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MISSING UNMARRIED WOMEN

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1. INTRODUCTION

It is a well established fact that in developed countries, married individuals experience lower mortality rates than their unmarried counterparts. This relative excess mortality for the unmarried occurs at all ages, for both sexes, for all ethnicities, and for all causes of death (Johnson et. al. 2000, Nagata et. al. 2003). The effect of death of a spouse on the mortality of the survivor, the "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.[1] 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). That 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

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[1]See Section 3.2.

(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.[2] Rituals of seclusion and general isolation of widows are a widespread practice in many 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, suspected witches in the family of the dead or sick are a prime focus of blame (Oppong 2006).

Given these extreme vulnerabilities faced by widows in developing countries, we expect that the excess mortality faced by the unmarried to be *relatively* more extreme for women in these regions. In this paper, we aim to provide systematic estimates of the degree of excess female mortality faced by adult unmarried women in developing regions. Our approach and methodology allow us to place our estimates in the context of the "missing women" phenomenon.

The concept of missing women, developed by Amartya Sen (1990, 1992) refers to the observation that in parts of the developing world, notably India and China, the overall ratio of women to men is suspiciously low. Sen translated these skewed sex ratios into absolute numbers by calculating the number of extra women who would have been alive (say in India or China) if these countries has the same ratio of women to men as in areas of the world in which they purportedly receive similar care. The possibility of gender bias at birth and the mistreatment of young girls are widely regarded as key explanations. Our earlier work (Anderson and Ray 2010, 2012) explicitly examined how these missing women were distributed across different age groups, regions, and cause of death. 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. Our estimates here suggest that there are approximately 1.5 million missing women of adult age (between 20 and 65) each year; this is in line with the numbers we obtain in Anderson and Ray (2010).

In this paper, we focus on adult female excess mortality between the age of 20 and 65. This is a large fraction of overall excess mortality. We ask if "unmarriage" *alone* might explain a significant proportion of this excess mortality. We consider several components. First, unmarried women are relatively more prevalent in developing countries. As one might guess, this is primarily due to spousal death: the incidence of widowhood is significantly larger at every age group in developing (relative to developed) countries. Second, unmarried women face relatively elevated mortality risk compared to their married counterparts. Third, this "elevation factor" itself varies across developing versus developed regions. However, fourth, there are widowers as well as widows, and they too are subject to elevated risks of death. So the entire analysis must turn on a comparison of different ratios, and not just the elevation factors *per se*, and we develop a methodology to separate and understand these components. On the whole, it turns out that more than 620,000 of missing

[2]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.

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 due to not having 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 old). We show that it is the relatively high mortality rates of this socially marginalized group of young unmarried women that drive this phenomenon, as opposed to the relatively high incidence of widowhood. 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 mainly to the relatively high incidence of widowhood in these developing regions.

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 been conducted. By carrying out such an exercise, our estimates place a magnitude on this problem in terms of the extreme excess mortality risk that unmarried women face.

2. METHODOLOGY

We first compute the number of missing women at adult ages. We then take into the 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.[3] 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 age-specific ratio prevailing in 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.

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.[4] 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,

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

[3]We discuss the appropriateness of using developed countries as the benchmark in Anderson and Ray (2010).

[4]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.[5] 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:

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

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 of these being excess female mortality at the pre-natal stage, or birth or 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.

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

[5]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.

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 EFM(a) = EFM$^0(a)$. But if there is elevation, then EFM$(a) >$ 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 "correction factors" for unmarried males and females that are naturally generated by the elevation factors, and by the proportions of married males and females.

If lack of marriage raises death rates, then the elevation factor $e^i(a)$ will exceed 1, which raises $c^i(a)$. Moreover, given that $e^i(a) > 1$, 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

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

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

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

There are two components in this equation. The first is what one might call the *level effect*, and is given by the term $[1 - (1/c^w(a))]\text{EFM}(a)$. Lack of marriage elevates 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; say, due to widowhood. Even if the reference death rate for women goes up entirely in proportion to that elevation (so that $\theta(a) = 1$), this will increase the total number of missing women relative to the marriage benchmark, for the absolute gap between the death rate and its reference counterpart will have widened. The second component is what might be termed the *correction factor 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.[6]) 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 degree in widowhood, the relative elevation ratio $e^w(a)/e^m(a)$

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

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:

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

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 $\text{EFM}_e^1(a)$ 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 $\text{EFM}_e^1(a)$, we focus on the ages 20 to 65.[7] 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 $\text{EFM}_e^1(a)$, 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

[7]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.

