MISSING UNMARRIED WOMEN

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ABSTRACT. That unmarried individuals die at a faster rate than married individuals at all ages is well documented. Unmarried women in developing countries face particularly severe vulnerabilities, so that excess mortality faced by the unmarried is more extreme for women in these regions compared to developed countries. We provide systematic estimates of the excess female mortality faced by older unmarried women in developing regions. We place these estimates in the context of the missing women phenomenon. There are approximately 1.5 million missing women of adult age each year. We find that more than 40% of these missing women of adult age can be attributed to not being married. These estimates vary by region. In India and other parts of South Asia, 55% of the missing adult women are without a husband. For Sub-Saharan Africa, the estimates are smaller at around 35%, and for China only 13%. We show that 70% of missing unmarried women are of reproductive age and that it is the relatively high mortality rates of these young unmarried women (compared to their married counterparts) that drive this phenomenon.

1. INTRODUCTION

It is a well established fact that in developed countries, married individuals experience lower mortality rates than their unmarried counterparts. It is a relationship that has been studied since the mid 1800s (beginning with the work of William Farr (1858) for France). Zheng and Thomas (2013) emphatically state that "the beneficial effect of marriage on health is one of the most established findings in medical sociology, demography, and social epidemiology.[1] This relative excess mortality for the unmarried occurs at all ages, for both sexes, and for all causes of death (Johnson et. al. 2000, Nagata et. al. 2003). This difference persists, for both sexes, after controlling for observed socioeconomic and health related variables (Randall et. al. 2011). The effect of death of a spouse

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[1]There is correspondingly an extensive literature on the subject: amongst numerous others, see Goldman 1993, Shor et. al. 2012, Robards et. al. 2012, Murphy et. al. 2007, Liu and Johnson 2009, and Rendall et. al. 2011.

on the mortality of the survivor — the so-called "widowhood effect" — is well established. The increased probability of death among recently bereaved has been found in men and women of all ages around the world (Subramanian et. al. 2008). None of this should come as a surprise: after all, marriage provides significant economic, psychological and environmental benefits, and it involves two partners caring for each other.

Developing countries are no exception. The data is sparser but the evidence we do have similarly indicates relative excess mortality for the unmarried in most age groups and for both sexes.[2] Arguably, most of this stems from widow(er)hood. After all, in developing countries, marriage at young ages is essentially universal, so that unmarried adults are typically widowed. Moreover, the price of widowhood is particularly steep for women. In South Asia, that marginalization is well documented for both India and Bangladesh (Chen and Dreze 1992; Jensen 2005, Rahman, Foster, and Menken 1992). Increased vulnerability is not only a result of losing the main breadwinner of the household (the husband), but also property ownership laws and employment norms which restrict the access of widows to economic resources.

Patrilocal norms exacerbate the situation. The economic and social support that a widow receives in her late husband's village is typically extremely limited. Add to these a variety of customs and beliefs: seclusion and confinement from family and community, a permanent change of diet and dress, and discouragement of remarriage. Widows in South Asia are considered to be bad luck and to be avoided; they are unwelcome at social events, ceremonies and rituals. The most infamous (though least widespread) manifestation of these social customs is *sati*, self-immolation on the husband's cremation pyre.

And this is no small matter. In India, there are estimated to be more than 40 million widows, which reflects the large husband-wife age gap (approximately 6 years) and greater remarriage incidence among widowers compared to widows (Jensen 2005).

A similar plight can be documented for African countries (Sossou 2002, Oppong 2006). There too, rules of inheritance and property rights restrict the access of a widow to her late husband's resources.[3] Rituals of seclusion and general isolation of widows are a widespread practice in many

[2]See Section 3.2.

[3]van de Walle (2011) shows how households headed by widows in Mali have significantly lower living standards than other households in rural and urban areas.

parts of Africa. Widows can be accused of witchcraft and persecuted, if suspected to have somehow caused their husbands' death. Witchcraft beliefs are widely held throughout Sub-Saharan Africa and elderly women are the typical targets of witch killings (Miguel 2005). Customarily, causes for any death are sought within the prevailing social system, and suspected witches in the family of the dead or sick are often a prime focus of blame (Oppong 2006).

Given these extreme vulnerabilities faced by widows in developing countries, we expect the excess mortality faced by the unmarried to be *relatively* more extreme for women in these regions. That can lead to excess female mortality among adult women. In this paper, we aim to provide systematic estimates of the extent of such excess female mortality in developing regions.

Our approach and methodology allow us to place our estimates in the context of the "missing women" phenomenon. The concept, developed by Amartya Sen (1990, 1992), is based on the observation that in parts of the developing world, notably India and China, the overall ratio of women to men is inappropriately low. Sen translated these skewed sex ratios into absolute numbers by calculating the number of extra women who would have been alive in a particular country if that country had the same ratio of women to men as in areas of the world with supposedly less gender bias in health. Our earlier work (Anderson and Ray 2010, 2012) examined how missing women were distributed across different age groups, regions, and cause of death. Received wisdom has it that gender bias at birth (say, via sex-selective abortions) and the mistreatment of young girls are dominant explanations. However, while we did not dispute the existence of severe gender bias at young ages, we found that the vast majority of missing women were of adult age.

In this paper, and following on the observations above, we focus on adult female excess mortality between the age of 20 and 64. As already stated, this is a large fraction of overall excess mortality. Indeed, in line with the numbers obtained in our earlier research, our estimates here suggest that there are approximately 1.5 million missing women of adult age (between 20 and 64) each year. Our objective is to estimate the share of this excess mortality that can be attributed to "unmarriage" *alone*.

We informally describe our methodology. To begin with, observe that unmarried women are relatively more prevalent in developing countries. As one might guess, this is primarily due to higher mortality rates at every age, so that the incidence of widowhood is significantly larger at every age group in developing (relative to developed) countries. As already noted, unmarried women face relatively elevated mortality risk compared to their married counterparts. To be sure, there are widowers as well as widows, and they too are subject to elevated risks of death. Nevertheless, as long as death rates are elevated in this manner, so are the absolute numbers of missing women — provided that the mortality rates are gender-skewed in the region to begin with. Below, we refer to this as the *marriage incidence effect*.

Moreover, there are additional distortions caused by variation in the elevation factors themselves. That is, the elevation in female mortality risk stemming from unmarriage could be relatively higher in the region of interest. We call this the *skewed elevation ratio effect*. To take this into account, the entire analysis must turn on a comparison of different ratios, and not just the elevation factors *per se*. We develop a methodology to separate and understand these two components.

It turns out that more than 620,000 of missing women of adult age each year can be attributed to unmarriage. These estimates vary by region. In India and other parts of South and Southeast Asia, roughly 55% of the missing adult women are without a husband. For Sub-Sahara Africa, the estimates are somewhat smaller at around 35%, and for China only 13%.

Furthermore, our estimates demonstrate that approximately 70% of the missing unmarried women are of reproductive age (between 20 and 45 years of age). We show that within this socially marginalized group of young unmarried women, the skewed elevation ratio effect is primarily responsible for excess female mortaility. The remaining 30% of the missing unmarried women are older (between 45 and 65). We find that excess female mortality amongst this older unmarried group is due largely to the marriage incidence effect.

The above decompositions are described in detail in what follows. But it is also important to point out what we do *not* do. This is not an exercise that identifies the causal channels that conspire to work through marriage — or its absence — in creating excess female mortality. Rather, the exercise is dedicated to showing that the effect exists, and it is large. Certainly, the vulnerabilities faced by unmarried women in developing countries have been discussed. But a systematic *quantitative* assessment of the problem, especially one that places such vulnerabilities in the larger context of excess female mortality, has not — to our knowledge — been conducted. The contribution, then, is to place a magnitude on this problem in terms of the extreme excess mortality risk that unmarried women face. That said, we discuss some of the relevant pathways in Section 6.

2. Methodology

We first compute the number of missing women at adult ages. We then take into account the role of marital status to generate estimates of excess female mortality as a consequence of being unmarried.

2.1. **The Basics.**

The methodology we employ is in the spirit of the Sen contribution. Any computation of missing women presupposes a counterfactual. For Sen this counterfactual is the set of developed countries and we adopt the same approach here.[4] For each age group we posit a "reference" death rate for females, one that would obtain if the death rate of females in that country were to bear the same ratio to the existing death rate of males as the corresponding ratio for developed countries. We subtract this reference rate from the actual death rate for females, and then multiply by the population of females in that category. This is the definition of "missing women" in the age group under consideration.

