International Journal of MCH and AIDS (2012), Volume 1, Issue 1, Pages 17-30

IJMA

INTERNATIONAL JOURNAL of MCH and AIDS
ISSN 2161-864X (Online)
ISSN 2161-8674 (Print)

Available online at www.mchandaids.org

ORIGINAL ARTICLE

Global Inequalities in Cervical Cancer Incidence and Mortality are Linked to Deprivation, Low Socioeconomic Status, and Human Development

Gopal K. Singh, PhD[1] ✉; **Romuladus E. Azuine,** DrPH, RN[1]; **Mohammad Siahpush,** PhD[2]

[1] US Department of Health and Human Services and Center for Global Health and Health Policy, Global Health and Education Projects, Washington, DC 20018, USA

[2] University of Nebraska Medical Center, Department of Health Promotion, Social and Behavioral Health, Omaha, NE 68198-4365, USA

✉Corresponding author e-mail: gsingh@mchandaids.org

ABSTRACT

Objectives

This study examined global inequalities in cervical cancer incidence and mortality rates as a function of cross-national variations in the Human Development Index (HDI), socioeconomic factors, Gender Inequality Index (GII), and healthcare expenditure.

Methods

Age-adjusted incidence and mortality rates were calculated for women in 184 countries using the 2008 GLOBOCAN database, and incidence and mortality trends were analyzed using the WHO cancer mortality database. Log-linear regression was used to model annual trends, while OLS and Poisson regression models were used to estimate the impact of socioeconomic and human development factors on incidence and mortality rates.

Results

Cervical cancer incidence and mortality rates varied widely, with many African countries such as Guinea, Zambia, Comoros, Tanzania, and Malawi having at least 10-to-20-fold higher rates than several West Asian, Middle East, and European countries, including Iran, Saudi Arabia, Syria, Egypt, and Switzerland. HDI, GII, poverty rate, health expenditure per capita, urbanization, and literacy rate were all significantly related to cervical cancer incidence and mortality, with HDI and poverty rate each explaining >52% of the global variance in mortality. Both incidence and mortality rates increased in relation to lower human development and higher gender inequality levels. A 0.2 unit increase in HDI was associated with a 20% decrease in cervical cancer risk and a 33% decrease in cervical cancer mortality risk. The risk of a cervical cancer diagnosis increased by 24% and of cervical cancer death by 42% for a 0.2 unit increase in GII. Higher health expenditure levels were independently associated with decreased incidence and mortality risks.

Conclusions and Public Health Implications

Global inequalities in cervical cancer are clearly linked to disparities in human development, social inequality, and living standards. Reductions in cervical cancer rates are achievable by reducing inequalities in socioeconomic conditions, availability of preventive health services, and women's social status.

Key Words

Cervical cancer • Incidence • Mortality • Global inequality • Human development • Gender inequality • Social inequality • Poverty • Literacy • GNI per capita.

Introduction

Cervical cancer is the third most common cancer in women after breast and colorectal cancers and is one of the leading causes of cancer death among women in the world [1]. In 2008, approximately 530,000 women were diagnosed with invasive cervical cancer worldwide and 275,000 women died from it [1, 2]. Cervical cancer is the top cancer site for women in most East African and South Asian countries both in terms of incidence and mortality[1, 2]. Indeed, developing countries as a whole experience a disproportionate share of the disease burden, accounting for 86% of all cervical cancer cases and 88% of all cervical cancer deaths worldwide [1-3]. While cervical cancer rates have declined markedly in industrialized countries over the past several decades, the rates have declined at a much slower pace in the developing world and, for many developing countries, the rates have actually been increasing [1, 2]. The latest data from the World Health Organization (WHO) show marked disparities in cervical cancer incidence and mortality rates across countries [1, 2].

A number of population-based studies from the United States and other industrialized countries have shown marked socioeconomic gradients in cervical cancer incidence and mortality, with those in more deprived groups or lower socioeconomic strata having 2-3 fold higher risk of cervical cancer than their affluent counterparts [4-9]. A few case-control studies in Asia, Africa, and South America also indicate substantially higher risks of cervical cancer among women in lower social class groups [9]. To our knowledge, the extent to which disparities in cervical cancer incidence and mortality rates between nations arise due to global differences in social inequality and human development factors has not yet been studied. Given the evidence of a strong association between socioeconomic status (SES) and cervical cancer from within-country studies, we should expect differences in education, socioeconomic conditions, material living standards, and health services to account for a substantial portion of global inequalities in cervical cancer incidence and mortality.

Assessing the impact of socioeconomic conditions and human development is important because they represent underlying causes of health inequalities both within and between nations [10, 11]. Improvements in the broader social determinants such as education, income distribution, gender inequality, labor force participation, employment, and health care have been suggested as central to reducing population health inequalities [10, 12]. International comparisons can highlight the extent of disease burden in specific countries and important cross-national differences and similarities in socioeconomic conditions, urbanization patterns, prevalence of cancer risk factors such as smoking and human papillomavirus (HPV) infection, and availability and use of cervical cancer screening programs [2, 4]. Analysis of global inequalities is also important in that cervical cancer tends to affect younger women (aged <45 years) more than the other major cancers, resulting in relatively high years-of-life lost, particularly among women in the developing world [2]. Moreover, cervical cancer rates appear to be rising among younger women in many developing as well as developed countries [13].

