Spatial Distribution of Breast Cancer in Sudan 2010-2016

Marwa Maweya Abdelbagi Elbasheer[1*], Ayah Galal Abdelrahman Alkhidir[2], Siham Mohammed Awad Mohammed[3], Areej Abuelgasim Hassan Abbas [4], Aisha Osman Mohamed[5], Isra Mahgoub Bereir[6], Hiba Reyad Abdalazeez[7], Mounkaila Noma[8]

1. Department of Histopathology & Cytology, Faculty of Medical Laboratory Sciences, Alzaiem Alazhari University, Khartoum, Sudan

2. Sudanese Medical Council, Khartoum, Sudan

3. Zanam Specialist Hospital, Khartoum, Sudan

4. Sudanese Medical Specialization Board, Khartoum, Sudan

5. Department of Histopathology & Cytology, Faculty of Medical Laboratory Sciences, Alzaiem Alazhari University, Khartoum, Sudan

6. Sudanese Medical Council, Khartoum, Sudan

7. Sudanese National Council for Medical & Health Professions, Khartoum, Sudan.

8. University of Medical Sciences and Technology, Khartoum, Sudan.

***Corresponding author**: marwamaweya@hotmail.co.uk (MMAE)

Abstract

Background:

Breast cancer is the most prevalent cancer among females worldwide including Sudan. The aim of this study was to determine the spatial distribution of breast cancer in Sudan.

Materials and methods:

A facility based cross-sectional study was implemented in eighteen histopathology laboratories distributed in the three localities of Khartoum State on a sample of 4630 Breast Cancer cases diagnosed during the period 2010-2016. A master database was developed through Epi Info™ 7.1.5.2 for computerizing the data collected: the facility name, type (public or private), and its geo-location (latitude and longitude). Personal data on patients were extracted from their respective medical records (name, age, marital status, ethnic group, State, locality, administrative unit, permanent address and phone number, histopathology diagnosis). The data was summarized through SPSS to generate frequency tables for estimating prevalence and the geographical information system (ArcGIS 10.3) was used to generate the epidemiological distribution maps. ArcGIS 10.3 spatial analysis features were used to develop risk maps based on the kriging method.

Results:

Breast cancer prevalence was 3.9 cases per 100,000 female populations. Of the 4423 cases of breast cancer, invasive breast carcinoma of no special type (NST) was the most frequent (79.5%, 3517/4423) histopathological diagnosis. The spatial analysis indicated as high risk areas for breast cancer in Sudan the States of Nile River, Northern, Red Sea, White Nile, Northern and Southern Kordofan.

Conclusions:

The attempt to develop a predictive map of breast cancer in Sudan revealed three levels of risk areas (risk, intermediate and high risk areas); regardless the risk level, appropriate preventive and curative health interventions with full support from decision makers are urgently needed.

***Keywords*:** Breast Cancer; Spatial Distribution; Risk Map; Sudan

Introduction

Breast cancer (BC) is a heterogeneous group of diseases characterized by different pathologies, biological characteristics and clinical behaviors. It is the leading cancer among females worldwide with 641,000 cases reported in 1980 and 1,643,000 cases in 2010; the annual incidence increased between the two years was 3.1% [1]. In the year 2012, globally, BC represented 25% of all cancers and 15% of the cancer deaths among females [2]; in 2015, WHO reported 571000 deaths [3] while by 2020, 1.7 million new cases are expected mostly in the developing countries [4]. The recent shift in its burden in the developing world is revealed by a high mortality rate and a poorer overall survival [2, 4]. The geographical distribution of BC in Africa revealed a marked variation in incidence within the continent with a high incidence rate of 130 cases/100,000 populations in Northern African countries and a lowest rate of 95 cases/100,000 populations recorded in the Western part of the African continent [5]. The highest standardized mortality rate worldwide according to WHO six regions was found in the East Mediterranean Office (EMRO) and Africa Regional Office (AFRO) with respectively 18.6% and 17.2% [6].

