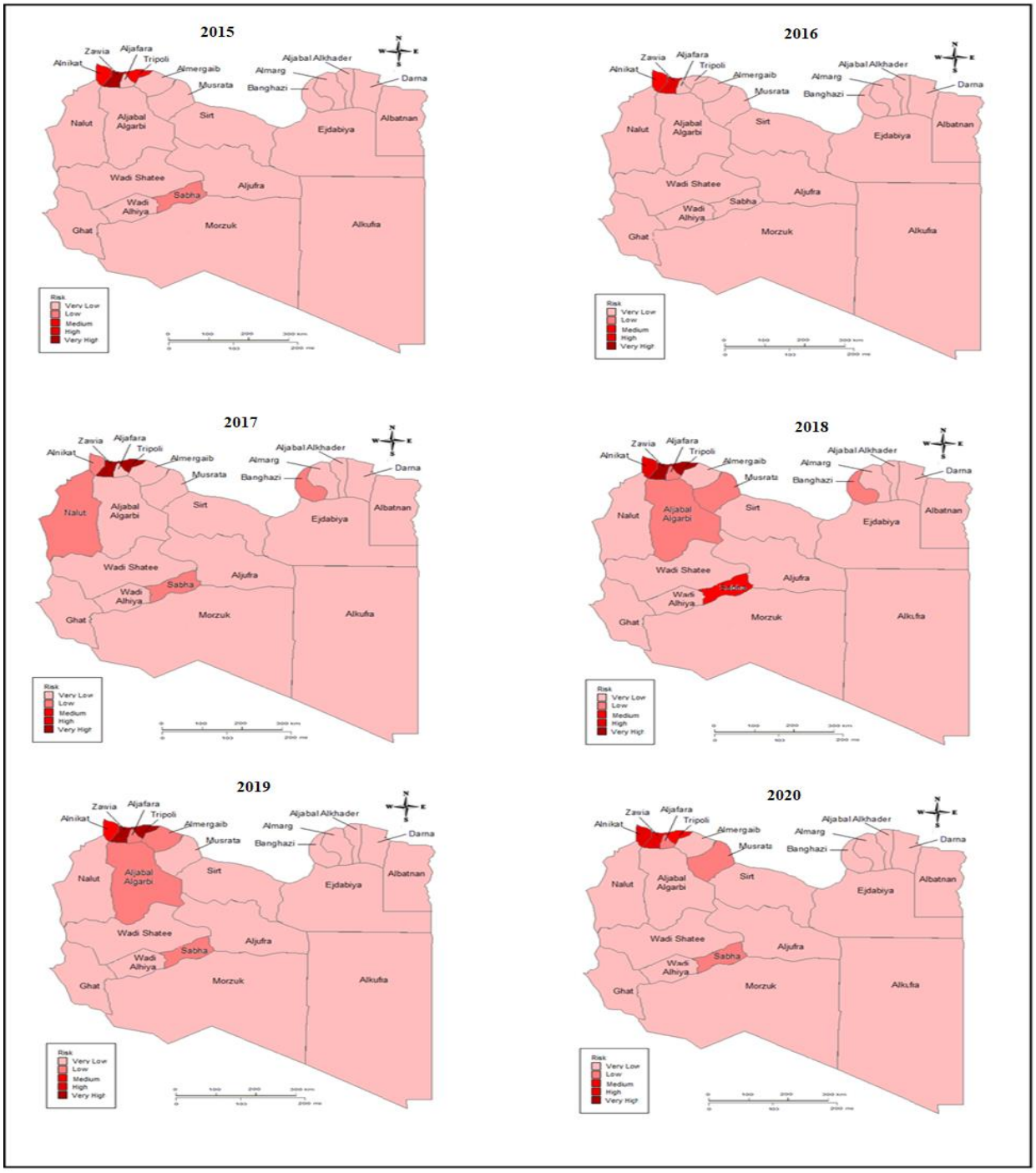

Figure 9: Summary maps of tolal numbers of breast cancer caese buring the years 2015 to 2020 for each district in Libya.

