Geographical variability of mammograms for breast cancer in Jalisco, Mexico, 2013-2015

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Abstract

An organized screening program by mammograms could help reducing mortality from breast cancer, so evidence is essential to decide where to target this strategy. Ecological design based on mammographic studies from 2013-2015 period, to examine the geographic variability of suspicious and highly suggestive results of malignancy in users of an oncology hospital in Guadalajara, Jalisco. Standardized rates and relative risks for each category were estimated according to the users municipality of residence. Considering 1,150 mammograms, 55.1% reported suspicious and 44.9% highly suggestive of malignancy. In Atoyac (southern area) 78.6 cases were reported with suspicious of malignancy per 100 thousand women ≥ 40 years, while in Ejutla (southwestern area) were 150.7 highly suggestive cases of malignancy per 100 thousand women ≥ 40 years. However, the detection risk in both categories, up to 4 times higher, spread from municipalities in the southwest to northeast of Jalisco. The geographical variability of detection with suspicious and highly suggestive of malignancy showed the municipalities where BC early detection programs could be targeted, according to users treated at the oncology hospital.

Key words: Breast neoplasms. Mammography. Relative risk. Spatial epidemiology. Geographic Information System.

Variabilidad geográfica de mastografías de cáncer de mama en Jalisco, México, 2013-2015

Resumen

Un programa de detección organizado mediante mastografías podría contribuir a reducir la mortalidad por cáncer de mama (CaMa), por lo que es indispensable contar con evidencia para decidir hacia qué lugares dirigir dicha estrategia. Se realizó un diseño ecológico basado en estudios mastográficos del trienio 2013-2015, para examinar la variabilidad geográfica de resultados sospechosos y altamente sugestivos de malignidad en usuarias de un hospital oncológico de Guadalajara, Jalisco. Se estimaron tasas estandarizadas y riesgos relativos para cada categoría según municipio de residencia de las usuarias. De 1,150 mastografías, el 55.1% reportó sospecha y el 44.9% altamente sugestiva de malignidad. En Atoyac (zona sur) se registraron 78.6 casos sospechosos de malignidad por 100 mil mujeres ≥ 40 años, mientras que en Ejutla (zona suroeste) fueron 150.7 casos altamente sugestivos de malignidad por 100 mil mujeres ≥ 40 años. Sin embargo, el riesgo de detección en ambas categorías, hasta cuatro veces mayor, se extendió desde municipios de la zona suroeste hasta el noreste de Jalisco. La variabilidad geográfica de la detección sospechosa y altamente sugestiva de malignidad mostró los municipios donde se podrían dirigir programas de detección temprana de CaMa, según las usuarias atendidas en el hospital oncológico.

Palabras clave: Neoplasias de mama. Mamografía. Riesgo relativo. Epidemiología espacial. Sistemas de información geográfica.

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Date of reception: 18-05-2020

Date of acceptance: 13-03-2021

DOI: 10.24875/j.gamo.M21000209

Available online: 18-06-2021

Gac Mex Oncol. 2021;21(3):26-33

www.gamo-smeo.com

Introduction

In recent years, malignant tumors have become one of the main causes of mortality in the Mexican population¹. In 2017, according to the National Institute of Statistics and Geography (INEGI – *Instituto Nacional de Estadística y Geografía*)², malignant tumors ranked third in both men and women; that year, 83,476 deaths³ were recorded, above liver diseases, traffic accidents and homicides, to name a few². Thus, breast cancer (BC) (C50) recorded 6,854 deaths², i.e. an increase of 8% ($n = 550$) in comparison with 2015⁴, mainly in women aged > 45 years, and it outranked others, such as cervical cancer², which had already been reported since 2006⁵. Moreover, according to BC mortality estimates, a continuous increase in women aged > 25 years is expected for the next few years⁶.

In view of this scenario, it has been suggested that the lack of an organized screening program⁶, capable of performing sufficient mammograms in the target population, of providing adequate diagnosis and treatment, as established by the NOM-041-SSA2-2011 standard for the prevention, diagnosis, treatment, control and epidemiological surveillance of BC⁷, could partially explain the magnitude of BC-related mortality in Mexico⁵, which has been recently documented²⁻⁴. In the USA, for example, the mortality decrease over several years has been associated, in part, with the implementation of early detection strategies using mammography, together with advances in medical treatments⁸. Some authors even argue that mortality is also a consequence of diagnoses at advanced stages, a problem that has been pointed out in Mexico since 2003⁹; one out of every two women is classified at stages IIb-IV^{6,10}. For this reason, it is argued that an organized program for BC early detection, as established by the NOM-041-SSA2-2011 standard⁷, together with sufficient human, material and technical resources to assign treatments, could reduce mortality by between 21⁶ and 40%⁷, in comparison with other methods, such as self-examination and clinical examination, which so far have not shown the same impact⁹.