In Sudan, the burden of cancer had increased from 303 cases in 1967 to 6303 in 2010 in which the BC represented the most common cancer [7]. Further studies [8,9] reported that the highest prevalence of cancers was recorded in the States of Khartoum, North Kordufan, Nile River, Northern, Gezira and White Nile states and BC was the most prevalent. According to the records of the Radiation Isotope Center Khartoum (RICK) and Gezira Institute for Cancer treatment and Molecular Biology (GICMB), BC was the most predominant malignancy among females with respectively 29-34.5% and 30.0% of the cancers registered. Most cases were young aged women. About 40% were below 45 years (mean age of 50) with late advanced disease. On the other hand, male cancer constituted 3.5-4% [10, 11]. Furthermore, studies from Red Sea State (2003-2006) and Central Sudan (1999-2006) revealed that the majority of the patients were premenopausal women (age <50 years) who presented with a late stage metastasized disease [12, 13].

A study [14] was conducted based on 6771 cases of cancers diagnosed in Khartoum State by Sudan First National Cancer registry during the period 2009 to 2010. The findings revealed that the most common cancer was Breast cancer with an incidence rate of 25.1 per 100,000. The study also reported the possibility of underestimation of the burden which could be due to factors such as stigmatization and poverty, leading to undiagnosed or untreated cases. Overestimation was also pointed out for elderly patients who might be treated symptomatically at primary care levels or died before reaching cancer specialized institutions.

Available statistics on breast cancer in Sudan are mostly restricted to central institutions such as RICK and GICMB and the geographical distribution of the disease yet is unknown. This paper aimed to estimate the burden of breast cancer and provide its spatial distribution country-wide.

Materials and methods

A facility based cross-sectional study was implemented. Data were extracted from eighteen histopathology laboratories within Khartoum State (Fig 1). In each of these laboratories, data collected included facility name, type (public or private), and geo-location (latitude and longitude). Personal data extracted from the facility records were name, age, marital status, ethnic group, state, locality, administrative unit, permanent address and phone number. Other information obtained from the records included the date of diagnosis and the histopathology diagnosis.

Fig 1: Geographical distribution of the histopathology laboratories

The master database, consisting of 4630 patient medical records was developed through Epi Info™ 7.1.5.2 and thereafter cleaned through the statistical package for social sciences (SPSS version 23) to exclude cases lacking important information such as the histopathology diagnosis, and date of diagnosis, as well as duplicated cases which were entered twice. The data of the remaining 4423 records was then summarized through SPSS to generate the frequency distribution of the cases in term of person (age, gender) and type of cancer diagnosed by the histopathology centers.

Histopathology diagnoses recorded were invasive ductal carcinoma, invasive lobular carcinoma, carcinoma in situ and others, which were then regrouped to fit WHO 2012 classification [15]. The epidemiological distribution of breast cancer in Sudan was based on 1135 records for which data on residence were available. Those 1135 records were geo-referenced to facilitate the plotting of the residence of the patients. Prevalence was estimated using the updated 2016 Sudan Census Bureau and Statistics population data as a reference. ArcGIS 10.3 spatial analysis features were used to develop a risk map based on the krigging method [16].

Ethical Statement

Study ethical clearance was obtained from Khartoum State Ministry of Health, Directorate of innovation and Scientific research Ethical Committee on 11th May 2017. (S1 file)

Results:

A total of 4423 cases of breast cancer were recorded (2010-2016) from eighteen laboratories distributed in Khartoum State. Patients were aged 12 to 103 years with an average (median) age of 48 years. They were predominately females 97.4% (4300/4413). The mean age at presentation was higher in males (61 years ±14.9) than in females (49 years ±14.2). Of the 4423 cases of breast cancer, invasive breast carcinoma of no special type (NST) was the most frequent histopathological diagnosis (79.5%, 3517/4423) followed by special subtypes of invasive carcinoma (12.4%, 547/4423) and precursor lesions (3.2%, 142/4423) and the remaining 4.9% were classified as others. Females were paying the highest burden with a crude prevalence of 3.9 cases per 100,000 female populations, ranging from 0.3 (Gedaref and Western Kordofan) to 22.1 in Khartoum as shown by Table 1 and Fig 2. On the other hand, male breast cancer was <1 per 100,000 male populations.

