RESEARCH ARTICLE

Global Sex Differences in Cancer Mortality with Age and Country Specific Characteristics

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Abstract

Background: The cancer research literature suggests that women, especially premenopausal women, have lower cancer mortality rates than men. However, it is unclear if that is true for populations at all age levels in all countries and what factors affect such sex differences. This paper attempts to fill that gap. Materials and Methods: Sex- and country-specific cancer mortality data were statistically analyzed with particular attention to geographic, social, and economic factors that may affect the sex differences. Results: The sex differences were age and country specific, rather than universal. Premenopausal women actually tend to have a disadvantage compared to men or postmenopausal women. Male cancer mortality appears to be the affecting factor in explaining variations in sex differences. Latitude of residence and literacy rate are the affecting factors in cancer mortality and sex differences. African and Latin American countries tend to have a female disadvantage, while East Asian and Eastern European countries are more likely to have a female advantage. Conclusions: The findings challenge the cancer mortality literature and indicate that the sex differences and their possible causes are more complicated than the current literature suggests. They also highlight the urgency of adapting age- and country- specific health systems and policies to better meet the needs of younger women.

Keywords: Cancer - epidemiology -, mortality - sex disparities -, geography - international health

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Introduction

Studies of global variations in cancer mortality have enhanced epidemiological advances (Althuis et al., 2005; Hirte et al., 2007; Leung et al., 2011), informed health policy (Coleman et al., 2011), and provided a key insight into the overall effectiveness of the health system (Quaresma et al., 2014). Authors have compared the overall cancer mortality rates (CMR) between more developed and less developed countries and among world major regions in both sexes (Jemal et al., 2010; 2011; Torre et al., 2015). They have also examined cancer mortality in terms of its spatial and sex differences (Jongsthapongpanth and Bagchi-Sen, 2010; Wheeler et al., 2013).

Geo-demographic analyses were shown to enhance the comparison of global inequalities in mortality (Day et al., 2008). A large variation exists among countries in terms of place of death of people with cancer (Cohen et al., 2015). Furthermore, studies have found latitude of residence as a likely predictor of cancer mortality, in agreement with the circadian disruption hypothesis, which postulates that light-at-night leads to desynchronization of the circadian system and, in turn, raises the risk of cancer development (Borisenkov, 2011). Some cancer rates increase significantly with increasing latitude and the impact of latitude is particularly evident with stomach cancer (Borisenkov, 2011) and skin cancer (Moan, Porojnicu, Dahlback, & Setlow, 2008). Latitude was found to be positively related to lung cancer incidence due to insufficient ultraviolet B irradiance at higher latitudes (Mohr, 2008). A woman's risk of being diagnosed as having advanced breast cancer was found to depend on where she lives (Baade et al., 2011).

Sex differentials were found in survival and physical health, with men having consistently higher mortality rates at all ages (Oksuzyan et al., 2014). Women generally have lower cancer mortality rate (CMR) than men do (Cook et al., 2009; 2011; Francisci et al., 2015), though substantial geographic variations exist among world regions and countries (Jemal et al., 2010; 2011; Tsu et al., 2013; Torre et al., 2014; Nur et al., 2015). The biological, environmental, and behavioral causes of such sex differences are largely contested. Studies have found that premenopausal women are less likely than men to die of cancer (Cook, 2011; Pinkston et al., 2006; Matheu et al., 2007; Qu et al., 2015). These findings have sparked a debate over the female advantage, and several theories have been advanced (Yang et al., 2012; OuYang et al., 2015; Harding et al., 2012). One such theory is the controversial "estrogenic hypothesis" which suggests that the female hormone enhances the survival of premenopausal women (Cook et al., 2011). Up-to-date evidence on levels and trends

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for age-sex-specific cancer mortality is essential for the formation of global, regional, and national health policies (GBDSMCDC, 2013). However, studies are lacking on the health concerns of women in their mid-adult years (Tsu, et al., 2013). Furthermore, CMR has not been examined in terms of global and country-specific variations in sex differences at different age levels using population-based statistics.

