A simple model to understand gender discrepancies in sexual behavior reports

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Abstract: Data from nine recent African Demographic and Health Surveys indicate that men report between 10 and 80% more sex partners than women do. These data also show that up to 3.6 times as many men report condom use at last sex than women do. This paper formalizes the notion that in a closed, heterosexual population without misreporting or sampling bias, the number of sex partners reported by men and women should balance and, perhaps less intuitively, that condom use reports do not have to balance. We work through several examples that highlight these points and then propose a simple equilibrium equation to investigate whether sampling bias could account for the range of gender gaps in number of partners we see in the data. Using plausible values of two key parameters – the fraction of sex workers in the population and the number of sex worker clients – we can explain the range of these gender gaps in our DHS samples. We present a related equilibrium model to show that a gender gap in condom use can persist as long as some individuals have multiple partners, some of these individuals have most recent sex with a non-regular partner and condom use differs across partner types. This is true even without misreporting or sampling bias. We again simulate the values of condom use reporting gaps using plausible parameter values and produce similar estimates to those in the DHS. Each of these modeling exercises provides a framework for thinking about adding-up constraints in the context of sexual behavior reports, and highlights the different role of that sex workers play in explaining partnership versus condom use gaps.

The gap between male and female reports of number of sex partners is a well-documented fact. Sexual behavior surveys typically find that men report upwards of 50% more partners than women (Morris 1995, Brewer et al 2000, Buller 2005).[1] In a recent New York Times article (Kolkata 2007a) mathematician David Gale argues as other researchers have done (Wiederman 1997) that in a closed population, this should not happen. It is logically impossible for heterosexual men to have a different total number of sex partners than heterosexual women.[2] However, as Table 1 indicates, across a range of African countries, men report between 10% and 80% more sex partners in the last twelve months than are reported by women, with a cross-country average of 40 % more partners for men. Restricting to the set of people who have any sex partners at all in the last year, men still report up to 70 % more partners than women. The corresponding figure for the USA (using medians and lifetime number of partners) is 75%. To explain the gap as it appears in any given data set, researchers generally appeal to some combination of sex-specific reporting bias (Gersovitz et al 1998) and under-sampling of high-activity female sex workers (Potterat et al 1990). Although there is no consensus on which explanation is more likely, the data on number of sex partners is typically mistrusted for both of these reasons.

While much work has been done to reconcile the gender gap in reporting of number of sex partners, self-reported condom use data has not been subject to the same level of scrutiny. As more recent Demographic Health Surveys (DHS) provide data on male as well as female behavior, a notable gender gap in these reported behaviors has become apparent. Table 1 indicates that in this set of African countries the proportion who report condom use at last sex is between 1.9 and 3.6 times higher for men than for women. At face value, this seems to pose the same sort of puzzle as the gender difference in average number of partners: in a closed, heterosexual population without reporting bias or sampling bias, the number of couples using condoms at last sex should surely be the same as the number of men and women reporting condom use at last sex. Since the prevalence of condom use at last sex is often used as a behavioral indicator of how well HIV-prevention policies are operating, it is important to have a sense of what may drive these gender differences in reports.[3]

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[1] Statistics on number of partners are variously reported as means, medians or totals over a 12-month period or over a lifetime.

[2] An unfortunate reference to mean number of partners by Gale, when most of the article referred to gaps in median number of partners in the U.S., does not invalidate his argument (Kolkata 2007b).

[3] See various program evaluation guidelines provided by MeasureDHS at www.measuredhs.com/hivdata/ind_tbl.cfm. The guidelines state that "A rise in this indicator is an indication that condom promotion campaigns are having an impact."

