Trends in Cancer Diseases Prevalence by Different Socioeconomic Strata in the United States

Mingsi Wang
College of Health Management of Harbin Medical University
Yi Ma
College of Health Management of Harbin Medical University
Liangru Zhou
College of Health Management of Harbin Medical University
Yi Cheng
College of Health Management of Harbin Medical University
Yue Li
College of Health Management of Harbin Medical University
Pengxin Cheng
College of Health Management of Harbin Medical University
Chengyao Sun
College of Health Management of Harbin Medical University
Guoxiang Liu (lgx6301@163.com)
College of Health Management of Harbin Medical University
Xin Zhang
College of Health Management of Harbin Medical University

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Abstract

Background

Income disparity among different socioeconomic strata in the United States has widened sharply in recent decades. Take into account the well-established link between income and health, this widening income gap may provide insight into the dynamics of the cancer disease burden in American adults. Assess the temporal trends of the 20-year predicted absolute cancer risk in American adults at different socioeconomic classes.

Methods

The cross-sectional analyses were carried out using data from adults aged 20 to 85 years between the 1999 and 2018 NHANES. Socioeconomic status was divided into three groups based on the family income to poverty ratio (PIR): high income (PIR ≥ 4), middle income (> 1 and <4), or at or below the federal poverty level (≤ 1).

Results

The analysis included 49 720 participants. The prevalence of lung cancer was lower in high-income participants than in middle-income participants (0.15% [n= 19] vs 0.35% [n= 92], p <0.001). For the low-income stratum, the prevalence of breast cancer was 1.12% [n = 117], but the number of adults in the middle (1.48% [n = 391], p = 0.009) and high-income levels (1.71% [n = 219], p <0.001) has increased.

Conclusions

The study found that the prevalence of cancer diseases was increasingly different among participants of different socioeconomic classes of NHANES from 1999 to 2018. Further research is required on the dynamics and health impact of income inequality, as well as public health policies and efforts to reduce these inequalities.

Background

Malignant tumor is a major public health problem, which has attracted worldwide attention. According to the World Health Organization[1], 7 out of every 10 deaths in the world die of non-communicable diseases, among which the first disease causing death is cardiovascular disease and the second is cancer. According to the International Cancer Research Institute, there will be 19.29 million new cancer cases in the world in 2020, and it is speculated that by 2040, the number of new cancer cases in the world will reach 28.4 million, an increase of 47% compared with 2020 [2]. Many studies have confirmed the role of socioeconomic status in the formation of cancer mortality and survival[3–7], however, there are few studies on the relationship between socio-economic status and cancer prevalence[8–11].

Over the past few decades, income inequality in the United States (US) has risen to its highest level[12]. The relationship between income and health has been set up, and higher income indicates healthier [13–17]. Health inequalities arise when individuals in a society enjoy unequal rights and the key determinants of health, including, but not limited to, escaping from discrimination, healthier food, clothing, better housing, education, cognitive of health and health care. Study data showed that the life expectancy of 65-year-old men in the highest-income group was estimated at 23.5 years, or 7.9 years higher than men in the lowest-income group [18]. Similarly, the woman with the lowest income of 65 years old had a life expectancy of 17.9 years, or 6.8 years lower than the highest income group[18]. There are socioeconomic differences in health, and individuals with lower socioeconomic status (SES) have a higher risk of developing mortality and morbidity than individuals with higher SES[19].

To our knowledge, there are limited studies comparing the prevalence of cancer risk factors in different socioeconomic classes. It is estimated that lung cancer will remain the leading cause of cancer death by GLOBOCAN 2020, with an estimated 1.8 million deaths (18%), followed by colorectal (9.4%), liver (8.3%), stomach (7.7%), female breast (6.9%) and esophagus (5.5%) cancers [2]. Therefore, the main aim of the study was to assess temporal trends in 20-year forecast absolute the six cancer risk in adults from three socioeconomic strata of the US: adults with high income, middle income and incomes at or below the federal poverty level.

Methods

Study Population

The National Center for Health Statistics (NCHS) established the National Health and Nutrition Examination Survey (NHANES), a series of cross-sectional surveys, using complex multi-stage probability design, obtained representative samples of the non-institutionalized civilian population residing in the 50 states and District of Columbia in the US. Details of these studies regarding sampling methods, survey instruments, and data collection have been published elsewhere[20–23]. The NHANES research was approved and agreed by the NCHS Research Ethics Review Committee. We analyzed data from the survey interview and physical examination within continuous NHANES (1999–2018, n = 102,956). For this analysis, the study population was limited to adults ≥20 years of age who had available data on family income to poverty ratio (PIR) and cancer or malignancy information (n=49,720) (Fig. 1).