However, the National Health System does not have sufficient resources to carry out population screening⁵ and, if required, to provide clinical care for BC in women¹¹, in addition to the fact that the available infrastructure is underused, which causes low coverage in several States of the country^{5,12}. Although it is true that identification of risk factors at the individual level, such as age or family history, allows defining population groups susceptible to screening⁷, it is also important for

the places (neighborhoods, municipalities, health regions) where early detection programs should be focused to be identified, which implies not only improving the distribution of health services aimed at this purpose and geographically bringing screening closer to the groups at higher risk (women aged ≥ 40 years)¹³, but also substantially increasing efficiency of the programs¹³.

In view of the above, it is essential to optimize available resources for screening programs, which are limited in a large part of the country, and this way try to adequately meet the demand for BC early detection in women, particularly in those places associated with a higher risk of detection at categories 4 or 5, according to the Breast Imaging Report and Database System (BIRADS) classification^{6,14}, since these categories suggest a suspicious or highly suggestive of BC malignancy result, respectively. Given the lack of research in Mexico involving an epidemiological and geographical approach (spatial epidemiology)¹⁵, a study was carried out in the State of Jalisco, the purpose of which was to examine the geographical variability of mammograms suspicious and highly suggestive of BC malignancy (BIRADS 4 and 5)^{6,14}, in order to identify risk areas where focusing or strengthening BC early detection programs is required.

Methodology

To achieve the proposed objective, an ecological design was used, which collected data related to the BC detection process in women residing in the State of Jalisco, whose medical care took place at a hospital specialized in the oncology area, located in the city of Guadalajara, during the 2013-2015 triennium; said hospital belongs to the Jalisco Ministry of Health, serves the general population diagnosed with different types of cancers and is one of the main referral centers for cancer care in Western Mexico. Prior to starting the research, approval by the ethics and research committee of the hospital was obtained.

Data source and collection

Data of interest were obtained by a process of clinical records review carried out at the aforementioned hospital, with users' confidentiality and anonymity being safeguarded. Those cases whose mammography examination reported the suspicious and highly suggestive of malignancy categories, i.e. BIRADS 4 and 5, respectively, of users aged ≥ 40 years who were

provided care in the study period, and who were residents of the State of Jalisco,^{6,14} were selected. In the data collection phase, standardization and reliability assessment was carried out, which is explained in detail somewhere else¹⁶. In brief, this process was carried out to verify that the captured and analyzed information was consistent with that reported in the medical records included in the study, and this way minimize possible biases in the design.

Data georeferencing and spatial unity

Once the collection stage was completed, data were integrated to the Jalisco Municipal Geostatistical Framework using the QGIS Geographic Information System (GIS) (version 3.10), which refers to the political-administrative delimitation of 125 municipalities according to the National Institute of Statistics and Geography (INEGI)¹⁷. This stage was useful for linking the collected data with a spatial reference, for grouping the municipalities according to the 13 health regions in the State, as well as for determining the frequency of both BIRADS categories by municipality (aggregated data), to subsequently estimate standardized rates by age, municipality and year.

Calculation of indicators and geostatistical analysis

Based on Jalisco's municipal delimitation, three spatial indicators were estimated for the study triennium: 1) suspicious cases and 2) cases highly suggestive of malignancy per 100,000 women aged ≥ 40 years, as well as 3) relative risk (excess risk) for each category. Rates estimation was obtained by direct method¹⁸, by dividing the total number of users aged ≥ 40 years whose mammography reported BIRADS 4 or 5 by municipality (2013-2015), among the female population aged ≥ 40 years reported at the municipal level during the same period, according to official data from the Health Information Board (DGIS – *Dirección General de Información en Salud*)¹⁹. Both indicators were grouped into quartiles in order to identify upper and lower outliers according to municipality. On the other hand, relative risk consisted of comparing, by means of a ratio, each estimated rate per spatial unit between the municipal average obtained in the triennium; all three indicators were calculated using the GIS GeoDa software (version 1.14).

Based on the above, a geostatistical analysis²⁰ was carried out in order to examine not only the magnitude,

but also the indicators' geographic variability, and thus determine areas of higher or lower risk. Additionally, spatial trend measurements were performed^{20,21} to identify the municipalities where the highest risk of detection of suspicious or highly suggestive of malignancy cases was concentrated. The results were presented through maps prepared in the aforementioned GIS.

Results

During the study triennium, 1,150 (N) medical records related to users diagnosed with BC were reviewed; out of these, 55.1% (n = 633) corresponded to cases suspicious for malignancy (BIRADS 4), whose average age was 52.4 years (standard deviation [SD] ± 11.9); while the highly suggestive of malignancy category (BIRADS 5) was reported in 44.9% (n = 517) of the cases; however, average age of this group was different ($p < 0.05$) from that of the previous one, i.e., 55.4 years (SD ± 11.9).