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.[8] 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.[9] For all of our variables we chose the data from the year 2000 or a year as close as possible to 2000.

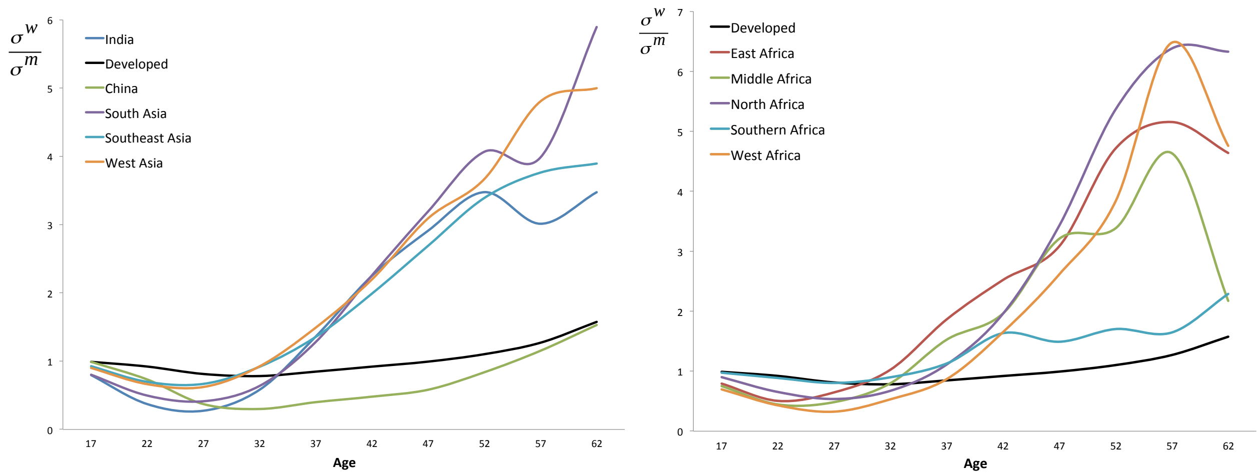
Mortality rates by age, gender, *and* marital status (needed to compute $e^w(a)$ and $e^m(a)$) are more difficult to obtain as this information is typically not collected in any regular way by national statistical agencies. The U.N. Demographic Yearbook 2003 reports this information for all of these 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.

[8]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*.

[9]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.



(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.[10] For more discussion, see Section 3.3.

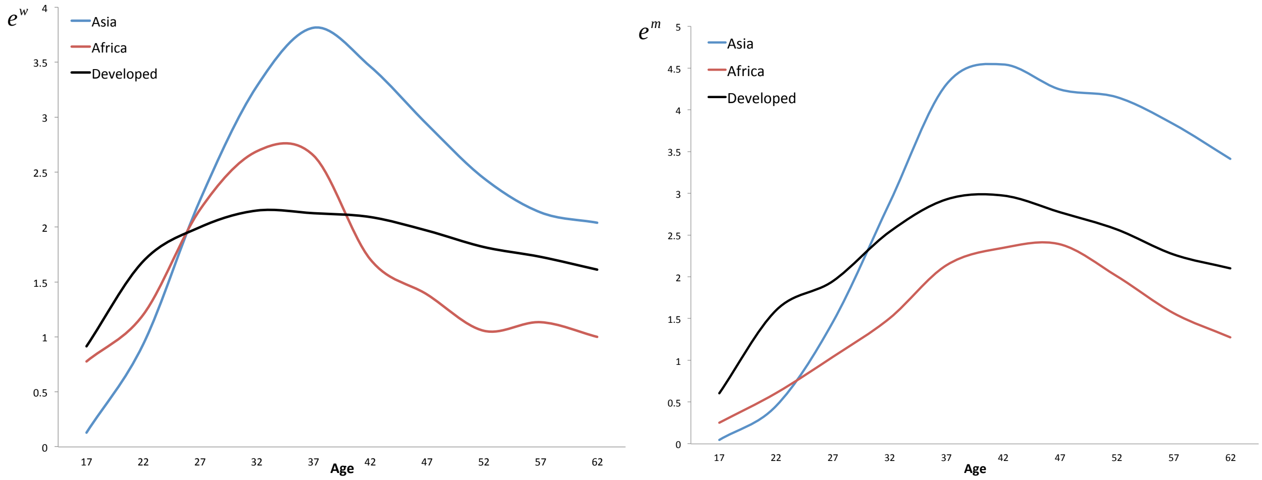
3.2. **Elevation.** The second key component in our computation of $\text{EFM}^1(a)$ are the elevation factors $e^m(a)$ and $e^w(a)$, which reflect the relative mortality rates of unmarried and married individuals by gender and age.