This paper attempts to fill in that gap in the literature by examining global sex differences in cancer mortality, engaging population-based country cancer statistics. It contributes to the current literature by addressing five specific questions. 1. What are the sex differences in global CMRs? 2. Do women in all countries really have lower CMRs than men do? 3. Do premenopausal women (aged 20-49) have an advantage? 4. Does a female advantage exist in all age groups? 5. What are the possible factors (including latitude of residence) affecting CMRs and FMCMRRs for population of all ages and population aged 20-49? Clearly answering these questions is a crucial prerequisite for understanding the sex differences and their possible causes. After examining CMR for population of all ages, the paper focuses on population aged 20-49.

Materials and Methods

The paper uses female-to-male CMR ratios (FMCMRRs) as a measurement of sex differences. A ratio value below 1 indicates a female advantage as compared to male. To investigate sex differences in CMRs, the 2000 and 2012 age-adjusted rates (ASR) of all cancer mortality data by country were downloaded from the WHO Global Health Observatory Data Repository (under the heading Cancer, deaths per 100,000 data by country) (GHODR, 2015a).

Countries were ranked by their male and female CMRs as well as FMCMRRs to examine whether women in all countries have lower CMR than men do. To investigate if premenopausal women had lower CMR than men do, age-specific CMRs for population aged 20-49 in 81 countries were obtained from WHO International Agency for Research on Cancer (IARC, 2015). Data were unavailable for the other countries. Many of the 81 countries were missing data for some years. Country data were for 2000-2013 or as recent as possible. For some countries the most recent data were for 2010, 2011, or 2012. The latest data were for the years 1990-1998 for Turkmenistan and 1990-2000 for China. China's data were also based on selected areas rather than the entire population. The use of multi-year averages instead of a single year data was to enhance data consistency among the countries. To determine if a female advantage exists in all age groups, CMR data for male and female CMRs and FMCMRRs were obtained from IARC (2015) for each five-year age group for countries with FMCMRRs below 1 for population aged 20-49. These datasets were collected by the WHO following its data collection standards and criteria. The main source of information is the cancer registry of the countries. The WHO recognizes that data quality varied among the countries. Therefore, it employs different methods to enhance data accuracy, completeness, and comparability across countries in the published datasets. Details of the data collection and enhancement may be found in Bray et al. (2015).

The study intended to include all variables that were known as possible factors in global variations in CMRs and FMCMRRs. However, only limited data were available. Fortunately, the GHODR (2015b) includes country-specific statistics of eight demographic and socioeconomic variables. Such an inclusion is an indication that the WHO regards these as variables known to affect health. Five of these were selected as they appeared to be more suitable for the study based our knowledge. These included GNI (growth national income) per capita (PPP int. $), cellphone subscribers (per 100 population), literacy rate among adults, male and female net primary school enrolment rates, and total fertility rate (per woman). The excluded variables were population, crude birth and death rate, and census and

Table 1. Global High and Low Cancer Mortality Rates (CMRs) and FMCMRRs (Female-to-Male CMR Ratios) for Populations of all Ages, 2012.