Covariant evaluation

The exposed variables were socioeconomic status and were evaluated according to PIR. According to the relationship between self-reported family income and the poverty line, family size and calendar year, the PIR of each family is calculated. A value of 1 or less is lower than the official poverty threshold, while a PIR value higher than 1 indicates that the income is higher than the poverty level. PIR is similar in each year of the survey because the revenue threshold for inflation is updated annually[24]. We divided the participants into three groups: adults with high income (PIR, ≥4), middle income (PIR, >1 and <4), and at or below the federal poverty level (PIR, ≤1). We selected the critical point for middle- and high-income adults under the thresholds used by the Patient Protection Affordable Care Act, in which adults with a PIR between 1 and 4 are eligible for insurance subsidies, while adults with over 4 PIR were not eligible for subsidies.

Information about age, race, marital status, insurance status, education level, citizenship status, alcohol, smoking in the past month, physical activity and family income is self-reported. Participants received a medical examination to measure weight, standing height and waist circumference in a standardized way. Race and ethnicity are divided into four categories: non-Hispanic whites; non-Hispanic black people; Mexican American and others, including other Hispanic, Asian and multiracial participants. Body mass index (BMI) was defined as the body weight (kg) divided by the square of height (m). We divide the education level into less than high school, high school graduation or a general educational development certificate, and greater than high school. Alcohol consumption was assessed by self-report and classified as non-drinker, less than 2 drinks per week and 2 or more drinks per week. Smoking was coded as non-smoker, former smoker and current smoker. Participants who smoked less than 100 cigarettes over a lifetime were classified as never smoking. Former smokers are defined as people who have smoked more than 100 cigarettes in their lifetime but have given up smoking. At present, smokers are defined as those who have smoked more than 100 cigarettes in their lives but still smoke. Physical activity is assessed by the number of moderate to high-intensity activities (such as walking, jogging, running, swimming, cycling, dancing or yard work) per week, while lack of physical activity is defined as never doing moderate or high-intensity activities.

Statistical analysis

Due to the complex sampling design of NHANES, all the analysis includes the research visit weight, main sampling units and hierarchical design of NHANES survey [20]. P value < 0.05 was used as a cut-off for statistical significance. Analyses were conducted using IBM SPSS statistical software (version 24, IBM, Armonk, NY, USA) and Stata statistical software (version 16.0; Stata Corp, College Station, TX, USA).

Continuous variables are expressed as mean standard deviation (SD), while classified variables are expressed as numbers and their proportions. We use the Chi-square test for classified variables, one-way ANOVA for normal continuous variables and Kruskar-Wallis test for skewed continuous variables. To examine the prevalence differences across income groups, we performed descriptive statistics and Chi-square test followed by Bonferroni correction to account for multiple comparisons. To confirm the prevalence changes in the six cancer diseases during consecutive surveys, we calculated the prevalence of each outcome by descriptive statistics.

Odds ratio (OR) and corresponding 95% confidence intervals (CI) were calculated using multivariate-adjusted logistic regression analyses to determine associations between cancer disease, demographics and cancer risk factors. Model 1 was adjusted for age (20-39, 40-59, and 60+), sex (men, or women), race/ethnicity (non-Hispanic white, Non-Hispanic black, Mexican American or others), marital status (married or not married), health insurance (covered or not covered), education level (less than high school, high school or equivalent, or higher than high school), citizenship status (US citizenship or non-US citizenship) and PIR (≤1.0, 1.0-4.0, or ≥4.0) and model 2 is further adjusted for BMI (<25.0, 25.0–29.9, or ≥30.0 kg/m^2), drinking status (non-drinker, <2drinks/wk, or ≥2drinks/wk), smoking status (never, former or current smoker) as well as physical activity (never, moderate or vigorous).

Results

From 1999 to 2018, the NHANES included 49,720 adults aged between 20 and 85 years, containing information about PIR and cancer or malignancy (Fig. 1). The general characteristics of these adults are detailed in the Table 1. Among the 12 811 participants in the high-income group, 6553 (51.2%) were men, 6258 (48.8%) were women. Among the 26 484 participants in the middle-income of the population, 12 857 (48.5%) were men, 13 627 (51.5%) were women. Among the 10 425 participants in the low-income group, 5844 (56.1%) were women, 4581 (43.9%) were men. The overall prevalence of lung cancer was 0.3% (n = 137), breast cancer was 1.5% (n = 727), esophagus cancer was 0.1% (n = 30), stomach cancer was 0.1% (n = 41), colon and rectum cancer were 0.8% (n = 383) and liver cancer was 0.1% (n = 35).

Table 1
Characteristics of Study Participants, 1999-2018.

