

Gender equality, development, and cross-national sex gaps in life expectancy

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Abstract

Female life expectancy exceeds male life expectancy in almost every country throughout the world. Nevertheless, cross-national variation in the sex gap suggests that social factors, such as gender equality, may directly affect or mediate an underlying biological component. In this article, we examine the association between gender equality and the sex gap in mortality. Previous research has not addressed this question from an international perspective with countries at different levels of development. We examine 131 countries using a broad measure of national gender equality that is applicable in both Less Developed Countries (LDCs) and Highly Developed Countries (HDCs). We find that the influence of gender equality is conditional on level of development. While gender equality is associated with *divergence* between female and male life expectancies in LDCs, it is associated with *convergence* in HDCs. The relationship between gender equality and the sex gap in mortality in HDCs strongly relates to, but is not explained by, sex differences in lung cancer mortality. Finally, we find that divergence in LDCs is primarily driven by a strong positive association between gender equality and female life expectancy. In HDCs, convergence is potentially related to a weak negative association between gender equality and female life expectancy, though findings are not statistically significant.

Keywords

cross-national, development, gender equality, life expectancy, sex differences

Female life expectancy exceeds male life expectancy in almost every country throughout the world.¹ While females' higher life expectancy is partly attributable to biological factors, including hormonal differences (Bird and Rieker, 2008), cross-national variation in the size of the sex gap suggests that the biological component is likely conditioned or directly affected by social factors.

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Gender equality, which refers to parity between women's and men's positions in society, is one social factor that may help explain cross-national variation in the sex gap in mortality.

Previous research offers insight into the association between gender equality and the sex gap in life expectancy, but is limited from a global perspective. First, cross-national research on gender equality and mortality, or the sex gap in mortality, is typically focused on either less developed countries (LDCs) or highly developed countries (HDCs). Second, the findings from studies in LDCs are not comparable to those in HDCs because researchers use different measures or proxies for gender equality in each setting. For example, studies in LDCs concentrate on educational, political, and economic measures of gender equality, while studies in HDCs tend to examine sex differences in epidemiological risk factors, such as smoking and alcohol consumption rather than gender equality per se. Third, research in LDCs and HDCs are further differentiated by the mortality outcomes analyzed. While female or child mortality is the dependent variable in most LDC studies, sex differences in mortality are more often the focus in studies of HDCs.

Although research in LDCs and HDCs is not directly comparable, we believe there is preliminary evidence to suggest that the sex gap in mortality varies by level of gender equality across nations and, furthermore, that this relationship is conditional on level of development. For example, gender equality extends female life expectancy in LDCs (Aden et al., 1997), and the few studies which examine sex differences in life expectancy find a positive relationship between the sex gap and gender equality (Fuse and Crenshaw, 2006; Williamson and Boehmer, 1997). Gender equality is also related to the sex gap in HDCs. For example, as gender equality increases, women have adopted many of the same risky behaviors, such as smoking and drinking (McKee and Shkolnikov, 2001; Rogers et al., 2010; Smith, 2004). This trend may have led to a convergence in sex differences in life expectancy (Bird and Rieker, 2008; Bobak and Marmot, 1996; Crawley et al., 2008; Degenhardt et al., 2008; McKee and Shkolnikov, 2001; Morley and Hall, 2008). The sex gap also appears to be smaller where there is more gender equality in the public sphere (Backhans et al., 2007; Crawley et al., 2008; Helweg-Larsen and Juel, 2000), and may also be exacerbated by women experiencing stress from work–family conflict (Schulz and Beach, 1999). While studies show that women's mortality in LDCs is lower where gender equality is higher, less is known about the nature of this relationship in HDCs. Moreover, it is unclear how male mortality is associated with gender equality at either level of development. Drawing on the literature, we hypothesize that the relationship between gender equality and sex differences in life expectancy is conditional on level of development. More specifically, we hypothesize that gender equality is associated with a divergence between men's and women's life expectancies in LDCs and a convergence in HDCs.

In this study, we examine the relationship between gender equality and the sex gap in mortality in 131 countries, including both HDCs and LDCs. To our knowledge, this is the first study to use a broad measure of gender equality to examine sex differences in mortality across a wide range of countries. We use common indicators of public sphere gender equality, including gender gaps in the economic, political and educational spheres, which are applicable across different levels of development. In contrast, epidemiological risk factors are specific to different causes of death, which vary cross-nationally and do not reflect the mortality experience in all countries (Link and Phelan, 1995). The analyses are divided into three separate sections. The first section examines the relationship between gender equality and the sex gap in five mortality outcomes, including three measures of adult mortality (life expectancy, healthy life expectancy [HALE], and adult probability of dying between ages 15 and 60) and two measures of youth mortality (infant and child mortality between ages 1 and 5). In the second section, we explore the potential contribution of smoking to the sex gap in mortality by comparing sex differences in lung cancer mortality versus all other causes. In the third section, we examine the association of gender equality with male and female

life expectancies as separate outcomes to better understand the patterns we observe with respect to sex gaps in mortality.

We find that greater gender equality is associated with *divergence* in life expectancy between the sexes in LDCs but *convergence* in HDCs. In LDCs, divergence is primarily driven by a strong positive association between gender equality and female life expectancy. In HDCs, convergence is possibly attributable to a negative association between gender equality and female mortality.

Mortality and gender research in LDCs

Gender equality in LDCs generally increases women's life expectancy, and some studies suggest that it contributes to divergence between men's and women's mortality. Gender equality has often been operationalized by factors such as levels of female labor force participation (LFP), female education, and reproductive health interventions.

Several studies show that the transition of women into the paid labor force increases female life expectancy relative to males (Baunach, 2003; Fuse and Crenshaw, 2006; Williamson and Boehmer, 1997). This relationship operates through several pathways. For example, spending time outside the home reduces women's exposure to the harmful indoor air pollution emitted from burning biomass fuel, which contributes to women's excess morbidity and mortality in LDCs (Murray and Lopez, 2002). In addition, women's employment in the service sector enhances women's economic value and discourages female infanticide and neglect (Fuse and Crenshaw, 2006). Decreases in female mortality at young ages have a profound effect on increasing female life expectancy at birth (Preston et al., 2001; Shrestha, 2006).