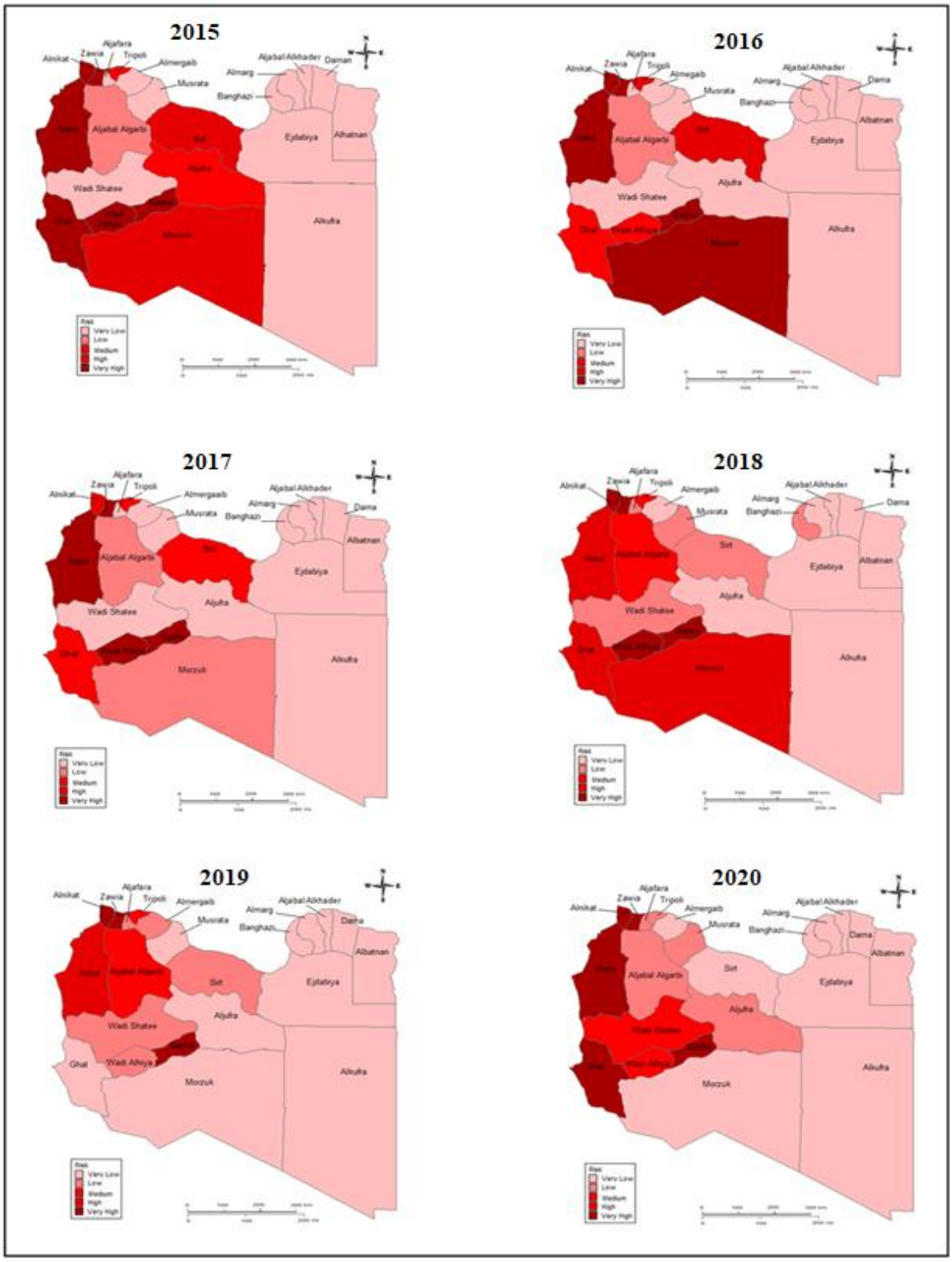

Figure 10: SMR maps of tolal numbers of breast cancer caese buring the years 2015 to 2020 for each district in Libya.

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