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Mapping of female breast cancer incidence and mortality rates to socioeconomic factors cohort: Path diagram analysis

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Abstract

BACKGROUND: 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, and socioeconomic factors. Comparisons of incidence and mortality rates of female breast cancer are useful approaches to define cancer-related socioeconomic disparities. **METHODS:** This was a retrospective observational cohort study on breast cancer of females in several developed countries between 1980 and 2012. The path diagram analysis for five factors, i.e. years, population, gross domestic product, gross domestic product per capita, and unemployment rate, were conducted using Excel database function, and the effects on breast cancer incidence and mortality rates were analyzed. 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. **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 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 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 national public wealth, and clearly was affected by the individual's economic wealth. 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. Background

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 [3] and space [4] on which human beings depend for survival constitutes the objective basis for the development of human society [5]. The second reason was the basic living necessities. Thirdly, human health issues are strongly tied to special spatial conditions [6, 7], such as longitude, latitude, altitude, temperature [8]. These environmental factors will cause or induce people to form a life and behavior habit or culture [9] that matches the geographical environmental conditions [10, 11]. Fourthly, human health problems

tightly relate to social development [12-14]. At different stages of development, human beings face different threats of diseases [3, 15]. The types and severity of diseases were different in different regions and ethnic groups at the same historical stage [16]. Hunger [17], disease [18] and death are the three basic threats for the objective existence of species [19], and the same is true of the advanced animals, i.e. human beings [20] (as shown in Fig. 1).

Today, cancers have brought a huge threat to human health. Human beings have made considerable progress in dealing with breast cancer, such as disease prevention [21], cancer screening [22], etiological analysis [23], targeted drugs [24, 25] and clinical surgery [26]. 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 [27]. The risk of breast cancer was significantly increased in developing countries [28]. 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 [29, 30] and their interactions [31] (e.g. support [32] and education, networks [33], emotion [34]) 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.

Studies have demonstrated that nature environmental, host genetic, and socioeconomic factors influence the breast cancer prevalence landscape with a far-reaching influence on racial disparity to subtypes of breast cancer [35]. The socioeconomic effects on the incidence and death of the breast cancer need pay enough attentions, the socio-economic disparities in breast cancer survival prevail even in this relatively homogenous society [36]. Note that the function of public wealth and individual wealth are different during the intervene process. Thus, the lower screening attendance for women with lower socioeconomic status, and higher socioeconomic status is linked to higher incidence but lower case fatality [37]. Importantly, there is limited understanding of the contribution of social factors to control patterns [30]. Further, the influence and interaction of many socioeconomic factors (e.g. disposable wealth and pressures of life) on breast cancer of women is complex, and it is difficult to expose the dominate factors by cutting off the cross effects of affect factors. As shown in Figure 2, the influence factors both from nature and society are various and are not available in a statistics way. In order to investigate the influence maps between the socioeconomic issues and breast cancer, we focused on two groups socioeconomic data, one is endogenous wealth and distribution related to economic development (General Domestic Products, GDP; General Domestic Products Per Capita, GDPPC), and the other is exogenous completion and pressure related to individual survive (unemployment rate; population). These socioeconomic factors were readily available and 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. This study is critical for the influences of the socioeconomic factors on the development of breast cancer, with a purpose of providing socioeconomic information for the high risk screening and diagnosis, prevention and managing long-term surveillance care of female breast cancer. This study is also useful for the instructive intervention of social welfare and public health policy, with consideration of the prevention and treatment on breast cancer of women in developed countries and regions.

2. Methods

In this study, a retrospective observational cohort study on breast cancer of females in Denmark, Norway, Italy, New Zealand, Israel, France, Germany and Japan between 1980 and 2012 was carried out. The regression analysis and multivariate analysis (path diagram analysis) for five factors, i.e. years, population, gross domestic product, gross domestic product per capita, and unemployment rate, were adopted using Excel database function, and the effects of socioeconomic factors on breast cancer incidence and mortality rates were analyzed. 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 were obtained from National Accounts Main Aggregates Database (<https://unstats.un.org/unsd/snaama/Basic>). An illustration of the incidence and

mortality of breast cancer is provided in [Figure 3](#).

Path diagram analysis is a form of structural equation model (SEM) and is generally tested by regression analysis [\[38\]](#). The structural model is fitted by mathematical statistics methods and principles [\[39\]](#). 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 unemployment ratio [\[40\]](#) (reads 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, $\beta_1, \beta_2 \dots \beta_5$ is partial regression coefficient. By fitting the regression equation of samples $\hat{Y} = a + b_1 X_1 + \cdots b_5 X_5$, and the least square method was used to find coefficients to minimize the sum of squares (SS) of residual errors.