Female education, through improved literacy, enrollment rates, and years completed, positively influences life expectancy for both sexes (Lee, 2000), and for women in particular (Williamson and Boehmer, 1997). Like employment, education increases daughters' economic value, thereby reducing parental preferences for sons and female's excess mortality at young ages (McNay, 2005). Education also contributes to increased female autonomy in the home. Exercised through decision-making, more equitable divisions of household labor and increased age at marriage, female autonomy improves maternal and child health (Caldwell and Caldwell, 1993; Li, 2004). Caldwell's seminal study (1986) shows that the most important route to overall low mortality in poor countries is the increase in female autonomy.

Gender equality has also increased women's life expectancy through reproductive health interventions, such as the use of midwives during childbirth (Kabeer, 2005; Shaw, 2006). Midwives decrease both infant and maternal mortality (Frankenberg and Thomas, 2001), thereby, increasing female life expectancy (Williamson and Boehmer, 1997). Higher contraceptive prevalence (Shen and Williamson, 1997; Williamson and Boehmer, 1997) and lower fertility rates (Fuse and Crenshaw, 2006; Pillai and Gupta, 2006; Williamson and Boehmer, 1997) also improve female life expectancy. Lastly, gender equality can improve women's mortality through increased access to other types of health services and improved nutritional well-being (Potter and Volpp, 1993).

The research summarized above has several limitations with respect our aim of comparing the relationship between gender equality and the sex gap in mortality cross-nationally in LDCs and HDCs. While some studies investigate *sex differences* in mortality (Baunach, 2003; Fuse and Crenshaw, 2006; Williamson and Boehmer, 1997), most of the studies described above examine only women's or child mortality. We cannot assume that increases in female life expectancy relate to divergence between the sexes because the same factors that increase female life expectancy may also improve male life expectancy. For example, maternal health and female education are positively associated with healthier sons and daughters, and the factors which increase female LFP and

improve women's health and life expectancy may also benefit men. Another caveat with respect to LDCs is that studies that do examine sex differences typically use only a small number of LDCs and are therefore limited in generalizability (Baunach, 2003; Fuse and Crenshaw, 2006; Williamson and Boehmer, 1997).

Mortality and gender research in HDCs

In HDCs, the sex gap in mortality is often attributed to sex differences in epidemiological risk factors such as tobacco and alcohol use. Improvements in gender equality may lead women to adopt riskier behaviors and lifestyles previously associated with men (Bird and Rieker, 2008; Rogers et al., 2010). For example, increases in female smoking rates have reduced the sex difference in mortality by 23 percent (Preston and Wang, 2006). Increases in female smoking and alcohol consumption have also decreased men's excess heart disease mortality (Crawley et al., 2008). Another study finds that about three-quarters of the sex gap in mortality is due to sex differences in smoking and alcohol related causes of death, including ischemic heart disease, lung cancer and traumatic deaths (Wong et al., 2006). In Eastern Europe, where sex differences in life expectancy are generally considered to be large, the gap is narrowing as women's alcohol and tobacco consumption approaches men's (Bobak and Marmot, 1996; Degenhardt et al., 2008; McKee and Shkolnikov, 2001). While most studies explain convergence in the sex gap in mortality through increases in female smoking rates (Morley and Hall, 2008), decreases in male smoking-related mortality is also a factor (Zatonski et al., 2007).

Although most studies in HDCs use epidemiological risk factors which may be related to gender equality, a few studies explicitly examine broader measures of gender equality in conjunction with sex differences in mortality. For example, Pampel (2001, 2002) examines gender differences in smoking-related mortality using an index of gender equality. Although he did not find an association, the gender equality index used included the Total Fertility Rate (TFR) and divorce rate, factors which have not been identified as standard measures of gender equality and are not highly correlated with more general measures of gender equality (McNay, 2005). Two Scandinavian studies use more standard indicators of public sphere gender equality, such as female LFP, the proportion of parliamentary seats occupied by women, and the ratio of female-to-male wages. One of these studies finds that gender equality, particularly equality in the division of labor and economic resources, is related to convergence in morbidity and mortality between the sexes (Backhans et al., 2007). While gender equality is negatively associated with mortality for both sexes, they conclude that convergence is attributable to a stronger negative association between gender equality and female mortality than with male mortality. Another study posits that as gender equality continues to increase in the future, and as men's and women's social positions become more similar, 'further convergent trends in gender differences in mortality can be expected' (Helweg-Larsen and Juel, 2000: 220).

Gender equality is often associated with an increase in female LFP, which may have both positive and negative implications for health and mortality. On the one hand, the increase in women's LFP in the United States over the past 20 years has improved women's self-rated health (Schnittker, 2007), a finding corroborated by earlier research (Repetti et al., 1989; Ross and Mirowsky, 1995). Labor force participation may also reduce female mortality. A study analyzing Wisconsin death certificates from the 1970s found that death rates among women in the labor force were generally lower than those of housewives (Passannante and Nathanson, 1985). On the other hand, a decrease in the gendered specialization of household and labor market production may mean that both sexes, but especially women, are working a second shift (Hochschild, 1989). Work-family conflict is