In this paper, we set out two simple models – one for number of sex partners and one for condom use at last sex – to achieve three aims. First, the models formalize which parameters are important for explaining gender gaps in reports of number of sex partners and of condom use at last sex. Second, using parameter estimates from the literature, we use the number of partners model to investigate whether sampling bias could plausibly account for all of the male/female differences. We find that contrary to Gale's intuition, neither implausibly large proportions of sex workers nor implausibly large numbers of sex-worker clients are necessary to explain this gap. Third, we show that the adding-up constraint that must hold for the number of sex partners in a closed, heterosexual population need not apply for condom use at last sex. Even without sampling or reporting bias, a gender difference in condom use at last sex will be observed as long as some individuals have more than one partner, some individuals most recently had sex with a non-regular partner, and condom use behavior differs across partner types. The analysis in this paper highlights the importance of considering adding-up constraints when investigating the validity of sexual behavior reports from both sides of the sexual market.

2. Related literature

Sex researchers in sociology, economics and public health explain male/female gaps in reported number of sex partners with a combination of sampling bias and sex-specific reporting bias related to social desirability. Typically, gender gaps are smaller when the question refers to a shorter period of time (in the last twelve months compared to lifetime partners), suggesting additional recall bias. Morris (1995) shows that a large part of the male/female discrepancy in mean number of lifetime partners is driven by the top of the partnership distribution. Excluding high-activity men who report more than 20 lifetime partners substantially reduces this gap.

Brewer et al (2000) assess the contribution of sampling bias to explaining the sex gap in partnership reports by adding estimates of high-activity females back in to the distribution and thus increasing the average number of female partners. They combine information from the U.S. General Social Surveys and the U.S. National Health and Social Life Survey to show that the male/female reporting ratio for total number of partners in the last twelve months (1.47-1.74) moves closer to 1 (0.98-1.19) after adjusting for estimates of the proportion of sex workers in the population and their average number of partners. They argue that female sex workers are more likely to be under-sampled in these surveys than male clients. Although Morris (1995) and Brewer et al (2000) make different types of data adjustments, their purpose is the same: they bring male and female reports closer together by ensuring that there are 'enough' female partners for male reports.

The bias due to under-sampling of sex workers is not universally accepted as an explanation of the gender gap. In making the argument that self-reported sex behavior is not to be trusted, Gale (Kolkata 2007a) states (without proving) that omitting sex workers is unlikely to explain much of the gender gap. Gersovitz et al (1998) provide evidence of internally-inconsistent answers for individuals within a survey and argue that misreporting is more likely to explain the gender-reporting imbalance. Wiederman (1997) shows that removing individuals who report that they lied about their behaviors in his survey shrinks the gender gap entirely and argues that men reporting large numbers of partners in "round" numbers is the main source of misreporting. Nnko et al (2004) use a census of men and women in rural Tanzania to show that even in a closed population, male and female reports of non-marital partnerships do not match. While this is evidence of reporting bias, the authors cannot establish whether men or women are misreporting more, or more often, and so cannot place reasonable bounds on the average of either male or female reports.

In contrast to this work on number of sex partners, much less work has been done on trying to understand the male/female gap in reports of condom use.[4] One study investigates macro-level discrepancies in reports of condom use by individuals and by distributors of condoms, but does not raise the issue of male/female reporting gaps (Meekers and Van Rossem 2004).[5] Since trends in condom use are often used as a measure of how well information campaigns are performing (see Foss et al 2003), it is surprising that this gender gap has not attracted more attention.

All of the approaches that try to reconcile inconsistencies in sexual behavior reports are data driven. Various adjustments are made to the data (for example: including estimates of sex workers and clients, excluding high-risk individuals, analyzing the data for heaping, eliminating inconsistent reports) to balance the total number of partners reported by men and by women. In this paper, we proceed in a different direction. We write down a set of simple equilibrium