Country	CMR female	CMR male	FMCMRR
Ethiopia	107.2	63.5	1.688
Fiji	119	76	1.566
Mali	113.8	78.5	1.45
Solomon Islands	116.3	90.7	1.282
Malawi	115.8	91.1	1.271
Mozambique	108.3	85.4	1.268
Djibouti	91.3	75.4	1.211
Somalia	127.9	108.5	1.179
Eritrea	97.5	83.8	1.163
Zambia	113.5	98.8	1.149
Burundi	142.4	130.2	1.094
Pakistan	91.8	84.6	1.085
Kuwait	78.4	73.4	1.068
El Salvador	112	107.9	1.038
Bolivia	109.9	106	1.037
Comoros	105	101.6	1.033
Zimbabwe	226.6	223.5	1.014
Guatemala	110	108.9	1.01
Mauritania	67.5	67.1	1.006
Slovenia	110.2	208.1	0.53
Greece	82.8	157	0.527
Romania	102.2	198.4	0.515
Slovakia	100.7	196.8	0.512
China	98	193.3	0.507
Moldova	91.8	181.1	0.507
Croatia	112.8	222.8	0.506
Japan	73.2	144.9	0.505
Belize	57.3	114.4	0.501
Ukraine	86.2	173.1	0.498
Latvia	115.7	238.1	0.486
Portugal	88.2	184	0.479
Estonia	103.6	216.2	0.479
Spain	80.8	169.3	0.477
Russia	105.7	223.1	0.474
Lithuania	100.7	221.1	0.455
Viet Nam	74.2	163.4	0.454
Turkey	86.9	198.5	0.438
Belarus	79	182.2	0.434
South Korea	74.8	174.8	0.428

Source: GHODR (2015a).

Table 2. Age-Specific FMCMRRs (Female-To-Male Cancer Mortality Rate Ratios) for Countries with Values below 1 for Populations Aged 20-49

Country year-year	20-49	20-24	25-29	30-34	35-39	40-44	45-49
China 90-00	0.645	0.802	0.781	0.728	0.659	0.632	0.607
Thailand 00-06	0.792	0.849	0.947	0.742	0.798	0.796	0.764
S Korea 00-12	0.737	0.787	0.983	1.164	0.991	0.749	0.589
Hungary 00-13	0.739	0.623	0.737	1.222	1.179	0.827	0.629
Portugal 00-03, 07-13	0.758	0.709	0.835	1.05	0.998	0.768	0.669
Slovakia 00-10	0.772	0.524	0.676	0.956	1.185	0.874	0.668
Belarus 00-11	0.79	0.755	0.953	1.106	1.033	0.801	0.596
France 00-11	0.802	0.603	0.817	1.077	1.207	0.94	0.673
Croatia 00-13	0.818	0.638	0.939	1.044	1.03	0.801	0.663
Romania 00-12	0.849	0.704	1.017	1.211	1.28	0.94	0.694
Spain 00-13	0.853	0.682	0.787	1.081	1.177	0.975	0.738
Turkmenistan 90-98	0.857	0.837	0.8	1.246	1.133	0.974	0.837
Slovenia 00-10	0.882	0.435	0.809	1.145	1.22	0.97	0.796
Moldova 00-13	0.896	0.784	0.947	1.239	1.361	0.932	0.728
Greece 00-12	0.909	0.671	0.877	1.11	1.144	1.024	0.81
Russia 00-11	0.909	0.803	1.037	1.234	1.223	1.003	0.754
FYROM 00-10	0.914	0.444	0.861	1.094	1.243	1.061	0.802
Ukraine 00-12	0.914	0.8	0.973	1.202	1.239	1.003	0.759
Czech 00-13	0.94	0.682	0.867	1.168	1.274	1.115	0.816
Bulgaria 00-12	0.945	0.666	0.86	1.241	1.422	1.043	0.796
Poland 00-13	0.945	0.644	0.781	1.022	1.169	1.068	0.877
Georgia 00-12	0.966	1.045	0.709	1.083	1.091	1.084	0.873
Latvia 00-12	0.978	0.589	0.839	0.836	1.172	1.117	0.934
Serbia 00-13	0.986	0.576	0.863	1.208	1.268	1.165	0.872

Source: IARC (2015).