related to an increase in stress (Coverman, 1989), which could have a negative effect on mortality. Stress related to care-giving for an aging parent, for example, has been found to increase the risk of mortality by as much as 63 percent (Schulz and Beach, 1999) compared with non-caregivers. This risk may be especially salient in the many HDCs that have female life expectancies of 80 or older. The negative impact of care-giving stress is particularly relevant for women, because daughters are much more likely to care for an aging parent than are sons (Wolf, 1994). Stress from other causes also contributes to an increase in female mortality. One study found that women who report high levels of stress are twice as likely to die from a stroke or coronary heart disease, and 1.5 times more likely to die from cardiovascular disease, compared with women who reported low stress (Iso et al., 2002). Finally, some research has shown that as women's presence in the labor market expands, they are more likely to exhibit the *coronary-prone behavior pattern*, also known as the 'type A personality', which may mitigate sex differences in mortality caused by coronary heart disease (Crawley et al., 2008; Waldron, 1978). However, other research has questioned the relationship between the type A behavior pattern and health risks, and instead argued that underlying hostility levels are more important (Williams et al., 1980). Taken together, research on female labor force participation and mortality describes a complex relationship. Some studies find that female labor force participation positively benefits women's health and mortality, while others find that work-family conflict may exacerbate the negative association between stress and mortality. However, these studies do not suggest that this potential negative relationship outweighs the many other positive benefits of gender equality and women's labor force participation for women and for society in general. Therefore, it remains unclear as to whether the relationship between gender equality and the sex gap in mortality in HDCs may operate through pathways other than risky behaviors such as smoking.

Data and methods

The analysis is conducted in three parts, and the description of the variables, methods used, and results for each part will be described in turn. Although the mortality outcomes, provided by the World Health Organization World Health Report (2010), are available for 193 countries, the analytical sample includes 131 nations, including LDCs and HDCs (see Appendix Table 1). To distinguish between HDCs and LDCs, we use the Human Development Index (HDI) (UN Human Development Report, 2010). Of the original 193 countries, we lose 26 countries where HDI is not calculated due to missing data, leaving 167 countries. The average sex difference in life expectancy is not significantly different for these 26 countries than for the remaining 167. Finally, gender equality is missing for an additional 36 of the remaining countries, 35 of which are LDCs, bringing the sample down to 131. Comparing the LDCs that are missing gender equality to those that are not, the average sex difference in life expectancy is one-tenth of a standard deviation lower among the missing gender equality countries. Thus, for missingness on gender equality to bias results towards a positive association between gender equality and the sex gap in life expectancy, gender equality would have to be higher in the non-sample LDCs, which is unlikely given that they are lower on HDI.

Gender equality and sex gaps in mortality

Mortality. We hypothesize that the association between gender equality and cross-national sex gaps in mortality is conditional on level of development. In this first part of the analysis, we consider five measures of sex gaps in mortality: the difference (in years) between females and males in 1) life expectancy at birth and 2) healthy life expectancy at birth (HALE); and the log of the sex ratios

for 3) the adult probability of dying between the ages 15 and 60 ($_{45}q_{15}$), 4) the Infant Mortality Rate (IMR, $_{1}q_0$), and 5) the probability of a child of dying between the ages one and five ($_{4}q_1$). These data derive from national death registrations from 2007 (HALE) or 2008 that are compiled by the World Health Organization (WHO) (*World Health Statistics 2010*, 2010). For all measures, larger values indicate a female advantage, where sex differences are calculated by subtracting male from female values, and sex ratios are calculated by dividing male by female values.

We include the sex gap in the adult probability of dying between ages 15 and 60 in part to control for variation in the age pattern of mortality. Sex gaps in life expectancy derive from a combination of two factors – sex differences in age-specific mortality rates and the age pattern of mortality. The age pattern of mortality contributes to the sex gap in life expectancy through the quantity of deaths that occur at specific ages. For example, when deaths are more concentrated at older ages (a rectangular age pattern of mortality), the gains in life expectancy produced by declines in age-specific death rates are smaller. Because women have a more rectangular age pattern of mortality than men, the sex differential in life expectancy could converge even if there were no change in sex differences in age-specific mortality rates. In a longitudinal study of high income countries, Gleit and Horiuchi (2007) argue that differences in the age pattern of mortality between men and women may be more important to convergence in the sex gap in life expectancy than changes in age-specific mortality rates. To address this potential concern, we examine the sex gap in mortality for a limited age range. Specifically, we model the log of the sex ratio of the probability of an adult dying between the ages 15 and 60 ($_{45}q_{15}$). This measure is less sensitive to sex differences in the rectangular age pattern of mortality than is life expectancy at birth.

Gender equality. We measure gender equality in the public sphere using a modified version of the Gender Gap Index computed by the World Economic Forum (WEF) (Hausmann et al., 2010). The original variable measures the gap between women and men in terms of economic participation and opportunity, political empowerment, educational attainment, and health and survival. Our measure excludes gender gaps in health and survival because of its overlap with the dependent variables. Each of the three domains in this analysis reflects gender inequalities, captured by the ratio of female to male values, in multiple areas.² *Economic participation and opportunity* encompasses four variables: the ratio of female to male labor force participation; wage equality between women and men for similar work; the sex ratio of legislators, senior officials and managers; and the sex ratio of professional and technical workers. *Educational attainment* encompasses four variables: sex ratios in a country's literacy rate, net primary and secondary enrollment rates, and gross tertiary enrollment rates. *Political empowerment* encompasses three variables: the sex ratio for parliamentary seats, the sex ratio at the ministerial level, and the ratio of the number of years with a female head of state or government over years with a male head. Each sub-index is calculated by averaging its variables after they have been normalized by their standard deviations.

To compute the gender equality score for each country, we averaged the scores for the three dimensions. A value of 100 in the gender equity index would indicate complete equality between males and females across the three domains, while a score of 0 would indicate complete inequality. The final measure ranges from 28.9 to 81.0, with an average score of 58.1 across all countries (see Appendix Table 1). Of the countries in the analysis, Yemen, Chad, and Pakistan have the lowest gender equality while the Scandinavian countries, including Finland, Norway, and Iceland, have the highest gender equality. We also examine each of the three sub-indices separately.

