Gender equality, development, and the sex gap in life expectancy: a world view

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Gender equality, development, and the sex gap in life expectancy: a world view

Female life expectancy exceeds male life expectancy in almost every country throughout the world. However, the extent of this gap varies cross-nationally, suggesting that social factors directly affect or condition the biological component. In this paper, we focus on gender equality, a key social factor associated with the sex gap in life expectancy. While previous research has examined the sex gap in either less developed countries (LDCs) or highly developed countries (HDCs) in isolation, we use a broad measure of gender equality that is applicable across 123 countries at both levels of development. We show that the effect of gender equality is conditional on level of social and economic development. While gender equality is associated with a *divergence* in adult male and female life expectancies in LDCs, it is weakly associated with a *convergence* in HDCs. We conclude that male and female life expectancy is diverging in LDCs in part because gender equality has a stronger positive effect on female than male life expectancy, while convergence in HDCs is due to a greater net benefit of gender equality to *male* mortality relative to female life expectancy.

Female life expectancy exceeds male life expectancy in almost every country throughout the world[1]. Although males' excess mortality is nearly universal, there exists cross-national, cross-cultural and historical variation in the sex gap. Therefore, while demographers agree that biological factors are partly responsible for female's higher life expectancy, it is likely that the biological component is conditioned or directly affected by social factors.

In this paper we focus on gender equality, a key social factor that appears to be associated with the sex gap in life expectancy. Gender equality refers to parity between women's and men's positions in society. In less developed countries (LDCs), sex differences in life expectancy tend to be greater with higher levels of gender equality (e.g., Fuse & Crenshaw, 2006; Williamson & Boehmer, 1997). In highly developed countries (HDCs), however, the sex gap appears to be lower with higher levels of gender equality (e.g., Backhans, Lundberg & Månsdotter, 2007; Crawley, Foley and Shehan, 2008; Helweg-Larsen and Juel, 2000). Hence, not only does the sex gap vary by level of gender equality, but this relationship itself seems to be conditional on level of development[2]. Prior research on sex gaps in life expectancy in HDCs and LDCs, however, are not directly comparable. While studies in LDCs focus on educational, political, and economic measures of gender equality, studies in HDCs tend to rely on epidemiological risk factors, such as tobacco and alcohol consumption, as proxies for gender equality.

In this study, we examine the relationship between the sex gap in life expectancy in 123 countries which include both HDCs and LDCs. Prior work has generally focused on either HDCs or LDCs in isolation. We use a broad measure of gender equality that is applicable across different levels of development and encompasses equality in three different domains: economic, political and educational. This approach is preferable to the use of epidemiological risk factors as proxies for gender equality. As HDCs and LDCs vary widely in leading causes of death, risk factors are not uniformly applicable across different economic settings. Moreover, we consider more fundamental causes of inequality across important dimensions of social life rather than focusing on proximate health behaviors (Link and Phelan, 1995). No study has considered a broadly-conceived measure of gender equality across a wide range of countries in relation to gender differences in life expectancy. In addition to the sex gap in life expectancy, we examine the effects of gender equality on additional sex differentials in mortality outcomes, including healthy life expectancy, the adult probability of dying, and youth and infant mortality. We also analyze the relationship between gender equality and male and female life expectancy separately. This approach enables us to better understand the converging and diverging patterns we observe. While prior research has shown that women's life expectancy in LDCs is higher where gender equality is higher (e.g., Aden et. al. 1997), less is known about the nature of this relationship in HDCs. Moreover, it is unclear how male life expectancy is associated with gender equality at either level of development.

We find that greater gender equality is associated with *divergence* in adult life expectancy between the sexes in LDCs but *convergence* in HDCs. Male and female life expectancy is diverging in LDCs in part because gender equality has a stronger positive effect on female than male life expectancy. Finally, a narrowing differential in male and female life expectancy in HDCs is potentially due to a greater net benefit of gender equality to *male* life expectancy relative to female life expectancy.

Gender equality and mortality

Sex differences in mortality in LDCs

As previously discussed, gender equality in LDCs is generally associated with an increase in women's life expectancy and a divergence between men's and women's life expectancies. Gender equality has often been operationalized by factors such as levels of female labor force participation (FLFP), female education, and reproductive health interventions.

Several studies show that the transition of women into the paid labor force is associated with increased female life expectancy relative to males (Baunach, 2003; Fuse & Crenshaw 2006; Williamson & Boehmer, 1997). This relationship operates through several pathways. For example, spending time outside the home reduces women's exposure to harmful indoor air pollution, which is responsible for 36 percent of lower respiratory infections and 22 percent of chronic obstructive pulmonary disease in LDCs (Murray & Lopez, 2002). Moreover, women's employment in the service sector enhances women's economic value and discourages female infanticide and neglect (Fuse & Crenshaw, 2006).

