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Correlation Between the Incidence of Breast Cancer and the Human Development Index

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1.Abstract

1.1. Introduction: Breast cancer is the second most frequent type in the world and is the most common among women. The increase in its incidence has been a cause of constant and growing concern, as the incidence rates vary greatly according to the degree of socio-economic development. Currently, the genesis of breast cancer and its risk factors have been receiving an important consideration, since these factors are crucial when thinking about its prevention. As developing countries are constantly growing, there is a change in their lifestyle habits, such as fat and alcohol intake, smoking, exposure to oral contraceptives, changes in procreation and breastfeeding patterns, birth profile. With this change, they also accumulate more diseases associated with this culture, among them breast cancer.

1.2. Objective: to analyze a possible relationship between HDI and the incidence of breast cancer worldwide.

1.3. Methods: The incidence of breast cancer in 164 countries was obtained from GLOBOCAN, derived from population-based cancer records. A list of human development index of the same 164 countries was obtained from the United Nations Human Development Report. Nonlinear regression models were obtained using the Levenberg-Marquardt estimation method.

1.4. Results and Conclusions: Of the 164 countries evaluated, 146 were in the range between 10 and -10 *of predicted variation*, which were between the fifth and 95th percentile values. The 18 countries whose incidences of CM were found to deviate outside this range (nine above and below, respectively) were considered *as discrepant observations.* Once the data from countries with *discrepant observations were removed*, nonlinear regression analysis of the group of 146 remaining countries was obtained using the Levenberg-Marquardt estimation method, identifying a value of "R^2" at 0.8343, confirming the high reliability of the proposed mathematical model. This result suggests the hypothesis that the factors included in the calculation of the Human Development Index are strongly related to those involved in the population incidence of breast cancer. The application of this model also suggested the existence of a group of countries that apparently present protective factors or that favor the onset of breast cancer.

2. Introduction

Breast cancer is the second most frequent type in the world and is the most common among women. If diagnosed is treated in due course, its prognosis is relatively good [3]. The increase in its incidence has been a cause of constant and growing concern, with an estimated 2.08 million new cases of cancer diagnosed in 2018

(24.2% of all cancers) [1]. Breast cancer incidence rates vary widely according to the degree of socio-economic development, with an estimated 2.3 million cases worldwide and 685,000 deaths in 2020, and cases are expected to reach 4.4 million in 2070 [10,11]. In general, its incidence is high in developed regions of the world (except Japan), with rates higher than 80/100000 women and low in most developing regions, with less than 40/100000 women. Its mortality rates are much lower in developed regions, but it is still high in developing countries [5]. As a result, breast cancer is the fifth leading cause of cancer death in general and is the most frequent cause of cancer death in women [2]. Relatively rare before the age of 35, above this age group its incidence grows rapidly and progressively. Statistics indicate an increase in its incidence in both developed and developing countries [4, 12-18]. According to the World Health Organization (WHO), in the 1960s and 1970s there was a 10-fold increase in age-adjusted incidence rates in population- based breast cancer records from several continents. Estimates of new cases of breast cancer for 2018 were 59,700, representing 29.5% of cases of neoplasms in women [6]. The Human Development Index (HDI) is a measure composed of health, education and income indicators. This measure was introduced in the first Human Development Report in 1990 as an alternative to purely economic assessments of national progress, such as GDP growth. The HDI soon became the most widely accepted and cited measure of its kind and was adapted by many countries for national use. HdI figures and classifications in the Global Human Development Report are calculated and published periodically by the UN, using the most recent data comparable between international sources [7-9]. The aim of this research was to analyze a possible relationship between HDI and breast cancer incidence worldwide.

3. Research Methodology

3.1. Incidence of Breast Cancer in the World

Data extracted from the “Incidence of Cancer on Five Continents”, published by the International Agency for Research on Cancer (IARC), where the incidence derives from population-based cancer records, were considered. This study, updated at intervals of approximately four to five years, includes in this version data referring to about 11% of the world population, where it was possible to obtain good epidemiological quality data. Although in most cases, the figures are related to the entire national population, in some cases the information derived from subnational regions or, in the case of some developing countries, only from large cities. As breast cancer increases its incidence with age, the age factor is a variable to be investigated, however to overcome this bias, it will be considered a standardized age rate (ASR), which is calculated as if the population had the age structure of a standard population.