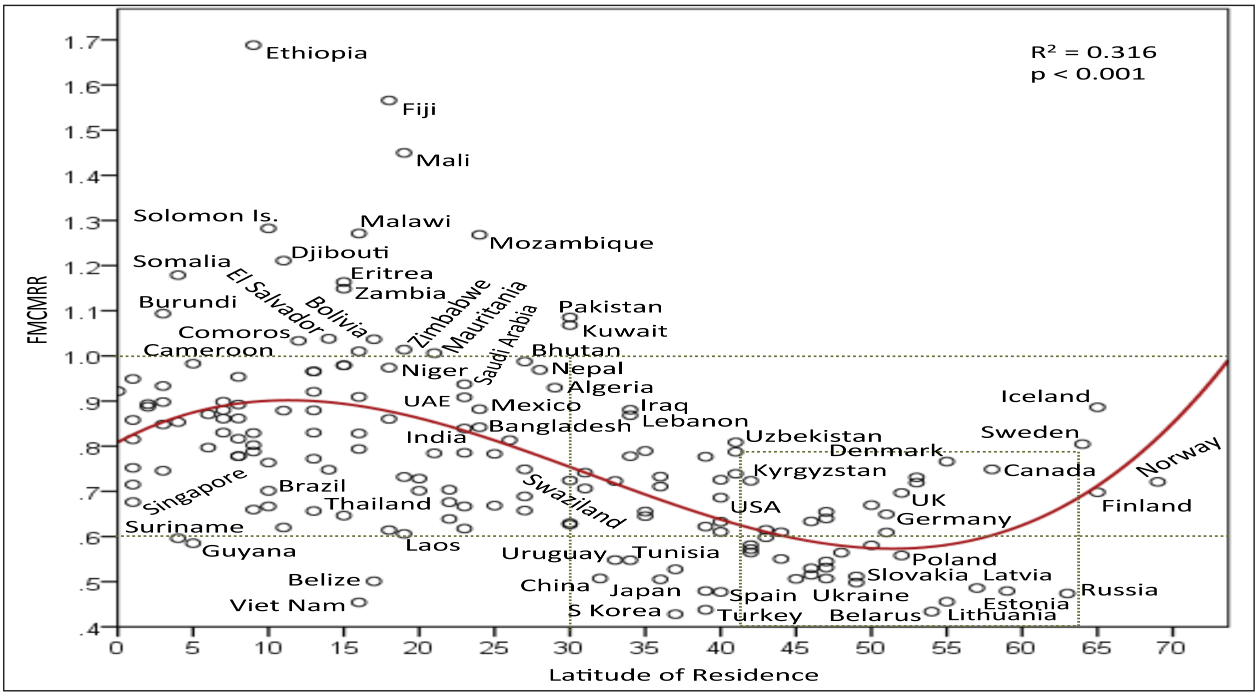

Figure 1. Relationship between Latitude and FMCMRR, Populations of All Ages, 2012

civil registration coverage. They were deemed to be unimportant variables for explaining global variations in CMRs and FMCMRRs. Instead, population density data were obtained from World Bank (2015a) and population physiological density (persons per unit of arable land) data were from de Blij and Muller (2014). In addition, the study included the Global Gender Gap variable with data obtained from World Economic Forum (Hausmann et al., 2012). This Index tracks country progress in women's educational attainment, health, economic participation, and political empowerment. Countries' central geographic latitude was used as a proxy for latitude of residence with data from GMT Time Date (2015). This is not ideal as the CMRs and FMCMRRs were for the entire geographical area of the country. Such discrepancy may be minor for small territories, but so large that caution is needed when interpreting the results for countries such as Russia, Canada, China, and the USA.