Female education, through improved literacy, educational attainment and enrollment rates, is associated with significantly higher life expectancy for both sexes (Lee, 2000), and for women in particular (Williamson & Boehmer, 1997). Like employment, the expansion of education increases the economic value of daughters, thereby reducing parental preferences for sons and female's excess mortality at young ages (McNay, 2005). Educational advancements also lead to increased female autonomy in the home. Exercised through decision making, a more equitable division of household labor and increased age at marriage, female autonomy positively affects 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. As gender equality improves, the use of midwives during childbirth expands (Kabeer, 2005; Shaw, 2006) decreasing both infant and maternal mortality (Frankenberg & Thomas, 2001) and, thereby, increasing female life expectancy (Williamson & Boehmer, 1997). Higher contraceptive prevalence (Shen & Williamson, 1997; Williamson & Boehmer, 1997) and lower fertility rates (Fuse & Crenshaw, 2006; Pillai & Gupta, 2006; Williamson & Boehmer, 1997) also improve female life expectancy. Lastly, gender equality can improve women's life expectancy through increased access to other types of health services and improved nutritional well-being (Potter & Volpp, 1993).

While some studies investigate *sex differences* in mortality , most of the studies described above examine women's or child mortality alone. Hence, we cannot assume that improvements in female life expectancy imply a divergence between the sexes because the same factors may increase both male and female life expectancy. For example, maternal health and female education are positively associated with healthier sons and daughters, and the factors which increase FLFP and improve women's health and life expectancy may also benefit men. Furthermore, studies that do examine sex differences (Baunach, 2003; Fuse & Crenshaw 2006; Williamson & Boehmer, 1997) typically use only a small number of LDCs and are therefore limited in generalizability.

Sex differences in mortality in HDCs

In HDCs, most studies examine how variation in the sex gap in mortality is associated with sex differences in epidemiological risk factors such as smoking and alcohol consumption. As gender equality expands, women adopt riskier behaviors and lifestyles that are similar to men. As gendered behaviors changed over the past 100 years making it socially acceptable for women to smoke (Smith, 2004), smoking-related causes of death "account[ed] for a reduction of 23 percent in the sex difference in mortality" (Preston & Wang, 2006, p. 641) and a decrease in men's excess heart disease mortality (Crawley, Foley and Shehan, 2008). Despite these changes, approximately 75 percent of the excess years of potential life lost to males in the United States (over females) is due to smoking and alcohol related causes of death including ischemic heart disease, lung cancer and traumatic deaths (Wong, Chung, Boscardin, Li, Hsieh & Ettner et al., 2006). While most studies emphasize the association of increased female smoking and converging mortality between the sexes (Morley & Hall, 2008), the decrease in male smoking-related mortality is also a contributing factor to convergence (Zatonski et al., 2007).

Sex differences in life expectancy in Eastern Europe are attributed to a combination of alcohol and tobacco consumption (Bobak & Marmot, 1996; McKee & Shkolnikov, 2001). As gender equality is strengthened in the region, women's alcohol and tobacco consumption is catching up with men's (Degenhardt et al., 2008). In Eastern Europe, the gap between male and female life expectancy narrows "primarily because of a break in the previously upward trend in female life expectancy" (McKee & Shkolnikov, 2001, p. 1053).

In addition to smoking and alcohol, men's excess death rates from coronary heart disease may be exacerbated by their greater tendency to exhibit the "type A personality" (Crawley, Foley and Shehan, 2008). As gender equality improves, women's presence in the paid labor force expands, increasing the *coronary-prone behavior pattern* among women, potentially mitigating sex differences in mortality (Waldron, 1978).

In addition to epidemiological risk factors, a few studies have used broader measures of gender equality to investigate sex differences in mortality. For example, Pampel (2002; 2003) examined gender differences in smoking-related mortality using an index of gender equality but did not find an association. However, the index that was used included the Total Fertility Rate (TFR) and divorce rate, factors which are not highly correlated with more general measures of gender equality (McNay, 2005). Two studies in Scandinavia used more commonly accepted indicators of gender equality to predict convergence in morbidity and mortality between the sexes. In a cross-sectional study of Swedish municipalities, factors such as FLFP, the proportion of parliamentary seats occupied by women, and the ratio of female-to-male wages, are negatively related to the sex gap in sickness and disability rates (Backhans, Lundberg & Månsdotter, 2007). A study in Denmark using similar indicators shows that gender equality is associated with mortality convergence and attributes this finding to a more favorable trend in male mortality relative to female mortality (Helweg-Larsen and Juel, 2000). The authors assert that other countries in Europe may soon be following the Danish trend as their own "gender differences in living conditions and health behavior are also narrowing" (Helweg-Larsen & Juel 2000, p. 220).

Thus far we have discussed how gender equality contributes to the convergence in the sex gap in life expectancy in HDCs primarily through a convergence in life styles and a potentially negative effect on female life expectancy. However, Crawley, Foley and Shehan (2008) show how gender equality can also improve female mortality. For example, as gender equality increases, women are more likely to have the heart-problem symptoms they report taken seriously by doctors. In addition, intimate partner violence, which is disproportionately aimed at women, decreases as gender equality improves.

Hypotheses

Drawing on the literature, we propose two hypotheses about the relationship between gender equality and sex differences in life expectancy. First, gender equality will lead to divergence between men's and women's life expectancy in LDCs. Second, gender equality will contribute to convergence in the sex gap in life expectancy in HDCs. In other words, we expect the effect of gender equality to be conditional on level of development. We expect that this relationship will hold for the other adult mortality outcomes we examine. However, due to the fact that the pathways through which gender equality could affect the sex gaps in child and infant mortality are specific to LDCs, we predict a weaker or non-existent relationship between gender equality and the sex differentials in youth mortality in HDCs.