More formally, let a stand for an age group. Let $d^m(a)$ and $d^w(a)$ represent the death rates at age a, for men and women respectively, in the region of interest (or "our region"). Use the label $\widehat{}$ for the same variables in the benchmark or reference region.[5] The *reference death rate* for women of age a in our region is defined by the number that equalizes *relative* gender-specific death rates in the region to the corresponding ratio in the reference region. That is, it is the value $r^w(a)$ that solves the condition $r^w(a)/d^m(a) = \widehat{d}^w(a)/\widehat{d}^m(a)$, or equivalently,

$$r^w(a) = \frac{d^m(a)}{\widehat{d}^m(a)/\widehat{d}^w(a)}. \tag{1}$$

[4]We discuss the appropriateness of using developed countries as the benchmark in Anderson and Ray (2010). In that paper, we also considered Latin America and the Caribbean as an alternative benchmark, as we find far fewer missing women in that region of the world. With this alternative benchmark the total number of missing women between the ages of 20 and 64 reduces by 8%. The World Development Report (2012) used our methodology to compute excess female mortality around the world for every developing country across the different age groups. Their estimates match those of Anderson and Ray (2010) very closely.

[5]We use the group of Established Market Economies as defined by the World Bank: Western Europe, Canada, United States, Australia, New Zealand, and Japan.

This methodology turns a blind eye to the prevailing *level* of the death rates in our region, thereby implicitly acknowledging that the region can be relatively poor and so prone to greater overall mortality. But it demands that whatever that higher death rate might be, the ratio of women dying relative to men should be no different compared to that in the reference region.[6] And if we accept that, then the number of age-specific extra female deaths, or "missing women," in our region in a given year would be equal to the difference between the actual and reference death rates for women, weighted by the number of women in that age group:

$$\text{EFM}(a) = [d^w(a) - r^w(a)]\, \pi^w(a), \tag{2}$$

where $\pi^w(a)$ is the starting population of women of age a. Notice that while the reference death rate is not affected by the average mortality rate, this estimate is: the absolute numbers of missing women would increase with higher average mortality, *ceteris paribus*.

Anderson and Ray (2010) discuss the interpretation of (2) in some detail. In particular, excess female mortality might arise from a number of causes, and only some of these are explicitly interpretable as discrimination against women, the most obvious examples being excess female mortality at the pre-natal stage, or at birth or in infancy. Other factors, such as excess female mortality from cardiovascular disease or HIV/AIDS, need a more nuanced interpretation. We do not revisit these issues here but refer the interested reader to our earlier paper.

2.2. **Marriage Rates and Elevation Ratios.** We describe a strategy for identifying excess female deaths, if any, due to unmarriage. This is a subtle problem. Typically, both unmarried men and women have higher death rates, correcting for age. To the extent that creates larger numbers of deaths all around, it also creates a larger number of *excess* female deaths as well. But there is a second factor at work, which is the *comparative* extent by which the death rates for women are raised. To be sure, these ratios are elevated for both our region as well as the reference region. For our purposes we will need to compare two sets of ratios. All this will be made clearer with a bit more notation and formalism.

[6] We are, of course, aware that any such "adjustment method" can be criticized; see Anderson and Ray (2010) for a discussion of this point. But keeping the ratio constant has a strong intuitive appeal. Besides, this is the approach predominantly taken in the literature since the work of Sen.

There is also the question of finer categories of unmarriage: widowed, divorced, or never-married. Data limitations force us to lump these subcategories together. We postpone further discussion to Section 3.3.

Let $\sigma^m(a)$ and $\sigma^w(a)$ be the incidence of unmarried men and women respectively in age group a. For instance, if $\sigma^m(a) = 0.1$, then 10% of all men in age group a are unmarried; and 90% are married. Denote by $e^m(a)$ and $e^w(a)$ the *elevation factors* for males and females respectively; that is, the relative rise in the death rates conditional on lack of marriage. For instance, if $e^w(a) = 1.1$, then unmarried women in age group a are 10% more likely to die, compared to married women in that age group.

2.3. **Excess Female Mortality by Marital Category.** Our focus is on marriage — or the lack thereof — and to get at this it will be useful to proceed in a couple of steps. Begin by carrying out the same exercise leading up to (1), but starting with *married* individuals. That is, let $\delta^w(a)$ and $\delta^m(a)$ be the death rates for married females and males, respectively. Use the label $\widehat{\ }$ to denote these same variables for the benchmark or reference region. We can now generate a "reference" death rate for married women of age a in our region of interest by

$$\rho^w(a) = \frac{\delta^m(a)}{\widehat{\delta}^m(a)/\widehat{\delta}^w(a)}, \tag{3}$$

and we are then in a position to define *excess female mortality with marriage benchmarks* (EFM^0) at age a by

$$\text{EFM}^0(a) = [\delta^w(a) - \rho^w(a)]\,\pi^w(a), \tag{4}$$

where $\pi^w(a)$ is, as before, the entire population of females of age a. Note that we are multiplying by the full female population, so this is not an estimate of how many women are missing among the married. It is an estimate of missing women in the entire population *under the presumption that the death rates for married individuals apply to everyone*. So, for instance, if the married and unmarried death rates were all the same for women and men, then $\text{EFM}(a) = \text{EFM}^0(a)$. But if there is elevation, then $\text{EFM}(a) > \text{EFM}^0(a)$. We are interested in the empirical magnitude of this difference.

Let us make the connection clearer by converting the values on the right-hand side of (4) into the aggregated rates that we have in (2). Recalling the elevation factors and marriage incidence rates already defined, we see that

$$d^i(a) = \left[\sigma^i(a)e^i(a) + (1 - \sigma^i(a))\right] \delta^i(a) \equiv c^i(a)\delta^i(a), \tag{5}$$

for $i = m, w$, where $c^m(a)$ and $c^w(a)$ are "corrections" that are generated by the elevation factors, and by the proportions of married males and females.

An increase in the elevation factor $e^i(a)$ raises $c^i(a)$. Moreover, given some $e^i(a) > 1$, a greater incidence of unmarriage will also increase $c^i(a)$, as there is a shift away from the lower death rate category. In short, larger values of c^i point to higher death rates in the unmarried category, and conditional on that, is correlated with a lower incidence of marriage.

Use the label $\widehat{}$ to denote these same variables for the benchmark or reference region. Invoking (5) for both regions and both genders, we have

$$\begin{aligned}
\rho^w(a) &= \frac{\delta^m(a)}{\widehat{\delta}^m(a)/\widehat{\delta}^w(a)} \\
&= \frac{d^m(a)}{\widehat{d}^m(a)/\widehat{d}^w(a)} \frac{1/c^m(a)}{\widehat{c}^w(a)/\widehat{c}^m(a)} \\
&= r^w(a) \frac{1/c^m(a)}{\widehat{c}^w(a)/\widehat{c}^m(a)},
\end{aligned} \tag{6}$$

where $r^w(a)$ is the unbiased death rate for all women in our region at age a, defined earlier in (1). Using (5) and (6) in (4), we must conclude that

$$\begin{aligned}
\text{EFM}^0(a) &= \left[\delta^w(a) - \rho^w(a)\right] \pi^w(a) \\
&= \left[\frac{d^w(a)}{c^w(a)} - r^w(a) \frac{1/c^m(a)}{\widehat{c}^w(a)/\widehat{c}^m(a)}\right] \pi^w(a) \\
&= \left[d^w(a) - r^w(a) \frac{c^w(a)/c^m(a)}{\widehat{c}^w(a)/\widehat{c}^m(a)}\right] \frac{\pi^w(a)}{c^w(a)} \\
&\equiv \left[d^w(a) - \theta(a) r^w(a)\right] \frac{\pi^w(a)}{c^w(a)},
\end{aligned} \tag{7}$$

where

$$\theta(a) = \frac{c^w(a)/c^m(a)}{\widehat{c}^w(a)/\widehat{c}^m(a)}$$

can be viewed as the *relative elevation* at age a in the region, compared to the reference region. Recall that $c^i(a)$ is larger the greater the elevation factors and the smaller the incidence of marriage. Moreover, the larger these differences in our region, compared to the reference region, the larger is the value of $\theta(a)$.