The major purpose of our paper is to quantify the links between inequalities in human development and socioeconomic conditions and global disparities in cervical cancer incidence and mortality. Specifically, we link socioeconomic, demographic, and human development indicators for various countries with the most recent international cervical cancer data to examine global patterns of cervical cancer incidence and mortality. In addition, we document the extent of global disparities in cervical cancer by identifying regions and countries in which women are at high risk of morbidity and mortality from this disease.

Methods

To analyze global inequalities in cervical cancer incidence and mortality, we computed age-adjusted incidence and mortality rates for women in 184 countries using the 2008 GLOBOCAN database [1]. The GLOBOCAN database, developed by the International Agency for Research on Cancer, provides contemporary estimates of the incidence of, mortality and prevalence from major type of cancers, at national level, for 184 countries of the world [1]. Details of the cancer database are provided elsewhere [1, 2]. Annual trends in incidence and mortality rates were analyzed for selected countries using the WHO cancer incidence and mortality databases [14, 15].

The data on the Human Development Index (HDI) and Gender Inequality Index (GII) were taken from the 2011 Human Development Report [16], while those on Gross National Income (GNI) per capita, international poverty rate (deprivation level measuring the proportion of population living in extreme poverty), literacy rate, urbanization, and health expenditure came from the 2011 World Health Statistics Report [17]. HDI, developed by the United Nations Development Programme, is a composite index of social and economic development and combines indicators of life expectancy, educational attainment, and GNI per capita. HDI varies between 0 and 1, with 0 indicating the lowest level and 1 representing the highest level of development [16]. GII is also a composite index that reflects women's relative social disadvantage in three dimensions – reproductive health, empowerment, and the labor market [16]. GII combines 5 indicators, maternal mortality ratios, adolescent fertility rate, educational attainment, parliamentary representation by each sex, and female labor force participation [16].

We used bivariate and multivariate ordinary least squares (OLS) regression models to estimate the impact of HDI, GII, and other socioeconomic factors on age-adjusted cervical cancer incidence and mortality rates. We used Poisson regression to model age- and country-specific incidence cases, deaths, and population estimates as a function of socioeconomic and human development factors [12, 18]. For Poisson modeling, we used three broad age-groups: <45, 45-64, and 65+ years. The OLS models were estimated by the SAS REG procedure [19], while Poisson models were estimated by the SAS GENMOD procedure [20].

Since HDI and GII both include education and economic components, these composite indices are highly correlated with the other individual predictors used in the study, such as literacy rate, per capita income, poverty, and urbanization. Because of estimation problems due to high multicollinearity, multiple regression models containing either HDI or GII and education and income indicators were not estimated. Instead, the net impact of health expenditure per capita was examined in multivariate models that included HDI or GII.

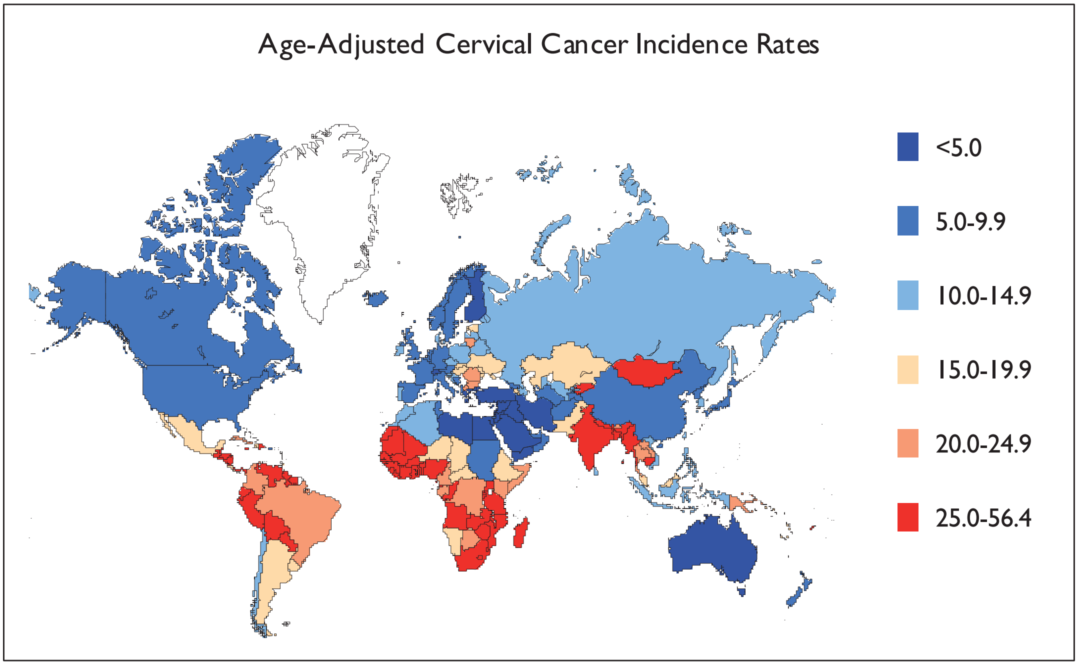
Log-linear regression models were used to estimate annual rates of change in cervical cancer incidence and mortality trends for selected countries [7, 12, 18]. Specifically, during the 1983-2002 or 1983-2008 period, the logarithm of the incidence or mortality rates respectively were modeled as a linear function of time (calendar year), which yielded annual exponential rates of change in incidence or mortality rates [7, 12, 18].