With respect to underlying trends in male and female life expectancy, there are several possible explanations for the divergence in the sex gap in LDCs and convergence in HDCs (summarized in Table 1). In order for life expectancy to diverge in LDCs, females need to benefit more from gender equality than males. For example, gender equality could improve both male and female life expectancy, but provide a larger boost for females than males (H_A^{LDC}); gender equality could increase female life expectancy but have no relationship with (H_B^{LDC}) or decrease (H_C^{LDC}) male life expectancy; gender equality could have no relationship with female life expectancy and a negative effect on male life expectancy (H_D^{LDC}); or gender equality could decrease both male and female life expectancy, but disadvantage male life expectancy more than female (H_E^{LDC}). On the other hand, in order for gender equality to affect convergence in HDCs, males need to benefit more from gender equality than females. In HDCs, gender equality could improve both male and female life expectancy, but better for males than females (H_A^{HDC}); gender equality could increase male life expectancy and have either no relationship with (H_B^{HDC}) or decrease(H_C^{HDC}) female life expectancy; gender equality could have no effect on male life expectancy and be bad for females (H_D^{HDC}); or finally, gender equality could disadvantage both male and female life expectancy, but be worse for females than males (H_E^{HDC}).

Methods

The current analysis is performed on 123 countries, including LDCs and HDCs (see Appendix). The multiple sources of data are described below in the discussion of specific variables.

Variables

Dependent Variables

Life expectancy and other mortality data are from 2003-2006[3] and derive from national death registrations compiled by the World Health Organization Statistical Information System (WHOSIS). We consider five different measures of sex gaps in mortality: the difference (in years) between females and males in (1) life expectancy and (2) healthy life expectancy (HALE), and log of the sex ratios for (3) the adult probability of dying (between the ages 15 and 60, ${}_{45}q_{15}$), (4) Infant Mortality Rate (IMR, ${}_{1}q_{0}$), and (5) child probability of dying (between the ages 1 and 5, ${}_{4}q_{1}$). We transform the sex ratios of the probabilities of dying to a logarithmic distribution in order to reduce heteroskedasticity, normalize the residuals, and simplify the interpretation of beta coefficients in the regression models. For all measures, larger values indicate a female advantage. Finally, the paper concludes with analysis of absolute (rather than relative) (6) female and (7) male life expectancy at birth to examine why we observe convergence in HDCs and divergence in LDCs.

Independent Variables

Gender Equality

We use a latent measure of public sphere gender equality which is based on the Gender Gap Index (Hausmann, Tyson, & Zahidi, 2007). The original variable, computed by the World Economic Forum, assesses countries on "the magnitude of the gap between women and men in four critical areas: economic participation and opportunity, political empowerment, educational attainment and health and survival" (Hausmann et al., 2007). Our analysis includes only the first three domains; we exclude gender gaps in health and survival because of its overlap with the dependent variables. Economic gender equality is itself an index of five variables including sex differences in labor force participation, wages and management positions in occupations. Educational gender equality, measured by four variables, encompasses sex differences in literacy and school enrollment rates. Finally, gender equality in the political sphere is composed of three variables concerning sex gaps in parliamentary and other political participation[4]. To compute the gender equality score for each country, we averaged the scores for the three dimensions. Theoretically, a value of 100 in the gender equity index indicates complete equality between males and females across the three domains, while a score of 0 indicates complete inequality. The final measure ranges from 39 to 76, with an average score of 57 across all countries. Of the countries in the analysis, Chad, Pakistan, and Nepal have the lowest gender equality while the Scandinavian countries, including Iceland, Finland, Norway and Sweden, have the highest gender equality. See Table 2 for average gender equality scores by level of development and the Appendix for a list of all countries used in the analysis and their corresponding gender equality score.

Level of Development

We hypothesize that gender equality operates differently in HDCs and LDCs. The criteria for determining level of development vary widely, from the purely economic to a combination of social and economic factors. In this study, we use two variables to control for level of development. First, we measure both social and economic development by a dummy variable indicating membership in the Organisation for Economic Co-operation and Development (OECD), an international organization of 30 countries that accepts the principles of representative democracy and free market economy. We use OECD status as opposed to relying solely on a purely economic indicator of development, such as Gross Domestic Product (GDP), for several reasons. Not only are the OECD countries among the wealthiest nations in the world[5], but they also share many social, geographical, and industrial characteristics that are shared by countries with the highest GDPs. For example, half of the non-OECD but high GDP countries are major oil exporters, many of which are located in the Middle East (e.g., United Arab Emirates, Bahrain and Saudi Arabia) (CIA World Factbook 2010). Therefore, we believe that the OECD status captures a group of countries that are similar in terms of both economic and social development. In order to assess the conditional effect of gender equality on life expectancy, the models also include an interaction between OECD status and gender equality.

In addition to the OECD dummy, we control for the log of Gross National Income (GNI) per capita in international dollars (Purchasing Power Parity, from the World Health Organization, 2006). The GNI per capita is the sum of the economic value produced within the country (its GDP) and net incomes from other countries, such as interest earned on investments[6].