The gap between EFM and EFM^0 can be viewed as the additional number of missing women due to unmarriage (and the consequently higher death rates). Call this gap EFM^1, then

$$\begin{aligned}
\text{EFM}^1(a) &\equiv \text{EFM}(a) - \text{EFM}^0(a) \\
&= \left[d^w(a) - r^w(a)\right]\pi^w(a) - \left[d^w(a) - \theta(a) r^w(a)\right]\frac{\pi^w(a)}{c^w(a)} \\
&= \left[1 - \frac{1}{c^w(a)}\right]\text{EFM}(a) + [\theta(a) - 1] r^w(a)\frac{\pi^w(a)}{c^w(a)}. \qquad (8)
\end{aligned}$$

There are two components in this equation. The first is what one might call the *marriage incidence effect*, and is given by the term $[1 - (1/c^w(a))]$EFM(a). Lower marriage — typically because of widow(er)hood — increases death rates for both men and women, and makes $c^w(a)$ larger than 1. This elevation is more accentuated the higher the rate of unmarriage. Even if the relative death rates for women change exactly the same way for both the reference region and the region of interest (so that $\theta(a) = 1$), this will *still* increase the total number of missing women relative to the marriage benchmark. After all, the absolute gap between the death rate and its reference counterpart will have widened.

The second component is what might be termed the *skewed elevation ratio effect*, and is given by the term $[\theta(a) - 1]r^w(a)(\pi^w(a)/c^w(a))$ in (8). If female death rates in our region climb with lack of marriage at a rate that exceeds the benchmark rate of the reference region, then this increases the value of $\theta(a)$ and contributes to missing women. (Even though it might increase the denominator $c^w(a)$ as well, the net effect is positive.[7]) We will need to be guided by the data on this matter, but there are reasons to believe that the female correction factor does indeed bear a higher ratio to its male counterpart in the region of interest, relative to the reference region. First, if there is a large gap between male and female age at marriage in the region of interest, adult women will tend to be widowed more often, so that the rate of unmarriage will be higher, especially in the middle-age category. Second, if the traditional discrimination against women is reflected to a proportional

[7]After all, $\frac{\theta(a)-1}{c^w(a)}$ equals $\frac{1/c^m(a)}{\hat{c}^w(a)/\hat{c}^m(a)} - \frac{1}{c^w(a)}$.

degree in widowhood, the relative elevation ratio $e^w(a)/e^m(a)$ will tend to be higher in the region of interest. Both factors work in the same direction: they raise the female correction factor relative to the male factor in the region of interest.

It is also worth reiterating that the correction term c is generated from two sources: one is the ratio of elevation factors, and the other is the incidence of unmarriage. Of course, the latter has no meaning in the absence of the former: if e were 1, then the incidence of unmarriage would be irrelevant. On the other hand, if $e > 1$ (and we shall see that this is indeed the case), then a lower marriage rate raises the correction term. In an effort to disentangle the "pure" effect of the elevation ratio from the additional impact of marriage incidence, we can decompose each component of (8) into two parts. We can do so by first shutting down the differential incidence of marriage altogether, by simply using the rates of marriage that prevail in the reference region. That is, we can define pseudo-correction factors for the region of interest by

$$c_e^i(a) \equiv \widehat{\sigma}^i(a)e^i(a) + (1 - \widehat{\sigma}^i(a))$$

for $i = m, w$, and a pseudo relative elevation, given by

$$\theta_e(a) \equiv \frac{c_e^w(a)/c_e^m(a)}{\widehat{c}^w(a)/\widehat{c}^m(a)}.$$

With these in hand, we can define a new measure of missing women from non-marriage, call it EFM_e^1, which allows for the elevation but not the different rates of marriage across the two regions. It is given by the following analogue of (8) for each age group a:

$$\text{(9)} \qquad \text{EFM}_e^1(a) \equiv \left[1 - \frac{1}{c_e^w(a)}\right] \text{EFM}(a) + [\theta_e(a) - 1] r^w(a) \frac{\pi^w(a)}{c_e^w(a)}.$$

It also has two components, of course, just as EFM_e^1 did. The remaining term is

$$\text{EFM}^1(a) - \text{EFM}_e^1(a)$$

as a matter of accounting, and can be tentatively interpreted as the additional number of missing women due to changes in marriage incidence alone. This term may be positive or negative. If unmarriage rates are high in the region of interest, say due to widowhood, this term will also make a positive contribution.

Just how large $\text{EFM}^1(a)$ and $\text{EFM}^1_e(a)$ are is in practice an empirical question, and the goal of this paper is to provide both estimates.

3. Data

In our computations of $\text{EFM}^1(a)$ and $\text{EFM}^1_e(a)$, we focus on the ages 20 to 64.[8] Our regions of interest are India, China, South Asia (excluding India), Southeast Asia, West Asia, East Africa, West Africa, Middle Africa, South Africa, and North Africa. That is, we focus on regions where there is excess female mortality to begin with: in other parts of the developing world, such as East Asia (excluding China), Central Asia, and Latin America and the Caribbean we find no excess female mortality at adult ages.

To compute $\text{EFM}^1(a)$ and $\text{EFM}^1_e(a)$, we require data to determine $d^w(a)$, $d^m(a)$, $\sigma^w(a)$, $e^w(a)$, $\sigma^m(a)$, $e^m(a)$ and $\pi^w(a)$ for our regions of interest and for our reference region. Estimates on mortality rates by age and gender ($d^w(a)$ and $d^m(a)$) for age groupings of five years, as well as female population by age ($\pi^w(a)$) are readily available for all countries from the United Nations Department of Economic and Social Affairs.[9] Accurate mortality data, by age and gender, for many developing countries is typically very difficult to obtain. Relying primarily on micro-level surveys and censuses, to the best of our knowledge, these are the best country-level estimates available. We discuss issues surrounding the quality of this mortality data , particularly for developing countries, further in the Appendix.

Estimates of marital status by age group ($\sigma^w(a)$ and $\sigma^m(a)$) are also available for all countries from the U.N. World Marriage Data 2012.[10] For all of our variables we chose the data from the year 2000 or a year as close as possible to 2000.

Mortality rates by age, gender, *and* marital status (needed to compute $e^w(a)$ and $e^m(a)$) are more difficult to obtain as this information is typically not collected in any regular way by national

[8]Marital status data is also available for the age group 15–19 but the percentage of unmarried individuals is too small for developed countries for reliable analysis.

[9]For the mortality data, see `http://esa.un.org/unpd/wpp/Excel-Data/mortality.htm`. For the data sources and methods used to derive the estimates for mortality rates by age and gender across the different countries refer to `http://esa.un.org/unpd/wpp/Excel-Data/data-sources.htm`. Population data come from *U.N. World Population Prospects: The 2012 Revision*.

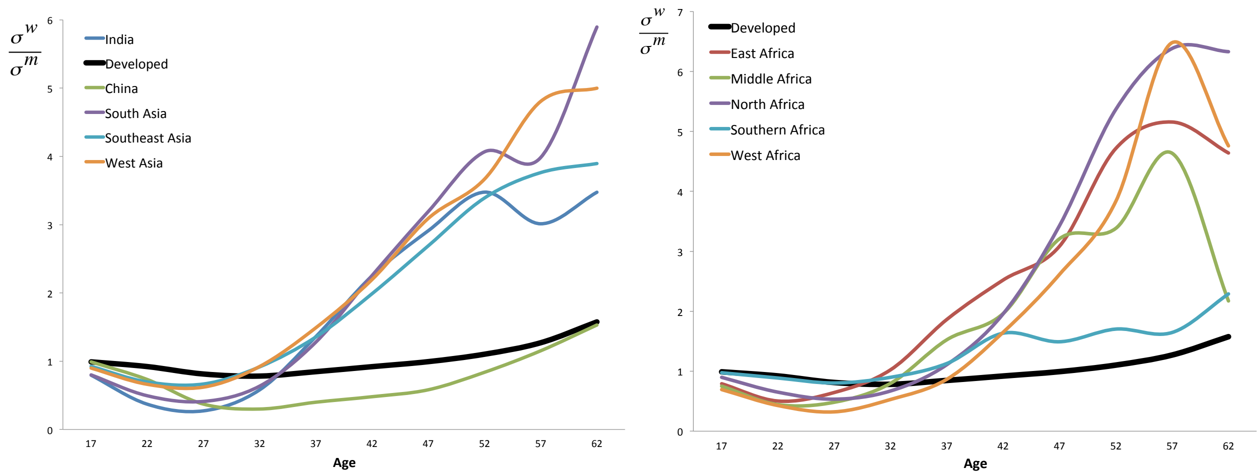
[10]Refer to: http://www.un.org/esa/population/publications/WMD2012/MainFrame.html.
The major sources of data on marital status presented in *World Marriage Data 2012* are censuses, sample surveys and national estimates based on population register data or an estimation methods using census data.