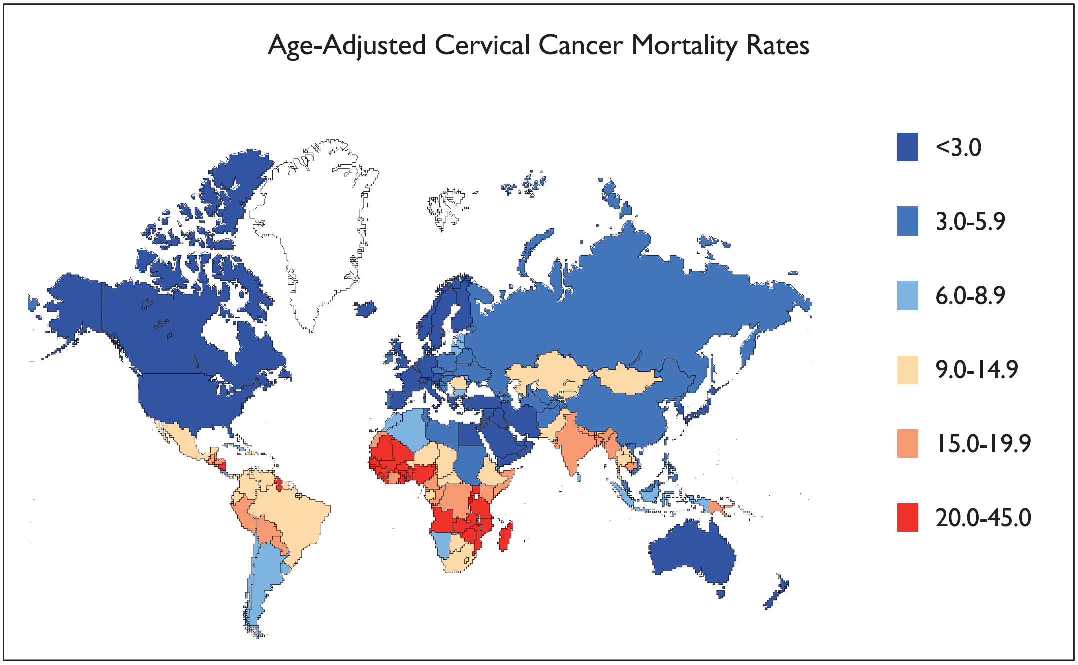
Results

Global Inequalities in Cervical Cancer Incidence and Mortality Rates

In 2008, cervical cancer incidence and mortality rates were higher in Eastern, Western, and Sub-Saharan regions of Africa and South Asia and lower in Western Asia, Western Europe, North America, and Australia/New Zealand (Figure 1). Overall, women in developing countries had two-fold higher cervical cancer incidence rates and three-fold

Figure 1. International Variations in Age-Adjusted Cervical Cancer Incidence and Mortality Rates per 100,000 World Standard Population, 2008





Source: WHO, International Agency for Research on Cancer, GLOBOCAN, 2008.

higher mortality rates than their counterparts from developed countries.

Long-term trends in cervical cancer incidence and mortality vary across countries (Figures 2 and 3). While incidence rates have generally decreased for most countries, the rates have remained stable at fairly high levels for certain countries such as Thailand (data not shown). During 1983-2002, although incidence rates decreased at 4.3%, 3.1%, and 1.7% per year in Brazil, India (Chennai), and the Philippines, respectively, they remained at much higher levels than those for Hong Kong and Shanghai, China (Figure 2). Mortality trends have also not been uniform across countries. During 1983-2008, while mortality rates in Hong Kong and Singapore decreased at about 4% per year, the rates have either decreased at a much slower pace for Brazil and Mexico or increased for some countries such as Cuba, Venezuela (Figure 3), Thailand, and the Philippines (trend not shown).

In 2008, cervical cancer rates varied widely across individual countries, with many African countries such as Guinea, Zambia, Comoros, Tanzania, and Malawi having at least 10-to-20 fold higher incidence and mortality rates than such countries as Iran, Saudi Arabia, Syria, Egypt, and Switzerland (Table 1). Cross-national disparities in cervical cancer mortality rates (as measured by the coefficient of variation and range) were greater than those in incidence rates. Guinea had the highest age-adjusted incidence rate of 56.3 per 100,000 women, 35 times greater than the rate of 1.6 for Egypt. Guinea also had the highest age-adjusted mortality rate of 41.7 per 100,000 women, 52 times higher than the rate of 0.8 for Syria (Table 1).