Characteristics	**No. (weighted %)**				***p* value**
	Total (N=49720)	**Family income to poverty ratio ≤1.0 (n =10425)**	**Family income to poverty ratio 1.0-4.0 (n =26484)**	**Family income to poverty ratio ≥4.0 (n = 12811)**	
Mean (SD) age, y	49(34, 64)	44(30,62)	50(34,67)	50(37,62)	<0.001
Sex					<0.001
Men	23991(48.3)	4581(43.9)	12857(48.5)	6553(51.2)	
Women	25729(51.7)	5844(56.1)	13627(51.5)	6258(48.8)	
Race/ethnicity					<0.001
Non-Hispanic white	22557(45.4)	3218(30.9)	11790(44.5)	7549(58.9)	
Non-Hispanic black	10315(20.7)	2577(24.7)	5651(21.3)	2087(16.3)	
Mexican American	8407(16.9)	2642(25.3)	4756(18.0)	1009(7.9)	
Other	8441(17.0)	1988(19.1)	4287(16.2)	2166(16.9)	
Marital status					<0.001
Married	25839(52.5)	3605(34.9)	13616(51.9)	8618(67.9)	
Not married	23392(47.5)	6713(65.1)	12609(48.1)	4070(32.1)	
Health insurance					<0.001
Covered	39650(79.8)	6652(63.9)	20866(78.9)	12132(94.7)	
Not covered	10021(20.2)	3752(36.1)	5596(21.1)	673(5.3)	
Education levels					<0.001
Less than high school	13232(26.6)	5004(48.1)	7359(27.8)	869(6.8)	

Continuous variables are expressed as mean standard deviation (SD), while classified variables are expressed as numbers and their proportions. We use Chi-square test for classified variables, one-way ANOVA for normal continuous variables and Kruskar-Wallis test for skewed continuous variables.

Abbreviations: GED, General Educational Development; BMI, body mass index.

Characteristics	No. (weighted %)				*p* value
	Total (N=49720)	Family income to poverty ratio ≤1.0 (n =10425)	Family income to poverty ratio 1.0-4.0 (n =26484)	Family income to poverty ratio ≥4.0 (n = 12811)	
High school diploma or GED certificate	11491(23.1)	2472(23.8)	7031(26.6)	1988(15.5)	
Greater than high school	24938(50.2)	2926(28.1)	12061(45.6)	9951(77.7)	
Citizenship status					<0.001
US citizenship	42926(86.5)	7914(76.2)	22968(86.8)	12044(94.1)	
Non-US citizenship	6724(13.5)	2473(23.8)	3491(13.2)	760(5.9)	
BMI, kg/m^2					
<25.0	13909(29.8)	2960(30.4)	7147(28.8)	3802(31.5)	
25.0-29.9	15699(33.6)	3061(6.6)	8319(33.5)	4319(35.8)	
≥30.0	17052(36.5)	3731(38.3)	9369(37.7)	3952(32.7)	
Drinking status					<0.001
Non-drinker	6142(17.6)	1707(25.1)	3440(18.9)	995(10.0)	
<2drinks/d	10229(29.2)	1362(20.0)	5206(28.6)	3661(36.8)	
≥2drinks/d	18616(53.2)	3744(54.9)	9584(52.6)	5288(53.2)	
Smoking status					<0.001
Non-smoker	26923(73.8)	5140(61.6)	14128(72.0)	7655(82.8)	
Former smoker	1094(3.00)	536(6.4)	995(5.1)	373(4.0)	
Current smoker	8475(23.2)	2760(29.9)	4497(22.9)	1218(13.2)	
Leisure time physical activity					<0.001

Continuous variables are expressed as mean standard deviation (SD), while classified variables are expressed as numbers and their proportions. We use Chi-square test for classified variables, one-way ANOVA for normal continuous variables and Kruskar-Wallis test for skewed continuous variables.

Abbreviations: GED, General Educational Development; BMI, body mass index.

Characteristics	No. (weighted %)				*p* value
	Total (N=49720)	Family income to poverty ratio ≤1.0 (n =10425)	Family income to poverty ratio 1.0-4.0 (n =26484)	Family income to poverty ratio ≥4.0 (n = 12811)	
Never	22427(45.1)	5814(55.8)	12533(47.3)	4080(31.8)	
Moderate	13615(27.4)	2181(20.9)	6910(26.1)	4524(35.3)	
Vigorous	13678(27.5)	2430(23.3)	7041(26.6)	4027(32.8)	
Continuous variables are expressed as mean standard deviation (SD), while classified variables are expressed as numbers and their proportions. We use Chi-square test for classified variables, one-way ANOVA for normal continuous variables and Kruskar-Wallis test for skewed continuous variables.					
Abbreviations: GED, General Educational Development; BMI, body mass index.					

The main demographic differences between the three groups included marital status and educational levels. Most of the high-income population is married (8618 [67.9%]) and has a college degree or above (9951 [77.7%]). Less than half of the low-income participants (3605 [34.9%) were married, and only a small proportion (2926 [28.1%) had a college degree or higher. The race/ethnicity composition also varied between the three groups. Among the high-income group, 7,549 participants (58.9%) were self- identified White, 2,087 participants (16.3%) were Black, and 1,009 (7.9%) were Mexican. In low-income populations, the percentage of Whites was lower (3 218 [30.9%]) and was higher in Blacks (2 577 [24.7%] or higher for Mexican (2 642 [25.3%]).

Overall Prevalence of Cancer Disease by Income Group

The prevalence of lung cancer was lower in high-income participants than in middle-income participants (0.15% [n= 19] vs 0.35% [n= 92], p <0.001) (Fig. 2A). We found an inverse relationship between income levels and breast cancer. For the low-income stratum, the prevalence of breast cancer was 1.12% [n = 117], but the number of adults in the middle (1.48% [n = 391], p = 0.009) and high-income levels (1.71% [n = 219], p <0.001) has increased (Fig. 2B). We found no statistically significant relationship between income levels and the prevalence of esophagus cancer, stomach cancer, colon and rectum cancer or liver cancer (Fig. 2C-F).