statistical agencies. The U.N. Demographic Yearbook 2003 reports this information for all of these variables for several countries between 1994–2003. We again select the data from the year 2000 or the closest to that year as possible, and for as many countries as we can. That gives us enough data to compute $e^w(a)$ and $e^m(a)$ for all developed countries. This information, however, is far rarer for developing countries. For our regions of interest, we have this data for four countries in Africa (Egypt, Mauritius, Reunion, and Tunisia), and ten countries in Asia (Hong Kong, Macao, Japan, Kazakhstan, Republic of Korea, Singapore, Qatar, State of Palestine, Georgia, and Azerbaijan). We use the data to compute various estimates of elevation factors for our regions of interest. For example, we compute one set of elevation factors for Africa by aggregating across the countries within this region that we have data for, and likewise for Asia. We will then compute our estimates of $\text{EFM}^1(a)$ and $\text{EFM}^1_e(a)$ for our regions of interest under different specifications which vary by the elevation factors we compute for these regions. We discuss the implications of different specifications in detail in Section 4. Given the paucity of data, it makes little sense to disaggregate "unmarriage" any further; on this, see Section 3.3.

Key to the computation of $\text{EFM}^1(a)$ is the size of $\theta(a)$, which is the female-male ratio of correction factors at age a in our region of interest, *relative* to the same ratio in the reference region. The larger the female-male correction factor in our region — influenced positively by both the elevation ratio and the overall incidence of unmarriage — the larger is the value of $\theta(a)$. That is, recalling that a typical correction factor $c(a)$ (dropping superscripts) is given by $\sigma(a)e(a) + (1 - \sigma(a))$, it follows that $\theta(a)$ is increasing in $e^w(a)/e^m(a)$ relative to the same ratio in our reference region, $\widehat{e}^w(a)/\widehat{e}^m(a)$. It is also increasing in $\sigma^w(a)/\sigma^m(a)$ relative to its reference value $\widehat{\sigma}^w(a)/\widehat{\sigma}^m(a)$. We now build these ratios from the data.

3.1. **Marital Status by Age.**

We first consider $\sigma^m(a)$ and $\sigma^w(a)$, the incidence of unmarried men and women respectively in age group a, in both our regions of interest and in our reference region. What is most relevant for the determination of $\text{EFM}^1(a)$ is the size of the ratio $\sigma^w(a)/\sigma^m(a)$ relative to the same ratio in our reference region, $\widehat{\sigma}^w(a)/\widehat{\sigma}^m(a)$. Figure 1 plots this relative ratio for our regions of interest, and for developed countries, our reference region. We see that the ratio $\sigma^w(a)/\sigma^m(a)$ for less developed regions is higher than for developed regions for ages older than 35. The only exception is China where this ratio is lower than for developed countries.



(a) Asia **(b)** Africa

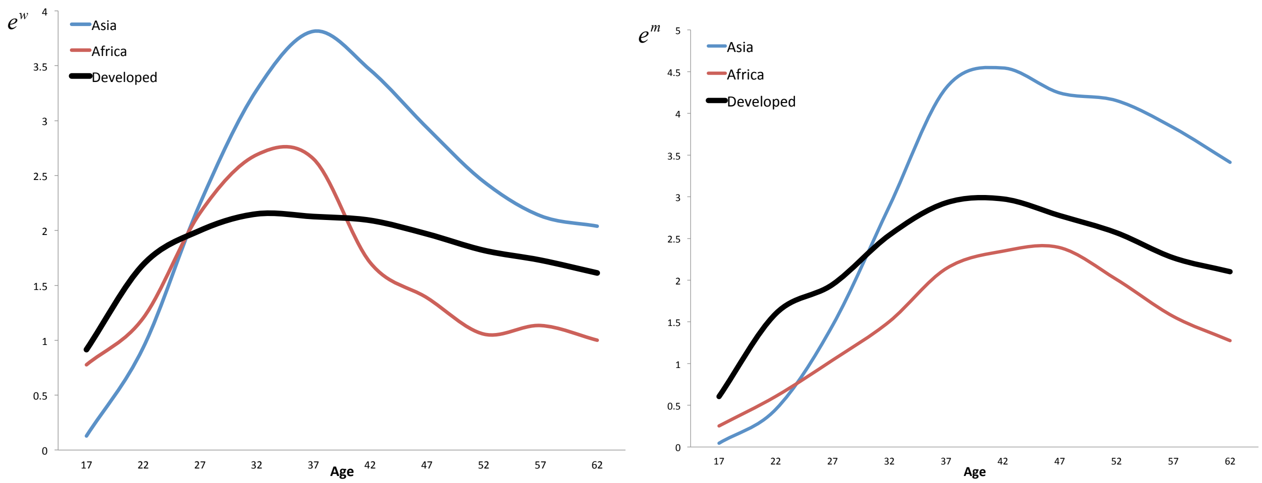
Figure 1. THE RATIO $\sigma^w(a)/\sigma^m(a)$ FOR DIFFERENT REGIONS AND AGES.

Unmarried individuals could be widowed, divorced or single. The second and third subcategories are largely symmetric across men and women, so the high values of $\sigma^w(a)/\sigma^m(a)$ are primarily driven by the proportions of widows (relative to widowers) in all regions. The fact that $\sigma^w(a)/\sigma^m(a)$ is lower in developed countries relative to developing is a sign of the fact that this imbalance is heightened in developing countries, at all age groups.[11] For more discussion, see Section 3.3.

3.2. **Elevation.** The second key component in our computation of $\text{EFM}^1(a)$ are the elevation factors $e^m(a)$ and $e^w(a)$, which reflect the relative mortality rates of unmarried and married individuals by gender and age.

As discussed, we construct three main sets of elevation factors. The first is for our reference region, which is a population-weighted average across all developed countries. We then construct average elevation factors for two areas of the developing world under consideration: Africa (using the available data from Egypt, Mauritius, Reunion, and Tunisia) and Asia (using data from Hong Kong, Macao, Japan, Kazakhstan, Republic of Korea, Singapore, Qatar, State of Palestine, Georgia, and Azerbaijan). We discuss the implications of relying on these samples of countries to construct the elevation factors for our different regions of interest in Section 4.

[11]In addition, relative to developed countries, divorce is far less common in developing countries. In India and the rest of South Asia, the incidence of divorce is less than 1% in all age groups for men and women. In the rest of Asia it is at most 2%. In Africa, divorce is somewhat more common at around 5%.



(a) Females **(b)** Males

Figure 2. ELEVATION FACTORS BY GENDER AND AGE.

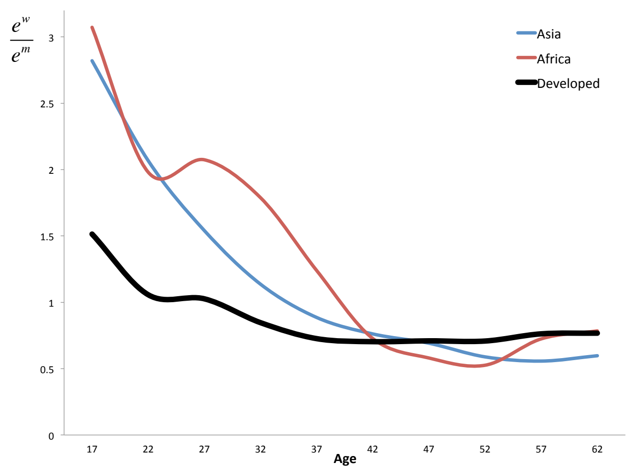
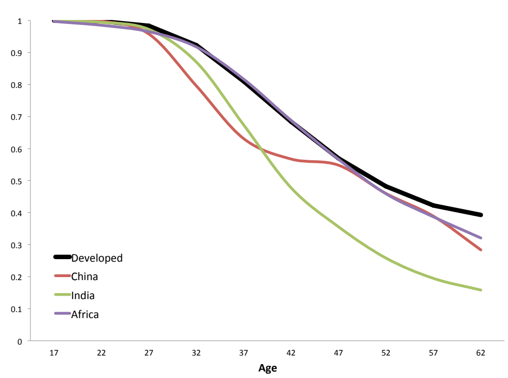


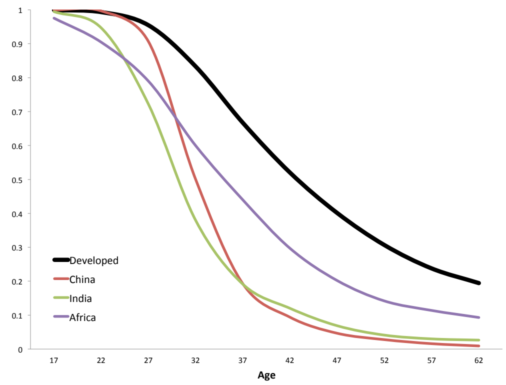
Figure 3. ELEVATION RATIOS BY AGE.