Table 3. Correlations between Cancer and Affecting Variables for Populations at All Ages

	N	Latitude	CMR both	CMR female	CMR male	FMCMRR
CMR both	172	0.433**				
CMR female	172	0.160*	0.860**			
CMR male	172	0.546**	0.933**	0.633**		
FMCMRR	172	-0.496**	-0.396**	0.097	-0.662**	
GNI per capita	162	0.460**	0.117	-0.034	0.184*	-0.294**
Global gender gap	171	0.294**	0.252**	0.156*	0.265**	-0.197**
Total fertility rate	172	-0.593**	-0.325**	-0.009	-0.475**	0.593**
Cellphone users	172	0.400**	0.138	-0.085	0.264**	-0.410**
Literacy rate	126	0.506**	0.341**	0.06	0.473**	-0.596**
Schooling female	127	0.424**	0.331**	0.183*	0.357**	-0.331**
Schooling male	127	0.408**	0.280**	0.135	0.306**	-0.302**

Notes: CMR = cancer mortality rate; FMCMRR = female-to-male cancer mortality rate ratio; GNI = growth national income (PPP int. $); Literacy and schooling data are for 2007-2012, the other data are for 2012; * Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed)

Table 4. A Cubic Curve Model of the Relationship between Latitude and CMRs and FMCMRRs for Populations at all ages, 2012

Dependent	a	b1	b2	b3	R2	Adjusted R2	F
FMCMRR	0.808	0.018**	-0.001***	1.02E-05***	0.316	0.304	26.4***
CMR male	132.794	-5.292***	0.246***	-0.002***	0.398	0.387	37***
CMR female	103.003	0.818*	0.061*	-0.001	0.068	0.052	4.1**
CMR both	113.885	-3.163***	0.139***	-0.001***	0.269	0.256	20.6***

Notes: CMR = cancer mortality rate; FMCMRR = female-to-male cancer mortality rate ratio;

Table 5. Correlations between Cancer and Affecting Variables for Populations aged 20-49

Variable	N	Latitude	CMR female	CMR male	FMCMRR
CMR female	81	-0.04			
CMR male	81	0.293**	0.735**		
FMCMRR	81	-0.515**	-0.068	-0.671**	
GNI per capita	78	0.382**	-0.338**	-0.18	-0.145
Global gender gap	81	0.056	0.114	-0.015	0.128
Total fertility rate	81	-0.381**	-0.141	-0.464**	0.547**
Cellphone users	81	0.187	-0.041	0.02	-0.08
Literacy rate	53	0.534**	0.144	0.334*	-0.409**
Schooling female	65	0.284*	-0.359**	-0.186	-0.068
Schooling male	65	0.273*	-0.360**	-0.189	-0.079
Population density	81	-0.086	-0.122	-0.02	-0.224*
Physiological density	81	-0.082	-0.116	-0.009	-0.232*

Notes: CMR = cancer mortality rate; FMCMRR = female-to-male cancer mortality rate ratio; GNI = growth national income (PPP int. $); Literacy and schooling data are for 2007-2012, the other data are for 2012; * Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed)

Table 6. A Cubic Curve Model of the Relationship between Latitude and FMCMRRs for Populations Aged 20-49

Dependent	a	b1	b2	b3	R2	Adjusted R2	F
FMCMRR	1.39	0.024*	-0.001**	1.65E-05***	0.428	0.406	19.23***

Notes: FMCMRR = female-to-male cancer mortality rate ratio; N=81; * $p < 0.15$, ** $p < 0.005$, *** $p < 0.001$

Pearson correlation and linear regression analyses were conducted on the cancer variables with the possible affecting factors. Based on the results of linear regression, curve estimation was used to determine the relationship between the affecting factors and cancer variables. R-squared and Adjusted R-squared were used to assess the goodness of fit of the model. F-tests were used to assess the reliability of the observed R-squared and thus the statistical reliability of the proposed relationship between the response variable and the predictor. No interactions between variables were assessed because only one independent variable latitude of residence was used in the regression model.