Trends in Cancer Disease Prevalence

In the high-income group, the prevalence of cancer disease decreased between 1999-2008 and 2009-2018. The prevalence of lung cancer decreased from 0.172% (n = 11) in 1999-2008 to 0.124% (n = 8) in 2009-2018 (p = 0.878); esophagus cancer from 0.627% (n = 4) in 1999-2008 to 0.016% (n = 1) in 2009-2018 (p = 0.217); colon and rectum cancer 0.736% (n = 47) in 1999-2008 to 0.700% (n = 45) in 2009-2018 (p = 0.808) and liver cancer 0.078% (n = 5) in 1999-2008 to 0.047% (n = 3) in 2009-2018 (p = 0.506). In contrast, the prevalence of breast cancer increased from 1.614% (n = 103) in 1999-2008 to 1.805 (n =

116) in 2009-2018 (p = 0.278) and stomach cancer from 0.031% (n = 2) in 1999-2008 to 0.046 (n = 3) in 2009-2018 (p = 1) (Fig. 3 and Supplemental Fig. 1).

In the middle-income group, lung cancer prevalence decreased from 0.378% (n = 49) in 1999-2008 to 0.318% (n = 43) in 2009-2018 (p = 0.878); the prevalence of stomach cancer decreased from 0.116% (n = 15) in 1999-2008 to 0.096% (n = 13) in 2018 (p = 0.621). In contrast, breast cancer prevalence increased from 1.421% (n = 184) in 1999-2008 to 1.529% (n = 207) in 2009-2018 (p = 0.463); the prevalence of esophagus cancer increased from 0.046% (n = 6) in 1999-2008 to 0.096% (n = 13) in 2009-2018 (p = 0.131); colon and rectum cancer prevalence non-significantly increased from 0.842% (n = 109) in 1999-2008 to 0.864% (n = 117) in 2009-2018 (p = 0.840) and liver cancer prevalence slightly increased from 0.077% (n = 10) in 1999-2008 to 0.089% (n = 12) in 2009-2018 (p = 0.747) (Fig. 3 and Supplemental Fig. S1).

Below the federal poverty level, the prevalence of lung cancer increased from 0.241% (n = 11) in 1999-2008 to 0.256% (n = 15) in 2009-2018 (p = 0.878); the prevalence of breast cancer increased from 0.986% (n = 45) in 1999-2008 to 1.229% (n = 72) in 2009-2018 (p = 0.242); the prevalence of esophagus cancer increased from 0.044% (n = 2) in 1999-2008c to 0.068% (n = 4) in 2009-2018 (p = 0.702); the prevalence of colon and rectum cancer increased from 0.547% (n = 25) in 1999-2008 to 0.683% (n = 40) in 2009-2018 (p = 0.384) and liver cancer prevalence slightly increased from 0.044% (n = 2) in 1999-2008 to 0.051% (n = 3) in 2009-2018 (p = 1). Conversely, the prevalence of stomach cancer decreased from 0.088% (n = 4) in 1999 to 0.068% (n = 4) in 2009-2018 (p = 0.736) (Fig. 3 and Supplemental Table 1).

Trends in the Association Between Income Group and Cancer Disease

Adjusting the models for demographic variables, the odds of reporting lung cancer were reduced in the highest resource population over time (odds ratio [OR], 0.431; 95%CI, 0.257-0.723; p = 0.001). Conversely, the richest participants had higher odds of reporting breast cancer (OR, 1.203; 95%CI, 1.001-1.446; p = 0.049), while no significant change was observed in esophagus cancer (OR, 0.511; 95%CI, 0.181-1.446; p = 0.206), stomach cancer (OR, 0.496; 95%CI, 0.182-1.352; p = 0.171), colon and rectum cancer (OR, 0.891; 95%CI, 0.686-1.157; p = 0.386) or liver cancer (OR, 0.627; 95%CI, 0.266-1.475; p = 0.285) (Supplemental Table 1-6). When cancer risk factors were included in the model, the odds of high-income group reporting lung cancer remained low over time (OR, 0.452; 95%CI, 0.234-0.875; p = 0.019), but no statistically significant change in the odds of reporting breast cancer (OR, 1.127; 95%CI, 0.899-1.412; p = 0.300) (Supplemental Table 7-12).

Over time, those in the middle-income level had higher odds of reporting lung cancer (OR,1.047; 95% CI, 0.657-1.668; p = 0.848), breast cancer (OR,1.041; 95% CI, 0.832-1.303; p = 0.725) and colon and rectum cancer (OR,1.061; 95% CI, 0.793-1.420; p = 0.689) but this difference was not statistically significant. In contrast, these participants were less likely to report esophagus cancer (OR,0.959; 95% CI, 0.344-2.677; p = 0.937), stomach cancer (OR,0.686; 95% CI, 0.304-1.545; p = 0.363) and liver cancer (OR,0.627; 95% CI, 0.266-1.475; p = 0.285), but the difference was not statistically significant (Supplemental Table 1-6).

