Mapping of female breast cancer incidence and mortality rates to socioeconomic factors: From univariate analysis to path diagram analysis

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Abstract

PURPOSE: Breast cancer is the leading cause of death in females around the world. Its occurrence and development has been linked to genetic factors, living habits and health conditions, but also by socioeconomic factors. Comparisons of incidence and mortality rates of female breast cancer are useful approaches to define cancer-related socioeconomic disparities. **METHODS:** International Agency for Research on Cancer's CANCERMondial clearinghouse was used to determine the incidence and mortality rates of female breast cancer data from several developed countries for 1980–2012. We subsequently investigated the effects of socioeconomic factors on breast cancer incidence and mortality rates by regression methods from univariate analysis to path diagram analysis. **RESULTS:** The relationship between socioeconomic factors and the occurrence and development of breast cancer did not follow a monotonic function. We found a positive, significant association of national public wealth (GDP) on the incidence and mortality of breast cancer. The path coefficients in the structural equations model are -0.51 and -0.39, respectively. In addition to the significant relationship between individual physical and psychological characteristics, social pressure, such as unemployment rate (UR) has a significant impact on the incidence and mortality of breast cancer. The path coefficients in the structural equations model are all 0.2. The path coefficients of individual economic wealth to the incidence rate and mortality rate of breast cancer is 0.18 and 0.27, respectively. **CONCLUSIONS:** A significant statistical relationship between the socioeconomic development and the crude rates of female breast cancer was shown in this study. The incidence and mortality rates of breast cancer can be regulated effectively by a moderate increase in GDP, and clearly was affected by the individual's economic wealth (GDPPC). In addition, the influence of social pressure (e.g., unemployment rate) on the incidence and mortality of breast cancer was not typical monotonous. The survival rate of breast cancer determined by the ratio of mortality rate to incidence rate also showed a similar pattern with socioeconomic factors.

Key words: Regression analysis, path diagram analysis, breast cancer, incidence, mortality, socioeconomic factors

1. Introduction

Through history, health was always one of the most fundamental issues of human development. In most of the historical stages, the culture, economy, trade and war experienced in each country were part of objective existence, and closely associated with individual health problems [1]. Health problems faced by human beings were influenced by the following aspects [2]. First, the time and space on which human beings depend for survival constitutes the objective basis for the development of human society. The second reason was the basic living necessities. Thirdly, human health issues are strongly tied to special spatial conditions, such as longitude, latitude, altitude, temperature [3]. These environmental factors will cause or induce people to form a life and behavior habit that matches the geographical environmental factors [4] [5]. Fourthly, human health problems tightly relate to social development. At different stages of development, human beings face different threats of diseases., The types and severity of diseases were different in different regions and ethnic groups at the same historical stage. Hunger [6], disease [7] and death are the three basic threats for the objective existence of species [8], and the same is true of the advanced animals, i.e. human beings [9] (as shown in Fig. 1).

Todays, cancers have brought a huge threat to human health. human beings have made considerable progress in dealing with breast cancer, such as disease prevention [10], cancer screening [11], etiological analysis [12], targeted drugs [13, 14] and clinical surgery. Despite important advances in the understanding of oncogenesis and development in the past decades, breast cancer remains one of the most common cancers diagnosed among women and the leading cause of female cancer death. The risk of breast cancer was significantly increased in developing counties [15]. The occurrence and development of breast cancer is complex and multi-stage processes, which prompt humankind to tackle at least two short or long-term goals. On the one hand, it is urgent to develop new-targeted drugs or explore minimally invasive surgical techniques. On the other hand, it is important to consider the factors of breast cancer occurrence and development from the perspective of social/environment factors [16, 17] and their interactions [18] (e.g. support [19] and education, networks [20], emotion [21]) on breast cancer occurrence and development. Numbers of individual and environmental factors may contribute to the risk of breast cancer and the prognosis in patients. Recently, the correlations between socioeconomic status and breast cancer incidence and mortality rates are increasingly recognized.

In this study, we focused on the socioeconomic factors that were involved in cancer control, such as population-level incidence rates, death rates and survival rates. Further, socioeconomic factors based on development were investigated by using stepwise regression analysis and path diagram analysis, with a purpose of providing sociological information for the diagnosis, prevention and control of female breast cancer.

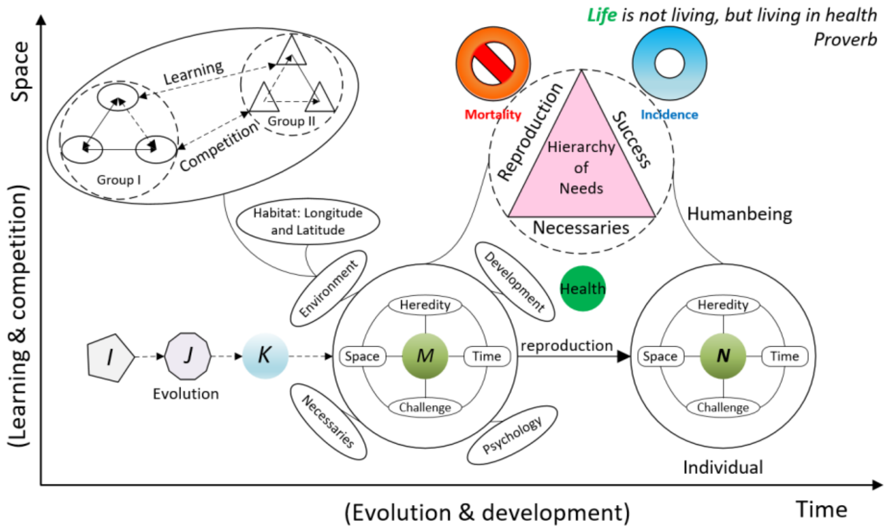


Figure 1 Illustration of the individual health issues from the perspective of human development

2. Data Sources and Methods

In this study, the breast cancer incidence and mortality data from 1980 to 2012 were obtained from Global Cancer Observatory (GCO) (http://gco.iarc.fr/#cancer-overtime). The socioeconomic data (including GDP, GDPPC, unemployment rate, and population) of several representative developed countries from 1980 to 2012 were obtained from National Accounts Main Aggregates Database (https://unstats.un.org/unsd/snaama/Basic).