Level of development. Each year, the United Nation (UN) publishes The Human Development Index (HDI) (*Human Development Report*, 2010), which measures and ranks countries by human

development. In this study, we use the non-income version of the HDI, which combines indicators of population health (life expectancy) and education (mean and expected years of schooling). After carefully examining the ranked countries, we chose the non-income HDI as opposed to the income version, which also includes Gross National Income (GNI) per capita. Some countries that have very high GNIs are significantly lower on other previously mentioned aspects of human development (e.g. Qatar, the United Arab Emirates, and Brunei Darussalam). As such, using the income version of the HDI combines countries that are very different from one another. The countries with the highest HDI values include New Zealand, Australia, and Norway, and those with the lowest HDI values include Chad, Mozambique, and Burkina Faso. The UN ranks countries by their HDI value from highest to lowest human development (1 to 169), and then divides them into four categories of equal size with the following labels: very high, high, medium, and low human development. From this point forward, we refer to the countries with 'very high' human development as HDCs, and other countries as LDCs. To assess how level of development modifies the association between gender equality and sex differences in life expectancy, we model an interaction between HDC and gender equality. Exploratory analysis shows that 'very high' is the cut-off point that is most salient for differences in the association of gender equality with sex differences in life expectancy.

One advantage to using the HDI as an indicator of development is that it includes life expectancy at birth for both sexes combined. The countries in this analysis vary widely in life expectancy, from a minimum of 42 years in Zimbabwe to a maximum of 83 in Japan. It is possible that the heterogeneous relationship between gender equality and the sex gap in life expectancy is driven by overall mortality levels in LDCs and HDCs. In countries where life expectancy is relatively low, there may be more room for life expectancy to be increased by factors such as gender equality. Because our measure of development includes life expectancy, it is unlikely that our results are driven by variation in overall levels of mortality.

Finally, models also control for the log of GNI per capita (Purchasing Power Parity, from the UN [*Human Development Report*, 2010]) to account for potential confounding from wealth.

Results

Table 1 shows descriptive statistics for all variables by level of development. Average sex gaps in mortality are larger in HDCs than LDCs, and life expectancies for both sexes are higher in HDCs. On average, HDCs are wealthier and have greater gender equality.

Regression results are presented in Table 2. Using Ordinary Least Squares (OLS), we regress each of the four sex gaps in mortality on gender equality, HDC status, the interaction between gender equality and HDC, and the log of GNI per capita. The main effect of gender equality in LDCs is represented by the first row of coefficients, and the estimated effect of gender equality in HDCs, computed as the sum of the main effect and interaction, is listed at the bottom of the table. To simplify the description of the results, we refer to a 10-point increase in gender equality when discussing associations with gender equality. Unless otherwise specified, results are significant at least at the $p < .05$ level. In Models 1 and 2, the outcome variable is the sex difference in life expectancy. Model 1 includes gender equality, HDC, the interaction between gender equality and HDC, and the log of GNI per capita. The interaction term is negative and highly significant. Results show that a 10-point increase in gender equality is associated with a 1.5 year increase in the sex difference in life expectancy in LDCs and a weakly significant 1.1 year decrease in the sex gap in HDCs ($p < .10$). Therefore, the influence of gender equality on the sex gap in life expectancy appears to vary by level of development. In Model 2, we remove the interaction between gender equality and

Table 1. Descriptive statistics for LDCs and HDCs

	LDCs (n = 89)				HDCs (n = 42)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Mortality								
Life expectancy at birth (both sexes)	66.213	9.107	42	78	78.667	3.074	71	83
Female life expectancy	68.517	9.855	42	81	81.571	2.401	76	86
Male life expectancy	64.056	8.536	42	78	75.690	3.751	66	80
Sex difference in life expectancy	4.461	2.861	0	13	5.881	2.098	2	12
Sex difference in HALE	2.584	2.285	-2	10	4.238	2.093	0	10
Sex ratio in adult probability of dying	1.580	0.479	1.005	3.387	2.000	0.418	1.368	2.964
Sex ratio in IMR	1.223	0.177	0.714	2.000	1.257	0.228	0.750	2.000
Sex ratio in child mortality	1.194	0.180	0.750	1.951	1.233	0.210	0.692	2.000
Sex ratio in all-cause ASDR	1.392	0.233	0.905	2.135	1.636	0.225	1.185	2.214
Sex ratio in cause-deleted ASDR	1.375	0.222	0.905	2.118	1.566	0.203	1.185	2.063
Sex ratio in lung cancer ASDR	3.901	2.664	0.983	14.292	3.652	2.037	1.115	9.603
Predictors								
Gender equality index	55.486	7.236	28.943	69.723	63.752	6.810	50.860	80.960
GNI per capita (PPP in international \$)	8,710,404	12,751,020	176,000	79,426,000	29,205,050	11,161,430	12,844,000	58,810,000
Economic gender equality	0.609	0.127	0.195	0.879	0.687	0.082	0.497	0.831
Educational gender equality	0.928	0.101	0.509	1.000	0.993	0.013	0.938	1.000
Political gender equality	0.128	0.094	0.000	0.410	0.233	0.152	0.031	0.675
HIV prevalence (% of adults)	2.597	5.099	0.100	24.800	0.288	0.289	0.100	1.400

Note: Sex differences refer to female-male values while sex ratios refer to male/female values.

Table 2. Regression of sex differences in mortality on gender equality and level of development ($n = 131$)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	LE	LE	HALE	Adult mortality	IMR	Youth mortality
Gender equality	0.150*** (0.035)	0.080* (0.032)	0.096** (0.031)	0.010** (0.003)	0.002 (0.002)	0.004+ (0.002)
Gender equality*HDC	-0.260*** (0.067)		-0.204*** (0.059)	-0.028*** (0.006)	0.001 (0.004)	-0.005 (0.004)
HDC	0.881 (0.672)	-0.056 -0.659	1.754** -0.589	0.179* -0.063	0.028 -0.044	0.040 -0.042
Log of GNI per capita	0.530* (0.227)	0.524* (0.239)	0.247 (0.199)	0.101*** (0.021)	0.000 (0.015)	0.006 (0.014)
Constant	5.116*** (0.287)	4.929*** (0.298)	2.948*** (0.252)	0.494*** (0.027)	0.188*** (0.019)	0.173*** (0.018)
Gender equality in HDCs	-0.110+ (0.058)		-0.108* (0.051)	-0.018*** (0.005)	0.003 (0.004)	-0.001 (0.004)
R^2	0.244	0.155	0.224	0.405	0.034	0.058

Note: Beta coefficients with standard errors in parentheses, + $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

HDC. Comparing the R -squared parameters between Models 1 and 2 indicates that the interaction explains 36.5 percent of the overall variation in the sex gap in life expectancy.