When cancer risk factors were included in the model, the risk trend had not changed and the difference was still not statistically significant (Supplemental Table 7-12).

Association Between Cancer Disease and Other Variables

Both logistic regression analysis models suggest that, in general, older age is associated with an increased likelihood of reporting cancer disease. The ORs of cancer disease ranged from 4.729 (95% CI, 1.330-16.822) to 11.776 (95% CI, 1.513-91.651) for participants aged 40 to 59 years and from 11.525 (1.319-100.709) to 38.696 (20.953-71.466) for people 60 years or older compared with the youngest age group (20-39 years). Conversely, men had a largely higher probability of cancer cancer disease than women (OR ranged from 1.448 [95% CI, 1.017-2.061] to 3.730 [95% CI, 1.567-8.881]), except for breast cancer 0.003 (95% CI, 0.001-0.011) and liver cancer 0.982(95% CI, 0.497-1.939).

Married vs nonmarried individuals had a lower probability of reporting a cancer disease (OR ranged from 0.194 [95% CI, 0.049-0.767] to 0.935 [95% CI, 0.765-1.141]), health insurance covered vs. not covered participants had higher odds of reporting cancer disease (OR ranged from 2.330 [95% CI, 1.570-3.460] to 8.152 [95% CI, 1.073-61.923]), and those with US citizenship had higher probability of reporting breast cancer compared with those without US citizenship (model 1: OR, 1.591 [95% CI, 1.041-2.431]; model 2: OR, 1.729 [95% CI, 1.005-2.974]) (Supplemental Table 1-12).

In the first model, the association between race/ethnicity and cancer diseases was mixed, which included only demographic variables. Compared to Black participants, White participants had a higher probability of reporting lung cancer (OR, 1.269; 95% CI, 0.829-1.943), breast cancer (OR, 1.539; 95% CI, 1.244-1.905), esophagus cancer (OR, 2.787; 95% CI, 0.946-8.211), colon and rectum cancer (OR, 1.497; 95% CI, 1.137-1.970) and liver cancer (OR, 1.311; 95% CI, 0.517-3.321) and a lower probability of reporting stomach cancer (OR, 0.660; 95% CI, 0.307-1.421) (Supplemental Table 1-6). The second model, which included cancer risk factors, yielded similar but more pronounced results. Compared with black participants, Hispanic and Mexican participants had a lower possibility of reporting cancer diseases (OR ranged from 0.528 [95% CI, 0.271-1.028] to 0.842 [95% CI, 0.551-1.287]) but not esophagus cancer (OR, 1.645; 95% CI, 0.140-19.279) or stomach cancer (OR, 1.493; 95% CI, 0.376-5.937) (Supplemental Table 7-12).

In the first model, an inverse correlation was found between level of education and the probability of reporting cancer disease. People with a high school diploma or general education development (GED) certificate (OR ranged from 0.497 [95% CI, 0.213-1.160] to 0.948 [95% CI, 0.604-1.489]) followed by those with a college degree or above (OR ranged from 0.421 [95% CI, 0.191-0.924] to 0.822 [95% CI, 0.635-1.064]) are the least likely to protect cancer disease than those without a high school diploma or GED certificate (Supplemental Table 1-6). When cancer risk factors were included in the second model, both groups had a generally lower probability of reporting cancer disease with higher education (Supplemental Table 7-12).

Discussion

The prevalence of lung cancer in high-income participants was lower than that in middle-income participants (0.15% vs 0.35%). When controlled for demographic variables and cancer risk factors, the model suggested that the individuals with the highest resource group were less likely to report lung cancer than the middle-income and low-income group. According to a previous study, lung cancer was relatively more common in low-income communities[25].It is well known that the inverse correlation between socioeconomic status and smoking prevalence at least partly explains the strong correlation between socioeconomic status and lung cancer incidence [26–28].

Some studies have shown a strong statistically significant correlation between community income and survival in breast cancer [29, 30]. Additionally, we found an inverse relationship between income levels and breast cancer. The results of our study observed an increased odds of reporting breast cancer in the middle-income stratum and the high-income stratum. We are not sure whether the higher rates of breast cancer observed in high-income populations reflect real changes in the biological incidence of these diseases. One hypothesis is that significant gradients in these cancer incidence stem from higher case detection rates in the more affluent sector of the region. Income and education level are positively correlated with disease cognition, so the highest resource group will participate in cancer screening more actively. Furthermore, many cancer cases are detected only due to screening, possibly also for breast cancer, although to a lesser extent, and that screening may be used more frequently in more affluent communities [31–35]. Differences in total breast cancer incidence may also reflect differences in screening rates rather than actual differences in disease rates.