Path diagram analysis is a form of structural equation model (SEM) and is generally tested by regression analysis [22]. The structural model is fitted by mathematical statistics methods and principles [23]. After the series test and analysis, the most suitable model was available to represent multiple complex relationships between independent variables and variables. In this study, we focused on certain socioeconomic factors such as time-dependent public wealth, living environment, including social population and social pressure, and individual economic wealth. As well known, these factors have complex interactions with each other. Therefore, path diagram analysis, based on multiple linear regression models, was used to explore the factors which influence female breast cancer using multi-dimensional causality and related strength analysis. The multivariate multiple linear regression formula was expressed as follows:

$$\mu_Y = \beta_0 + \beta_1 X_1 + \cdots \beta_5 X_5 \quad (1)$$

where β_0 is intercept, β_1, $\beta_2 \ldots \beta_5$ is partial regression coefficient. By fitting the regression equation of samples $\hat{Y} = \mathrm{a} + b_1 X_1 + \cdots b_5 X_5$, and the least square method was used to find coefficients to minimize the sum of squares (SS) of residual errors.

$$SS = \sum_{i=1}^{5} (Y_i - a - b_1 X_{i1} - b_2 X_{i2} \ldots - b_5 X_{i5})^2 \quad (2)$$

The structure of path diagram analysis was represented by a series of regression parameters, as seen in Table 1. Hypotheses involved the correlational and regression-like relations between the incidence/mortality rate and the socioeconomic factors. That is, some factors were observed variables and the others were latent variables. There might be a relationship between the observed variables and latent variables, and some variables maybe functions of other variables. In this study, we used incidence and mortality rates as dependent variable. Generally, temporal and spatial variables were regarded as the most basic independent variable, and the other factors were function of time.

Table 1 Regression sketch of numerical variable for the path diagram analysis

Route	Regression parameters						Function
R_1	X_1	X_2	X_3	X_4	X_5	Y_1	$Y_1=f_1(X_1,X_2,\ldots X_5)$
R_2	X_1	X_2	X_3	X_4	Y_2		$Y_2=f_2(X_1,X_2,\ldots X_4)$
R_3	X_1	X_2	X_3	Y_3			$Y_3=f_3(X_1,X_2,X_3)$
R_4	X_1	X_2	Y_4				$Y_4=f_4(X_1,X_2)$
R_5	X_1	Y_5					$Y_5=f_5(X_1)$

Note: The sample includes information for numerical variables from several representative countries (e.g. Denmark, Norway, New Zealand, Canada, Israel, France, Germany, Japan), including information on economics and breast cancer during 1980-2012. R_i (i=1-5) is the stepwise route of the regression analysis. During each process of regression, X_i is an independent variable, which consists of years, population, gross domestic product (GDP), gross domestic product per capita (GDPPC), and unemployment rate (UR). Y_j (j=1-5) is the dependent variable, in this case, the incidence rate and mortality rate of breast cancer. During the process of stepwise regression analysis, note that the identity of X_i (except for the lowest-order independent variable X_1) would transform into a dependent variable Y_j.

A graphical explanation of the process of path diagram analysis and the raw five-factor model was shown in Fig. 2. Clearly, in this study, we assumed that the five factors (x_1, x_2, x_3, x_4, x_5) of years, population, GDP, GDPPC, and unemployment rate affect breast cancer incidence and mortality rates (y_1, y_2). Further, we supposed that time was the most basic variable, and GPD was a low-order variable. GDP as a function of social wealth was impacted by years, a measure of time, GDPPC, population, and unemployment rate, which were all high-order variables and affected by other variables. The survival rate of breast cancer was measured using the mortality-to-incidence ratio

(MIR) [24] and to illustrate the effects of socioeconomic factors [25]. All variables were normalized before regression analysis. In mathematical form, the regression equation of path diagram analysis was formed by linking these variables with some coefficients.

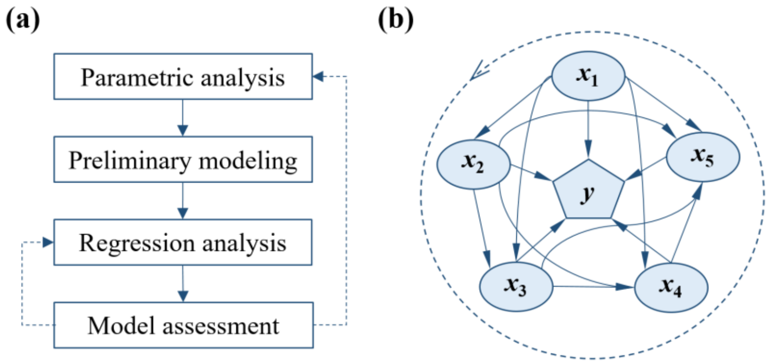


Figure 2 Graphical procedures and structural model for path diagram analysis.

3. Results

3.1 Univariate analysis of the correlation between wealth and breast cancer incidence and mortality

(1) Country-independent GDP

In Figure 3, the effect of country-independent GDP values on the incidence and mortality of breast cancer in women based on years were shown. As an important macroeconomic indicator, GDP best measured the economic strength and wealth of a country. The national GDP has an economic impact on the living standards and health of citizens. As seen in Fig. 3(a), the influence of GDP on the incidence of diseases shows a significant separation phenomenon. In Fig. 3(b), the effect of GDP on the mortality of diseases showed a significant separation phenomenon.