Figure 1 shows the distribution of users classified at BIRADS 4 during the 2013-2015 triennium according to municipality of residence. Based on this, all of them were identified to reside only in 68.8% (n = 86) of Jalisco's municipalities, where the frequency of cases ranged between 1 (27 municipalities) and 164 (Guadalajara). In addition, the municipalities located at the central zone, which belong to the Zapopan, Tonalá, Tlaquepaque and Guadalajara health regions, concentrated the highest proportion of cases, i.e. up to 6 out of every 10 (n = 389).

Regarding standardized values at the municipal level, only two municipalities recorded an upper outlier: Ejutla (southwestern zone) with 75.3 and Atoyac (southern zone) with 78.6 cases with suspicion of malignancy per 100,000 women aged ≥ 40 years, in comparison with the lower outliers recorded at the Lagos de Moreno health region (Fig. 1). However, the highest risk for BIRADS 4 detection spread to those municipalities located from southwest to northeast Jalisco, which is represented by the ellipse in figure 2; as a result, Acatlic, Atoyac, Ejutla, Totatiche and Unión de Tula (in black color) showed a relative risk up to four times higher than municipal average (Poncitlán: 18.9 cases suspicious for malignancy per 100,000 women aged ≥ 40 years).

On the other hand, considering the area of residence of the users classified in the highly suggestive of malignancy category (Fig. 3), all of them were identified to reside in 65.6 % (n = 82) of Jalisco's municipalities, with a frequency of cases ranging from 1 (28 municipalities)

Figure 1. Frequency of cases ($n = 633$) suspicious for malignancy by municipality of residence in Jalisco, 2013-2015 (own creation based on field work and on the National Geostatistical Framework, 2018¹⁷).

to 130 (Guadalajara); but, in comparison with the others, central (Zapopan, Tonalá, Tlaquepaque and Guadalajara health regions) and northeastern municipalities (Tepatitlán health region) concentrated up to 62% ($n = 320$) of users classified in said category.

Figure 3 shows the magnitude and variability of the highly suggestive of malignancy category detection, the upper outliers of which were: 71.8 (Santa María del Oro, Tamazula health region), 73.3 (Cañadas de Obregón, Tepatitlán health region), 87.5 (Valle de Guadalupe, Tepatitlán health region) and 150.7 (Ejutla, Autlán health region) cases per 100,000 women aged ≥ 40 years; unlike the lower outliers recorded at the Puerto Vallarta and Autlán health regions. However, relative risk was up to four times higher in municipalities at the southwest and northeast of the State (ellipse) (Fig. 4), i.e., Ejutla, Santa María del Oro, Valle de Guadalupe and Cañadas de Obregón, in comparison with the municipal average of 15.8 cases classified as highly suggestive of malignancy per 100,000 women aged ≥ 40 years recorded at Encarnación de Díaz.

Discussion

Geographic variability of BC detection by mammography showed municipalities with an up to four times higher risk in comparison with other areas of the State of Jalisco and, thus, the administrative and medical area of the oncology-specialized hospital, as part of the National Health System, could contribute to reinforce early detection programs in the municipalities of residence and at higher risk according to the users who are generally cared for. On the other hand, the analyzed BI-RADS 4 and 5 categories suggest that mammography appears to be an option for diagnostic evaluation rather than a method for BC early detection, as established by the NOM-041-SSA2-2011 standard⁷.

Undoubtedly, one of the main purposes of screening programs is to improve BC detection and diagnosis processes and favor the use of effective therapies in women^{6,7,13}. However, several important problems that prevent achieving this purpose at the national level have been documented. On one hand, a limited

Figure 2. Relative risk for the detection of cases suspicious for malignancy according to users' municipality of residence in Jalisco, 2013-2015 (own creation based on field work and on the National Geostatistical Framework, 2018¹⁷).

coverage of mammograms has been reported⁵, which ranges between 11.7 and 22.8% for the groups of women of 40-49 and 50-69 years of age, respectively. According to the area of residence, differences have also been found, which range from 19.1% (40-49 years) in rural zones to 17.7% (50-69 years) in urban areas¹². If we consider also that BC diagnosis in Mexico is generally carried out at advanced stages^{6,10}, analyzing the BIRADS categories reported by mammographic examination is important, as well as the age at which this occurs. According to the results herein presented, there were significant differences ($p < 0.05$) between BIRADS 4 and 5 categories according to average age, i.e., 52 and 55 years, respectively; a similar range (of risk)⁶ to that reported in another study¹⁰. Therefore, it is possible that the guidelines established by NOM-041-SSA2-2011⁷, regarding the detection process in women according to the age group they belong to, for example, self-examination, clinical examination or screening programs, are not working in some municipalities located at the southwest and northeast of

Jalisco, which could contribute to increase the number of mammographic examinations as an early detection method.