The subsequent models in Table 2 show the regression of three additional sex gaps in mortality on the same explanatory variables included in Model 1. In Model 3, a 10-point increase in gender equality is associated with a 1.0 year increase in the sex difference in HALE in LDCs and a 1.1 year decrease in HDCs. The results shown in Model 4 indicate that gender equality is associated with divergence in the sex differential in the adult probability of dying in LDCs and convergence in HDCs. Specifically, a 10-point increase in gender equality contributes to a 10.3 percent increase in the sex ratio in adult mortality in LDCs, and a 18.0 percent decrease in the sex gap in HDCs. This suggests that the association we find between gender equality and the sex gap in mortality is not merely an artifact of the age pattern of mortality.

In contrast to the adult outcomes, we do not observe a statistically significant interaction between gender equality and HDC for either IMR or child mortality. The relationship between the log of the sex ratio in IMR and gender equality is not significant at either level of development, shown in Model 4. Finally, in Model 6, gender equality has a weak positive association with child mortality in LDCs, increasing the sex ratio by 4.1 percent for every 10-point increase in gender equality ($p < .10$), and a non-significant association in HDCs. In models excluding the interaction between gender equality and HDC for the child outcomes, gender equality is not significantly related to the sex ratio in IMR or youth mortality at either level of development (models not shown).

Figure 1 illustrates the relationship between gender equality and each of the four sex gaps in mortality described above. The regression lines are estimated from models which control for GNI per capita, and the scatter points are from observed data. In LDCs, the positive slopes of the regression lines for the three adult outcomes support the divergence hypothesis that gender equality is associated with an increase in the sex gap in life expectancy. In HDCs, the weaker but negative slopes of the regression lines are consistent with convergence between male and female life

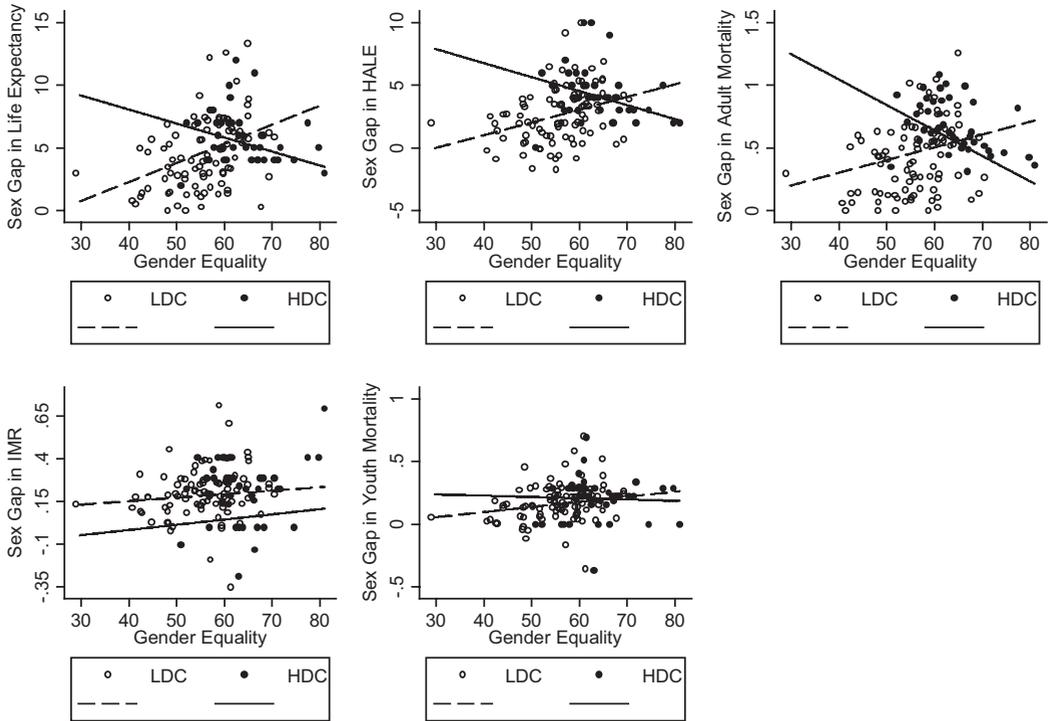


Figure 1. Relationship between gender equality and sex gaps in mortality by level of development.

expectancies and healthy life expectancies in countries with greater gender equality. The relationship between gender equality and the sex gaps in the two youth mortality outcomes looks quite different. In Figure 1d, gender equality has almost no visible association with the log of the sex ratio in IMR at either level of development. We observe a weak slope of gender equality on the log of the sex ratio in the probability that a child dies between ages 1 and 5 in Figure 1e for both LDCs and HDCs. In summary, results for adults support the heterogeneous association between gender equality and sex gaps in mortality. In contrast to the sex gap in adult mortality, gender equality has a weaker relationship with the sex gap in youth mortality that is not dependent on level of development.

In Table 3, we examine the relationship between the sex gap in life expectancy with each of the three sub-indices of gender equality: economic participation and opportunity, educational attainment, and political empowerment. Results indicate that the overall pattern is consistent with the composite gender equality index. There is a positive association between each sub-index and the sex gap in life expectancy in LDCs, though the coefficient for political gender equality is not statistically significant. The interaction between HDC and gender inequality is negative for all three sub-indices. In HDCs, both political and economic gender equality are negatively related to the sex gap in life expectancy, though economic gender equality is not statistically significant. The only result that deviates from the composite gender equality results is educational gender equality, which while not statistically significant, has a positive association with the sex gap in life expectancy in HDCs. This result is not surprising given the very small amount of variation in educational gender equality among HDCs.