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

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	$Y_1=f_1(X_1, X_2, \dots, X_5)$
R ₂	X ₁	X ₂	X ₃	X ₄	Y ₂		$Y_2=f_2(X_1, X_2, \dots, X_4)$
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 X₁) 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 [Figure. 42](#). Clearly, in this study, we assumed that the five factors (x₁, x₂, x₃, x₄, x₅) of years, population, GDP, GDPPC, and unemployment rate affect breast cancer incidence and mortality rates (y₁, y₂). 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) [\[41\]](#) and to illustrate the effects of socioeconomic factors [\[42\]](#). 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.

3. Results

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 [46]. 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 [47]. The so-called structural equations consist of these matrices, as expressed by $C = F(I - A)^{-1}S(I - A)^{-1'}F'$. 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 [46, 48, 49]. 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 ($R^2 = 1 - SS(\text{residual})/SS(\text{all})$) 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	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	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 Figure. 5. 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 Figure. 5(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 led 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 (Figure. 5(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.

4. Discussion

4.1 Country-independent GDP

In [Figure 6](#), 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. 6\(a\)](#), the influence of GDP on the incidence of diseases shows a significant separation phenomenon. In [Fig. 6\(b\)](#), 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. 6](#).

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 [\[43\]](#). 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. Therefore, the low-income countries need allocate sufficient resources to increase screening participation [\[50\]](#). Thereafter, it is available for the fairly high quality of occurrence data and the adoption of accurate methods to estimate incidence and mortality.

4.2 GDP per capita

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 [44]). 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 [45]. In Figure 7, 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.

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. This result is different from the previous study. However, the effect on mortality is different. Overall mortality was greater among breast cancer patients of the lowest income group than in the highest one [51]. 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 7](#)).

Sociological pressure is accompanied by every process of growth. Specifically, health deterioration from unemployment is likely to be large, and unemployment is a public health problem that needs more focus [\[52\]](#). Usually, an increase in the unemployment rate is a signal of economic weakness and a reflection of social pressure. For individual, the unemployment or insecure employment closely relates to the degree of happiness and social pressure, specifically psychological complaints and life satisfaction. The impact of unemployment rate on individuals is reflected in psychological stress, which in turn affects an individual's breast cancer incidence and mortality. A 1 % increase in unemployment is associated with a significant increase in colorectal cancer mortality in both men and women [\[53\]](#). As an important chronic disease, breast cancer was associated with the national unemployment rate (UR) on the affected individuals.

[Figure 8](#) 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, this trend is also consist to the structure equation analysis result. 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 [\[54\]](#). 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 [55].

In Figure 8, 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 [56]. This consistency accounts for the dependence of human beings on social production relations and/or basic survival needs [57]. 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 [58]. This result also reads the five-year survival rate (more than 60%), which is hoped to be a useful information for the patients of breast cancer. In this sense, external social pressure (such as unemployment) might be fitted discretely in the curve of UR-incidence and mortality of breast cancer. However, the effects of unemployment is clearly. Our results are broadly consistent with literature [59], unemployment significantly increases the risk of being dead at the end of follow-up by nearly 50%. The fact may ask for the deep think on the unemployment insurance system for the potential protective effects on the patients of breast cancer [54].

4.3 On mortality-to-incidence ratio

Five-year survival rate of breast cancer usually is proxied by mortality-to-incidence ratio (MIR) of breast cancer for women health [42], Adams et al. investigated the accessibility and importance of mammography services [60]. 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. 9, 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. MIR obeyed a power function from the trend of the power function of incidence and mortality aforementioned, but the correlation coefficient of regression analysis is small and 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 [61].

5. Conclusions

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.

Abbreviations

ANOVA: Analysis of Variance;

MIR: mortality-to-incidence ratio;

GCO: Global Cancer Observatory;

GDP: General Domestic Products;

GDPPC: General Domestic Products per Capita;

SEM: structural equation model;

SS: sum of squares;

UR: unemployment rate.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for Publication

Written informed consent for publication was obtained from all participants.

Availability of data and material

The datasets used or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have declared that no competing interests exist.

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Authors' contributions

Conceptualization, Qiongle Peng and Xiaoling Ren; Methodology and software, Bing Cui; formal analysis and investigation, Qiongle Peng; visualization and project administration, Henggui Cui; writing and funding acquisition, Qiongle Peng. All

authors have read and agreed to the published version of the manuscript.

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Figure Legends

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

Figure 2 Fishbone diagram of the affecting factors both from nature and society on the breast cancer of women.

Figure 3 Illustration of incidence and mortality of breast cancer of women in given developed countries after GCO data.

Figure 4 Graphical procedures and structural model for path diagram analysis.

Figure 5 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.

Figure 6 Differentiated effects of social public wealth on incidence and mortality rates of female breast cancer.

Figure 7 Effects of country-independent GDPPC on the incidence and mortality rates of female breast cancer.

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Figures

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(a)

(b)

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Figure 9

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

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