The importance of an effective population screening lies, among other aspects, in increasing detection at preclinical stages, as well as timely referral and, eventually, reducing BC mortality rates in women^{6,8,9}; otherwise, the cost of medical care increases and the possibilities of survival considerably decrease^{6,9}. However, in Jalisco, a coverage of mammograms $< 30\%$ ¹² has been reported, i.e. twice below the recommendation of the World Health Organization of screening at least 70 % of the at-risk population²²; this could be partially explained by the lack of infrastructure in the National Health System to perform sufficient mammograms in women aged ≥ 40 years^{5,7}. In view of this situation, improving or reinforcing an organized detection program as established by NOM-041-SSA2-2011⁷, as part of secondary prevention measures becomes necessary^{7,23}. Consequently, identification of groups and areas of higher risk becomes important in order to

Figure 3. Frequency of cases ($n = 517$) classified as highly suggestive of malignancy according to municipality of residence in Jalisco, 2013-2015 (*own creation based on field work and on the National Geostatistical Framework, 2018*¹⁷).

determine on whom and where it is necessary, for example, for screening programs to be focused, organized according to the profile of users who are generally cared for at hospitals that provide cancer care.

In this sense, the spatial epidemiology approach, through mapping and analysis of data associated with BC detection and diagnosis¹⁵, contributes to the identification of risk areas that could benefit from focused interventions, whether related to advanced stages of the disease, or to higher-than-expected mortality rates, as it has been done in other countries^{24,25}. Moreover, identification of risk areas could be adapted to different territorial scales as, for example, census units, neighborhoods, municipalities, health regions, where there is even sociodemographic or health services information that could complement an analysis with a spatial epidemiological approach.

Indeed, one of the non-communicable diseases on which more research has been carried out from the

spatial epidemiological perspective is cancer^{15,24}. The potential of this approach lies, among other aspects, in examining spatial variations and patterns using geo-spatial technology, which could support BC epidemiological control and surveillance, identify places where developing more (epidemiological) research or focusing interventions is needed²⁵, as well as where improving population screening effectiveness is required, for example, by geographical approach to this type of health services in order to increase early detection of cases, increase survival, improve quality of life and, eventually, reduce BC mortality rates⁹.

Considering the presented epidemiological design, it is necessary for some limitations to be pointed out. On one hand, the use of a secondary source limited the possibility of knowing whether users' mammographic examination was used as a screening or diagnostic method, according to NOM-041-SSA2-2011 criteria⁷, since this could provide evidence regarding the

Figure 4. Relative risk for the detection of cases classified as highly suggestive of malignancy according to users' municipality of residence in Jalisco, 2013-2015 (own creation based on field work and on the National Geostatistical Framework, 2018¹⁷).

process of referral, diagnosis and treatment of users cared for at the cancer care hospital. Furthermore, since this is a state referral center that also receives patients from other states, it is probable that the majority of mammographic examinations are related to BI-RADS categories that are suspicious and highly suggestive of malignancy in comparison with the others.

On the other hand, determining the subcategories established in BIRADS classification 4 was not possible^{6,14}, which certainly would have provided more specific results than those reported in the mammographic examinations. However, this largely depends on data accessibility and availability, which, by the way, reflects the fact that this design was not population-based, i.e. users of the private sector or other health services (Mexican Institute of Social Security, Institute of Social Security and Services for State Workers, among others) were not included. Even so, an aspect to be highlighted of the presented design is the geographic

analysis of clinical data that generally are not accessible, or are only used in the clinical setting. Therefore, the results contributed another perspective to the series of problems problem currently represented by the BC detection process in women at the State of Jalisco, which could well complement activities in the administrative and medical fields of hospitals that provide oncological care.

Conclusions

In conclusion, mammographic examination results of users cared for in an oncology hospital (2013-2015) allowed to identify, on one hand, differences on average age of detection of cases suspicious and highly suggestive of BC malignancy, i.e., between 52 and 55 years, respectively. On the other hand, municipalities where the detection risk for both categories increased up to four times were identified, i.e., the southwestern and northeastern zones of Jalisco.

Therefore, the evidence could contribute to determine which are the municipalities where population screening programs need to be focused, as an alternative to improve detection processes and, therefore, increase the chances for BC early diagnosis in women who are cared for at the oncology hospital that is part of the National Health System.

Funding

This manuscript was generated as part of the research for a doctoral thesis, whose financial support corresponded to a scholarship granted by the National Council of Science and Technology (CONACYT) in relation to the National Quality Postgraduate Program (PNPC).

Conflict of interests

The authors declare that they have no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this research.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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