[4] There is a well-established literature that examines differences in contraceptive-use reports between husbands and wives. See for example Becker et al (2005). In this literature, spousal disagreements in reporting are more likely for contraceptive methods that do not require both partners to participate in use (e.g. the pill), and reporting gaps are smaller for methods that involve husbands and wives (e.g. condoms).
[5] Meekers and Van Rossem (2004) treat condom use reports in the DHS as the 'demand' side of the market and try to reconcile these reported totals with administrative data on total condom sales and distribution (the 'supply' side). Using three methods of aggregating up condom use reports (using information on condom use at last sex on the previous day, condom use at last sex regardless of when that occurred, or typical condom use patterns) they calculate very different estimates of the probability of condom use. They conclude that using survey data to calculate the number of condoms actually used is unlikely to yield reliable totals.

equations for sexual behaviors that are motivated by some key adding-up constraints. These equations involve parameters for the fraction of sex workers in the population, the number of clients per sex worker and the fraction of men visiting sex workers most recently.

Our goal is to show how much of the gender gap in reports of number of sex partners could be explained by plausible values of key parameters.[6] In the process, we also highlight a third set of factors (beyond sampling bias and misreporting) that contribute to the male/female gap in reports of condom use at last sex. These factors relate to the form in which condom use data is collected. The typical indicator used to monitor trends in safe-sex practices is condom use at last sex. However, in a population in which some individuals (men and women) have multiple partners and have different condom-use practices with these partners, the last sex act for men may not refer to the same last sex act for women. Therefore, the timing of this question is important for explaining the imbalance in condom use reports between men and women.

3. Description of Demographic Health Survey data

Before turning to the models, we briefly describe the data which produce the sexual behavior reports that we are trying to understand. The Demographic Health Surveys (DHS) are nationally-representative household surveys that provide data on a range of variables related to population, health, and nutrition. We use data from nine African countries that have their most recent DHS survey round between 2002 and 2007. These surveys combine a male questionnaire with the traditional female survey instrument.[7] These surveys produce many of the statistics used by the World Health Organization and UNAIDS to monitor and evaluate country-level progress in meeting HIV-prevention and treatment targets.

One important aspect of the DHS data for this paper concerns the universe represented by the DHS samples. The samples shown in Table 1 include women aged 15-49 and a subsample of men age 15-59 who live in the household of an age-eligible woman.[8] Certain types of men are likely to be heavily under-represented in this sample – men who live with other men, men who live alone, or men who live with women who are too young or old to be part of the survey.

[6] Note that throughout, we do not consider how much misreporting accounts for these gaps. Rather, we aim to show whether plausible values of key parameters close the reporting gaps – to the extent that they do not, misreporting may close any remaining gaps.
[7] We exclude the following African countries that have had recent DHS rounds but for which (a) data is not currently available (b) data are restricted or (c) the survey is still in the field: Benin, Chad, Congo, Ethiopia, Liberia, Mali, Namibia, Senegal, Swaziland, Zimbabwe.
[8] Age-eligibility for men varied across country. In most areas, 15-59 is the relevant range. In Kenya and Malawi, the range is ages 15-54 and in Mozambique, the range is 15-64.

Analysis of 1999 census data from Kenya indicates that about 25% of all Kenyan men live in such households and would be missed by the DHS sample design. The census data indicate that these men are significantly more likely to have moved from their province of birth and to have moved in the five years prior to the census. If these men are more likely to be sexually active, have more partners, and have different condom-use practices than men who live with DHS-eligible women, estimates of sexual behaviors of men are likely to be biased when we omit these men from the sample. This is a different type of sampling bias than is usually discussed in the literature, and would most likely contribute to even higher male/female reporting ratios of number of partners and condom use at last sex. The analysis of the effect of omitting these types of men is beyond the scope of this paper, but we raise the issue since analysis of DHS data using the male sub-sample is likely to become increasingly popular as the male questionnaire is extended to cover more countries.