Fig 2: Epidemiological distribution of Breast Cancer in female population in Sudan (n=1135)

Table 1: Crude Prevalence (cases/100,000 population) of Breast Cancer in Sudan, data from eighteen histopathology laboratories located in Khartoum State (n=1135)

	Cases recoded from Labs			Prevalence per 100,000 population*		Total population		SCBS
States	**Number**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**2016**
Khartoum	786	766	20	22.1	0.5	3,464,536	3,920,622	7,385,158
Red Sea	79	77	2	12.5	0.2	616,423	828,930	1,445,353
El Gezira	45	44	1	1.8	0.1	2,464,166	2,295,598	4,759,764
Northern Kordofan	45	44	1	2.7	0.1	1,628,070	1,512,107	3,140,177
White Nile	43	42	1	3.5	0.1	1,183,915	1,140,529	2,324,444
River Nile	30	29	1	4.2	0.1	699,980	729,533	1,429,513
Southern Darfur	27	26	1	2.1	0.1	1,244,275	1,299,942	2,544,217
Northern	20	19	1	4.4	0.1	438,160	448,851	887,011
Sennar	17	17	0	1.8	0.1	912,230	865,752	1,777,982
Northern Darfur	14	14	0	1.2	0.0	1,115,490	1,165,395	2,280,885
Blue Nile	7	7	0	1.3	0.0	517,492	531,874	1,049,366
Southern Kordofan	6	6	0	1.2	0.0	501,841	490,106	991,948
Western Darfur	6	6	0	2.0	0.1	285,234	273,108	558,342
Kassala	5	5	0	0.5	0.0	1,053,571	1,306,512	2,360,083
Gedaref	3	3	0	0.3	0.0	1,012,329	999,285	2,011,614
Western Kordofan	1	1	0	0.3	0.0	282,473	275,868	558,342
Rumbeck**	1							
Total	**1135**	**1105**	**29**	**3.9**	**0.1**	**17,420,186**	**18,084,011**	**35,504,197**

SCBS: Sudan Census Bureau and Statistics
*** Crude prevalence computed as number of breast cancer cases/ total female population x 100,000 female population all age**
**** In Lakes State of South Sudan**

The spatial analysis confirmed that Breast Cancer is a country-wide health problem. The risk of breast cancer according to the map generated using the kriging method of the spatial distribution indicated three gradient scale colors of risk (Fig 3). Risk areas included Western, Central, Southern Darfur and partially Northern states, and a large part of Red Sea; Invasive carcinoma was predominant type in those States. Intermediate risk areas, a mosaic for invasive carcinoma NST, Special Subtypes of Invasive Carcinoma and Precursor lesions, included the States of Khartoum, Gezira, White Nile, Kassala, Gedaref, Sennar, Eastern Darfur, and focally Northern Darfur. High risk areas were the States of Nile River, Northern, Red Sea (focal), White Nile, Northern and Southern Kordofan.

Fig 3: Breast Cancer risk map in Sudan (n=1135)

Discussion

Our findings revealed a crude prevalence of 3.9 cases per 100,000 female populations for the period 2010 to 2016. This burden of Sudan females was also reported elsewhere in Sub-Saharan African countries, fluctuating from 4.5% (Zimbabwe) to 38.9/100 000 females in (South Africa) [17].

The average age of our patients was 48 years revealing that younger population was affected as reported in Central Africa (45.83 years) and Ghana (49.1 years) [18, 19]. On the contrary in developed countries, women are affected at older age respectively at 57 years and 62 years in New Zealand and United States [20, 21].

Invasive carcinoma of NST was the prevalent type (79.5%) of breast cancer in our study as previously published in Sudan [10], elsewhere it was 60% of breast cancer cases as reported by Badowska-Kozakiewicz, et al. [22].

The Epidemiological map generated per states indicated that the highest prevalence was recorded in Khartoum and Red Sea States with respectively 22.1 and 12.5 per 100,000 female populations. The figures from Khartoum and Red Sea States may be interpreted as related to the fact that most of the cases were reported from those States. We endorse the contrary based on the modeling which revealed that the spatial distribution predicts Khartoum State as intermediate risk whereas Red Sea State was displayed with a highly focal risk area. In the overall, we would like to emphasis that the breast cancer is a country wide public health problem. The delineated belt is a subject for further discussion related to the modeling technique and the limitations of the data which not include environmental and socio-economic factors.

This rapid evidence based delineation of breast cancer areas is a tool for guiding public health professionals and decision makers to establish a breast cancer program for fine tuning the epidemiological map and the subsequent risk map generated as applied in health sector in Iran [23] and elsewhere in Saudi Arabia [24] where the geographical information was used to set priorities.

One of the limitations of our model is the lack of environmental data to better assess the pattern of breast cancer which is a multi-factorial condition. The risk map was developed based on individual location of residence reported by the patients which may be a limiting factor leading to the over estimation or under estimation of the number of cases per State. This potential bias according to us was triggered out by the modeling approach of the krigging method which was used.