Table 3. Regression of the sub-indexes of gender equality on the sex gap in life expectancy ($n = 131$)

	Model 1	Model 2	Model 3
	Economic participation and opportunity	Educational attainment	Political empowerment
Subindex	6.028** (2.087)	16.170*** (2.979)	3.029 (2.939)
Subindex*HDC	-10.350+ (5.652)	-10.760 (29.540)	-8.560* (4.020)
HDC	0.438 (0.676)	1.320 (1.451)	0.657 (0.681)
Log of GNI per capita	0.692** (0.237)	-0.205 (0.267)	0.705** (0.244)
Constant	4.951*** (0.296)	4.660*** (0.270)	4.918*** (0.320)
Subindex in HDCs	-4.318 (5.237)	5.410 (29.319)	-5.531* (2.699)

Note: Beta coefficients with standard errors in parentheses, + $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.
^a $p = .104$.

Effects of smoking

Gender equality may lead to an increase in female smoking behaviors, especially in HDCs. Many studies have shown that increases in female smoking rates are associated with declining sex differences in mortality, both longitudinally and cross-nationally. Indeed, gender equality may be related to the sex gap in mortality through its association with smoking behaviors. To consider this possibility, we examine the contribution of smoking through a comparison of sex gaps in mortality with and without lung cancer. While a simple adjustment for lagged smoking rates would be an alternate approach, lagged measures of smoking are not available for the majority of our sample. Lung cancer mortality is a commonly used method to estimate deaths attributable to smoking (Bird and Rieker, 2008; Ezzati and Lopez, 2003; Ezzati et al., 2008; Fenelon and Preston, forthcoming; Peto et al., 1992; Preston et al., 2010). While smoking may lead to other causes of death, such as deaths from heart disease and other cancers, the vast majority of lung cancer deaths are attributable to smoking (Office of the Surgeon General, 2004). To assess whether gender equality is related to the sex gap in life expectancy above and beyond the association between smoking behaviors and lung cancer, we compare the Age Standardized Death Rate (ASDR) for lung cancer versus all other causes of death. By examining the causes of death other than lung cancer, also referred to as a 'cause-deleted' or 'associated single decrement' (Preston et al., 2001: 80), we ask what mortality would look like in the absence of lung cancer. This allows us to assess whether the negative effect of gender equality on the sex gap in mortality in HDCs is driven primarily by the relationship between gender equality and lung cancer, or if gender equality affects the sex gap in mortality through additional pathways. We use the ASDR as opposed to the sex gap in the adult probability of dying because the latter is not available by cause. The data derive from the WHO and refer to the year 2008 (*Global Burden of Disease*, 2010), and are available by sex and country.³ The outcome variables in this part of the analysis are the log of the sex ratio of the ASDR (males/females) for all cause mortality, lung cancer mortality, and cause-deleted mortality (mortality in the absence of lung cancer).

Table 4. Analysis of the sex ratio in the ASDR ($n = 128$)

	Model 1	Model 2	Model 3
	All causes	Causes other than lung cancer	Lung cancer
Gender equality	0.009*** (0.002)	0.008*** (0.002)	0.006 (0.009)
Gender equality*HDC	-0.016*** (0.004)	-0.014*** (0.004)	-.054** (0.016)
HDC	0.184*** (0.041)	0.145*** (0.039)	0.265 (0.163)
Log of GNI per capita	0.005 (0.014)	0.001 (0.013)	-0.002 (0.055)
Constant	0.302* (0.118)	0.319** (0.114)	1.202* (0.475)
Gender equality in HDCs	-0.007* (0.003)	-0.006+ (0.003)	-0.048*** (0.014)

Note: Beta coefficients with standard errors in parentheses, + $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

The results summarized in Table 4 suggest that sex differences in smoking rates greatly contribute to, but cannot explain, convergence in the sex gap in mortality in HDCs. A 10-point increase in gender equality is associated with a decrease in the sex ratio in the ASDR for all causes of mortality combined (7 percent) and for causes other than lung cancer (6 percent). The same 10-point increase in gender equality cuts the sex ratio in the lung cancer ASDR almost in half, by 48.3 percent. Therefore, the interaction between gender inequality and development is three times larger for lung cancer mortality relative to that for all-causes and causes other than lung cancer, suggesting that lung cancer makes a major contribution to the convergence of male and female life expectancies in HDCs. In LDCs, gender equality is positively associated with the sex ratio in the ASDR for all cause and cause-deleted mortality, but not related to the sex gap in lung cancer ASDR. These findings also support the notion that an association of gender equality with sex-related changes to smoking behaviors is more so a phenomenon in HDCs than LDCs.

Explaining divergence and convergence in the sex gaps in life expectancy

To better understand why gender equality has a conditional relationship with the sex gap in life expectancy, we estimate the association between gender equality and male and female life expectancies as separate outcomes. When analyzing male and female life expectancies, we use the seemingly unrelated regression procedure (*sureg* in STATA) to account for any correlation in the error terms due to the fact that estimates come from the same sample of countries. In order for gender equality to contribute to divergence in LDCs, females have to benefit *more* from gender equality than males. On the other hand, convergence in HDCs is possible only if females benefit *less* from gender equality than males. A divergence (or convergence) in the sex gap can be attributed to a variety of underlying patterns with respect to the relationship between gender equality and female and male life expectancies (summarized in Table 5). For example, we could observe divergence in the sex gap if gender equality increases both female and male life expectancies but has a stronger effect for females than males (H1). Alternatively, gender equality could increase female life expectancy but have no effect on male life expectancy (H2) or even decrease male life expectancy (H3)

Table 5. Hypotheses for conditional relationship between gender equality and sex gap in mortality

Hypothesis	Divergence in LDCs		Convergence in HDCs	
	Females	Males	Females	Males
1	+	+	+	+
2	+	null	null	+
3	+	-	-	+
4	null	-	-	null
5	-	-	-	-

Note: **Bold** signs indicate a stronger relationship.