3.2. Human Development Index

The current analyses of the human development index, provided through analyses and reports from the United Nations, were obtid. This information base was chosen due to the multifactorial analysis of this index, which includes the analysis of three dimensions and their respective parameters: health (life expectancy at birth); knowledge (adult literacy rate, primary, secondary and tertiary combined schooling rate) and standard of living (Gross Domestic Product). Details on the calculation of the Human Development Index can be obtained from the Human Development Reports web site.

4. Findings

A complete set of data on breast cancer incidence and human development index were obtained from 164 countries, 47 from Africa (28.70%), 42 from Asia (25.60%), 41 from Europe (25.0%), 27 from Latin America /the Caribbean (16.5%), 2 from North America (1.2%) and 5 from Oceania (3.0%). For the group of countries studied, the mean incidence of breast cancer was 53.11 /100 000 women (SD = 19.22) and an average human development index of 0.75 (SD = 0.108). (Table 2) presents the results of breast cancer incidence (MCI) and Human Development Index (HDI), according to geographic macroregions. The insertion of the data in a simple scatter plot shown in Figure 1 suggests the existence of a nonlinear (cubic) relationship between ICM and HDI. From these data, a regression model was obtained, presented in Equation 2.

$ICM = 452.35\ HDI^3 - 534.99\ HDI^2 + 212.28\ HDI - 6.3927$ Equation 2

This model was associated with an R^2 of 0.7198 and was applied to the human development index of each country in order to define the predicted incidence of breast cancer, which was used to calculate the standard deviation for the ICM observed, as shown in the example-extract presented in (Table 3). 146 countries are located in the range between the fifth and 95 percentiles of the scatter plot (Figure 1). The 18 countries outside these limits were considered discrepant, whose data are presented in (Table 4 and Table 5). Equation 3 is the resulting model of a nonlinear regression analysis performed with data from all other 146 countries, except the discrepant ones, which showed an R^2 of 0.8343.

ICM= 581.9 *HDI3* - 755.19 *HDI2* + 330.39 *HDI* - 26,253 Equation 3.

Figure 1: Geographic distribution of countries with lower than expected incidence of breast cancer

Table 2: Average and Standard Deviation Values of MCI and HDI according to the geographical distributions of the countries.

	Icm		HDI	
Continent	MEDIA	Dp	MEDIA	Dp
AFRICA	23,30	8,05	0,47	0,124
ASIA	32,83	15,35	0,66	0,133
EUROPE	65,01	21,43	0,81	0,106
A.LATINA	39,35	18,86	0,7	0,08
A.NORTH	79,6	5,09	0,9	0,002
OCEANIA	48,78	35,4	0,7	0,22

Table 3: The 10 countries with low incidence of breast cancer (MCI) observed and predicted, and respective Human Development Index (HDI); and the 10 countries with high ICM observed and predicted and HDI, as well as the difference between predicted and found (PD) of them.

Country	HDI	Icm Observed	Icm Predicted	Dp
Mongolia	0,642	8,0	29,11	21,1
Lesotho	0,440	8,3	21,96	13,7
Swaziland	0,515	9,9	22,82	12,9
Tanzania	0,454	10,1	22,03	11,9
Malawi	0,387	12,1	21,85	9,8
Comoros	0,430	12,2	21,93	9,7
Rwanda	0,419	12,3	21,90	9,6
Mozambique	0,312	13,1	21,50	8,4
Guatemala	0,569	15,0	24,53	9,5
Botswana	0,626	15,4	27,82	12,4
.	.	.	.	.
.	.	.	.	.
New Zealand	0,906	89,4	83,24	-6,2
Switzerland	0,899	89,4	80,64	-8,8
Uruguay	0,773	90,7	46,98	-43,7
Irlânda	0,905	93,9	83,00	-10,9
Iceland	0,897	95,5	79,90	-15,6
Israel	0,884	96,8	75,57	-21,2
Holland	0,905	98,5	83,01	-15,5
France				
0,880	99,7	74,34	-25,4	
Denmark	0,891	101,1	77,96	-23,1
Belgium	0,883	109,2	75,40	-33,8

Table 4: Countries with values below the 5th percentile (P5)

Country	DP above P5
Mongolia	21,1
Libya	21,8
Saudi Arabia	22,7
Norway	23,0
United Arab Emirates	26,2
Greece	27,7
Japan	36,7
Republic of Korea	38,5
Brunei	39,8

Table 5: Countries with values above the 95th percentile (P95)

Country	DP below P95
Uruguay	-43,7
Belgium	-33,8
France (metropolitan)	-25,4
Argentina	-24,1
Barbados	-23,5
Denmark	-23,1
Paraguay	-21,5
Israel	-21,2
United Kingdom	-21,0

5. Discussion

(Graph 1) presented above, demonstrating the dispersion obtained by the insertion of data collected from the incidence of breast cancer and human development index of the 164 countries showed a clear positive but nonlinear relationship, with an apparent deflection of the trend line to the points associated with HDI greater than 0.7.