Conclusion

Our findings provided an understanding of the pattern of the spatial distribution of breast cancer country wide with hot spots defined as high risk and intermediate risk areas. As further data may be needed to improve the risk map, the decision makers and the health professionals should for equity reasons look at decentralizing of the health system which could not be efficient and operational if all the expertise are concentrated mainly in the State hosting the capital of country.

Acknowledgements

Authors would like to acknowledge the administration and staff of the eighteen histopathology laboratories for permitting the extraction of the data.

References

1. Forouzanfar MH, Foreman KJ, Delossantos AM, Lozano R, Lopez AD, Murray CJ, *et.al*. Breast and cervical cancer in 187 countries between 1980 and 2010: a systematic analysis. Lancet. 2011; 378(9801): 1461-84.

2. Lindsey A. Torre, Freddie Bray, Rebecca L. Siegel, Jacques Ferlay, Joannie Lortet-Tieulent, Ahmedin Jemal. Global cancer statistics, 2012. CA Cancer J Clin. 2015; 65: 87–108.

3. World Health Organization. Cancer Fact Sheet 2018. Accessed March 13, 2018. http://www.who.int/cancer/world-cancer-day/2018/en/.

4. The Lancet. Breast cancer in developing countries. Lancet Oncol. 2009; 10:1077-85.

5. Ferlay J, Soerjomataram I, Ervik M, Dikshit R, Eser S, Mathers C, Rebelo M, Parkin DM, Forman D, Bray, F. GLOBOCAN 2012 v1.0, Cancer Incidence and Mortality Worldwide: IARC

199 CancerBase No. 11 [Internet]. Lyon, France: International Agency for Research on Cancer; 2013.
200 Available from: http://globocan.iarc.fr, accessed on 31/3/2018.

201 6. MahshidGhoncheh, Zahra Pournamdar, Hamid Salehiniya. Incidence and Mortality and
202 Epidemiology of Breast Cancer in the World. Asian Pac J Cancer Prev. 2016;17:43-6.

203 7.Amany Elamin, Muntaser E. Ibrahim, DafallaAbuidris, Kamal Eldin H. Mohamed and Sulma
204 Ibrahim Mohammed. Part I: cancer in Sudan-burden, distribution, and trends breast, gynecological,
205 and prostate cancers. Cancer Medicine. 2015; 4(3):447-56.

206 8. Ali AA, Ibrahim FE. Incidence and geographical distribution of cancer in Radiation and Isotopes
207 Center in Khartoum. Sudan Medical Monitor. 2014; 9(3):109-11.

208 9. Saeed ME, Cao J, Fadul B, Kadioglu O, Khalid HE, Yassin Z, et al. A Five-year Survey of
209 Cancer Prevalence in Sudan. Anticancer Res. 2016 Jan; 36(1):279-86.

210 10. Elhoweris, Mohammed. Sudan First International Conference on Breast Cancer 5th-7th
211 December 2011, Khartoum Sudan. Sudan Med J. 2012 April; 48(1).

212 11. AmanyElamin, Muntaser E. Ibrahim, DafallaAbuidris, Kamal Eldin H. Mohamed and Sulma
213 Ibrahim Mohammed. Part I: cancer in Sudan-burden, distribution, and trends breast, gynecological,
214 and prostate cancers. Cancer Medicine. 2015; 4(3):447–56.

215 12. Ali K. Ageep, Babikir M. Ali, Mohamed A. Awadelkarim. Pattern and Incidence of Cancer in
216 Red Sea State, Sudan. Sudan JMS. 2007; 2(2): 115-17.

217 13. Elgaili M Elgaili, Dafalla O Abuidris, Munazzah Rahman, Arthur M Michalek, Sulma I
218 Mohammed. Breast cancer burden in central Sudan. International Journal of Women's Health.
219 2010; 277-82.

220 14. Intisar E Saeed, Hsin-Yi Weng, Kamal H Mohamed, and Sulma I Mohammed. Cancer
221 incidence in Khartoum, Sudan: first results from the Cancer Registry, 2009–2010. Cancer Med.
222 2014 Aug; 3(4): 1075–84. doi: 10.1002/cam4.254

223 15. Hans-Peter Sinna and Hans Kreipe. A Brief Overview of the WHO Classification of Breast
224 Tumors, 4th Edition, Focusing on Issues and Updates from the 3rd Edition. Breast Care. 2013;
225 8:149–54.