4. Equilibrium in mean number of sex partners

The intuition behind the sampling bias explanation of the gender gap can be explained with an elaboration on the Gale theorem provided in Kolkata (2007a). Suppose there are 100 girls who attend a prom with 100 boys. At the end of the evening we survey boys and girls about the number of partners they danced with. If each girl dances only with the partner she arrived with, then the total number of partners listed by girls is 100, the number of partners listed by boys is 100, and the mean number of partners for girls (μ_f) and boys (μ_m) will equal 1. As a second case, suppose that each girl dances with her own partner and the partner to the right of her partner. Then, each girl will report 2 different partners, each boy will report 2 different partners, and $\mu_m = \mu_f = 2$. These extreme cases seem straightforward, but the intuition does carry over to cases of heterogeneous behavior for girls and boys. Consider a third case with within-gender heterogeneity: 50 of the girls dance only with the partner they came with, while the other 50 girls dance with their original partner and one other boy. The boys' behavior is symmetric: 50 dance only with their original partner, while 50 dance with the original partner plus one other girl. The total number of partners reported by girls will be 150, and μ_f will be 1.5. The total number of partners reported by boys is also 150 and μ_m is also 1.5, making the reporting ratio equal to 1.

A more interesting case is when behavioral heterogeneity is not symmetric for boys and girls. It is possible to balance the total number of partners with a small fraction of high-activity girls, a large fraction of medium-activity boys and a large fraction of low-activity girls. Indeed, they must balance no matter how heterogeneous the behavior within or across genders. A final example makes this clear: suppose that each of the 100 girls dances once with the partner she arrived with. For the rest of the evening, 98 girls sit out and only 2 girls (the high-activity girls) continue to dance. Each high-activity girl dances with 50 different boys. At the end of the evening, each boy will have danced with 2 different girls, making a total of 200 different partners reported by boys, or $\mu_m=2$. Each girl who sat out reports 1 partner while the 2 girls who continued dancing report 51 partners each, or 102 total partners. The female total number of partners is 98+102=200, with $\mu_f=2$, the same as the mean for boys. Even in this extreme case, the male/female reporting ratio in the mean number of partners is 1. If we were unable to observe the behavior of the high-activity girls, however, then the mean number of female partners would fall to 1 and the reporting ratio would rise to 2. While we are primarily interested in what happens to the mean, it is worth noting that the median number of partners is 1 for girls and 2 for boys, even if the high activity girls are included in the sample.

Formalizing these examples with an equilibrium equation clarifies the key parameters that could drive a male/female reporting gap. Suppose there are two types of sexually active women, sex workers and wives. To simplify terminology and notation, we refer to all non-sex-worker women as 'wives' throughout. Let s be the fraction of female sex workers in the female population and (1-s) the fraction of wives in the female population. Let μ_w be the average number of sex partners in the last year reported by wives, μ_s the average number of sex partners in the last year reported by sex workers and μ_m the average number of sex partners in the last year reported by men. We assume the same number of men (M) and women (F) in a closed heterosexual population, no misreporting, and no sampling bias. Then, the total number of sex partners reported by all women must always equal the total number of sex partners reported by all men in this closed population. We can write this as an identity in terms of averages, which will be invariant to the total number of people in the population:

$$\mu_f = (1-s)\mu_w + s\mu_s = \mu_m \tag{1}$$

Let k denote the ratio of the mean number of partners reported by men to the mean number of partners reported by wives, $k=\mu_m/\mu_w$. Then the mean number of sex partners of sex workers in the population can be written as some multiple (≥1) of the number of partners of wives:

$$k\mu_w = s\mu_s + (1-s)\mu_w$$
$$\mu_s = \mu_w\left[\frac{k-(1-s)}{s}\right]$$

To correspond to the reporting gap in average number of partners presented in column (3) of Table 1, we can re-write k as:

$$k = \frac{\mu_m}{\mu_w} = 1 + s\left[\frac{\mu_s - \mu_w}{\mu_w}\right] \qquad (2)$$

Equation (2) shows that the reporting gap will be larger, the larger is the fraction of sex workers in the population, and the larger is the difference between the average number of partners of wives and of sex workers. With μ_w close to 1, the reporting ratio observed in the data is approximately $1+s\mu_s$.