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.

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

[10]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.

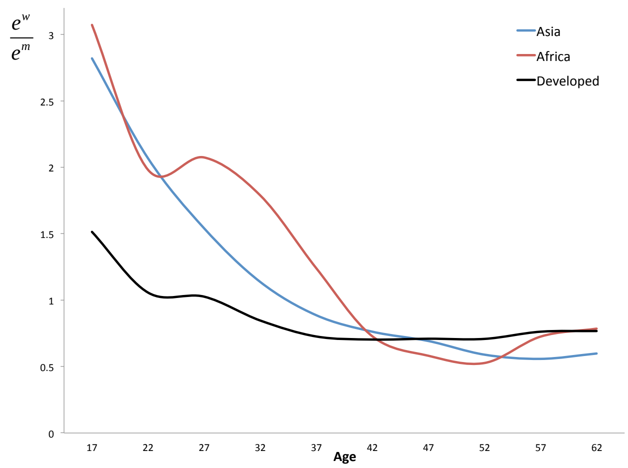
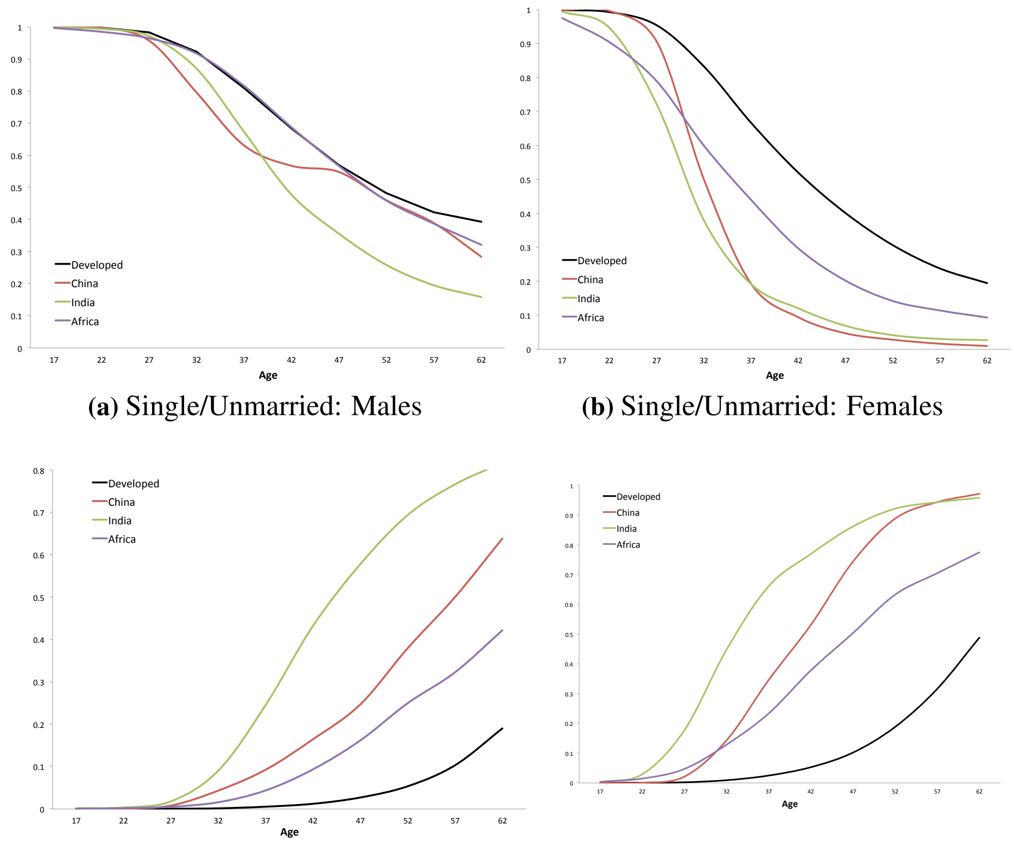