Tobacco Use

In addition to gender equality and social and economic development, sex differences in tobacco use may explain some variation in the sex gap in life expectancy, especially in HDCs. We include a measure of the sex difference in the percentage of adults who use tobacco products where male values are subtracted from female (WHOSIS, 2005). Our results are robust to different specifications of tobacco use (e.g., the sex ratio in tobacco use and separate indicators for males and females), as well as to the inclusion of government expenditures on health (results not shown).

Analyses

The original number of countries available for the mortality outcomes was 193. The sample was reduced to 128 countries due to availability for the measure of gender equality, and then to 125 countries due to the inclusion of Gross National Income (GNI) per capita, one of our control variables. We eliminated two additional countries, Yemen and Turkey, after examining the distribution of the data and performing post-regression diagnostic tests, including DFITS and DFBETA for outliers and influential observations. Yemen has by far the lowest level of gender equality of any other country in our sample; its gender equality score is 27, an extreme outlier with respect to the rest of the countries where the minimum score is 39. While Yemen is an outlier with respect to all countries, Turkey is an outlier with respect to other OECD countries; its gender equality score is 44 compared to the minimum score of 53 in other OECD member states. Including these two countries in the analysis dramatically changes the results; thus, the estimated coefficients are strongly influenced by Yemen and Turkey. By removing these two outliers, the estimates better reflect the relationship between gender equality and the sex gap in life expectancy for the majority of countries.

We use Ordinary Least Squares (OLS) regression to model the influence of gender equality on sex differentials in life expectancy and other mortality outcomes. Each of each of our five measures of the sex gap in mortality is modeled separately, with gender equality, OECD status (level of development), an interaction between gender equality and OECD, and other covariates as predictor variables. The interaction term allows us to assess variation in the effect of gender equality on the sex difference in mortality across levels of development. In order to provide meaning to the intercept coefficient, we first mean center continuous covariates separately by OECD status, and then combine the transformed variables into a single measure. We also examine the effects of gender equality on male and female life expectancy separately. Because we are comparing male and female life expectancy from the same selection of countries, the error terms between the male and female regressions may be correlated. To account for this, we use the seemingly unrelated regression procedure (*sureg* in STATA). Post-estimation diagnostics, including the Breusch-Pagan statistic, reject the assumption for independent equations, thus providing support for using this estimation technique.

Results

Table 2 shows descriptive statistics of the variables used in the analysis in OECD and non-OECD countries. All of the sex gaps in mortality are larger in OECD than non-OECD countries, and male and female life expectancies are both higher in OECD countries. Furthermore, OECD countries have more gender equality, spend more on health, and are more economically developed. Only the sex difference in tobacco use is greater in non-OECD countries. Although men use tobacco more than women at both levels of development, this disparity is larger in non-OECD countries.

Tables 3, 4, and 5 present results for the regression of mortality outcomes on the covariates previously described. To simplify the discussion, when we describe the effect of gender equality, we refer to a 10 percent increase in gender equality. Table 3 shows regression results for models of the sex difference in life expectancy. Model 1 includes gender equality, OECD, and the gender equality*OECD interaction as predictors. Because non-OECD countries are the reference category, the estimated effect of gender equality in non-OECD countries is represented by the coefficient for the main effect of gender equality. In Model 1, a 10 percent increase in gender equality increases the sex difference in life expectancy in non-OECD countries by 2.4 years. The interaction term between gender equality and OECD is statistically significant, indicating that the effect of gender equality on the sex differential in life expectancy varies by level of development. For OECD countries, the marginal effect of gender equality is calculated as the sum of the main effect and the interaction term and is shown at the bottom of the table. Here, the sex gap in life expectancy in OECD countries decreases by 1.1 years for every 10 percent increase in gender equality. .

Model 2 additionally controls for the log of GNI per capita, which is positively associated with the sex difference in life expectancy. The inclusion of GNI slightly reduces the main effect of gender equality on the sex gap in non-OECD countries, from 2.4 to 2.1 years for every 10 percent increase in gender equality. In OECD countries, the inclusion of GNI amplifies the negative effect of gender equality on the sex gap in life expectancy in OECD countries, from 1.1 years to 1.3 years. Model 2 is also a better fit than Model 1, explaining 34 percent of the variance in the sex difference in life expectancy compared to 27 percent in Model 1. Therefore, the log of GNI per capita explains about six percent of the overall variation in the sex gap in life expectancy.

In order to determine the explanatory power that the interaction between gender equality and OECD has on the variation in the sex gap in life expectancy, we remove the interaction term in Model 3 and compare the results to Model 2. The explained variance in Model 2 (with the interaction) is 34 percent and is 23 percent in Model 2 (without the interaction). Thus, the interaction between gender equality and OECD explains about 13 percent of the overall variation in the mortality outcome, over twice the explanatory power of GNI per capita.