At lower national GDP (i.e., the national economic status is in poverty), the incidence and mortality of female breast cancer were both higher. In addition, the incidence and mortality are highly concentrated in the range of 50-200 (per 100,000 persons) and 20-60 (per 100,000 persons). Under higher national GDP, where the national economic status was in rich and defining threshold was 10,000 billion, a good quasi-linear relationship between the incidence and mortality of female breast cancer and GDP was shown. When the GDP was between 10,000 and 30,000 billion, the incidence and mortality of female breast cancer increased slowly with the increase of GDP. This phenomenon might be related to the source of national wealth and industrial level. These factors might produce benefits to working females and work pressure, working environment, and labor intensity. When the GDP was greater than 30,000 billion, the influence of GDP on the incidence and mortality of breast cancer also shows a significant bifurcated separation phenomenon, such as "o" and "h/p" in Fig. 3.

There were possible reasons for this pattern. First, some samples reflect that the country were wealthy, where people's living standard significantly improved. In these countries, the increasing incidence and mortality of breast cancer were related to over nutrition, obesity and other problems associated with rapid economic development. In addition, in these countries, the working intensity of the people was surplus/deficiency, which leads to the deviation of individual physique from the healthy range [26]. Secondly, in other emerging economies, with the increase of GDP, the national investment in research and development of preventive medicine and medical technology was enhanced. The national awareness of disease prevention and health has significantly grown, resulting in a gradual decline in the incidence and mortality of breast cancer.

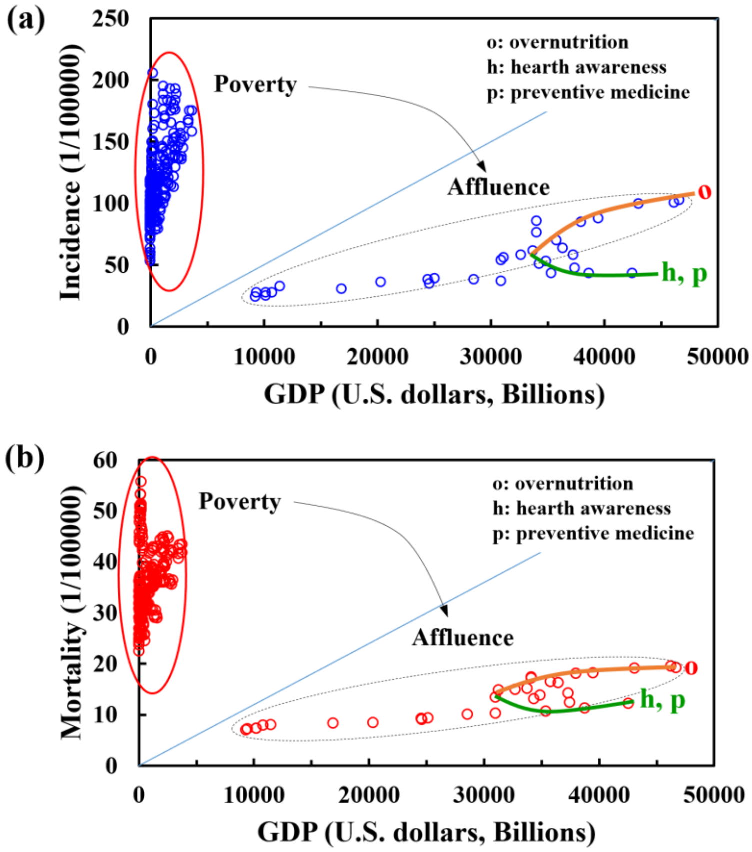


Figure 3 Differentiated effects of social public wealth on incidence and mortality rates of female breast cancer

As an important reference indicator for improving the per capita income level and living standard of residents, the GDP per capita (GDPPC) indirectly reflects the average purchasing power level of social individuals and the degree of independence of life. GDPPC was additionally used as an important economic index for individuals and families, and is related to the objective conditions of life and the judgment of the facts and values of the state (e.g. happiness index [27]). High GDPPC might enhance individual happiness through the individual's independent, free, and pleasurable experience in life. The economic index reduces cancer incidence and mortality [28]. In figure 4, the influence of per capita GDP on the incidence of female breast cancer and the trend of mortality have a power function change trend, but there were large differences in the two key parameters of coefficient and power index. For example, the coefficient of the power function of incidence rate is twice the power function of mortality rate.

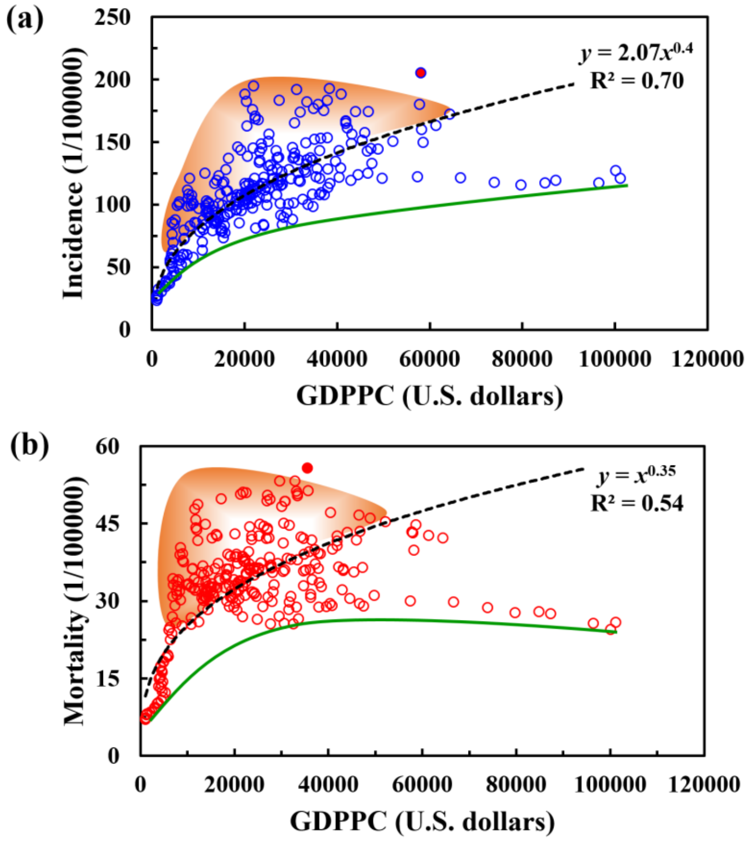


Figure 4 Effects of country-independent GDPPC on the incidence and mortality rates of female breast cancer