226 16. ESRI. How Kriging works. http://desktop.arcgis.com/en/arcmap/10.3/tools/3d-analyst-
227 toolbox/how-kriging-works.htm.

17. Surbhi Grover, Yehoda M. Martei, Priya Puri, Pooja Prabhakar, Miriam Mutebi, Onyinye D. Balogun, et.al. Breast cancer and HIV in SSA: a complex relationship. J Glob Oncol. 2017.

18. Augustin Balekouzou, Ping Yin, Christian Maucler Pamatika, Ghose Bishwajit, Sylvain Wilfrid Nambei, Marceline Djeintote, et al. Epidemiology of breast cancer: retrospective study in the Central African Republic. BMC Public Health. 2016. 16: 1230. doi: 10.1186/s12889-016-3863-6

19. Ohene-Yeboah M and Adjei E. Breast Cancer in Kumasi, Ghana. Ghana Medical Journal. 2012; 46(1):8-13.

20. National Cancer Institute. SEER Cancer Statistics Review, 1975-2014. Bethesda, MD Accessed on March 22 2018. , http://seer.cancer.gov/csr/1975_2014/, 2017.

21. Seneviratne S, Lawrenson R, Harvey V, Ramsaroop R, Elwood M, Scott N, et.al. Stage of breast cancer at diagnosis in New Zealand: impacts of socio-demographic factors, breast cancer screening and biology. BMC Cancer. 2016 Feb 19;16:129. doi: 10.1186/s12885-016-2177-5.

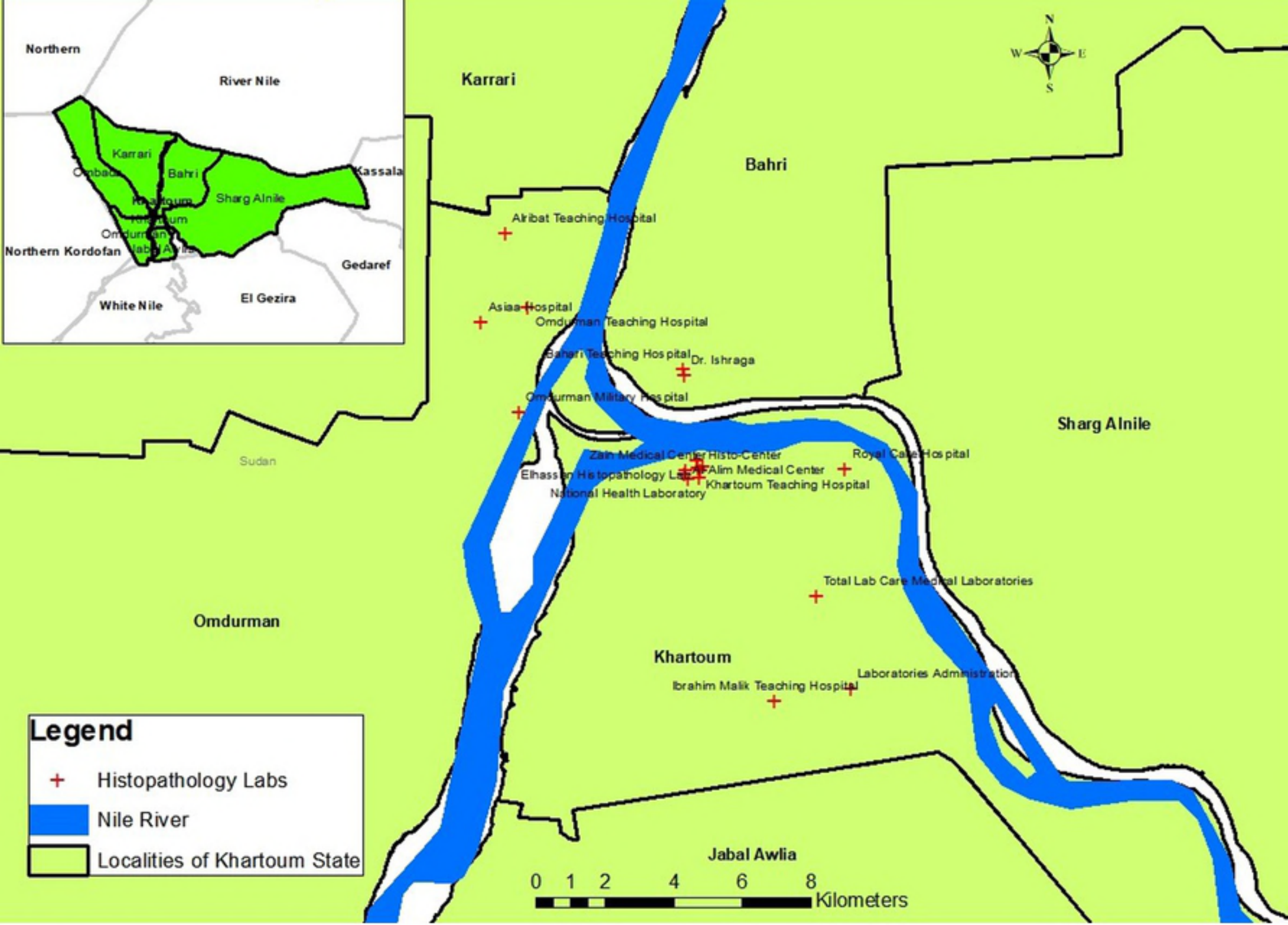
22. Anna M. Badowska-Kozakiewicz, Anna Liszcz, Maria Sobol, and Janusz Patera. Retrospective Evaluation of Histopathological Examinations in Invasive Ductal Breast Cancer of No Special Type: An Analysis of 691 Patients. Archives of Medical Science. 2017; 13(6): 1408–15. doi: 10.5114/aoms.2015.53964