Table 6. Regression of male and female life expectancy, separately ($n = 118$)

	Model 1	Model 2
	Female LE	Male LE
Gender equality	0.376*** (0.073)	0.145* (0.073)
Gender equality*HDC	-0.441*** (0.122)	-0.087 (0.121)
HDC	0.672 (1.245)	0.470 (1.240)
HIV prevalence	-0.990*** (0.098)	-0.766*** (0.097)
Log of GNI per capita	5.757*** (0.470)	5.191*** (0.468)
Constant	73.114*** (0.551)	67.542*** (0.548)
Gender equality in HDCs	-0.065 (0.099)	0.058 (0.099)

Note: Beta coefficients with standard errors in parentheses, $+ p < .10$; $* p < .05$; $** p < .01$; $*** p < .001$.

in LDCs. We could also observe no relationship for females and a negative relationship for males (H4). Finally, gender equality could disadvantage both female and male life expectancy but be worse for males (H5). Explanations for convergence are the opposite of (or mirror) those proposed for a divergence.

Data for male and female life expectancy come from the WHO *World Health Statistics* report (2010). In addition to the covariates included in the previous analysis of sex gaps, we control for HIV prevalence among adults ages 15 to 49. HIV prevalence comes from the WHO (*Global Health Observatory Data Repository*, 2009), and is missing for 13 countries, reducing the sample to 118. In prior models for sex gaps in mortality, its inclusion as a covariate did not modify our results so we excluded it from the final models to preserve the sample size.⁴

Table 6 shows the results for the regression of female and male life expectancy, separately. In LDCs, we find that gender equality is positively related to life expectancy for both sexes. A 10-point

increase in gender equality is associated with a 3.7 year increase in female life expectancy and a 1.4 year increase in male life expectancy ($p < .10$). These results support Hypothesis 1 to explain divergence in the sex gap in life expectancy: gender equality is positively related to life expectancy for both sexes but has a stronger positive effect on female life expectancy than male life expectancy.

In HDCs, we do not find statistically significant associations between gender equality and life expectancy for either sex, but the estimate is weakly negative for females and weakly positive for males. The interaction between gender equality and HDC is statistically significant for females, implying that there is a different relationship between gender equality and female life expectancy in LDCs than in HDCs. Hence, though lacking statistical significance, we can speculate that convergence in HDCs may, to some extent, be driven by a negative association of gender equality with female life expectancy and a positive association with male life expectancy.

Discussion

In this article, we find evidence of a heterogeneous relationship between gender equality and sex differences in life expectancy. In LDCs, gender equality is associated with divergence in the sex gap in life expectancy: as gender equality increases, women gain additional years of life over males. In HDCs, on the other hand, gender equality is associated with convergence in the sex gap in life expectancy. These patterns also describe the sex difference in healthy life expectancy and the adult probability of dying.

To understand why the association between gender equality and the sex gap in life expectancy is conditional on level of development, we analyzed male and female life expectancy separately. In doing so, we found that gender equality contributes to divergence in LDCs because gender equality has a stronger positive association with female life expectancy than with male life expectancy. Although researchers typically assume that the benefits of gender equality are greater for females than males, convergence in HDCs is only possible if males experience a net benefit. Though lacking statistical significance, our results suggest that convergence may be attributable to a negative association of gender equality with female life expectancy and a positive association with male life expectancy.

Why might gender equality differentially affect female life expectancy in LDCs versus HDCs? A vast body of research has established that gender equality has numerous positive effects on women's quality of life and life expectancy, especially in settings where they are marginalized and disadvantaged. In this study, gender equality reflects three areas: economic participation and opportunities, educational attainment, and political empowerment. We separately examined each of these areas, and found that the pattern we found for gender equality as a whole is reflected in its parts. In LDCs, economic and educational gender equality showed a strong positive association with the sex gap in life expectancy. This finding is consistent with the literature on sex and mortality in LDCs that show that expansions in female educational and occupational opportunities improve female mortality outcomes (Baunach, 2003; Fuse and Crenshaw, 2006; Williamson and Boehmer, 1997). As education expands, health services improve, and labor market opportunities open to women, female autonomy increases and prior work shows reductions in their mortality and increases in life expectancy.

For HDCs, we found that composite gender equality, as well as political gender equality, was associated with a decrease in the sex gap in life expectancy, a finding which confirms the relationship observed in previous research (Helweg-Larsen and Juel, 2000). Political gender equality may

increase women's access to the right to engage in risky behaviors already practiced by men, such as smoking and drinking (Bird and Rieker, 2008; Rogers et al., 2010). To further investigate the effects of smoking, we compared the sex gap in mortality for lung cancer to causes other than lung cancer. We found that gender equality had a strong negative relationship to the sex gap in lung cancer mortality, a finding consistent with the large body of research on the effects of smoking on population health (Bobak, 2003; Degenhardt et al., 2008; McKee and Shkolnikov, 2001). This suggests that smoking behaviors have largely contributed to the convergence in the sex gap in life expectancy observed in HDCs. However, the analysis also showed that gender equality is negatively related to the sex gap in mortality from causes other than lung cancer. Therefore, we cannot exclude the possibility that gender equality is associated with the sex gap in mortality beyond its association with smoking. One potential mechanism is the increased stress women may face as a result of working in the labor force while simultaneously fulfilling care-giving responsibilities, such as was found (Schulz and Beach, 1999). Smoking could also contribute to convergence in ways that we were not able to examine in this study. In addition to lung cancer, smoking leads to other causes of death, such as deaths from other cancers, respiratory diseases, and cardiovascular diseases (Wong et al., 2006). The remaining association between gender equality and the sex gap in cause-deleted mortality could be driven by these other causes of death. Additional research is needed to see if the relationship between gender equality and the sex gap in mortality persists after all smoking-attributable effects are removed.