Table 2 reports some of these comparative statics for the examples of the high-school prom. Even in the extreme case of 98 girls sitting out and 2 girls dancing with 51 partners each (row 1), the true male/female ratio of number of partners is 1, while the observed reporting ratio, excluding the 2 high-activity girls, is 2 (final column). These results are invariant to the size of the population (row 2).

The table highlights two additional points: first, that keeping the behavior of boys the same (rows 1-4), there are several different behaviors of girls that produce the same reporting ratio of 2: there could be a much smaller fraction of high-activity girls with more partners (row 3) or a larger fraction of these girls with fewer partner (row 4). Second, keeping the behavior of girls constant (rows 2 and 7), we can still generate the same reporting ratio with heterogeneous male behavior: in row 2, all boys had 2 partners while in row 7, half of the boys had 3 partners and the remainder had only 1.

Is the sex-worker effect negligible?

The fairly consistent reporting gap in mean number of partners across countries in Table 1 places some natural bounds on what the combination of s and μ_s might be. Could omitting reports of high-activity sex workers explain a 10% to 80% difference in reports of men and women? Gale states that “invoking women who are outside the survey population cannot begin to explain a difference of 75% in the number of partners…Something like a prostitute effect, he said, `would be negligible.’ ” (Kolkata 2007a).

In Table 3, we run through another set of simple simulations to assess this statement. To do this, we calculate k, which is a function of s and μ_s. We have two cases for μ_w: it is either equal to 0.85 (the mean number of partners reported by wives in Table 1) or to 1. We draw on a range of values for the fraction of sex workers and the mean number of clients per sex worker that have been reported in the literature, and evaluate k given these values and small deviations from these values. In doing this, we test whether plausible parameter values for s and μ_s can generate k within a range of 1.1 and 1.8, with a mean around 1.4.

Since sex workers are a challenging population to survey, estimates of these parameters are not easy to find. Potterat et al (1990) estimate the annual prevalence of full-time sex workers in the U.S. at 0.023% and Brewer et al (2000) estimate the annual number of partners of sex workers to be between 694 and 858 male partners annually for a sample drawn from a particular US site.[9] Vandepitte et al (2006) perform a meta- analysis of research estimating *s* in different regions of the world. The range of *s* is 0.7% to 4.3% in sub-Saharan Africa, with the estimate being particularly high in urban centers (e.g. 3% in Kenyan towns). Elmore-Meegan et al (2004) report an *s* of 6.9% for Kenya, and using a smaller survey of sex workers, estimate the median number of clients of female sex workers at between 4 (in rural areas) and 9 (in urban areas) per week. We turn these weekly estimates into annual estimates of between 208 and 468 partners in rural and urban areas respectively.

The first two columns of Table 3 show different values of *s* and μ_s taken from these papers. Deviations from these estimates are displayed in italics. The example using U.S. estimates in Row 1 shows that if we combine the Potterat et al. (1990) estimate that s=.0002 with the Brewer et al. (2000) estimate that μ_s=694, and if we assume that μ_w=1, then the mean number of partners reported by men must be 1.16. The intuition is that men must have 16% more partners than wives in order to produce the number of partners for sex workers implied by *s* and μ_s. If we set μ_w=0.85, the average number of sex partners reported by females in Table 1, then *k*, the ratio of men's report to women's report, must rise to 1.19. This is at the low end of the range shown in column 3 of Table 1 based on DHS data. The next two rows show that if we lowered either *s* or μ_s, *k* would have to fall. The example for Kenya in Table 3 shows that if we take the estimates from Elmore-Meegan et al. (2004) that s=0.069 and μ_s=208, the mean number of partners for men in the last year would have to be 15.28. This is far out of line with any estimates shown in Table 1, and suggests that these values for *s* and μ_s. are highly implausible for the entire population. As a reminder of how the balancing equation works, it is worth noting that if we included the sex workers in the sample of women they would raise the mean number of partners for women from 1.0 to 15.42, exactly balancing the mean for men. Changing the values of *s* and μ_s we see that we would have to lower the number of clients for sex workers to 12 in order to bring the reporting ratio below 2, given s=0.069. If we use s=.0002 from the U.S. panel and keep μ_s=208, the reporting ratio falls to 1.05.