Modeling the Impact of HDI, GII, and Socioeconomic Factors

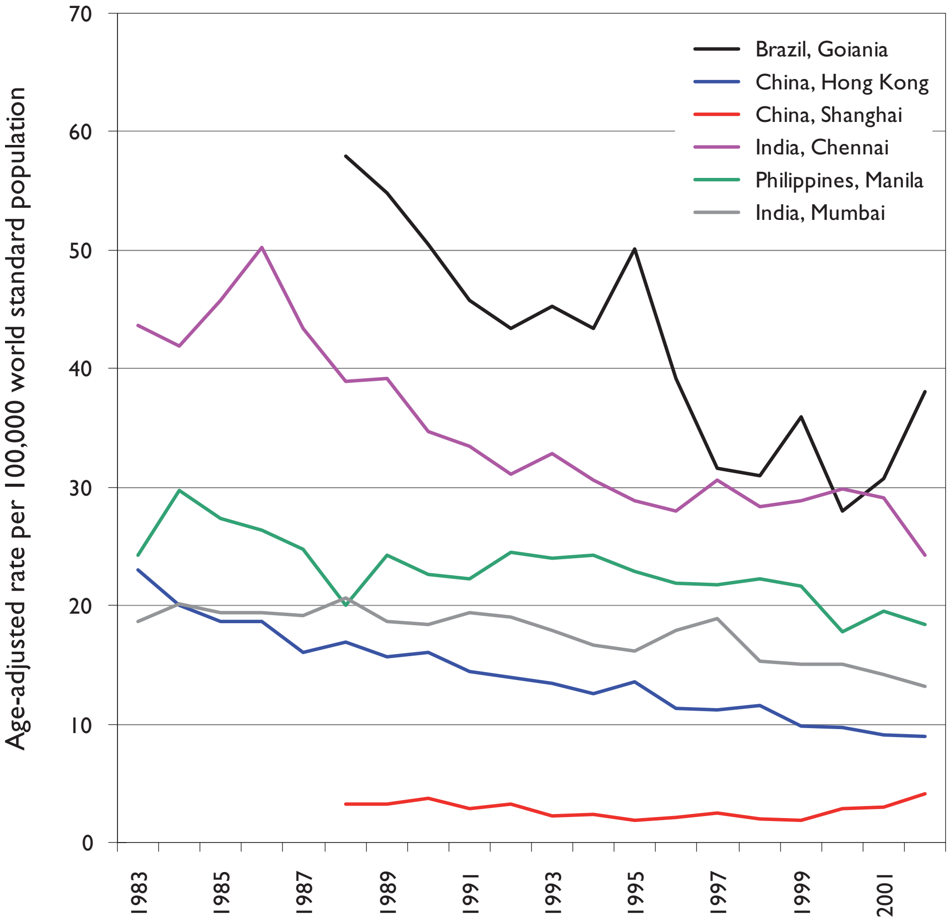
HDI, GII, international poverty rate, health expenditure per capita, urbanization, and literacy rate were all significantly related to cancer incidence and mortality, with HDI and poverty rate each explaining >52% of the global variance in mortality (Table 2 and Figure 4). Both incidence and mortality rates increased in relation to lower levels of human development and higher levels of gender inequality. In bivariate models, a 0.2 unit increase in HDI was on average associated with an 8.7 point decrease in incidence rates and a 7.8 point decrease in mortality rates. A 0.2 unit increase in HDI was associated with a 20% decrease in the risk of cervical cancer incidence and a 33% decrease in the risk of cervical cancer mortality (Table 2).

Cervical cancer incidence and mortality rates increased by 7.1 and 5.9 points, respectively, for every 0.2 unit increase in GII. The risk of a cervical cancer diagnosis increased by 24% and of cervical cancer death by 42% for a 0.2 unit increase in GII (Table 2). GII explained approximately 24% and 33% of the global variance in incidence and mortality rates, respectively.

Deprivation levels or poverty rates were a strong predictor of cross-national variations in cervical cancer incidence and mortality. A 10-percentage point increase in poverty rates was expected to result in an 8% higher risk of incidence and a 14% higher risk of death from cervical cancer. A $5,000 increase in GNI per capita was associated with an 8% lower incidence risk and a 14% lower mortality risk. Incidence risks decreased by 11% and mortality risks by 21% for every 20-percentage point increase in literacy rate. Incidence and mortality rates and risks decreased at increasing levels of urbanization (Table 2).

In multivariate models, higher health expenditure levels were independently associated with decreased incidence and mortality risks. Even after adjusting for the effects of HDI or GII, for every $1,000 increase in healthcare expenditure per capita, there was at least a 7% decrease in the risk of cervical cancer (Table 2). The corresponding net decrease in cervical cancer mortality risk was 8-11% for a similar increase in health expenditure per capita.

Figure 2. Trend in Cervical Cancer Incidence Rates in Selected Countries, 1983-2002