Results

Women May Have Higher CMRs in Some Countries

A female advantage is apparent as the 2012 world average age-standardized CMRs were 126 per 100,000 for men and 83 per 100,000 for women (Cancer Research UK, 2015). However, this advantage is not shared by all countries. Of the 172 countries in the WHO database, 30 (over 17%) had a FMCMRR above 1 in 2000 (GHODR, 2015a), where women actually had a disadvantage. The number was 19 in 2012 which still meant that 11% of the countries had a female disadvantage. These 19 countries are compared to 20 countries where female advantage is outstanding (FMCMRRs were 0.53 or less) (Table 1). A

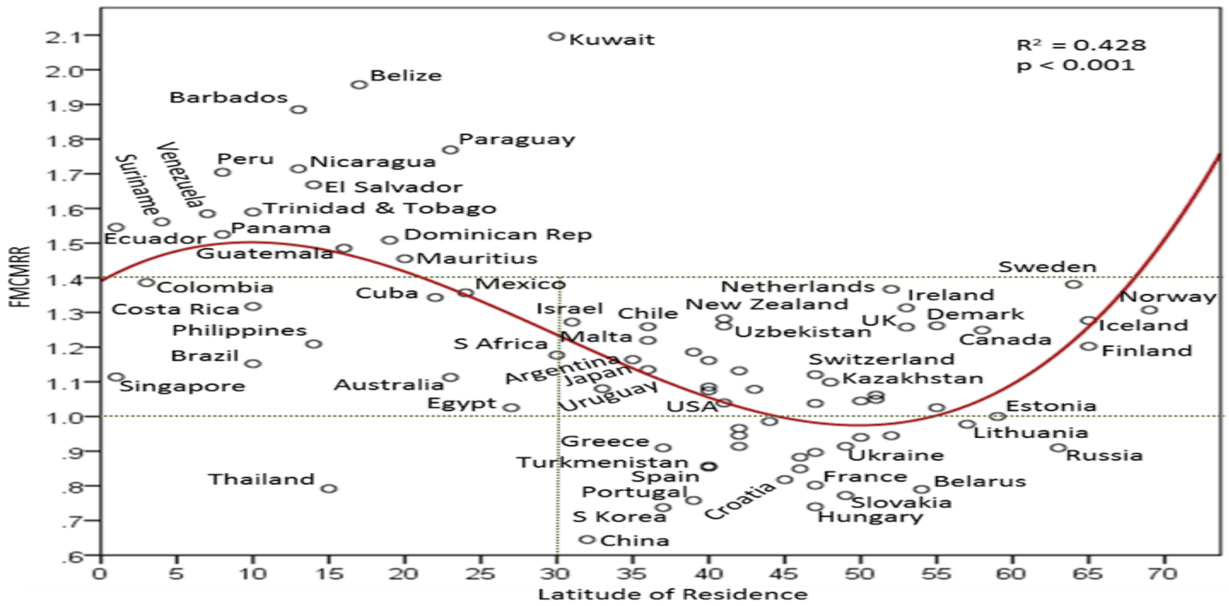

Figure 2. Relationship between Latitude and FMCMRRs, Populations Aged 20-49

global disparity exists with the highest FMCMRR (1.688 for Ethiopia) being almost four times of the lowest (0.428 for South Korea).

The world average CMRs were used to divide the 39 countries into high and low CMR groups for men and women (Table 1). This division helped illustrate the relationship between FMCMRRs and CMRs by gender. High FMCMRRs (above 1) tended to be the result of a low male CMR and a high female CMR. The exceptions were Burundi and Zimbabwe with high CMRs for both genders and Kuwait and Mauritania with low CMRs for both genders. On the other hand, low FMCMRR countries tended to have a high CMR for both genders, but higher for men than women. Again, there were some exceptions. Belize had a low CMR for both genders. Greece, Japan, Spain, Viet Nam, Belarus, and South Korea had low CMRs for women.