In Model 4, we include the sex difference in adult tobacco use, which is associated with a slight convergence in the sex difference in life expectancy. In other words, the smaller the gap between male and female tobacco use, the smaller the sex gap in life expectancy. Tobacco use improves the fit of the model, itself explaining 10 percent of the variation in the sex difference in life expectancy. Including tobacco also mitigates the negative effect of gender equality on the sex gap in life expectancy in OECD countries. In Model 4, a 10 percent increase in gender equality reduces the sex gap by approximately 1 year ($p = .104$). Thus, while some of the effect of gender equality in OECD countries is due to cross-national differences between male and female tobacco use, we still find a negative impact of gender equality on the sex gap in life expectancy.

Figure 1 shows a scatter plot of sex differences in life expectancy against gender equality for each country. The regression lines are estimated from Model 3 described above. In non-OECD countries, the slope of the line is positive, indicating divergence, or an increase in the sex gap in life expectancy with increasing gender equality. In OECD countries the regression line has a weaker but negative slope, consistent with convergence between male and female life expectancies as gender equality rises.

In order to test the robustness of the conditional nature of the relationship between gender equality and the sex gap in life expectancy, we examine four additional mortality outcomes: the sex difference in healthy life expectancy (HALE) and the log of the sex ratios for adult probability of dying, IMR and child probability of dying. The sex difference in HALE and the log of the ratio for the adult probability of dying are shown in Models 1 and 2 in Table 4. For these adult outcomes, patterns are consistent with those observed for sex differences in life expectancy: increasing gender equality is associated with larger sex gaps in non-OECD countries and smaller gaps in OECD countries. A 10 percent increase in gender equality increases the sex difference in HALE by 2 years in non-OECD countries and decreases the sex gap by 1.2 years in OECD countries. The sex ratio in the adult probability of dying increases by 19 percent in non-OECD countries and decreases by 17.2 percent in OECD countries for every 10 percent increase in gender equality. In addition to the models shown in Table 4, we tested the effect of the sex difference in tobacco use on adult mortality outcomes. The results (not shown) indicate that the sex difference in tobacco use does not improve the overall fit of the model or meaningfully change the effects of gender equality.

In contrast to the sex gap in adult mortality, gender equality has a weaker relationship with youth mortality and contributes to divergence across all countries. In Model 3, gender equality has a weak positive association with child mortality, increasing the sex ratio by 5.8 percent in non-OECD countries and 7.4 percent in OECD countries for every 10 percent increase in gender equality. The effect of gender equality remains the same when we remove the OECD dummy and the interaction term (results not shown). In Model 5, the effect of gender equality on the sex ratio in IMR is not statistically significant at either level of development. After removing OECD and the interaction, the sex difference in infant mortality increases by about 3.7 percent for every 10 percent increase in gender equality, though the effect is not strongly significant ($p = .067$).

In summary, the relationship between gender equality and the sex gap in life expectancy is conditional on social and economic development. In non-OECD countries, gender equality is associated with divergence between the sexes. In OECD countries gender equality is associated with convergence between the sexes, albeit a weaker relationship than that in non-OECD countries. In addition to life expectancy, the same pattern holds for HALE and the adult probability of dying. While results are robust for adults, gender equality is weakly associated with divergence in the sex ratios in child and infant mortality in both OECD and non-OECD countries.

The previous models used gender equality to predict the sex differences in life expectancy and other mortality outcomes. To better understand why the effect of gender equality on the sex gap in life expectancy is conditional on level of development, we estimate the effect of gender equality on male and female life expectancy separately. Earlier, we outlined several possible underlying patterns that could lead to divergence in the sex gap in LDCs and convergence in HDCs, summarized in Table 1. In order for gender equality to lead 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.

Table 5 presents the results of male and female life expectancies separately regressed on gender equality and other covariates. We begin by estimating the effects of gender equality, OECD and their interaction. Models 1 and 4 indicate that gender equality is positively associated with both female and male life expectancies in non-OECD countries, where a 10 percent increase in gender equality contributes to approximately a 0.5 year increase in female life expectancy and a 0.3 year increase in male life expectancy. Comparing Models 1 and 4, the positive effect of gender equality is stronger for females than males. In OECD countries, gender equality does not have a statistically significant effect on either male or female life expectancy, though the direction of the coefficients is positive and larger for males than females. Thus, the findings provide some support for the first hypothesis (H_A^{HDC}) described in Table 1: divergence in the sex gap in life expectancy in non-OECD countries is partially explained by the fact that gender equality is better for females than males, while the convergence observed in OECD countries may occur because gender equality has a stronger positive effect on male than female life expectancy.

In Models 2 and 5, the log of GNI per capita is added to the models. Not surprisingly, we observe a positive association, where a 10 percent increase in GNI per capita increases female life expectancy by 0.7 years and male life expectancy by 0.6 years. Controlling for GNI also reduces the effect of gender equality on life expectancy in non-OECD countries; the positive effect of gender equality on female life expectancy is cut in half and the effect of gender equality on male life expectancy disappears completely. Therefore, controlling for GNI per capita, we find support for the second hypothesis (H_B^{LDC}) to explain divergence in non-OECD countries. In OECD countries, gender equality has no association to male life expectancy and has a negative effect on female life expectancy, consistent with H_D^{HDC}. While the main effect of gender equality on female life expectancy in OECD countries is non-significant, the marginal effect of the interaction indicates that the gender equality has a significantly lesser effect on female life expectancy in OECD countries compared to non-OECD countries.