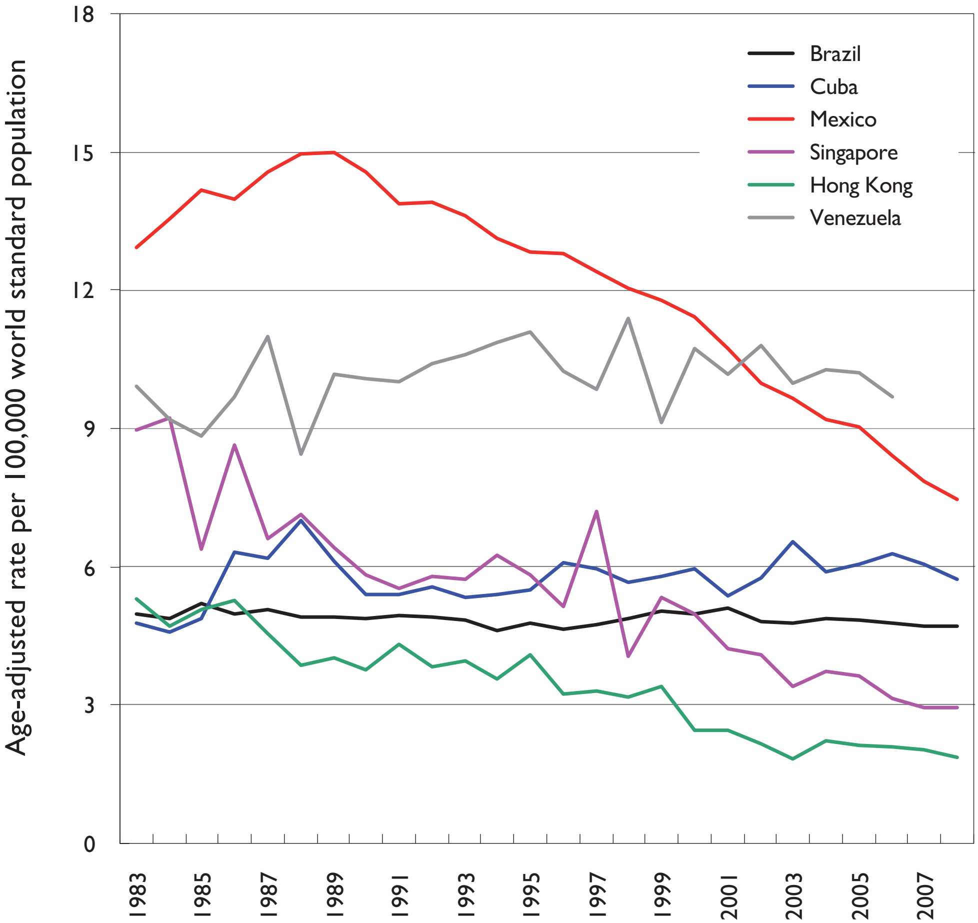


Log-Linear Regression Trend Models of Cervical Cancer Incidence, 1983-2002

	Brazil	China	China	India	India	Philippines
1983-2002	**Goiania**	**Hong Kong**	**Shanghai**	**Chennai**	**Mumbai**	**Manila**
Regression slope (b)	-0.043	-0.045	-0.010	-0.031	-0.018	-0.017
SE (slope)	0.007	0.002	0.015	0.003	0.003	0.003
R-Square	0.740	0.972	0.034	0.848	0.723	0.602
Annual rate of change (%), (exp(b)-1)*100	-4.25	-4.45	-0.99	-3.06	-1.81	-1.65
95% lower confidence limit	-5.58	-4.79	-3.82	-3.65	-2.32	-2.26
95% upper confidence limit	-2.90	-4.11	1.91	-2.47	-1.29	-1.03

Source: WHO, International Agency for Research on Cancer, Cancer Incidence in Five Continents Annual Dataset.

Figure 3. Trend in Cervical Cancer Mortality Rates in Selected Countries, 1983-2008



Log-Linear Regression Trend Models of Cervical Cancer Mortality, 1983-2008

1983-2008	Brazil	Cuba	Mexico	Singapore	Hong Kong	Venezuela
Regression slope (b)	-0.002	0.005	-0.010	-0.041	-0.043	0.002
SE (slope)	0.001	0.002	0.002	0.003	0.003	0.002
R-Square	0.221	0.156	0.470	0.858	0.912	0.060
Annual rate of change (%), (exp(b)-1)*100	-0.18	0.50	-0.94	-3.98	-4.17	0.24
95% lower confidence limit	-0.31	0.03	-1.34	-4.61	-4.68	-0.15
95% upper confidence limit	-0.04	0.97	-0.54	-3.34	-3.67	0.63

Source: WHO, International Agency for Research on Cancer, Cancer Mortality Database.

Table 1. Age-adjusted Cervical Cancer Incidence and Mortality Rates per 100,000 World Standard Population, 2008

	Incidence cases	Age-adjusted incidence rate		Deaths	Age-adjusted mortality Rate
Top 25 countries with the highest incidence rates			**Top 25 countries with the highest mortality rates**		
Guinea	1,736	56.3	Guinea	1,217	41.7
Zambia	1,839	52.8	Comoros	76	39.1
Comoros	110	51.7	Zambia	1,276	38.6
Tanzania	6,241	50.9	Malawi	1,621	38.3
Malawi	2,316	50.8	Tanzania	4,355	37.5
Mozambique	3,690	50.6	Burundi	900	37.2
Swaziland	198	50.0	Uganda	2,464	34.9
Burundi	1,270	49.1	Mozambique	2,356	34.5
Uganda	3,577	47.5	Zimbabwe	1,286	33.4
Zimbabwe	1,855	47.4	Sierra Leone	466	33.0
Jamaica	624	45.7	Swaziland	116	31.4
Guyana	161	44.7	Liberia	341	31.2
Sierra Leone	670	41.9	Mali	1,010	28.4
Liberia	487	41.8	Ghana	2,006	27.6
Nicaragua	869	39.9	Guinea-Bissau	130	26.0
Ghana	3,038	39.5	Mauritania	244	25.5
Honduras	1,014	37.8	Senegal	795	25.5
Mali	1,491	37.7	Rwanda	678	25.4
El Salvador	1,145	37.2	Gambia	133	24.4
Bolivia	1,422	36.4	Benin	616	24.4
Mauritania	364	35.1	Nigeria	9,659	22.9
Guinea-Bissau	185	35.1	Lesotho	178	22.7
Benin	925	35.0	Angola	1,008	21.9
Lesotho	279	35.0	Togo	417	21.8
Paraguay	864	35.0	Burkina Faso	838	21.5
Bottom 15 countries with the lowest incidence rates			**Bottom 15 countries with the lowest mortality rates**		
Cyprus	27	4.5	Greece	172	1.6
Finland	151	4.5	Turkey	556	1.6
Turkey	1,443	4.2	New Zealand	53	1.6
Greece	345	4.1	Italy	906	1.5
Switzerland	221	4.0	Australia	241	1.4
Lebanon	85	3.8	Finland	63	1.2
Jordan	71	3.6	Iran	286	1.0
Iraq	309	3.1	Egypt	299	1.0
Yemen	162	3.0	Switzerland	72	0.9
Iran	643	2.2	Saudi Arabia	55	0.8
Saudi Arabia	152	2.1	Syria	54	0.8
Malta	7	2.1	Iceland	4	0.8
Syria	140	2.0	Gaza Strip & West Bank	3	0.3
Egypt	514	1.6	Qatar	1	0.3
Gaza Strip & West Bank	5	0.4	United Arab Emirates	2	0.2