Figure 2 plots elevation factors at different ages in different regions. We see that for all regions, $e^m(a)$ is greater than one after age 25 and $e^w(a)$ after age 20. Elevation factors are typically highest in Asia, for both men and women. Elevation factors for women in Africa are higher than in developed countries at younger ages (25–40) but not after. Elevation factors for men in Africa are lower than those for developed countries.

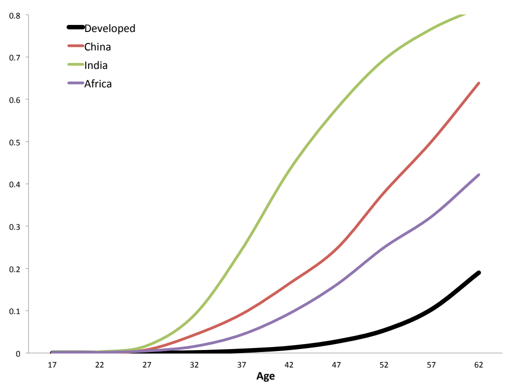
However, as already discussed, what is particularly relevant for our computation of $\text{EFM}^1(a)$ is the size of the *ratio* of elevation factors — call it the *elevation ratio* $e^w(a)/e^m(a)$ — relative to the same ratio in our reference region, $\widehat{e}^w(a)/\widehat{e}^m(a)$. Figure 3 plots this elevation ratio for our different



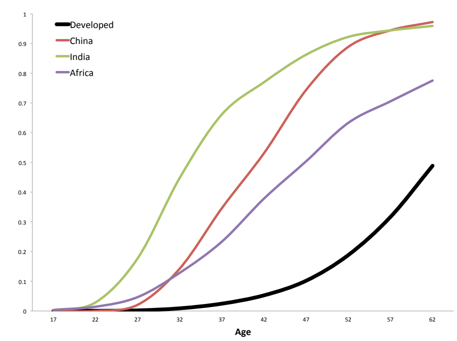
(a) Single/Unmarried: Males



(b) Single/Unmarried: Females



(c) Widowed/Unmarried: Males



(d) Widowed/Unmarried: Females

Figure 4. PROPORTIONS OF SINGLE AND WIDOWED INDIVIDUALS AMONG THE UNMARRIED.

regions. We see that for both Asia and Africa, this ratio is higher than in developed countries at all ages below 45, after which is it typically lower. Moreover, this ratio is larger than 1 for developed countries only between ages 15–19, but exceeds 1 for Asia up to age 35 and for Africa up to age 40, implying that relative mortality rates for unmarried compared to married women are significantly higher than for men at these younger ages in Africa and Asia.

3.3. **Subcategories of Unmarriage.** Both our methodology and computations treat the different unmarried categories (single, divorced, widowed) as one group. However, it is certainly the case that the proportions of individuals occupying each of these categories, as well as the corresponding elevation ratios across these different categories, varies by country.

Marriage occurs earlier in developing countries. It is therefore likely the proportion of the unmarried population that is single (as opposed to widowed or divorced), especially at younger ages, will be smaller in our regions of interest. In similar vein, because mortality rates are higher in

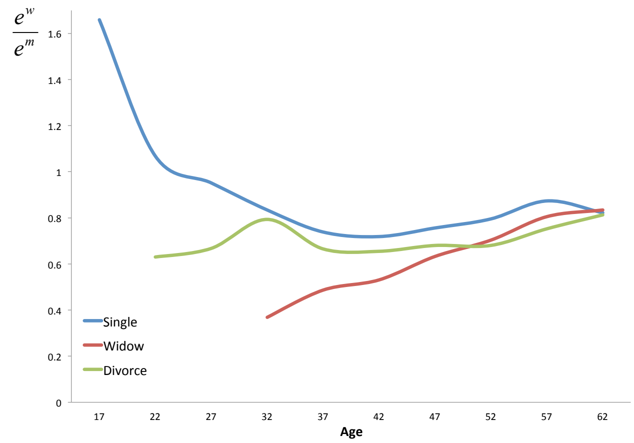


Figure 5. ELEVATION RATIOS FOR DIFFERENT UNMARRIED SUBCATEGORIES.

developing countries, the proportion of widows (as opposed to those who are single or divorced) will be correspondingly higher in the regions of interest.

Figure 4 plots the proportion of unmarried individuals who are single or widowed in the different regions of interest, as well as in the reference region. Panels (a) and (b) show that the proportion of singles is higher in developed countries for all age groups, for both males and females. Panels (c) and (d) similarly show that the proportion of the unmarried who are widowed is lower in developed countries for all ages, again for both males and females. We see also that the proportion of widows is highest in India (for both men and women) compared to other developing regions.

Here is the basic reason that we cannot accommodate these finer subcategories in our analysis. Figure 4 shows that widowhood, for both men and women, is very uncommon in developed countries at younger ages. We therefore do not have reliable data on elevation ratios for this subcategory of the unmarried. Likewise, because divorce is very rare in some parts of the developing world, we do not have reliable data on elevation ratios for that subcategory. Furthermore, as already noted, even data on death rates conditioned on marital status is not universally available. Therefore, all things considered, we need to group the unmarried categories together in our analysis.

The question is whether our analysis overstates the case for unmarried missing women by lumping these subcategories together, as we are forced to do. Specifically, the concern is that at younger ages, we are more likely to be comparing widows in our region of interest to single (and divorced) people in our reference region, which could bias our estimates of $\text{EFM}^1(a)$ upwards. This would

Age	(1) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	(2) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	(3) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$
20-24	16	28	16	27	23	47
25-29	7	35	7	36	10	42
30-34	13	25	13	24	14	28
35-39	21	13	21	12	19	9
40-44	24	4	25	5	19	-5
45-49	25	1	26	1	20	-10
50-54	25	-4	26	-4	21	-14
55-59	18	-7	20	-5	14	-14
60-64	34	1	41	6	29	-7
Total	184		194		170	
% Unmarr. Females	0.48		0.51		0.45	

Table 1. Unmarried Excess Female Mortality (2000, in 000s), India. *Sources and Notes.* U.N. World Marriage Data 2012; U.N. Demographic Yearbook 2003; U.N. World Population Prospects: The 2012 Revision. For the estimates in (1), the elevation ratios assumed to hold for India are computed from our available data for all Asian countries; in (2), we exclude West Asian countries in our computations for India; and in (3) we additionally exclude Japan.

be the case if $\widehat{e}^w(a)/\widehat{e}^m(a)$ for widows were higher in our reference developed countries compared to the corresponding ratio for single individuals.

Using the data available, we plot $\widehat{e}^w(a)/\widehat{e}^m(a)$ for the different unmarried categories for developed regions. We see, from Figure 5, that for all ages, the ratio $\widehat{e}^w(a)/\widehat{e}^m(a)$ is highest for single individuals, implying that if anything, the estimates to follow are biased downwards.

4. Unmarried Excess Female Mortality

With this information in hand, we can now compute $\text{EFM}^1(a)$ for the year 2000 in our regions of interest, for each age category between 20 and 64, using the methodology outlined in Section 2.

4.1. Asia.

We begin with Asia. As already noted, we concentrate on regions in which there is excess female mortality, so we do not compute $\text{EFM}^1(a)$ for East Asia (excluding China) and Central Asia.