There were several reasons for this finding. First, women have a high degree of initiative and enthusiasm in the pursuit of personal value and economic wealth before the onset of breast cancer. At the same time, the increase in personal income, work stress and work intensity were also increased significantly, which results in an increase in the incidence of breast cancer. However, the effect on mortality is different. When income is low, expensive medical expenses are major stressor for breast cancer patients. The economic resources have a great impact on families. All aspects of stress will promote the negative beliefs in breast cancer patients, further resulting in accelerated illness and death. This was represented in the upper part of the fitted curve. In wealthy families, the presence of breast cancer patients will not put significant economic pressure on families or related members. After the pain and suffering caused by the disease, breast cancer patients are willing to pay for better therapy and nursing. Furthermore, an open-minded attitude of life has reduced the mortality rate to some extent (see the lower part of the fitted curve in Figure 4).

3.2 Univariate analysis of the correlation between unemployment rate and breast cancer incidence and mortality

As an important chronic disease, breast cancer was associated with the sociological negative factors of the affected individuals, for example, the national unemployment rate (UR). An increase in the unemployment rate is a signal of economic weakness and a reflection of social pressure. For individual, the degree of happiness and social pressure closely relates to the unemployment rate. The impact of unemployment rate on individuals is reflected in psychological stress, which in turn affects an individual's breast cancer incidence and mortality.

Figure 5 shows the association of the country-independent unemployment rate on the incidence and mortality rates of female breast cancer. The unemployment rate has a reverse corresponding relationship with the economic growth rate. When the unemployment rate is too high, it impacts the income of unemployed group, and also psychologically increases the insecurity of the unemployed. Some unemployed individuals may even cause a series of problems in the case of poor psychological quality. This involuntary diffusion effect will increase the insecurity of workers in the industry, thereby increasing the overall insecurity of the society and having an important impact on the physical and mental health of individuals.

In Figure 5, with the gradual increase of the unemployment rate, the incidence of breast cancer showed a growth trend of power function $y=42.27x^{0.48}$ ($R^2=0.30$); breast cancer mortality showed a power function $y=12.93x^{0.48}$ ($R^2=0.28$). Incidence and mortality have the same power exponent for the power function of independent variables, which can reflect the consistency of social pressure factors on individuals in the population. This is consistency accounts for the dependence of human beings on social production relations and/or basic survival needs. These needs, which are of great importance to the quality of life and health factors of individuals (e.g., safety, food, and shelter), relate to the cognitive level of individuals themselves.

In addition, there is an approximate three-fold relationship between the coefficient of the incidence power function and the coefficient of the mortality power function, which relates to the individual's desire for life, health and happiness. The incidence is generally for healthy individuals, and disease usually does not cause instant death. In this sense, external pressure (such as unemployment) might be fitted discretely in the curve of UR-incidence and mortality of breast cancer..

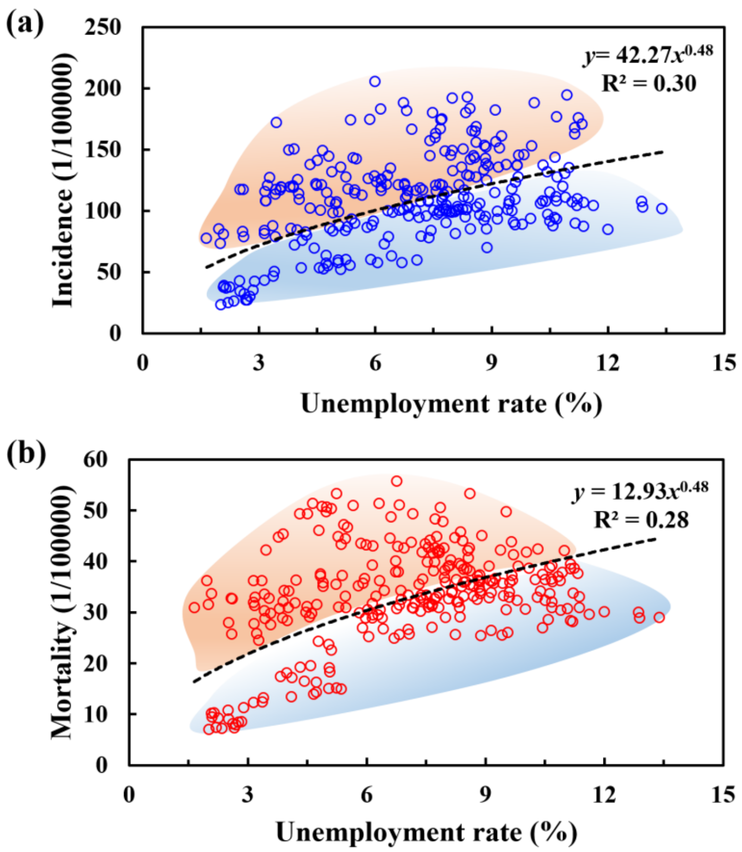


Figure 5 Effects of country-independent sociological UR on the incidence and mortality rates of female breast cancer

3.3 Univariate analysis of the correlation between the socioeconomic factors and the mortality-to-incidence ratio of female breast cancer

We further investigated the influences of four socioeconomic factors (including years, GDP, GDPPC and UR) on mortality-to-incidence ratio (MIR) of female breast cancer. In Fig. 6, a sharp increase in the MIR of female patients with breast cancer was revealed with the increase of GDP and GDPPC from 1980 to 2012. The MIR obeyed obeys a power function from the trend of the power function of incidence and mortality aforementioned, but the correlation coefficient of regression analysis is small, while the dispersion degree of data is high. However, the impact of the increased UR on MIR was almost constant. Therefore, the scatter plot shows that the differentiation was serious, which was mainly related to the individual's physical quality, personal will and survival belief.