Source: WHO, International Agency for Research on Cancer (IARC), GLOBOCAN 2008.

Table 2. Ordinary Least Squares (OLS) and Poisson Regression Models Showing the Effects of Human Development Index, Gender Inequality Index, and Socioeconomic and Health Care Factors on Age-Adjusted Cervical Cancer Incidence and Mortality Rates, 2008 (N = 184 Countries)

	OLS Models					Poisson Models		
Covariate	b	β	t-stat	P-value	Adj. R^2	RR	95% CI	P-value
Cervical cancer incidence								
Bivariate models								
Human Development Index (HDI)[a]	-8.72	-0.60	-9.60	<0.001	35.86	0.80	0.80–0.80	<0.001
Gender Inequality Index[b]	7.06	0.50	6.66	<0.001	24.28	1.24	1.24–1.25	<0.001
Adult literacy rate[c]	-5.15	-0.36	-4.53	<0.001	12.53	0.89	0.89–0.89	<0.001
Gross National Income per capita (Int. $)[d]	-2.29	-0.51	-7.73	<0.001	25.55	0.92	0.92–0.92	<0.001
Poverty rate (PPP international $)[e]	2.94	0.57	6.90	<0.001	31.33	1.08	1.08–1.08	<0.001
Urban population (%)[f]	-2.60	-0.45	-6.64	<0.001	19.83	0.94	0.94–0.94	<0.001
Health expenditure per capita (PPP int. $)[g]	-4.62	-0.46	-6.81	<0.001	20.88	0.88	0.88–0.89	<0.001
Multivariate models								
Model 1: Human Development Index+	-7.25	-0.50	-5.41	<0.001	34.67	0.89	0.89–0.90	<0.001
Health expenditure per capita	-1.28	-0.13	-1.40	0.162		0.92	0.92–0.93	<0.001
Model 2: Gender Inequality Index+	3.95	0.28	2.67	<0.009	27.36	1.18	1.17–1.18	<0.001
Health expenditure per capita	-2.74	-0.29	-2.76	<0.007		0.93	0.93–0.93	<0.001
Cervical cancer mortality								
Bivariate models								
Human Development Index (HDI)[a]	-7.80	-0.72	-13.36	<0.001	52.12	0.67	0.67–0.67	<0.001
Gender Inequality Index[b]	5.93	0.58	8.21	<0.001	32.97	1.42	1.41–1.43	<0.001
Adult literacy rate[c]	-4.60	-0.46	-6.06	<0.001	20.69	0.79	0.78–0.79	<0.001
Gross National Income per capita (Int. $)[d]	-1.79	-0.54	-8.31	<0.001	28.47	0.86	0.86–0.86	<0.001
Poverty rate (PPP international $)[e]	2.91	0.73	10.65	<0.001	52.45	1.14	1.14–1.14	<0.001
Urban population (%)[f]	-2.25	-0.53	-8.22	<0.001	27.56	0.89	0.88–0.89	0.327
Health expenditure per capita (PPP int. $)[g]	-3.58	-0.49	-7.28	<0.001	23.11	0.81	0.80–0.81	<0.001
Multivariate models								
Model 1: Human Development Index+	-7.80	-0.72	-9.02	<0.001	50.37	0.73	0.73–0.74	<0.001
Health expenditure per capita	0.08	0.01	0.13	0.897		0.92	0.92–0.92	<0.001
Model 2: Gender Inequality Index+	4.23	0.42	4.17	<0.001	34.38	1.31	1.30–1.32	<0.001
Health expenditure per capita	-1.46	-0.22	-2.15	0.033		0.89	0.89–0.90	<0.001

Notes: b=unstandardized regression coefficient; β =standardized regression coefficient; R^2=percentage variance explained.

[β] is also equal to the correlation coefficient in bivariate OLS regression models

[a] Increase in incidence/mortality rates or risks associated with a 0.2 unit increase in HDI

[b] Increase in incidence/mortality rates or risks associated with a 0.2 unit increase in the Gender Inequality Index

[c] Increase in incidence/mortality rates or risks associated with a 20-percentage point increase in the adult literacy rate