23. Mahdavifar N, Pakzad R, Ghoncheh M, Pakzad I, Moudi A, Salehiniya H. The Spatial Analysis of Breast Cancer Incidence in Iran. Asian Pac J Cancer Prev. 2016; 17, Cancer Control in Western Asia Special Issue: 59-64. DOI:http://dx.doi.org/10.7314/APJCP.2016.17.S3.59

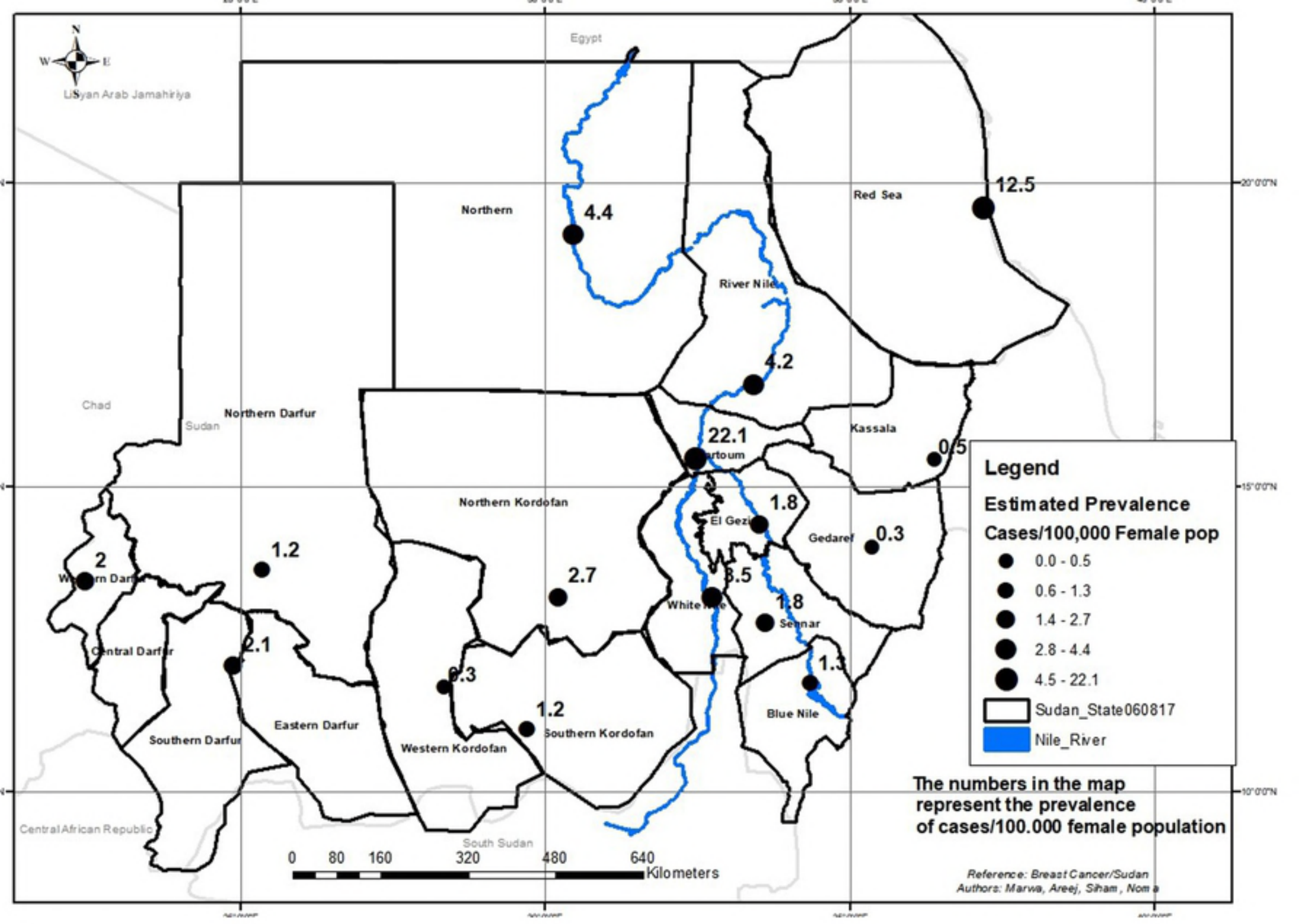
24. Gouri Sankar Bhunia, Pravat Kumar Shit, Ramkrishna Maiti. Comparison of GIS-based interpolation methods for spatial distribution of soil organic carbon (SOC). Journal of the Saudi Society of Agricultural Sciences. 2016, http://dx.doi.org/10.1016/j.jssas.2016.02.001.