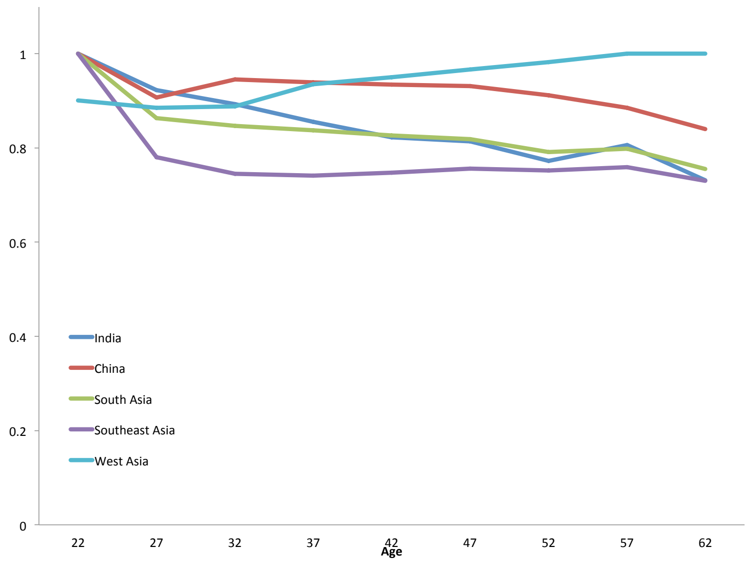


Figure 6. PROPORTION OF $\text{EFM}^1(a)$ ATTRIBUTABLE TO THE CORRECTION FACTOR EFFECT IN ASIA.

The first column of Table 1 lists the numbers of missing unmarried women in each age sub-category in the overall range 20–65, for India. In all see that there are approximately 180,000 missing women due to unmarriage in India in the year 2000. A significant proportion of this number (44%) are in the reproductive age category 20–45.

In this first set of estimates listed in Column 1, the assumed elevation ratios $e^w(a)/e^m(a)$ for India are computed from our available data for all Asian countries. In the next set of estimates (Column 2), we exclude West Asian countries in our computations of the elevation ratio. In the final set of estimations (Column 3), we also exclude Japan so that the sample of countries used to compute the elevation ratios for India are only from East Asia (excluding China and Japan) and Central Asia. (In both these regions we find no excess female mortality for ages older than 15.) We see that our estimates of $\text{EFM}^1(a)$ do not change significantly across the different approximations. Given the evidence of discrimination against unmarried women in India and the rest of South Asia (discussed in the introduction), we would expect that $e^w(a)/e^m(a)$ would most likely be higher for India and other South Asian countries compared to the rest of Asia, particularly compared to East Asia (excluding China and Japan) and Central Asia. If this is the case, then our estimates of $\text{EFM}^1(a)$ for India are, if anything, biased downwards.

In Section 2.3, we demonstrated how $\text{EFM}^1(a)$ could be divided into two components, the marriage incidence effect and the skewed elevation ratio effect. In Figure 6, we plot the proportion of

$\text{EFM}^1(a)$ which can be attributed to the skewed elevation ratio effect for different Asian regions, including India, by age. We see that $\text{EFM}^1(a)$ is primarily composed of this factor for all ages, with a slight decrease with age. This demonstrates the importance of a high value of

$$\theta(a) = \frac{c^w(a)/c^m(a)}{\widehat{c}^w(a)/\widehat{c}^m(a)}$$

in determining excess female mortality from the absence of marriage in Asia in general, and India in particular. That is, the female correction factor does indeed bear a higher ratio to its male counterpart in India, relative to the reference region. As the discussion to follow will show, it is not just the elevation ratios but also the high rates of widowhood in India (after age 40) that drive the large values of $\theta(a)$.

Recall from Section 2.3 that the correction factor, which drives excess female mortality from the absence of marriage, is generated from two sources. One is that the elevation ratios $e^w(a)/e^m(a)$ are larger in our country of interest, compared to those in our reference region. The other is that the incidence of marriage is different across the two regions. We now attempt to disentangle these two effects. For each of the estimates in Columns 1–3 in Table 1, we report corresponding estimates of $\text{EFM}^1_e(a)$ for each age group. Recall from Section 2.3 that this particular estimate of missing unmarried women allows for different elevation ratios but not different rates of marriage across the two regions. That is, we assume the rate of unmarriage by age group is identical across India and our reference region. We see that these estimates are largest in the younger age categories (ages 20 to 40). This implies that the excess unmarried female mortality at these younger ages, primarily follows from the fact that the elevation ratio for Asia is high relative to the same ratio in our reference region. But above the age of 40, a different phenomenon takes over. Notice that $\text{EFM}^1(a)-$ $\text{EFM}^1_e(a)$ is a measure of missing women due to changes in marriage incidence alone. These numbers are large and positive for ages above 40. So in other words, it is the large incidence of widowhood in India, at ages above 40, which is primarily driving the excess mortality for unmarried women at these older ages.

Table 2 turns to South Asia, excluding India. In this region, we see that there are more than 60,000 missing unmarried women each year. As a percentage of the total population of unmarried females, there is a lower number of missing women due to unmarriage in South Asia compared to India. But the remaining pattern is roughly similar to that in India. Again, approximately 45%

Age	(1) EFM$^1(a)$	EFM$_e^1(a)$	(2) EFM$^1(a)$	EFM$_e^1(a)$	(3) EFM$^1(a)$	EFM$_e^1(a)$
20-24	7	10	7	10	10	18
25-29	3	9	3	9	4	11
30-34	4	8	4	8	5	9
35-39	6	6	6	6	6	5
40-44	7	4	7	4	6	2
45-49	7	2	7	3	6	0
50-54	8	1	8	1	7	-1
55-59	7	0	8	0	7	-1
60-64	12	2	14	4	12	1
Total	60		64		63	
% Unmarr. Females	0.36		0.37		0.37	

Table 2. Unmarried Excess Female Mortality (2000, in 000s), South Asia excluding India. *Sources and Notes.* U.N. World Marriage Data 2012; U.N. Demographic Yearbook 2003; U.N. World Population Prospects: The 2012 Revision. For the estimates in (1), the elevation ratios assumed to hold for South Asia are computed from our available data for all Asian countries; in (2), we exclude West Asian countries in our computations; and in (3) we additionally exclude Japan.

of the missing unmarried women are of reproductive age. Figure 6 also tells us that as in India, EFM$^1(a)$ for South Asia is primarily composed of the skewed elevation ratio effect at all ages, with a slight decrease with age. Likewise, our estimates of EFM$_e^1(a)$ for South Asia show that it is the high elevation ratios in Asia which drive excess mortality from the absence of marriage at these younger ages, whereas it is the incidence of widowhood which drives it at the older ages.

Table 3 records 85,000 missing unmarried women each year in Southeast Asia. As a percentage of the total population of unmarried females, there are fewer missing unmarried women in this region compared to the countries of South Asia (not counting India). Again, from Figure 6, we see that EFM$^1(a)$ for Southeast Asia is primarily composed of the skewed elevation ratio effect at all ages, though this component is slightly smaller compared to other regions of Asia. Our estimates of EFM$_e^1(a)$ suggest that the patterns of excess unmarried female mortality by age follow similar patterns across this region and the countries of South Asia, where again high elevation ratios in Asia drive this excess mortality at the younger ages and the incidence of widowhood drives it at the older ages.

Age	(1) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	(2) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	(3) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$
20-24	11	17	11	17	17	30
25-29	7	11	6	10	8	13
30-34	8	8	8	7	9	8
35-39	10	4	10	4	8	2
40-44	11	2	11	2	8	-2
45-49	11	1	11	1	8	-4
50-54	10	-2	10	-2	8	-6
55-59	9	-4	9	-4	7	-7
60-64	11	-2	14	-1	10	-6
Total	87		91		82	
% Unmarr. Females	0.23		0.24		0.22	

Table 3. Unmarried Excess Female Mortality (2000, in 000s), South-East Asia. *Sources and Notes.* U.N. World Marriage Data 2012; U.N. Demographic Yearbook 2003; U.N. World Population Prospects: The 2012 Revision. For the estimates in (1), the elevation ratios assumed to hold for Southeast Asia are computed from our available data for all Asian countries; in (2), we exclude West Asian countries in our computations; and in (3) we additionally exclude Japan.