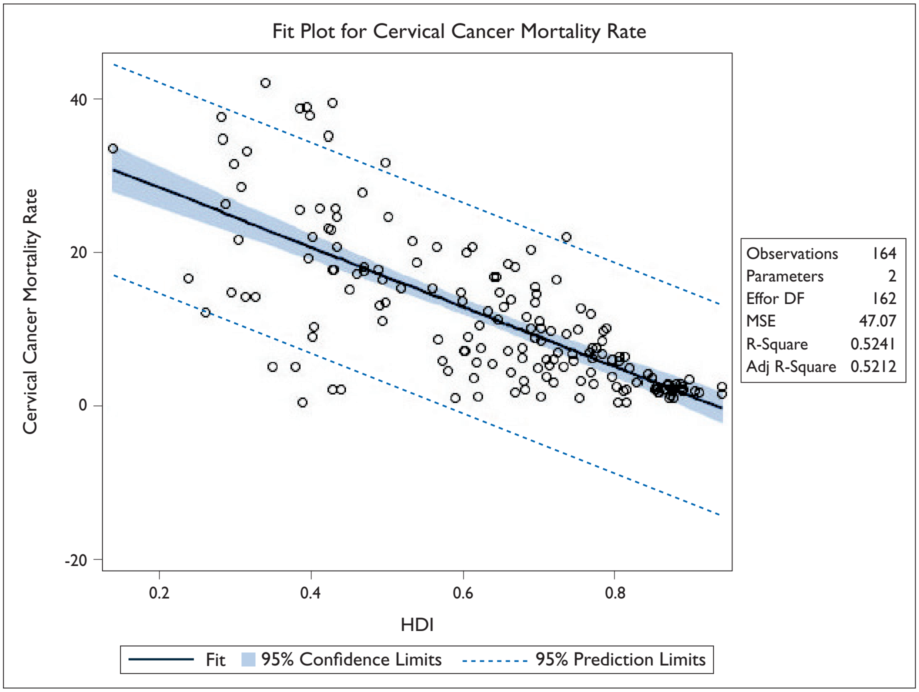
[d] Increase in incidence/mortality rates or risks associated with a $5,000 increase in GNI per capita

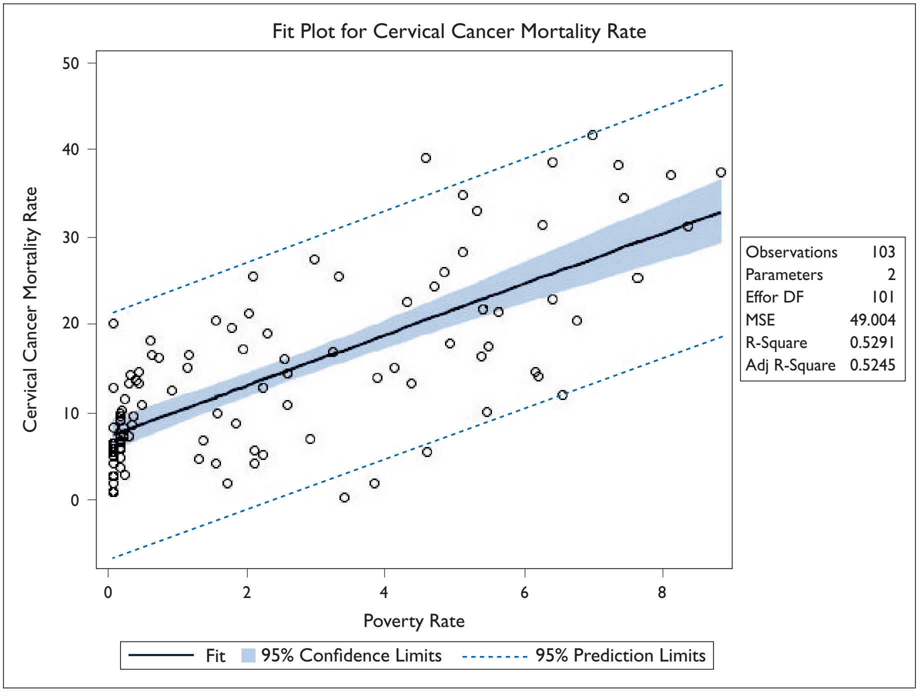
[e] Increase in incidence/mortality rates or risks associated with a 10-percentage point increase in the poverty rate

[f] Increase in incidence/mortality rates or risks associated with a 10-percentage point increase in the urban population

[g] Increase in incidence/mortality rates or risks associated with a $1,000 increase in health expenditure per capita

Figure 4. Observed and Fitted Plots Showing the Impact of Human Development Index (HDI) and Poverty on Age-Adjusted Cervical Cancer Mortality Rates per 100,000 World Standard Population, 2008





Discussion

In this study, by using the latest global sociodemographic, health, and cancer statistics, we have identified countries at high risk of cervical cancer morbidity and mortality and have examined the impact of socioeconomic and human development factors on cross-national variations in cervical cancer incidence and mortality rates. High rates of incidence and mortality observed for many low- and middle-income countries indicate cervical cancer to be a major public health problem in the developing world [2]. In terms of absolute numbers, Indian women bear the greatest burden of the disease as more than a quarter of new cases and cervical cancer deaths in the world occur in India alone [1, 2].

We have estimated the magnitude of cervical cancer disparities between countries and attempted to explain these disparities in terms of the effects of major societal determinants. It is important to note that social inequalities in cervical cancer are quite marked within individual countries as well [4, 6, 8, 9]. As mentioned earlier, this pattern holds for both developed and developing countries [4, 8, 9]. However, population-based studies of social inequalities are rare for the developing countries that have the greatest disease burden; more studies are needed in these countries to shed light on the magnitude and causes of social inequalities in cervical cancer incidence and mortality.