The reduced effect of gender equality in OECD countries in Models 2 and 5 implies that GNI explains the positive association that gender equality has on male and female life expectancy in Model 1. In other words, the gender equality correlated with economic development is positively associated with both male and female life expectancy, but the gender equality in OECD countries independent of economic development either has no effect on life expectancy, as is the case for males, or is negatively associated with life expectancy, as for females. In the discussion, we speculate as to what aspects of gender equality these are.

Given the association between tobacco consumption and both gender equality and life expectancy as discussed in the literature, it is important to examine the effect tobacco use has on life expectancy and the relationship it has with gender equality. The inclusion of female or male tobacco use in Models 3 and 6 does not substantially modify the effects of gender equality on life expectancy for either sex. While tobacco use explains about 10 percent of the variation in female expectancy and 6 percent of male life expectancy, the two variables are not significantly related.

Discussion

In this paper, we find evidence of a heterogeneous relationship between gender equality and sex differences in life expectancy. In non-OECD (less developed) countries, gender equality is associated with a divergence in the sex gap in life expectancy: as gender equality increases, women gain additional years of life over males. In OECD (highly developed) countries, gender equality is associated with a less pronounced convergence in the sex gap in life expectancy. The conditional nature of the association between gender equality and the sex difference in life expectancy is robust and found for all indicators of adult mortality used in the analysis, including life expectancy, HALE and the adult probability of dying.

Unlike its relationship to adult mortality, gender equality does not have a conditional relationship with the sex gap in youth mortality. Instead, gender equality is weakly positively associated with the sex gap in child and infant mortality in both less developed and highly developed countries, though the relationship is stronger in LDCs. This finding is consistent with the hypothesis that the pathways through which gender equality affects sex gaps in youth mortality are specific to LDCs. For example, advances in gender equality increases the sex ratio in infant and child mortality through better and safer delivery, post-natal care, and reducing a preference for sons (e.g., Fuse and Crenshaw 2006).

After establishing that the effect of gender equality on the sex gap in life expectancy is conditional on level of development, we examined male and female life expectancy separately to illuminate the source of the relationship. In doing so, we found that gender equality contributes to divergence in LDCs because gender equality has a stronger positive effect on female life expectancy than on male life expectancy. This finding is robust even after controlling for GNI per capita and the national percentage of male and female tobacco use, and is consistent with the literature on gender, development and mortality.

In HDCs, gender equality is associated with convergence between male and female life expectancies. Although researchers typically assume that the net benefits of gender equality are greater for females over males, we argue that convergence is only possible if gender equality benefits male life expectancy more than female. When we exclude all covariates, gender equality is weakly but positively related to both male and female life expectancy in HDCs. However, once we control for GNI per capita, we find that gender equality has no relationship with male life expectancy and a weak negative association with female life expectancy. Comparing the gender equality coefficients in models with and without GNI per capita, we argue that the gender equality associated with economic development increases male and female life expectancy in both LDCs and HDCs, but that the gender equality uncorrelated with economic development may decrease life expectancy for females in HDCs. We speculate that the potential negative effects of gender equality could derive from one or more of the following pathways. First, a decrease in gendered specialization of household and labor market production may mean that both sexes, but especially women, are working a second shift (Hochschild, 2007). The increased stress, work-family conflict, and time pressures could take a negative toll on health. Second, gender equality is associated with a higher prevalence of risky health behaviors among women, such as smoking. This is consistent with the negative association between gender equality and female life expectancy in HDCs. More research should investigate what factors may be positively related to gender equality and simultaneously decrease life expectancy.

This study has limitations. Although we study the impact of gender equality in the public sphere, our measure does not capture all of the potentially important effects of gender equality on sex differences in life expectancy. Future research should incorporate measures of private sphere gender equality into the analysis. For example, measures of housework, childcare, and elderly care may reflect other important elements of gender equality that affect the convergence in life expectancyin HDCs and divergence in LDCs. Such a measure could be especially important as women enter the labor force in increasing numbers world wide. A measure that quantifies the 'double burden' women face in their responsibilities in the home and in their jobs may potentially explain an additional proportion of the variation in sex differences in life expectancy. This study finds that a comprehensive measure of gender equality can explain sex differences in life expectancy across levels of development at one point in time. A longitudinal perspective could provide additional leverage in better understanding this relationship. The theory posited here is easily adaptable to an explanation of the changing relationship between male and female life expectancy.

In conclusion, we show that the effect of gender equality on the sex gap in life expectancy is conditional on level of development. In LDCs, greater gender equality is associated with a divergence in life expectancy between the sexes. Male and female mortality is diverging in LDCs in part because gender equality has a stronger positive effect on female than male life expectancy. In HDCs, gender equality is associated with a slight convergence the sex gap in life expectancy. The narrowing minor differential in male and female life expectancy in HDCs is due to a net positive effect of gender equality on male life expectancy relative to female life expectancy.