Figure 3. ELEVATION RATIOS BY AGE.

same ratio in our reference region, $\widehat{e}^w(a)/\widehat{e}^m(a)$. Figure 3 plots this elevation ratio for our different 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,



(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.

will be smaller in our regions of interest. In similar vein, because mortality rates are higher in 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.

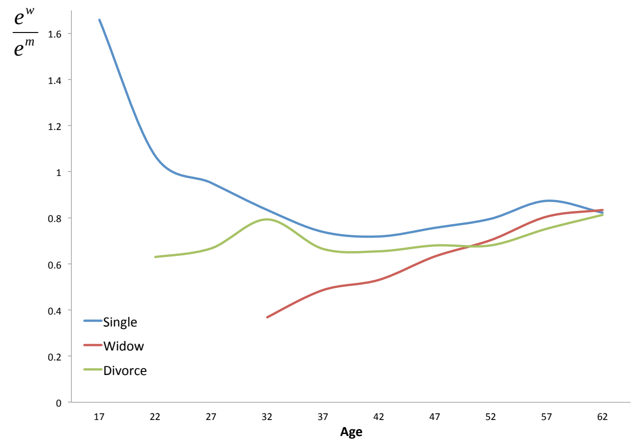


Figure 5. ELEVATION RATIOS FOR DIFFERENT UNMARRIED SUBCATEGORIES.

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 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.

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.

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.

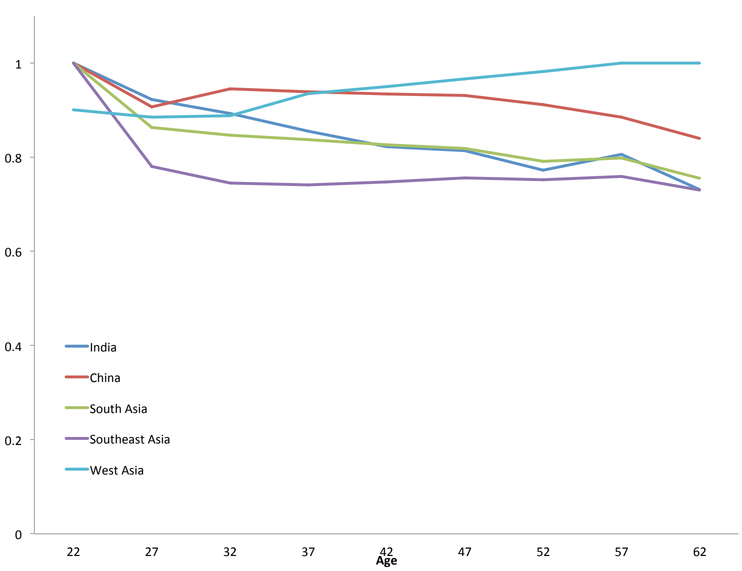


Figure 6. PROPORTION OF $\text{EFM}^1(a)$ ATTRIBUTABLE TO THE CORRECTION FACTOR EFFECT IN ASIA.

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 EFM$^1(a)$ for India are, if anything, biased downwards.