Results from a cross-sectional epidemiological study showed no significant correlation between community income and survival was observed in stomach or colon cancer[25]. Other epidemiological studies showed that there was a moderate and strong negative correlation between income levels and the incidence of lung, gastrointestinal tract and colon and rectum cancer [29, 36–38]. Moreover, we found no statistically significant relationship between income levels and the prevalence of esophagus, stomach, colon and rectum or liver cancer. The disparities in six cancers between 1999-2008 and 2009-2018 did not have statistically significant among different socioeconomic strata. This gap was most obvious in terms of esophageal cancer prevalence, which increased approximately two-fold in middle-income populations. However, incidence data in esophagus, stomach, colon and rectum or liver cancer are poor and sometimes even do not exist for some places or time periods. It should be mentioned that because of the small sample sizes for cancer incidence outcome, comparison among different socioeconomic strata in this study was limited by the multivariate-adjusted logistic regression analyses.

There are important limitations in our study. First, we analyzed several cross-sectional surveys, but failed to determine a causal relationship between income and cancer disease. Second, the evaluation results depend on the self-reported information. Any missed reporting of cancer reports leads to artificially low morbidity. If this were more prevalent in poor areas, then it will lead to a significant increase in incidence with increasing income. However, previous analyses suggest that self-reported results of NHANES are an effective tool for assessing prevalence [39]. Third, the sample size of this study is small and does not meet the requirements of EPV (event per variable). Therefore, the results may not be robust enough.

However, considering that such patients are rare and the results are interpretable, they are still displayed. The reliability of this result needs to be confirmed by further research.

Conclusions

The cross-sectional study found significant and increasing differences in cancer disease rates across socioeconomic strata in the United States. In the past 20 years, the decline in lung cancer prevalence has mainly occurred in high-income people, while the prevalence of breast cancer has increased in middle-and high-income adults. Overall, recent progress in controlling cancer risk factors in the United States has not benefited adults of all socioeconomic strata equally. There is clearly a need for further efforts to decrease income disparities in controlling cancer risk factors. Importantly, these findings reinforce calls for action on policies based on socioeconomic inequalities in cancer disease.

Declarations

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Author contributions

Conceptualization, M.W. and Y.M.; methodology, Y.C.; software, Y.L.; validation, M.W. and P.C.; formal analysis, C.S.; investigation, L.Z.; resources, Y.C.; data curation, Y.L.; writing—original draft preparation, M.W.; writing—review and editing, G.L.; visualization, X.Z.; supervision, X.Z.; project administration, G.L. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

The datasets generated and analyzed during the current study can be obtained on the website of National Center for Health Statistics (https://www.cdc.gov/nchs/nhanes/ (accessed on 27 April 2021)).

Ethics approval and consent to participate

The NHANES survey was approved by the National Center for Health Statistics Institutional Review Board. The study reported in this manuscript was exempt from ethical committee approval because it was based on publicly available data. NHANES has obtained the written informed consent from all participants. All procedures were performed in accordance with relevant guidelines.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no financial or non-financial competing

interests.

Author details

[1] Department of Health Economics, College of Health Management of Harbin Medical University, Harbin, China