Notes

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[1] According to WHOSIS data from 2006, only Tonga and Zimbabwe had higher male life expectancies than female.
[2] There is support for a conditional relationship between and a demographic outcome. A recent study showed that the effect of social development, measured by the Human Development Index, on fertility levels varies by level of economic development (Myrskyla, Kohler, & Billari, 2009).
[3] All outcomes are from 2006 except for HALE, which is from 2003.
[4] We use this measure of gender equality, as opposed to more commonly used indicators such as the Gender Development Index (GDI) computed by the United Nations or the Gender Empowerment Measure for several reasons. First, the GDI is composed of three indices that measure gaps between men's and women's equality in terms of GDP, life expectancy, and educational enrolment and literacy. Due to its overlap with both the dependent (life expectancy) and independent (GNI) variables in our study, it would lead to specification errors if included in the models. While GEM is similar to the index we use to measure gender equality, it is only available for 109 countries (and uses older data?). Therefore, we are confident that the measure of gender equality used in this study is the best cross-national measure of gender equality currently available.
[5] Of the 30 OECD countries, 27 have GDPs ranked within the highest 40 GDP countries and all are ranked within the top 50 countries.
[6] While GDP and GNI are highly correlated (r=0.98), the World Bank cautions against using the GDP for inter-country comparison since it is sensitive to a country's market fluctuations. Furthermore, in an increasingly global economy, the GNI better captures international transfers, which in some cases are quite large.

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Data

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World Bank http://econ.worldbank.org

World Economic Forum (Gender Gap Index) www.weforum.org/en/initiatives/gcp/Gender%20Gap/index.htm

World Health Organization Statistical Information Systems. www.who.int/whosis/en/index.html

Appendix. 123 countries in analysis and gender equality score

Yemen	-3.88	**Mexico**	**-0.45**	Ghana	0.11	**United States**	**0.55**
Chad	-2.32	**Japan**	**-0.43**	**Poland**	**0.11**	Macedonia	0.55
Pakistan	-1.97	Kuwait	-0.43	Georgia	0.15	Estonia	0.55
Nepal	-1.88	Madagascar	-0.42	Armenia	0.17	Costa Rica	0.56
Saudi Arabia	-1.85	Nicaragua	-0.41	**Slovak Republic**	**0.18**	Namibia	0.61
Benin	-1.83	Malaysia	-0.40	Venezuela	0.18	**Austria**	**0.64**
Morocco	-1.77	Chile	-0.38	**Luxembourg**	**0.19**	Lesotho	0.67
Turkey	**-1.60**	Mauritius	-0.37	Ukraine	0.19	Bulgaria	0.69
Egypt	-1.54	**Italy**	**-0.32**	Suriname	0.20	Colombia	0.70
Iran	-1.40	Malawi	-0.31	Thailand	0.21	Belarus	0.74
Oman	-1.37	Zimbabwe	-0.29	**France**	**0.23**	Moldova	0.84
Burkina Faso	-1.35	Kenya	-0.28	Uganda	0.26	**Belgium**	**0.89**
Cameroon	-1.33	Cyprus	-0.25	El Salvador	0.28	**Canada**	**0.90**
Bahrain	-1.28	Indonesia	-0.22	Romania	0.29	South Africa	0.90
Ethiopia	-1.21	Tajikistan	-0.20	Slovenia	0.29	Croatia	0.91
Mauritania	-1.20	Bolivia	-0.16	Trinidad and Tobago	0.29	**Australia**	**0.92**
Angola	-1.17	Uruguay	-0.15	Botswana	0.30	Sri Lanka	0.94
Mali	-1.16	Malta	-0.11	Russian Federation	0.31	Lithuania	0.95
India	-1.13	Brazil	-0.10	Ecuador	0.33	Latvia	1.13
Algeria	-1.08	Peru	-0.09	Mozambique	0.34	**Netherlands**	**1.24**
Guatemala	-0.98	**Greece**	**-0.08**	Viet Nam	0.38	**United Kingdom**	**1.34**
Nigeria	-0.97	Kyrgyz Republic	-0.08	Azerbaijan	0.39	**Spain**	**1.35**
Syrian Arab Republic	-0.84	Paraguay	-0.07	**Switzerland**	**0.41**	**Ireland**	**1.38**
Jordan	-0.84	Honduras	-0.06	Uzbekistan	0.41	**Denmark**	**1.51**
Tunisia	-0.69	Singapore Republic	-0.05	Jamaica	0.44	**Germany**	**1.64**
Zambia	-0.64	Dominican Republic	0.01	Panama	0.46	Philippines	1.65
Cambodia	-0.61	**Czech Republic**	**0.04**	**Portugal**	**0.50**	**New Zealand**	**1.71**
Bangladesh	-0.55	Mongolia	0.06	Argentina	0.51	**Iceland**	**2.06**
Maldives	-0.49	**Hungary**	**0.06**	Kazakhstan	0.51	**Finland**	**2.39**
Belize	-0.48	China	0.08	Israel	0.52	**Norway**	**2.42**
Korea, Republic of	**-0.46**	Albania	0.09	Tanzania	0.53	**Sweden**	**2.60**

Note: Sorted by gender equality; **bold** countries are members of the OECD

Tables and Figures

Table 1. Hypotheses for conditional relationship between gender equality and sex gap in mortality

Hypothesis	Divergence in LDCs		Convergence in HDCs	
	Females	Males	Females	Males
A	**+**	+	+	**+**
B	**+**	null	null	**+**
C	**+**	-	-	**+**
D	null	**-**	**-**	null
E	-	**-**	**-**	-