Premenopausal Women May Have a Disadvantage

FMCMRRs were higher for population aged 20-49 than for population of all ages. The highest FMCMRR was 2.019 for Kuwait, which was 3.25 times the lowest FMCMRR (0.645 for China). In contrast, 49 (over 28%) of the countries had a FMCMRR below 0.645 for population of all ages. Twenty-four (less than 30%) of the countries had a FMCMRR below 1 among population aged 20-49, as compared to 89% in population of all ages. These 24 countries were further examined to find out if a female advantage was present in all of the age groups. The results showed that only two countries (China and Thailand) had a FMCMRR below 1 at all six 5-year age groups between ages 20 and 49 (Table 2). However, even for these two countries, FMCMRRs were still higher for population before age 50 than later years. The peak FMCMRRs were ages 20-24 for China and 25-29 for Thailand. Ages 30-34 appeared to have peak FMCMRRs for most countries.

Relationship among the Variables

Table 1 indicates that variations in FMCMRRs were more associated with CMRs for men than women, possibly because the range of CMR was greater for men than women. Correlation analyses confirmed that the FMCMRRs were highly correlated to male CMRs, but were not correlated with female CMRs (Table 3). That means that male CMRs were the affecting factor in explaining variations in FMCMRRs. The lower the male CMRs, the higher the FMCMRRs. FMCMRR was correlated to all the demographic and social factors. Male and female CMRs were positively correlated, meaning that countries with higher male CMRs also tended to have higher female CMRs. Latitude was negatively correlated to FMCMRR and TFR and positively correlated to all the other variables. Population density and physiological density were not correlated to any of the other variables.

Further analyses attempted to understand the relationship between FMCMRRs and the other variables. Linear regression results show that latitude of residence and literacy rate were the factors affecting the variation in the FMCMRRs, while the other variables were not. The model is able to explain about 50% of the variations in FMCMRRs. In addition to FMCMRRs, latitude was also the factor affecting the variations in CMR, while GNI per capita and GAP were explanatory variables at a lower level of significance.

The relationship between latitude and FMCMRRs is illustrated in Figure 1. All 43 countries with ratios above 0.881 (including 19 countries with ratios above 1) are located within 30 degrees north and south latitudes. Among the 105 countries/regions located at or below 30 degrees north and south latitudes, only four (less than 4%) have a ratio below 0.6, compared to 29 (more than 46%) among the 63 countries located between 30 and 60 degrees north and south latitudes. Rather than a linear model, a cubic curve model was found to be the best fit for the relationship between latitude and the FMCMRRs (Figure 1, Table 4). Countries located near the equator had high FMCMRRs but the highest FMCMRRs were found for countries located from 9 to 24 degrees north and south latitudes. Beyond that, FMCMRRs continued to decline until 64 degrees north latitudes followed by an increase in higher latitudes. Countries with the lowest FMCMRRs tended to be located between 30-63 degrees north latitudes. Most of these countries were from East Asia and Eastern Europe.

Level of income did not seem to be able to explain such trends, as discussed earlier with linear regressions. Though poor countries in Africa tended to have high FMCMRRs, many other high FMCMRR countries were middle or high income economies. According to the World Bank (2015b), Algeria, Fiji, Lebanon, and Peru were upper middle income countries, while Kuwait and Saudi Arabia were high income economies. Furthermore, low FMCMRR countries tended to be middle income rather than the wealthiest economies. A cubic curve model was also the best fit for the relationship between latitude and CMRs for male (R^2=0.389, p <0.001) and both sexes (R^2=0.269, p<0.001) (Table 4). Latitude was able to explain over 30% of the variations in FMCMRRs, nearly 40% in male CMRs, and over 25% in CMRs for both genders, though its explanatory power over female CMR was rather weak. A significant F-test indicates that the proposed relationship was statistically reliable.

Compared to population of all ages, population aged 20-49 had higher disparities in CMRs. For population aged 20-49 years old in the 81 countries, CMRs ranged from 6.6 in Turkmenistan to 47.1 in Hungary for females and from 7.3 in Kuwait to 63.71 in Hungary for males. For either male or female, the highest CMR was over 7 times the lowest. Kuwait, Turkmenistan, Kazakhstan, and Dominican Republic had the lowest CMRs for both men and women. On the other hand, Russia, Moldova, Romania, Ukraine, and Hungary had the highest CMRs for both men and women.