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Figures

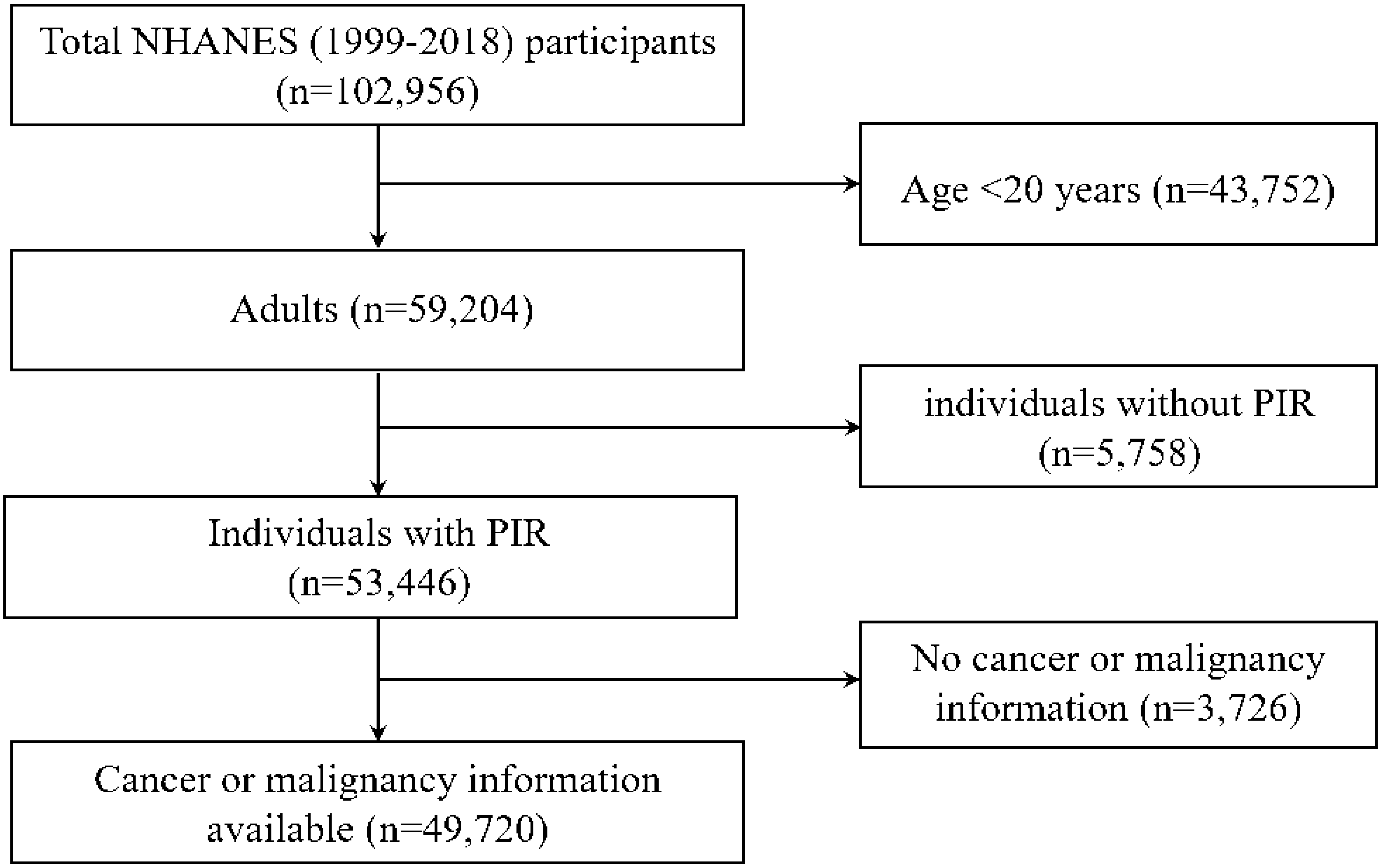

Figure 1

Flow chart of the study population. Describes how the present sample of participants was composed. NHANES = National Health and Nutrition Examination Survey.