Supporting Information

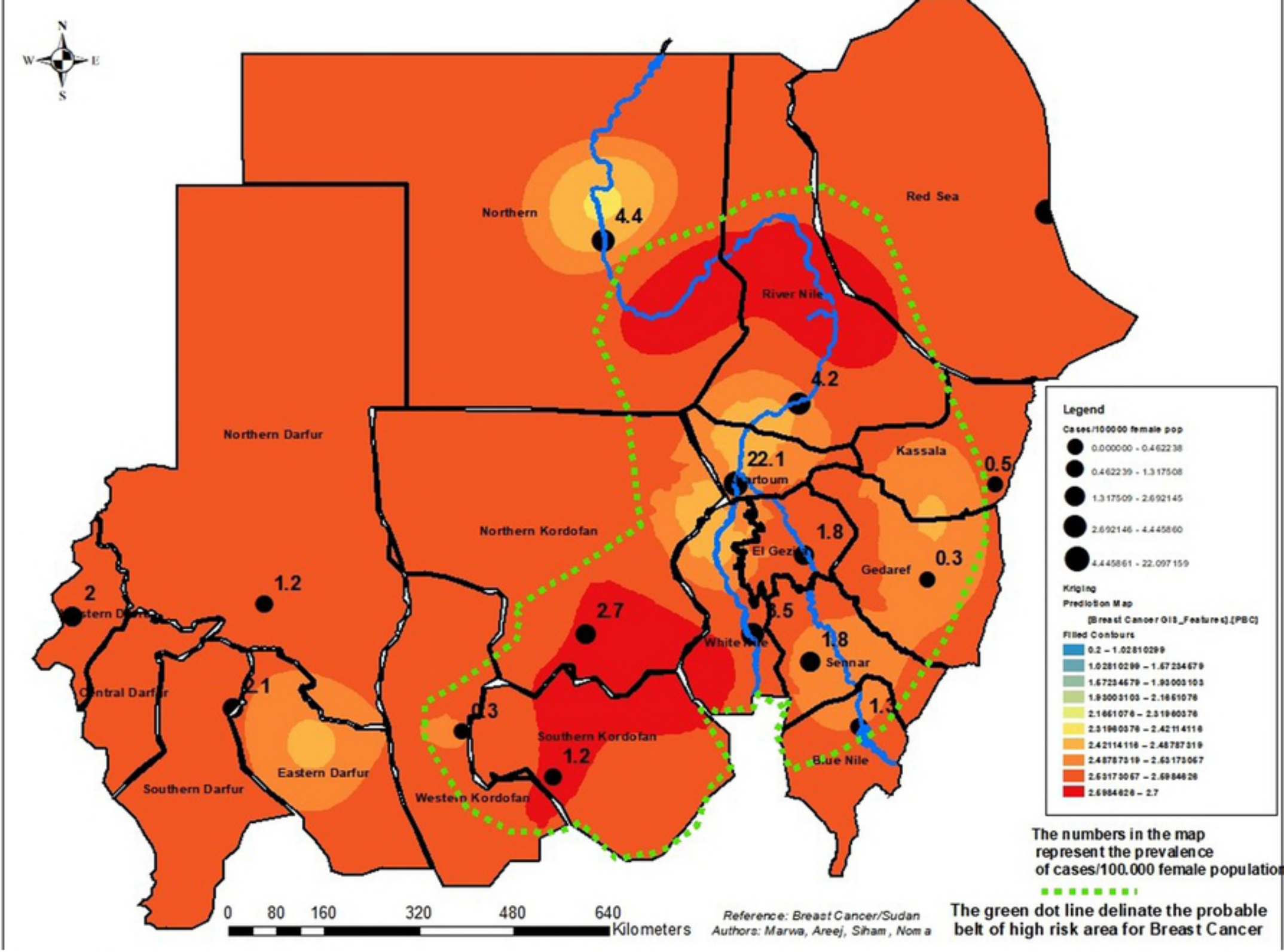
S1 File: Ethical Clearance Certificate


Northern
River Nile
Karrari
Bahri
Kassala
Sharg Alnile
Northern Kordofan
Gedaref
White Nile
El Gezira
Karrari
Bahri
Sharg Alnile
Alribat Teaching Hospital
Asiaa Hospital
Omdurman Teaching Hospital
Bahari Teaching Hospital
Dr. Ishraga
Omdurman Military Hospital
Sudan
Zain Medical Center Histo-Center
Royal Care Hospital
Elhassen Histopathology Lab
Alim Medical Center
Khartoum Teaching Hospital
National Health Laboratory
Total Lab Care Medical Laboratories
Omdurman
Khartoum
Laboratories Administration
Ibrahim Malik Teaching Hospital
Jabal Awlia
0 1 2 4 6 8
Kilometers
N
W
E
S
Legend
Histopathology Labs
Nile River
Localities of Khartoum State

Figure


N
W
E
Egypt
Libyan Arab Jamahiriya
Chad
Sudan
Central African Republic
South Sudan
Northern
Red Sea
River Nile
Northern Darfur
Kassala
Northern Kordofan
Gedaref
White Nile
Sennar
Blue Nile
Central Darfur
Eastern Darfur
Southern Darfur
Western Kordofan
Southern Kordofan
4.4
12.5
4.2
22.1
0.5
1.8
0.3
2
1.2
2.7
3.5
1.8
2.1
0.3
1.2
1.3
20°0'0"N
15°0'0"N
10°0'0"N
Legend
Estimated Prevalence
Cases/100,000 Female pop
0.0 - 0.5