Table 4 provides our estimates for China. We see that relative to countries in South and Southeast Asia, there are very few missing unmarried women in China. The few that are missing are at the younger adult ages and they are due to the high elevation ratios for Asia that we've imputed to China. There are almost no unmarried missing women in China due to the relatively high incidence of widowhood (or not being married). The final two columns of Table 4 demonstrate that likewise there is little excess female mortality due to the absence of marriage in West Asia. From Figure 6, we see that $\text{EFM}^1(a)$ for these two regions is almost entirely composed of the *elevation ratio effect* component for all ages.

4.2. **Africa.** We now turn to Africa.

Table 5 shows that there are approximately 255,000 missing unmarried women in Africa in the year 2000. Roughly 47% of these are from East Africa, where as a percentage of the total population of unmarried women the numbers are also the highest. By contrast, the countries of North Africa have the lowest levels of excess female mortality from unmarriage.

Age	China (1) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	China (2) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	China (3) $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	West Asia $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$
20-24	12	16	12	17	9	12	3	4
25-29	5	19	5	19	2	15	1	2
30-34	6	16	6	15	4	12	2	2
35-39	7	9	6	9	6	6	2	1
40-44	5	4	4	5	5	3	2	0
45-49	3	5	3	5	4	2	1	0
50-54	0	-1	0	-1	0	-3	1	-1
55-59	-4	-5	-4	-4	-4	-6	0	-2
60-64	-3	-2	0	2	-2	-2	-2	-3
Total	31		32		23		9	
% Unmarr. Females	0.07		0.07		0.05		0.07	

Table 4. Unmarried Excess Female Mortality (2000, in 000s), China and West Asia. *Sources and Notes.* U.N. World Marriage Data 2012; U.N. Demographic Yearbook 2003; U.N. World Population Prospects: The 2012 Revision. For the estimates in (1), the elevation ratios assumed to hold for China are computed from our available data for all Asian countries; in (2), we exclude West Asian countries in our computations for China; and in (3) we include only countries from East Asia. In the final two columns we use the elevation ratios from West Asian countries to obtain corresponding estimates for West Asia.

Age	East $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	Middle $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	Southern $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	West $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$	North $\text{EFM}^1(a)$	$\text{EFM}^1_e(a)$
20-24	12	21	4	8	3	3	14	22	4	4
25-29	21	40	5	10	8	8	11	25	3	4
30-34	32	43	6	9	10	9	10	20	3	4
35-39	30	28	6	6	8	7	9	13	3	3
40-44	14	6	3	2	4	2	6	3	2	1
45-49	6	0	2	0	1	0	4	0	2	0
50-54	2	-2	0	-1	-1	-1	2	-2	1	-1
55-59	2	0	1	0	0	0	3	0	1	0
60-64	0	-1	-1	0	0	0	-1	-1	0	-1
Total	119		28		31		58		19	
%	0.79		0.59		0.46		0.54		0.15	

Table 5. Unmarried Excess Female Mortality (2000, in 000s), Africa. *Sources and Notes.* U.N. World Marriage Data 2012; U.N. Demographic Yearbook 2003; U.N. World Population Prospects: The 2012 Revision.

In Figure 7, we plot the proportion of $\text{EFM}^1(a)$ which is attributable to the skewed elevation ratio effect for the different African regions by age. We see that, like the regions of Asia, $\text{EFM}^1(a)$ is primarily composed of this component for all ages. Compared to Asia, this component is somewhat smaller in Africa, and unlike in Asia it also increases slightly with age. But overall, Figure 7 is in accordance with Figure 6 in that they both demonstrate the importance of a high value of $\theta(a)$ in

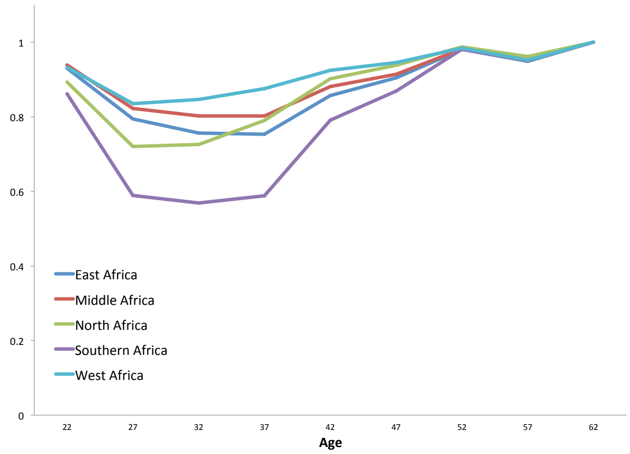


Figure 7. PROPORTION OF $\text{EFM}^1(a)$ ATTRIBUTABLE TO THE CORRECTION FACTOR EFFECT IN AFRICA.

determining excess female mortality from the absence of marriage in Africa as well. That is, the female correction factor does indeed bear a higher ratio to its male counterpart in Africa, relative to the reference region.

Almost all of the missing unmarried women in Africa are at the younger ages: 91% of them are between the ages 20 and 45. From our computations of $\text{EFM}^1_e(a)$ across the regions of Africa, we see that these are mainly due to the high elevation ratios for Africa relative to the same ratio in our reference region.

Notice that the elevation ratios assumed for Africa are derived primarily from available data from North Africa. That, incidentally, is the region in Africa with the least overall excess female adult mortality. To the extent that the mortality risks that unmarried women face in the other regions of Africa are higher, our estimates of $\text{EFM}^1(a)$ for these other regions are likely underestimates.

5. UNMARRIED EXCESS FEMALE MORTALITY AND MISSING WOMEN

We are now in a position to compare our estimates of unmarried excess female mortality, $\text{EFM}^1(a)$, to *overall* estimates of overall excess female mortality, $\text{EFM}(a)$. In Table 6, we compute aggregate measures of both kinds of excess mortality by aggregating age-specific estimates of $\text{EFM}(a)$ and $\text{EFM}^1(a)$ across different age groups (20 to 64). Comparing these totals enables us to determine how much of the overall excess female mortality in developing regions can be attributed to not having a husband.

Region	EFM	EFM[1]
India	378	184
South Asia	134	60
Southeast Asia	86	82
China	242	31
West Asia	17	9
East Africa	309	119
Middle Africa	82	28
Southern Africa	69	31
West Africa	210	58
North Africa	35	19
Total	1562	622

Table 6. Unmarried Excess Female Mortality (2000, in 000s), Ages 20–64. *Sources and Notes.* Sources: U.N. World Marriage Data 2012; U.N. Demographic Yearbook 2003; U.N. World Population Prospects: The 2012 Revision.

Across Asia and Africa, there are approximately 622,000 missing unmarried women in the year 2000. This number implies that approximately 40% of the missing women of adult age can be attributed to not being married. If we break this up by age, 47% of the missing women aged 20 to 45 are due to the absence of marriage, and 31% for the older ages (45 to 65). These estimates also vary by region. In India and other parts of Asia (particularly South and Southeast Asia), approximately 50% of the missing adult women are due to not having a husband. For African regions, the estimates are somewhat smaller at around 40%, and for China only 13%.

6. Pathways

We are absolutely explicit that our analysis is fundamentally an accounting device that exposes different components of excess female mortality — unmarriage, in this particular instance — and contextualizes those components relative to overall excess mortality. That said, the analysis is incomplete without some discussion of the relevant pathways.

In the situation we study, there are three central differences between the region of interest and the reference region. The first is the usual scale effect: because our regions are poorer, they exhibit higher death rates for *both* men and women. The second difference is a corollary of these higher overall mortality rates: there is a higher incidence of "unmarriage" (via widowhood and widowerhood) in our regions of interest.[12] Finally, there is a gender bias, reflected in varying *relative* elevation ratios across women and men.

Following standard practice (for an extended discussion, see Anderson and Ray 2010), the scale effect is not included in our computation of excess unmarried female mortality. Indeed, the entire exercise presumes that the relative, age-specific death rates in the reference region *are* the "unbiased" death rates, and it is precisely the departures from those "reference rates" that generate our estimates. How appropriate is this choice? How do we know that gender-based death rates are not somehow "naturally" different at different levels of development?