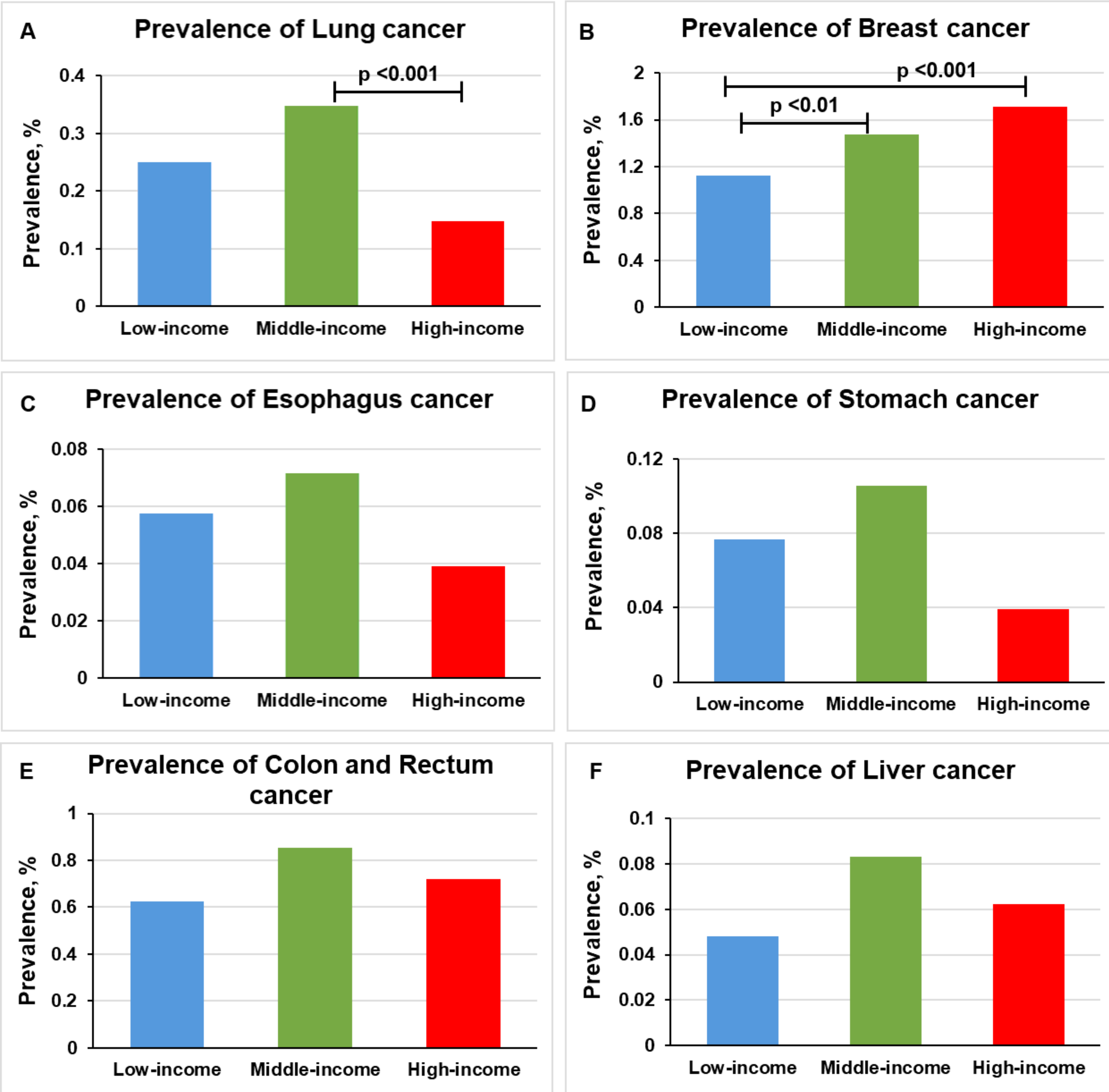

Figure 2

Overall Prevalence of Cancer Disease Among Participants 20 Years or Older Stratified by Income Group, 1999-2018. Significant at $p < 0.00167$ after Bonferroni correction.

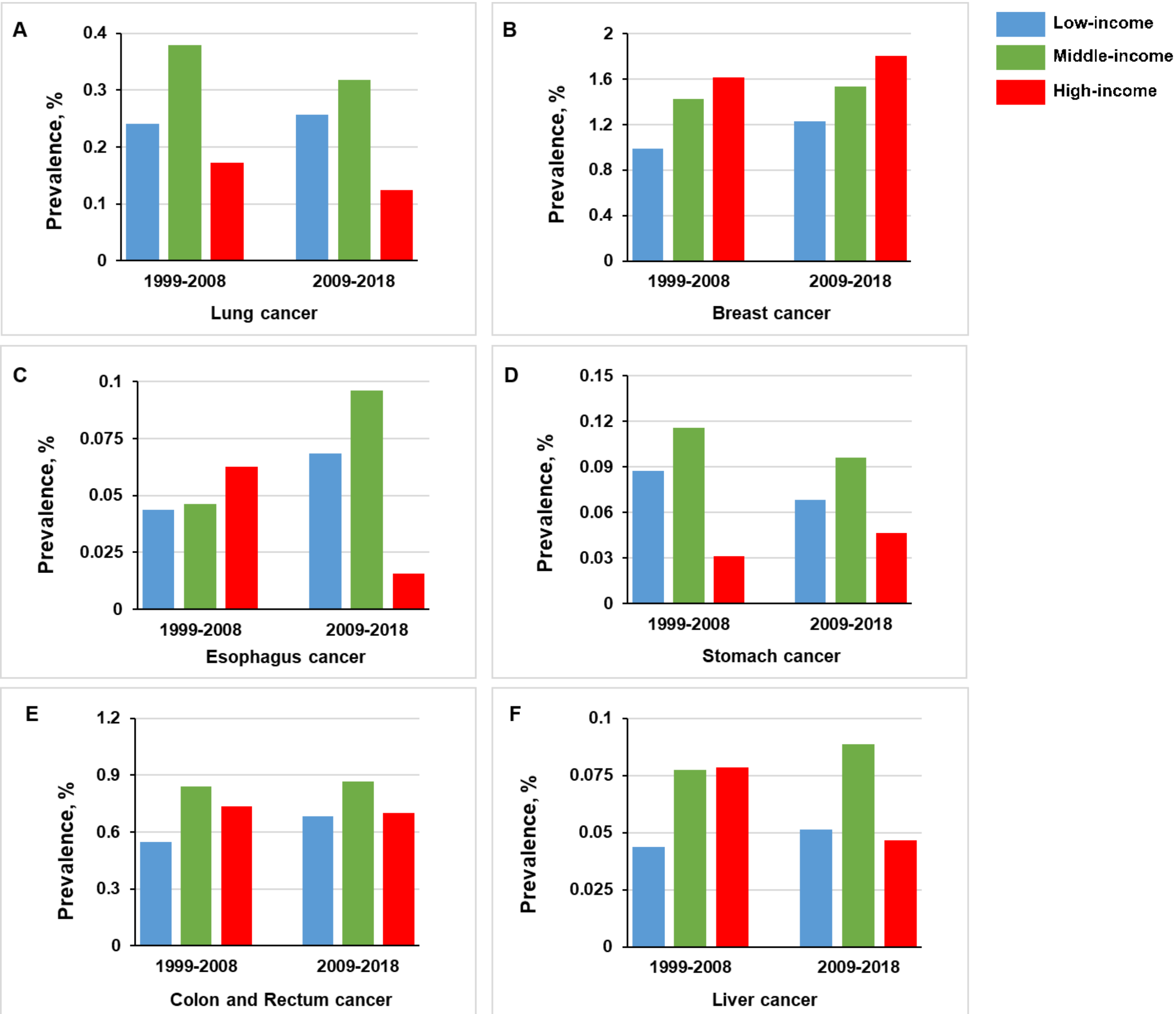

Figure 3

Comparison of Prevalence in 1999-2008 vs 2009-2018, Stratified by Income Group.

Supplementary Files

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