0.6 - 1.3
1.4 - 2.7
2.8 - 4.4
4.5 - 22.1
Sudan_State060817
Nile_River
The numbers in the map represent the prevalence of cases/100.000 female population
0 80 160 320 480 640
Kilometers
Reference: Breast Cancer/Sudan
Authors: Marwa, Areej, Siham , Noma

Figure


N
W
E
S
Northern
4.4
Red Sea
River Nile
4.2
Northern Darfur
Kassala
22.1
0.5
1.8
Northern Kordofan
0.3
1.2
2
2.7
3.5
1.8
Sennar
2.1
1.3
Southern Kordofan
1.2
Blue Nile
Eastern Darfur
Southern Darfur
Western Kordofan
Legend
Cases/100000 female pop
0.000000 - 0.462238
0.462239 - 1.317508
1.317509 - 2.692145
2.692146 - 4.445860
4.445861 - 22.097159
Kriging
Prediction Map
[Breast Cancer GIS_Features].[PBC]
Filled Contours
0.2 – 1.02810299
1.02810299 – 1.67234679
1.67234679 – 1.93003103
1.93003103 – 2.1661078
2.1661078 – 2.31960376
2.31960376 – 2.42114116
2.42114116 – 2.48787319
2.48787319 – 2.63173067
2.63173067 – 2.6984626
2.6984626 – 2.7
The numbers in the map represent the prevalence of cases/100.000 female population
The green dot line delinate the probable belt of high risk area for Breast Cancer
0 80 160 320 480 640
Kilometers
Reference: Breast Cancer/Sudan
Authors: Marwa, Areej, Siham , Noma

Figure