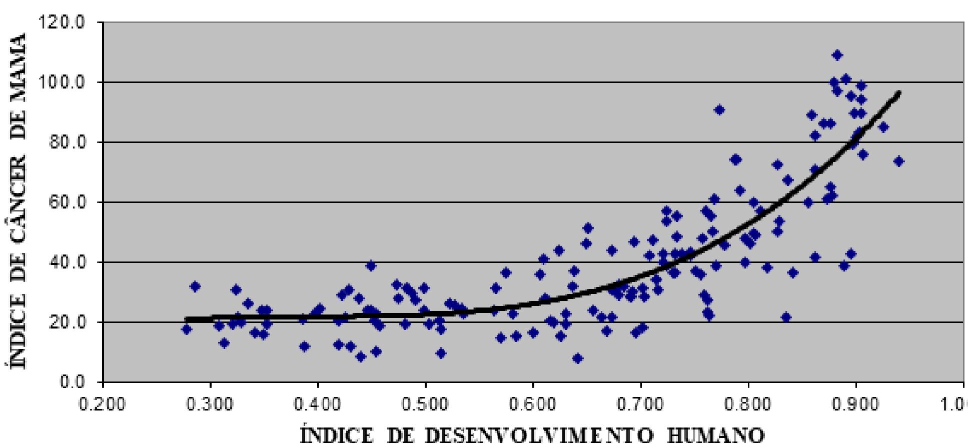
The identification of eighteen countries with discrepant indexes was not very enlightening in order to evidence clear related factors. However, some aspects related to its geographical distribution can be mentioned, as we see below:

Countries with lower than expected incidence of breast cancer (Figure 1):

Group composed of nine countries, three of which are located in Latin America/Caribbean (Argentina, Paraguay, Uruguay), four in Europe (Belgium, France (metropolitan), Denmark, United Kingdom) and only two countries were located in geographically isolated regions (Barbados and Israel).

Countries with higher than expected incidence of breast cancer (Figure 2):

The group of nine countries demonstrated a large concentration of countries in Asia including Mongolia, Saudi Arabia, the United Arab Emirates, Japan, the Republic of Korea and Brunei. Norway and Greece in Europe and Libya the only isolated country located in Africa. Although these data are insufficient to obtain conclusions, it seems that the difference in geographic distribution between these two groups may suggest the existence of factors related to characteristics such as lifestyle, diet, genetic factors and the organization of health care. On the other hand, obtaining an R^2 of 0.8343 in the analysis of the 146 remaining countries demonstrates the robustness of the mathematical model applied in order to observe the correlation between the degree of development of countries, measured here in a standardized way through hdi, and the incidence of breast cancer. However, we reaffirm that the use of information from epidemiological databases mentioned above intrinsically presupposes the existence of limitations inherent to studies of this nature, where the large number of variables involved prevents statistical data obtained at population scales from leading to inadequate inferences at individual levels, characterizing the *so-called ecological fallacy*. Similarly, specific geographical characteristics capable of influencing the incidence of breast cancer as cultural aspects, eating or religious habits may also act to explain possible deficiencies in correlation with the HDI according to the model demonstrated here. Thus, it can be concluded from this study that the human development index can represent an objective tool for the analysis of factors related to the incidence of breast cancer. From its use, it was also demonstrated the existence of countries whose incidence is outside the expected curve and, consequently, the analysis of its characteristics can contribute to a better understanding of factors related to the incidence of breast cancer.



Graph 1: Scatter plot of the observed relationship between ICM and HDI from 164 countries (trend line)

Figure 2: Geographic distribution of countries with higher than expected incidence of breast cancer

6. Final Considerations

The present study identified the existence of a pattern of direct correlation between the incidence of breast cancer and the human development index (HDI) in countries in different regions of the world. Through the application of the mathematical model defined in this study, it was possible to identify countries that present variations in this pattern capable of suggesting the existence of factors that can modify the risk of breast cancer incidence.

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