In Section 2.3, we demonstrated how EFM$^1(a)$ could be divided into two components, the level effect and the correction factor effect. In Figure 6, we plot the proportion of EFM$^1(a)$ which can be attributed to the correction factor effect for different Asian regions, including India, by age. We see that 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 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 EFM$^1(a)-$ 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% 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 correction factor effect at all ages, with a slight decrease with age. Likewise, our estimates of EFM$^1_e(a)$ 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 correction factor effect at all

Age	(1) EFM$^1(a)$	EFM$^1_e(a)$	(2) EFM$^1(a)$	EFM$^1_e(a)$	(3) EFM$^1(a)$	EFM$^1_e(a)$
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.

Age	(1) EFM$^1(a)$	EFM$^1_e(a)$	(2) EFM$^1(a)$	EFM$^1_e(a)$	(3) EFM$^1(a)$	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.

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.

ages, though this component is slightly smaller compared to other regions of Asia. Our estimates of $\text{EFM}^1_e(a)$ 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.

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.

In Figure 7, we plot the proportion of $\text{EFM}^1(a)$ which is attributable to the correction factor 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

Age	East EFM$^1(a)$	EFM$^1_e(a)$	Middle EFM$^1(a)$	EFM$^1_e(a)$	Southern EFM$^1(a)$	EFM$^1_e(a)$	West EFM$^1(a)$	EFM$^1_e(a)$	North EFM$^1(a)$	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.

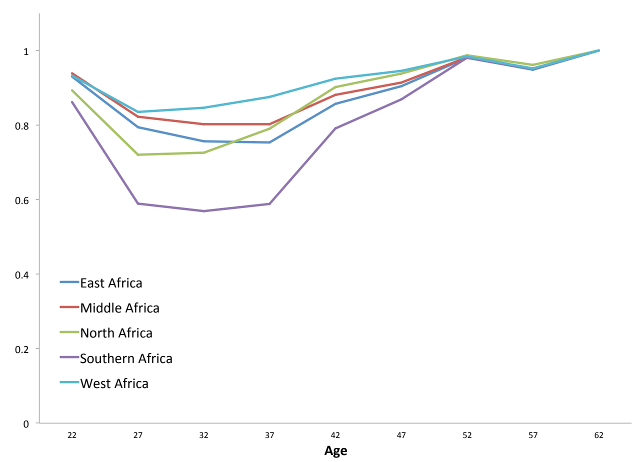


Figure 7. PROPORTION OF EFM$^1(a)$ ATTRIBUTABLE TO THE CORRECTION FACTOR EFFECT IN AFRICA.

accordance with Figure 6 in that they both demonstrate the importance of a high value of $\theta(a)$ in 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 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

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.

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.

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. Conclusions

It is well known that the absence of marriage — widowhood, in particular — can pose significant risks, and that such risk can and does manifest itself in higher mortality rate for the widowed. In principle, this is true of both men and women who are widowed. 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 problem. This percentage is as high as 55% from India and other regions of South Asia and 45% from Africa. Both these developing regions are characterized by high excess female adult mortality and a very low social standing for unmarried women.

Our methodology demonstrates that there are two central factors that drive excess female mortality from unmarriage. One is that the *ratio of elevation factors* — female to male — is higher in our region of interest, compared to a "reference region" of developed countries. The second is that the incidence of marriage is different across the two regions. Indeed the data show that the incidence of widowhood is significantly larger at every age group in developing countries compared to that in their developed counterparts.

Approximately 70% of the missing unmarried women are of reproductive age (between 20 and 45 years old). We have demonstrated that it is the relative elevation ratios which drive the phenomenon at these younger ages. That is, these younger unmarried women are missing because, relative to their married counterparts, these women die at a higher rate, relative to men, in these parts of Asia and Africa. This is most likely due to limited access to resources and health care for this very socially marginalized group.

The remaining 30% of the missing unmarried women are older (between 45 and 65). Our computations demonstrate that excess female mortality amongst this older unmarried group is driven mainly by the second key factor, that the relative incidence of widowhood is larger in these developing regions. We might consider that this factor is less likely linked directly to gender discrimination and more to do with patterns of mortality across age and gender with development. But further research is needed to identify exactly the sources generating the significant excess female mortality from the absence of marriage amongst women in parts of Asia and Africa.

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