The findings of our study are consistent with two earlier studies that examined global patterns in cervical cancer rates using the 2008 GLOBOCAN database [2, 3]. These studies examined disparities in incidence and mortality rates across countries and various regions of the world in much detail [2, 3]. However, unlike our study, no efforts were made in these studies to link cervical cancer disparities with global patterns of human development and socioeconomic conditions.

Global inequalities in cervical cancer mortality are substantially larger than those in cervical cancer incidence, which indicate the prominent role of cross-national disparities in patient survival rates, the extent of disease at diagnosis, and the impact of differential access to health services and cancer treatment [4-8]. Cancer survival varies greatly across countries, with cancer patients in Europe, North America, Australia and New Zealand having higher survival rates than their counterparts in developing countries [21]. A recent study showed wide variation in cervical cancer survival rates among African, Asian, Caribbean, and Central American countries [22]. The 5-year age-standardized relative survival rate for cervical cancer ranged from a low of 19% in Uganda and 23% in Gambia to a high of 76% in Seoul, South Korea and 77% in Hong Kong, China [22]. The current 5-year relative survival rate is 69% for US women [23]. Survival inequalities exist within individual countries as well. For example, the 5-year survival rate for cervical cancer patients in Bhopal, India was 31%, as compared with 60% for women in Chennai, India [22].

Lower cancer survival and higher mortality rates partly result from higher rates of late-stage cancer diagnosis among women in developing countries, which is largely due to the lack of effective cervical cancer screening programs in most developing countries [2, 4, 24]. About 81% of cervical cancer patients in Singapore are diagnosed at an early, localized stage, compared with only 7% in Chennai, India, 33% in Costa Rica, 35% in Manila, Philippines, and 53% in Cuba [24]. The high rate of early-stage diagnosis in Singapore is higher than the rate for many industrialized countries, including the United States, where only 52% of invasive cervical cancers in 2008 were diagnosed at localized stage [7, 23].

Detection of cancer at an early stage may be considered a marker for access to health care and preventive health services, including cervical cancer screening. Screening can reduce rates of both cervical cancer incidence and mortality by detecting precancerous lesions (hence preventing cancer) and detecting invasive cervical cancers at an early stage, thereby increasing patient survival [4, 7, 25]. Data from the United States and other industrialized countries indicate that rural and socioeconomically disadvantaged women are significantly less likely to receive Pap smear tests than their urban and affluent counterparts [4, 5, 7, 8]. According to a recent study, only 19% of women in developing countries use cervical cancer screening, compared with 63% in developed countries [24]. However, rates of cervical cancer screening vary widely within the developing world, ranging from 1% in Bangladesh to 73% in Brazil [24]. Consistent with inequalities in cervical cancer screening within the developed world, socioeconomic inequalities in countries such as Brazil and China are quite large, and, globally, women in the poorest wealth decile are seven times less likely to receive cervical cancer screening than their rich counterparts (9% versus 64%) [24].

Inequalities in cervical cancer partly reflect global disparities in the prevalence of HPV infection, which is the primary cause of cervical cancer [2, 4, 9, 13, 26]. HPV prevalence tends to be higher in Eastern and Western Africa, Latin America, and South Asia and lower in West Asia and the Mediterranean region [2, 27]. Globally, HPV prevalence seems to correspond closely with cervical cancer incidence rates ($\gamma = 0.68$) [2]. Another indicator of high-risk sexual behavior is the HIV prevalence among the adult population, which, according to our analysis (not shown), is fairly highly correlated ($\gamma > 0.40$) with both cervical cancer incidence and mortality rates globally.

Conclusions and Public Health Implications

Developing and developed countries differ greatly in their levels of human development and gender inequality [16]. Many of the countries with the highest cervical cancer rates such as Guinea, Comoros, Zambia, Malawi, Burundi, and Mozambique also tend to score the lowest on HDI. Countries with low levels of human development also tend to perform poorly with respect to gender equality; women in these societies fare much worse in reproductive health, educational achievements, empowerment, and work force participation than their counterparts in more egalitarian countries [16]. As shown previously for the United States and other individual industrialized countries, deprivation, material living conditions, and social inequality are also powerful determinants of cervical cancer incidence and mortality at the global level.

The extent of global inequalities in cervical cancer incidence and mortality, as documented here, contributes substantially to the overall cancer-related health disparities worldwide, since cervical cancer continues to be a leading cancer site among women in many developing countries [1, 2]. Unfavorable socioeconomic conditions and low levels of human development may hinder a country's efforts to invest in its health care infrastructure, provision of health services, and in its education sector, which could mean less than optimal resources available for public health improvement and cancer prevention and control efforts. Formulation and implementation of broad societal initiatives are, of course, necessary to address important health and developmental goals, including poverty reduction, larger investments in women's health and education, expanding economic opportunities for women, and a greater commitment toward gender and social equality in the distribution of power, money, and resources [11, 16, 17]. Additionally, public health measures such as establishment of cancer prevention and early detection programs through increased cervical cancer screening, public health education programs promoting condom use to reduce risks of sexually transmitted infections such as HPV and HIV, and introduction of affordable HPV tests and vaccination are critical in reducing global cervical cancer disparities, particularly among women in low- and middle-income developing countries [2].

Financial Disclosure: None to report. **Funding/Support**: None. **Conflicts of Interest**: None.

Acknowledgements: None. The views expressed are the authors' and not necessarily those of the US Department of Health and Human Services and Global Health and Education Projects, Inc.

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