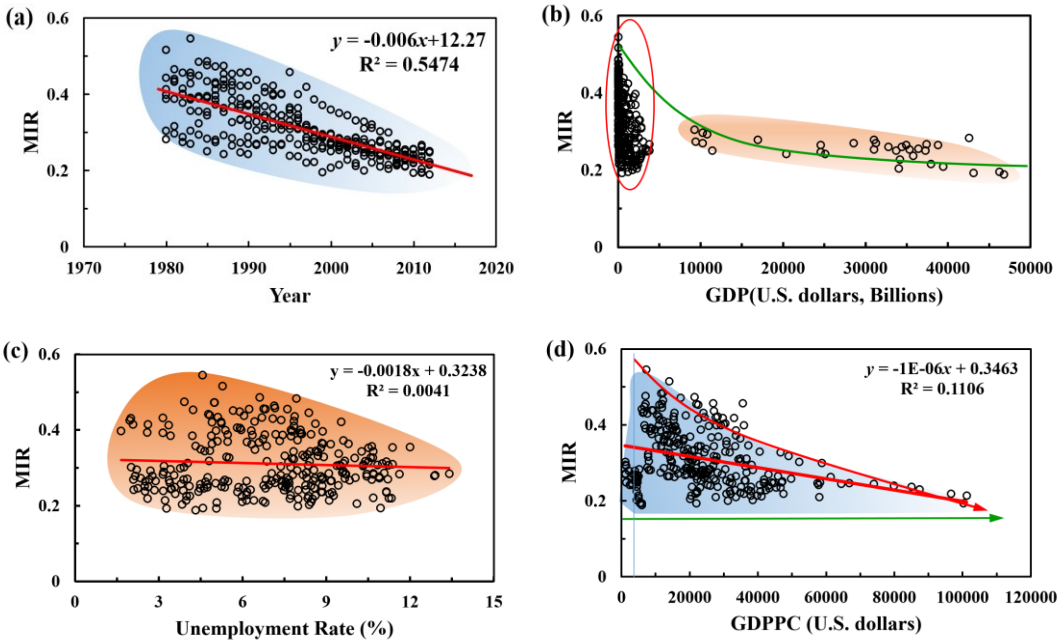
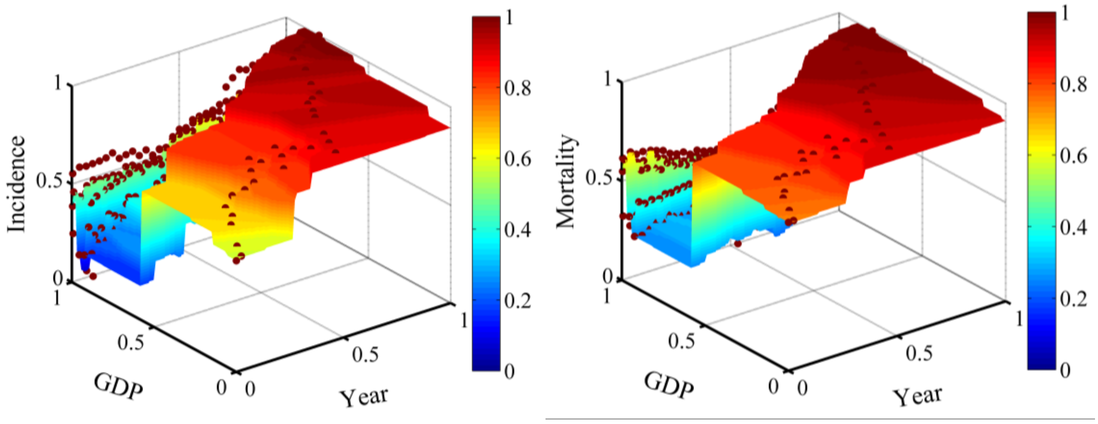


Figure 6 Effects of socioeconomic factors on the mortality-to-incidence ratio (MIR) of female breast cancer