The results of this study raise questions regarding the relationship between gender equality and the sex gap in youth and infant mortality. While we observed a robust relationship between gender equality and the sex gap in mortality for adults, results are not as salient for the sex gap in youth and infant mortality. Gender equality has a weak and relatively small positive association with the sex gap in child mortality in LDCs, and there is no observable association between gender equality and the sex difference in IMR at either level of development. These findings are consistent with the fact that many of the mechanisms through which gender equality affects mortality pertain to adults, such as through educational attainment, occupational opportunities, and health behaviors. However, previous studies have posited that gender equality may lead to divergence in the sex gap in youth mortality in LDCs through better and safer delivery, post-natal care, and reducing a preference for sons (Fuse and Crenshaw, 2006). Further research should examine why gender equality does not impact the sex gap in IMR and only weakly is related to the sex gap in youth mortality.

In this study, we find that gender equality is not significantly associated with male life expectancy in either LDCs or HDCs. Although some improvements in gender equality affect only female life expectancy (e.g. an increase in midwives reducing maternal mortality), other aspects of gender equality affect population health more broadly. Future research should focus attention on the relationship between gender equality and male mortality, a relationship that is much less understood than that between gender equality and female mortality.

A limitation of this study is that it uses cross-sectional data. The idea that gender equality first improves and then later mitigates women's mortality advantage over men implies that a process occurs over time. Therefore, a longitudinal perspective could clarify how changes in gender equality are related to the changing relationship between male and female life expectancy.

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Appendix Table 1. 131 countries in analysis and gender equality score

28.94	Yemen	53.94	Malaysia	58.79	Vietnam	62.93	Uganda
39.03	Chad	53.98	Maldives	58.86	Venezuela	63.02	Barbados
41.01	Pakistan	54.27	Mauritius	59.02	United Republic of Tanzania	63.14	Portugal
43.19	Mali	54.33	Japan	59.05	Ukraine	63.16	Nicaragua
43.23	Côte d'Ivoire	54.40	Kenya	59.31	Uruguay	63.18	Argentina
43.63	Saudi Arabia	54.50	Belize	59.48	Thailand	63.27	Mongolia
44.21	Benin	54.99	Azerbaijan	59.72	Colombia	63.43	Costa Rica
44.52	Morocco	55.04	Mexico	59.72	Greece	63.93	Luxembourg
45.83	Turkey	55.29	El Salvador	59.74	Peru	64.28	Namibia
46.09	Egypt	55.99	Indonesia	59.82	Honduras	64.48	Australia
46.49	Syrian Arab Republic	56.08	Brazil	59.85	Botswana	65.39	Trinidad and Tobago
46.72	Iran (Islamic Republic of)	56.11	Tajikistan	59.87	Croatia	65.68	Mozambique
47.80	Ethiopia	56.13	Zimbabwe	59.93	Singapore	65.68	Canada
48.29	Jordan	56.23	Cyprus	60.32	Kyrgyzstan	66.18	USA
48.49	Algeria	56.51	Georgia	60.44	Israel	66.40	Latvia
48.71	Nigeria	56.80	Malta	60.47	Bulgaria	66.79	Sri Lanka
49.05	Qatar	56.84	Angola	60.77	China	66.93	Netherlands
49.08	Nepal	57.01	Hungary	60.86	Chile	67.14	UK
49.38	Mauritania	57.07	Madagascar	60.99	Estonia	67.50	Belgium
49.43	Cameroon	57.50	Bangladesh	61.02	France	67.78	Germany
49.89	Burkina Faso	57.51	Gambia	61.17	Jamaica	68.21	South Africa
50.52	Guatemala	57.61	Bolivia	61.18	Russian Federation	68.21	Spain
50.77	Fiji	57.68	Armenia	61.20	Poland	68.36	Switzerland
50.86	Bahrain	57.72	Slovakia	61.42	Kazakhstan	69.41	Philippines
51.02	India	57.78	Brunei Darussalam	61.44	TFYR Macedonia	69.72	Lesotho
51.47	Tunisia	57.88	Italy	61.45	Slovenia	70.44	Denmark
51.61	Zambia	57.95	Dominican Republic	61.76	Ecuador	71.31	Ireland
52.13	Republic of Korea	58.18	Ghana	61.79	Panama	71.78	New Zealand
52.21	Kuwait	58.19	Paraguay	61.90	Guyana	74.55	Sweden
52.95	Suriname	58.43	Romania	61.93	Austria	77.48	Finland
53.07	Senegal	58.45	Albania	62.39	Bahamas	79.73	Norway
53.25	United Arab Emirates	58.69	Czech Republic	62.44	Lithuania	80.96	Iceland
53.78	Cambodia	58.72	Malawi	62.82	Republic of Moldova		

Note: Sorted by gender equality; **bold** countries are HDCs.

Notes

1. According to WHO data from 2008, only Tonga and the Central African Republic had higher male life expectancies than female.
2. The WEF derives each component of the index from the following sources: the International Labour Organization *Key Indicators of the Labour Market* and *LABORSTA* Internet online database; the United

Nations Development Programme *Human Development Report*; UNESCO Institute for Statistics *Education Indicators*, the World Bank's *World Databank: World Development Indicators & Global Development Finance*, The World Economic Forum *Executive Opinion Survey*, the Inter-Parliamentary Union *National Women in Parliaments* and *Women in Politics*.

3. Because the cause-deleted ASDR is not directly observable, we calculate this outcome by multiplying the all cause ASDR by the proportion of deaths (ages 60 and over) that are not due to lung cancer. We restrict the proportion of deaths not due to lung cancer to ages 60 and over as opposed using the proportion for all ages combined to focus on the effects of smoking. By using ages 60 and older, we are more likely to remove deaths that are due to smoking than if we removed lung cancer deaths at earlier ages.
4. HIV prevalence has a strong negative association with both female and male life expectancies ($r = -0.6$ for both sexes), but a much weaker association with the sex gap in life expectancy ($r = -.3$)

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