This assumption is well-nigh impossible to test with available data. The best we could do is *presume* — at least for a sizable set of countries once poor, or poor countries today — that there is no gender discrimination, so that the relative rates in those countries are the "natural" relative rates. In our earlier work (Anderson and Ray 2010) we did use Latin American and Caribbean countries as an alternative reference group. Our estimates of excess female mortality for the age group 20–64 decrease by only 8%. So one might presume that the reference regions are not far off the mark to begin with.

But there is a deeper conceptual reason: the use of any reference group that does not replicate what we see in developed countries today runs the risk of burying important gender differentials under the cover of an "alternative benchmark." For instance, we could be labeling as natural and non-discriminatory the tendency for females to die *relatively more* in developing countries. We see absolutely no reason why this should be the case. In our opinion, it is far more satisfactory to presume that the "natural" relative death rates are indeed constant with development, and then to view every departure from that benchmark as *prima facie* cause for suspicion (though not as conclusive evidence).

Our focus, then, is on differences in the incidence of marriage as well as in the relative elevation ratios. As we explain in Section 2.3, our methodology allows us to disentangle these two effects.

As an application, split the age range 20–65 that we consider into two groups. Approximately 30% of the missing unmarried women are in the older group 45-65. Our computations demonstrate that

[12] It is true that the incidence of marriage is typically higher in our regions, but this is outweighed by the higher mortality rates.

excess female mortality amongst this older unmarried group is driven mainly by a high relative incidence of widowhood in the regions of interest. It may well be that this marriage incidence effect is not linked directly to gender discrimination, and is just the outcome of age/gender mortality correlations with development. Further research is needed to identify exactly the sources generating the significant excess female mortality from the absence of marriage amongst older women in parts of Asia and Africa.

The remaining 70% of the missing unmarried women are of reproductive age (between 20 and 45 years old). We have demonstrated that it is the skewed elevation ratio effect that that drives excess female mortality at these younger ages. Younger unmarried women are missing not because their death rates are elevated — that is true of the reference region as well —but because the elevation *factor* for women (compared to that for men) is relatively high in the parts of Asia and Africa we've studied. This is plausibly due to limited access to resources and health care for women in this very socially marginalized group.

That said, we want to be extremely cautious in interpreting our results as providing direct evidence of discrimination. We do not want to assert that our numbers — large though they might be — fully represent overt (or even implicit) discrimination against unmarried women. In general, there will be an entire complex of social, behavioural, and economic pathways that will need to be invoked. Our objective in this paper is simply to flag unmarriage as a factor in determining excess female mortality at older ages in a unified and comparable way across developing countries. The numbers are striking: in each year, over 620,000 unmarried women are missing.

We cannot, however, prove a *causal* link between marriage and excess unmarried female mortality. In the literature examining the relationship between marital status and mortality in developed countries, a long-standing debate attempts to disentangle the role of "marriage protection" versus "marital selection" in explaining the observed differences (Goldman 1993). Much of that literature focuses on the role of "marriage protection", i.e., the social, psychological, economic, and environmental benefits associated with having a spouse, and that help to prevent premature mortality. A competing explanation is the role of "marital selection": that healthier individuals (and those with more stable behavioral traits) are more likely to marry.

Since a randomly controlled experiment is impossible to conduct to identify the relative importance of these two explanations, researchers have typically turned to large-scale individual-level longitudinal data to establish a causal role from marriage to better health outcomes, controlling for observables most likely linked to selection into marriage. Rendall et. al. (2011) claim that these more recent analyses have led to a stronger case for the "marriage protection" hypothesis. Moreover, as there does not appear to be significant differences in mortality rates for the different categories of "unmarriage" (never married, divorced/separated, and widowed) it is difficult to argue that the particular traits systematically determining worse health outcomes could simultaneously explain selection into these different states of "unmarriage". Nonetheless, we cannot rule out the possibility of selection effects in explaining some of the excess unmarried female mortality that we find for developing countries. It is not just the binary consideration that healthy people tend to marry, unhealthy people don't, but the plausibly positive assortative marriage matching based on health. With such matching, less healthy individuals are more likely to be widows (or widowers) due to the premature death of their likewise unhealthy spouse. The skewed elevation ratio effect would then require that the marital sorting on health status in developing countries is more pronounced relative to the corresponding sorting in developed countries. Moreover, such an explanation would further require that this sorting pattern is more prevalent in India (and other parts of South Asia) compared to Africa and China.

7. Conclusions

It is well known that the absence of marriage can pose significant risks, and that such risk can and does manifest itself in higher mortality rate for the unmarried. In principle, this is true of both men and women. There is a more subtle perception that the elevation of risk is higher for women then for men, and that this *relative* elevation is particularly acute for developing countries. This is the starting point of our paper, which attempts to establish the magnitude of this problem and situate it in a larger context: the phenomenon of "missing women" or excess female mortality in developing regions.

The numbers we put on this phenomenon are quite remarkable. All told, there are approximately 1.5 million missing women between the ages of 20–64, each year. We find that more than 40% of these missing women of adult age — over 620,000 of them — can be attributed to "unmarriage," which underlines the fundamental relevance and importance of this issue. This percentage is as high as 55% in India and other regions of South Asia and 45% in Africa. Both these developing regions are characterized by high excess female adult mortality and a very low social standing for unmarried women. Further research is needed to identify exactly the sources generating the significant excess female mortality for this very marginalized group of women.

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Appendix: Data Sources

For this paper we rely on mortality data compiled by The Population Division of the United Nations (UN), who provide the most comprehensive estimates by gender and age across all countries. This division collaborates actively with other international institutions as well as academic researchers in the development of new methods for the estimation and projection of mortality.

The UN uses a variety of sources to obtain estimates of death rates. For developed countries, data on population numbers, births, and deaths come from vital registration data. For developing countries, reliable vital registration systems are generally incomplete. Indeed, almost no developing country has complete vital registration data; this holds true for most of Africa and also for India, China, and elsewhere in Asia. In the absence of complete vital registration data, the UN combines censuses and survey materials together with demographic techniques to compute their estimates. The micro-level surveys they rely on include: the Demographic Health Surveys (which cover 80% of countries in sub-Saharan Africa (as well as most developing countries in Asia), and includes child and sibling mortality information); World Fertility Surveys (a predecessor of the DHS surveys); the Multiple Indicator Cluster Surveys (collected by UNICEF); National Integrated Household Surveys (akin to the Living Standard Measurement Surveys collected by the World Bank); and numerous other country-specific household-level health related surveys. (For more details, refer to http://esa.un.org/unpd/wpp/Excel-Data/data-sources.htm.)

Using all of the available data at hand, together with estimation techniques and a set of model life tables, the UN computes estimates for mortality rates by age and gender for all developing countries. Model life tables are a demographic tool used to describe mortality rates in a given population.[13] To compute their model life tables, the UN uses reliable documented data from developing countries. As more high-quality data for less developed countries become available, the model life table parameters are re-estimated and updated. These UN Model Life Tables are meant to supplement the older Coale-Demeny Model Life Tables extracted mainly from historical European experience.

In our earlier work (Anderson and Ray 2010), because of our focus on cause of death, we relied instead on mortality data put together by the World Health Organization (WHO). In their estimates, they adjusted the UN Model Life Tables and made use of approximately two thousand additional model life tables. (Refer to descriptions from the WHO: http://www.who.int/healthinfo/paper08.pdf and http://www.who.int/healthinfo/statistics/LT_method.pdf). Murray et. al. (2003) provide a detailed description of how these life tables were computed using data from both developed and developing countries, the latter representing about a third of the sample.

The recent World Development Report (2012) employed our methodology (from Anderson and Ray 2010) to compute excess female mortality around the world for every developing country. Their estimates of mortality rates by gender and age come from both the WHO and the UN data.

The estimates of excess adult female mortality in this paper, our older paper (Anderson and Ray 2010), and the World Development Report (2013) all match up very closely, despite that different model life tables and methods were used to compute the mortality data in each case. From this standpoint, our estimates of excess female mortality appear robust to varying expert methods for computing mortality in developing countries. Nevertheless, given the numerous and necessary interpolations, as well as reliance on a variety of data sources, caution is still required when inferring comparability of mortality rates across countries. However, to the best of our knowledge, the UN and WHO country-level mortality estimates are the most comprehensive and highest quality available for our purposes.

[13]See http://www.un.org/esa/population/publications/Model_Life_Tables/Model_Life_Tables.htm.