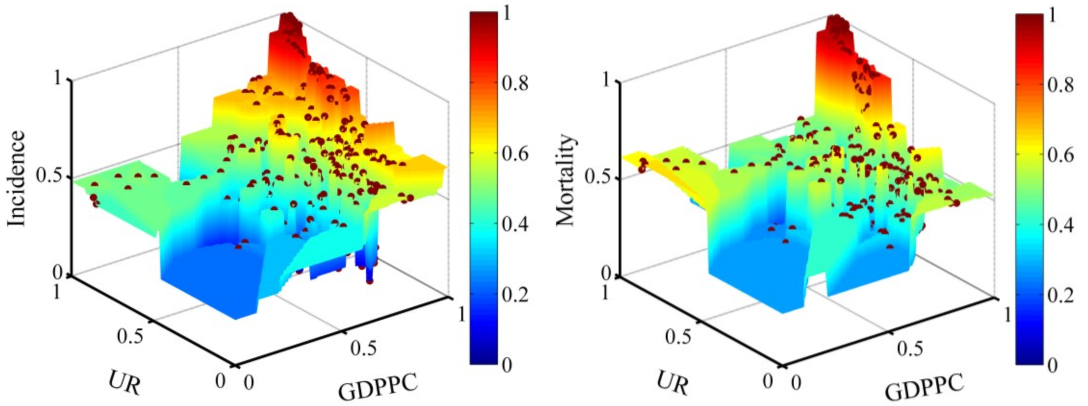
3.4 Two-factor analysis

In the previous section, we assumed that each variable was a single factor influencing the incidence and mortality of breast cancer. Considering the possible coupling effect between different two factors, we intend to analyze the simultaneous effects of the two factors, we intended to analyze the simultaneous effects of two factors. In order to avoid the misjudgements due to the quantitative differences, we standardized the variables using Min-Max scaling ($X_{norm} = (X - X_{min})/(X_{max} - X_{min})$). The simultaneous effects of socioeconomic two-factors on the incidence and mortality rates of female breast cancer were shown in Fig. 7 and Fig. 8. We showed that the influencing trends of socioeconomic factors on the incidence and mortality of breast cancer were consistent with the results of single factor analysis. The incidence and mortality of breast cancer decreased significantly with the increase of public wealth. The overall trend of the two groups of two-variables (time and public wealth, individual wealth and social pressure) on incidence and mortality were similar, but the weights of the two factors are significantly different.



(a) Incidence rate (b) mortality rate

Figure 7 Simultaneous effects of time (year) and public wealth (GDP) on the incidence and mortality rates of female breast cancer



(b) Incidence rate (b) mortality rate

Figure 8 Simultaneous effects of individual wealth (GDPPC) and social pressure (UR) on the incidence and mortality rates of female breast cancer

In addition, the survival index expressed by the mortality-to-incidence ratio (MIR), and the simultaneous effects of the two socioeconomic factors were shown in Fig. 9.

The effect of binary variables on survival rate of breast cancer patients was consistent with the univariate analysis. The influence of each variable on survival rate was similar. However, the description of the quantitative effects required further analysis.

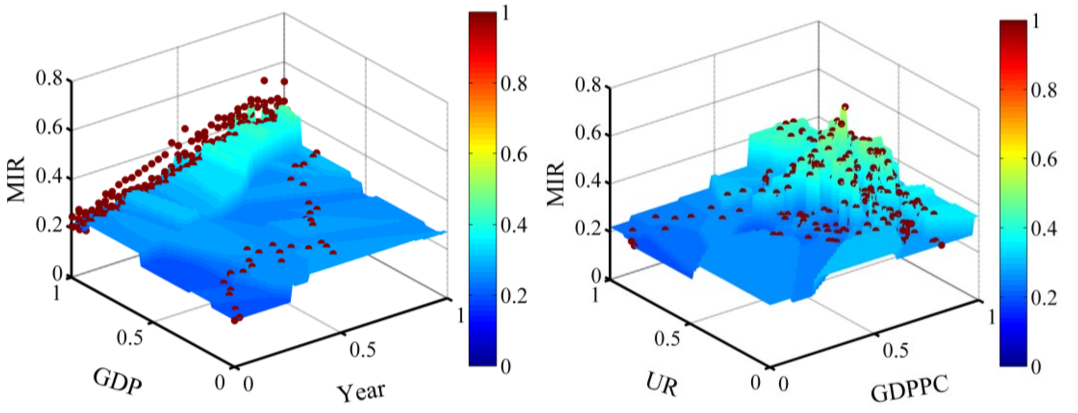


Figure 9 Simultaneous effects of socioeconomic two-factors on the incidence and mortality rates of female breast cancer

3.5 Multivariable analysis of the relationship among socioeconomic factors and breast cancer incidence and mortality

Path analysis is one form of structural equations model (SEM), which initial was applied in econometrics. The attractive feature is that uses the structural equations to present the implied values and compare them with the observed values [29]. That is, it explicitly assumes that every variable we observe is an imperfect measure of some potential causal variables and that the causality of interests is always between these potential variables. During the modeling of structural equations, there are three matrices (**A**, **S**, and **F**) which are defined by McArdle and McDonald [30]. The so-called structural equations consist of these matrices, as expressed by$\mathrm{C} = \mathrm{F}(\mathrm{I}-\mathrm{A})^{-1}\mathrm{S}(\mathrm{I}-\mathrm{A})^{-1\prime}\mathrm{F}'$. Where matrix **A** contains paths for asymmetric relations, **S** contains correlations and residual variances for symmetric relations, and matrix **F** filter the observed variables from the total data. Therefore, path diagram analysis is interesting and allow for novel applications [29, 31, 32]. In this study, it is possible to form three path analysis models, according to the previous assumptions about high-order variables (i.e. implied values) and low-order variables (i.e. observed values). The correlation coefficients and determination coefficients of the regression analysis of these three models are shown in Table 2. It can be seen that there is a significant relationship between breast cancer incidence and time and socioeconomic factors (i.e. population, GDP, GDPPC, and UR) (R>0.8), except for factors identified by the stepwise regression model. The fifth regression analysis (for the model of population versus time, R<0.2), there are significant multi-factor correlations. This finding verifies that the model as a whole is reasonable.

Table 2 Model summary for the multivariable regression analysis

Model	Regression statistics	Step I	Step II	Step III	Step IV	Step V
Model 1	Multiple R	0.8389	0.7698	0.5657	0.7858	0.1408
	R Square	0.7038	0.5927	0.3199	0.6176	0.0198
	Adjusted R Square	0.6986	0.5869	0.3128	0.6149	0.0164
	Std. Error	0.0968	0.2041	0.1624	0.1043	0.2116
Model 2	Multiple R	0.6171	0.7434	0.7859	0.7858	0.1408
	R Square	0.3808	0.5527	0.6176	0.6176	0.0198
	Adjusted R Square	0.3720	0.5480	0.6149	0.6149	0.0164
	Std. Error	0.1552	0.2135	0.1043	0.1043	0.2116
Model 3	Multiple R	0.8340	0.4751	0.7420	0.7858	0.1408
	R Square	0.6956	0.2257	0.5506	0.6176	0.0198
	Adjusted R Square	0.6913	0.2175	0.5474	0.6149	0.0164
	Std. Error	0.0934	0.1733	0.2137	0.1043	0.2116

Note: Complex correlation coefficient R is used to measure the degree of correlation between independent variables x and y. Complex determination coefficient R^2 ($\mathrm{R}^2 = 1 - SS(\text{residual})/SS(\text{all})$) is used to explain the degree of variation of dependent variable y with the independent variable x, i.e. determine the fitting effect of dependent variable y. The adjusted complex coefficient R^2 ($R^2_{adj} = 1 - \frac{MS(\text{residual})}{MS(\text{all})}$) can reflect the percentage of independent variable influencing dependent variable. Std. Error is used to measure the degree of fitting. The sample size is 288 in this study.