Note: **Bold** signs indicate stronger relationship

Table 2. Descriptive statistics for non-OECD and OECD countries

	non-OECD (n=94)		OECD (n=29)	
	Mean	SD	Mean	SD
Outcomes				
Sex difference in life expectancy[a]	5.01	(2.89)	5.76	(1.43)
Female life expectancy	69.05	(10.45)	82.00	(2.02)
Male life expectancy	64.04	(9.24)	76.24	(2.76)
Sex difference in HALE[a]	3.21	(2.55)	4.31	(1.17)
Sex ratio in adult probability of dying[b]	1.67	(0.49)	1.96	(0.38)
Sex ratio in IMR[b]	1.20	(0.17)	1.26	(0.16)
Sex ratio in child mortality[b]	1.18	(0.15)	1.24	(0.17)
Predictors				
Gender equality index	55.11	(6.06)	62.73	(6.80)
Gender equality in economic sphere	60.85	(11.07)	66.23	(7.17)
Gender equality in educational sphere	93.19	(9.94)	99.18	(1.23)
Gender equality in political sphere	11.28	(7.20)	22.77	(15.31)
GNI per capita (PPP in international $)	8103.94	(8911.63)	31565.17	(10473.81)
Sex difference in tobacco use[c]	-25.38	(13.98)	-10.57	(10.60)
Female tobacco use (%)[c]	9.53	(9.49)	25.73	(7.52)
Male tobacco use (%)[c]	35.24	(13.73)	36.30	(9.17)

[a] Female – Male values
[b] Female / Male values
[c] Only available for 72 non-OECD countries

Table 3. Regression of sex difference in life expectancy

	Model 1	Model 2	Model 3	Model 4
Gender equality	0.244***	0.212***	0.116**	0.205***
	(0.04)	(0.04)	(0.04)	(0.04)
Gender equality*OECD	-0.355***	-0.341***		-0.303***
	(0.07)	(0.07)		(0.07)
OECD	0.958	-0.225	-1.589*	-0.488
	(0.61)	(0.68)	(0.68)	(0.69)
Log GNI per capita		0.742***	0.805**	1.008***
		(0.22)	(0.24)	(0.23)
Sex difference in tobacco use				-0.0324+
				(0.02)
Constant	5.449***	5.392***	5.219***	5.476***
	(0.25)	(0.24)	(0.25)	(0.25)
Gender equality (OECD)	-0.111+	-0.129*		-0.098
	(0.063)	(0.061)		(0.060)
N	123	123	123	101
R-sq	0.273	0.337	0.209	0.44

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

Table 4. Regression of sex gaps in mortality outcomes

	Healthy Life Expectancy	Adult prob. of dying	Child mortality	IMR
	Model 1	Model 2	Model 3	Model 4
Gender equality	0.195***	0.0188***	0.006**	0.003
	(0.03)	(0.00)	(0.00)	(0.00)
Gender equality*OECD	-0.313***	-0.0362***	0.002	0.003
	(0.06)	(0.01)	(0.00)	(0.00)
OECD	0.565	0.0415	-0.030	0.002
	(0.61)	(0.06)	(0.04)	(0.04)
Log GNI per capita	0.480*	0.116***	0.018	0.005
	(0.20)	(0.02)	(0.01)	(0.01)
constant	3.563***	0.504***	0.164***	0.178***
	(0.21)	(0.02)	(0.01)	(0.02)
Gender equality (OECD)	-0.118*	-0.017**	0.007*	0.006
	(0.05)	(0.01)	(0.00)	(0.00)
N	123	123	123	123
R-sq	0.333	0.461	0.161	0.052

Note: Beta coefficients with standard errors in parentheses, * p<.05, ** p<.01, *** p<.001
All models adjust for GNI per capita and expenditures on health.

Table 5. Regression of male and female life expectancy, separately

	Female life expectancy			Male life expectancy		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Gender equality	0.528***	0.227*	0.206*	0.285*	0.016	0.031
	(0.15)	(0.11)	(0.10)	(0.14)	(0.10)	(0.09)
Gender equality*OECD	-0.46	-0.325+	-0.321+	-0.105	0.016	-0.030
	(0.28)	(0.20)	(0.17)	(0.26)	(0.19)	(0.16)
OECD	11.60***	0.388	-0.690	10.64***	0.612	0.313
	(2.34)	(1.88)	(1.68)	(2.15)	(1.77)	(1.59)
Log GNI per capita		7.038***	7.225***		6.296***	6.450***
		(0.60)	(0.58)		(0.57)	(0.55)
Adult tobacco use (F or M)			0.037			-0.034
			(0.03)			(0.02)
Constant	70.00***	69.46***	69.71***	64.55***	64.07***	64.31***
	(0.94)	(0.65)	(0.62)	(0.86)	(0.61)	(0.59)
Gender equality (OECD)	0.068	-0.098	-0.115	0.179	0.031	0.001
	(0.24)	(0.17)	(0.14)	(0.22)	(0.16)	(0.13)
N	123	123	101	123	123	101
R-sq	0.334	0.683	0.772	0.316	0.657	0.721

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

Figure 1. Relationship between gender equality and the sex difference in life expectancy by level of development