Similar to the all-age data, male CMRs were correlated to female CMRs and FMCMRRs while female CMRs were not correlated to FMCMRRs (Table 5). Latitude was correlated to male CMRs and FMCMRRs but not female CMRs. It was also correlated to GNI per capita, TFR, literacy and schooling. FMCMRRs were also correlated to TFR, literacy, population density, and physiological density. Linear regression analyses again found latitude to be the factor explaining the variations in FMCMRRs. None of the other independent factors were statistically significant. A cubic curve model was again the best to describe the relationship between latitudes and the FMCMRRs with a significant F-test (Table 6).

Discussion

The finding of higher FMCMRRs for population aged 20-49 than for population of all ages means that premenopausal women did not have an advantage compared to women in general. Different from Figure 1, Figure 2 shows that high FMCMRR countries were mainly from Latin America instead of Africa. That might possibly be related to the absence of African countries in this database, while there was no way to check on that possibility due to lack of data. Data were available for only three African countries. The 26 countries located at or below 30 degrees north and south latitudes included all 15 countries with a FMCMRR above 1.4. Here only one (less than 4%) country had a ratio below 1 (Thailand), compared to 22 (40%) among the 55 countries located above 30 degrees north and south latitudes. Income levels did not seem to be a good explanation. For example, Kuwait was a high income country with the highest FMCMRR. Countries with a ratio below 1 tended to be middle income economies. Similar to Figure 1, Figure 2 shows that the 24 countries with FMCMRRs below 1 tended to be from Eastern Europe and East Asia located between 30 and 63 degrees north latitudes.

In conclussion, This paper is the first to examine CMRs in terms of global and country-specific variations in sex differences at different age levels using population-based statistics. It demonstrates that although women have lower global average in CMRs than men do, they have higher CMRs than men in at least one tenths of the countries in the world. For population aged 20-49, women may have a disadvantage in over 70% of the countries. Furthermore, only two countries were found to have a female advantage in all 5-year age groups. Population aged 20-49 has higher FMCMRRs than population of all ages. Ages 30-34 appeared to have peak FMCMRRs for most countries. That means that premenopausal women have a disadvantage in CMR, compared to women in general. This finding is different from the general belief and the large literature in women's health advantages and the estrogenic hypothesis.

Furthermore, male, rather than female, CMRs appear to be the affecting factor in explaining variations in FMCMRRs. The paper contributes to studies in health care for women by enhancing better understanding of global sex differences in cancer mortality. It supports the notion that latitude of residence may be a likely predictor of health differences (Borisenkov, 2011). Among the selective variables, latitude of residence and literacy rate are the factors affecting the variation in the FMCMRRs. A cubic curve model is the best fit for the relationship between latitude and male CMRs and CMR for both genders, as well as FMCMRRs. A female disadvantage starts high in the tropical regions and keeps rising with a peak in the subtropical regions. It declines toward the mid-latitudes and rises again in the high latitudes. African and Latin American countries tend to have a female disadvantage, while East Asian and Eastern European countries are more likely to have a female advantage.

Future research should look into the causes of regional disparities. The relationship between latitude and cancer and the cubic curve model contradict the literature in female advantage in cancer mortality and imply that female advantages and their possible causes are more complicated than the current literature suggests. They highlight the urgency of adapting age and country specific health systems and policies to better meet the needs of younger women in their fight against cancer. Further research should also look into sex differences in particular types of cancer in different countries and find out their global patterns and trends. Cancer mortality is the result of interaction of many complicated factors. As such, the missing data and lack of better social and location variables present limitations to this study. The findings are preliminary rather than conclusive, as this is the first such study. The interpretation of the research results should take these limitations into consideration. However, the statistically reliable relationship between latitudes and health variables should inspire further research, rather than being regarded as an accident, to reexamine the study questions when better data become available.

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