The main function of Analysis of Variance (ANOVA) table is used to judge the regression effect of regression model by joint hypotheses test (F test). The ANOVA data of each step regression analysis is listed in Table 3. In the process of decreasing regression, the degree of freedom (*df*) of potential variables is reduced by one for each regression. The significant level, or F statistics for each step of the regression analysis has different P values, which is less than the stated significance level of 0.05. Therefore, the regression equation for each step has the statistical significance of regression process. Further, the obtained interception and partial regression coefficient are used to express the each regression equation. The revalued coefficients for the selected models of the multivariable analyses are presented in Table 4.

Table 3 Analysis of variance (ANOVA) results of regression models for incidence rate

Step	Variation sources	*df*	*SS*	*MS*	*F*	Significance F
I	Regression	5	4.0823	0.8164	47.8654	9.48E-36
	Residual	282	4.8101	0.0171		
	Total	287	8.8924			
II	Regression	4	17.1575	4.2894	102.9645	5.35E-54
	Residual	283	11.7895	0.0417		
	Total	287	28.9470			
III	Regression	3	3.5235	1.1745	44.5455	1.27E-23
	Residual	284	7.4880	0.0264		
	Total	287	11.0115			
IV	Regression	2	5.0085	2.5043	230.1414	3.23E-60
	Residual	285	3.1012	0.0109		
	Total	287	8.1097			
V	Regression	1	0.2594	0.2594	5.7892	0.0167
	Residual	286	12.8143	0.0448		
	Total	287	13.0737			

Note: Significance F (F significant statistic) has the P values that is less than the significance level of 0.05, so the regression equation has a statistical significance.

Note that the P-value of items of “intercept”, “year” and “population” in the first regression are larger than the significance level of 0.05. The item of "GDPPC" in the second regression also has no statistical significance ($^{**}P > 0.05$). These shows that, the hypothesis that female breast cancer mortality is a function of time and population is not statistically significant in the structural equations model. In addition, the hypothesis that population is a function of GDPPC has no statistically significance. Therefore, some path coefficients in this structural equations models need eliminated for the reasonable hypothesis and correction SEM model. According to the path coefficients we can understand and identify the cause–effect relationship between the latent variables. Further, the path diagram based on the structural equations models are obtained and as shown in Fig. 10. In the path diagram model, the magnitude of the path coefficient indicates the relationship between the influence degree of variables and dependent variables, while the positive and negative values indicate the positive and negative effects of the influence trend.

In Fig. 10(a), year was the most basic time variable which was always related to the incidence of breast cancer, regardless of which implied value, the path coefficient is the largest. The weight of mapping relationship was the largest, which ultimately leaded to the highest degree of impact on breast cancer incidence. In addition, social public wealth (GDP) has a greater impact on the incidence of breast cancer. Its negative value (-0.51) reflected that the incidence of breast cancer declines with the increase of GDP, which was benefited from the improvement of public health conditions, the development of medical technology, disease prevention and control propaganda and other interventions. The influence of social pressure (UR), personal economic wealth

(GDPPC) and population on the incidence of breast cancer is very close (the path coefficients are about 0.2). In different structured variance models, the positive and negative of path coefficients remain unchanged, but the values of path coefficients were different. These deep-seated socioeconomic relations were not discussed here.

Table 4. A structural equations model based on the regression analysis of the incidence and mortality rates of female breast cancer

Step		Coefficients	Standard errors	t Stat	P-value	Lower 95%	Upper 95%
I (Incidence)	Intercept	-20.208	2.0584	-9.8175	9.24E-20	-24.2597	-16.1563
	Year	20.7499	2.0960	9.8999	5.02E-20	16.6242	24.8756
	GDP	-0.5088	0.0550	-9.2508	5.74E-18	-0.6171	-0.4006
	GDPPC	0.1795	0.0616	2.9114	0.0039	0.0581	0.3008
	UR	0.1864	0.0371	5.0271	8.87E-07	0.1134	0.2594
	Population	0.1956	0.0282	6.9352	2.77E-11	0.1401	0.2511
I (Mortality)	Intercept	3.1114	2.7758	1.1209	<u>0.2633</u>	-2.3526	8.5755
	Year	-2.6725	2.8265	-0.9455	<u>0.3452</u>	-8.2364	2.8913
	GDP	-0.3906	0.0742	-5.2658	2.77E-7	-0.5366	-0.2446
	GDPPC	0.2654	0.0831	3.1927	0.0016	0.1018	0.4290
	UR	0.1967	0.0500	3.9332	0.0001	0.0983	0.2952
	Population	0.0170	0.0380	0.4475	<u>0.6548</u>	-0.0578	0.0919
II	Intercept	12.0378	4.2787	2.8134	0.0052	3.6157	20.4598
	Year	-12.1658	4.3577	-2.7918	0.0056	-20.7434	-3.5881
	GDP	1.3156	0.0856	15.3741	3.42E-39	1.1472	1.4841
	GDPPC	0.1652	0.1295	1.2755	<u>0.2032</u>	-0.0898	0.4202
	UR	0.3932	0.0746	5.2720	2.68E-07	0.2464	0.5400
III	Intercept	-23.3425	3.1094	-7.5072	7.84E-13	-29.4629	-17.2222
	Year	24.28957	3.1530	7.7036	2.22E-13	18.0833	30.4958
	GDP	-0.64	0.0565	-11.3269	8.63E-25	-0.7512	-0.5288
	GDPPC	-0.77568	0.0922	-8.4125	1.99E-15	-0.9572	-0.5942
IV	Intercept	-25.0936	1.3344	-18.8053	7.37E-52	-27.7201	-22.4671
	Year	25.5634	1.3453	19.0016	1.41E-52	22.9154	28.2114
	GDP	-0.3654	0.0291	-12.5382	5.13E-29	-0.42272	-0.3080
V	Intercept	-6.3643	2.6814	-2.3735	0.0183	-11.6422	-1.0864
	Year	6.5029	2.7027	2.4061	0.0168	1.1832	11.8227

Note: In this structural equations model, the dependent variables (i.e. incidence rate and mortality rate) have the highest ranking. We assume that the other variables are their independent variables no matter whether implied values or not. That is, the breast cancer incidence and mortality rates are no longer used as variables to explore structural equation models after first-order regression. The underlined values of P in the table indicate the mathematical relationships that are not of statistical significance.

However, the mortality and socioeconomic factors of breast cancer patients are different from the incidence of breast cancer (Fig. 10(b)), The direct impact of year and population were not significantly, and thus we eliminated the two factors. The increase of public wealth helped to reduce the mortality rate of breast cancer patients, but the increase of personal wealth (GDPPC) and social pressure (UR) induced the increase of mortality rate of breast cancer patients. Therefore, reasonable control of personal economic wealth and release of social pressure are helpful to prolong the survival rate of breast cancer patients. The path coefficients obtained by low-order regression are consistent with the incidence variables.

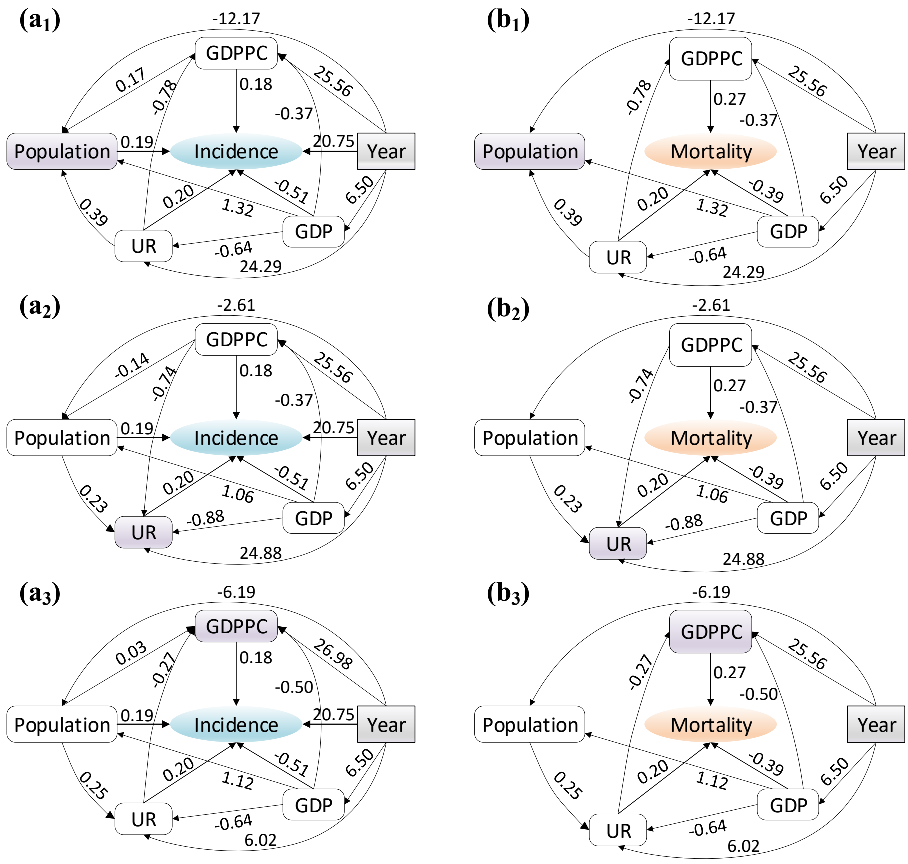


Figure 10 Structural equations model used to illustrate the relation between the incidence and mortality rates and socioeconomic factors: In the corresponding structural equation models, the dependent variables are (a) breast cancer incidence and (b) mortality respectively. Subscripts 1, 2 and 3 represent the structural equation models under three hypothetical conditions.

4. Conclusion

Social public wealth has a threshold limit on the regulation of breast cancer occurrence and development. The public wealth produces significant intervention ability until the value reaches at a certain level. The impact of social pressure (unemployment rate) on the incidence and mortality of female breast cancer was not typical monotonous, but showed a power function trend in a specific range. Individual economic wealth has a strong intervention effect on the incidence and mortality of breast cancer. The survival index determined by the ratio of mortality to incidence also showed a similar pattern with socioeconomic factors.

Bivariate analysis generally supported the results of univariate analysis. By using path coefficients and structured equations, the multivariable structured equation model analysis further accurately delineate the impact of socioeconomic factors on breast cancer incidence and mortality. The first-order structural equation model was subject to socioeconomic factors, but the second-order structural equation model was related to the correlation between socioeconomic factors. The establishment and expression of mathematical models related to socioeconomic factors were of great value to the accurate analysis and quantitative prediction of the occurrence and development of breast cancer, and further provide an effective theoretical basis for the prevention and treatment of female breast cancer.

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