[9] Their study estimates average annual number of partners of sex workers from a sample of individuals in Colorado Springs.

The bottom panel of Table 3 shows uses estimates of the proportion of sex workers in various countries in sub-Saharan Africa from Vandepitte et al. (2006). If we combine their estimate of s=0.004 for capital cities, and assume that $\mu_{s.}$=100, the estimated reporting ratio when μ_w=0.85 is 1.4. This is in the middle of the range of the ratios in column 3 of Table 1. If we use their estimate of s=0.007 for all urban areas, then we only need $\mu_{s.}$=50 to produce estimates of the reporting ratio that are in the middle of the range for DHS countries in Table 1.

These simple simulations suggest that sampling bias due to omission of reports of a small fraction of women who are sex workers and who have a large number of partners annually could explain the entire reported gender gap in number of sex partners. The "sex-worker" effect need not be negligible at all, and indeed appears to be a plausible candidate to explain the kind of gender gaps that we see in reports of number of partners in the last twelve months in DHS data

5. A simple model for condom use at last sex

Unlike reports on the number of sex partners in a population, reports about condom use at last sex need not balance. Here, we provide a simple extreme example and go on to formalize with another simple equation. We assume no recall bias or misreporting of condom use by men and women, and no under-sampling of any part of the population.

Suppose there are 100 men and 100 women, with half the men and women married to each other and the other half unmarried.[10] Suppose that each married woman has only one sex partner (her husband) and each unmarried man has just one partner (an unmarried woman). All married men have two partners (a wife and an unmarried woman) and all unmarried women have two partners each (an unmarried man and a married man). The average number of partners for men and women is then 1.5, and the ratio of the mean number of partners is 1.

Suppose that all married couples never use condoms ($c=0$) and any liaison involving an unmarried man or woman always involves a condom ($c=1$). Then the proportion of women reporting condom use at last sex is 0.5*(0) + 0.5*(1) = 0.5. The proportion of men reporting condom use at last sex depends on the fraction of married men that last had sex with their wives relative to sex with their unmarried female partners. For illustration, assume that half of the married men last had sex with their wives (and hence did not use condoms) and the other half last had sex with the unmarried partners (and hence did use condoms). Then, the proportion of men

[10] In this section, we refer to married and regular partners interchangeably, where regular partner includes a married spouse, a cohabiting partner, or a girlfriend/boyfriend/fiancé. A non-regular partner refers to casual acquaintances and sex-workers.

using condoms at last sex is 0.5*1 + 0.25*0 + 0.25*1 = 0.75. Even with full reporting and complete coverage of the population, more men than women report condom use, with a reporting ratio in this example of 1.5. The critical parameter that drives the difference in male and female reports is the fraction of men who last had sex with non-marital partners. Under the assumptions of this simple model, the only cases in which male and female reports would balance are (trivially) if every person has only 1 partner, if there is no variation in condom use across partner type or if all men with multiple partners last had sex with their wives.

To formalize the example, let c_w be the proportion of wives reporting condom use at last sex, c_s the proportion of sex workers using condoms at last sex, and let s continue to be the proportion of all women who are sex workers. Then, the proportion of women using a condom at last sex is:

$$c_f = (1-s)c_w + sc_s \tag{3}$$

The equation for the proportion of men who report condom use at last sex, c_m, is more complicated. It depends on the proportion of men who last had sex with a sex worker, which will be the product of the fraction of women who are sex workers, s, times the number of clients for each sex worker, μ_s, times a multiplier ρ that represents the proportion of each sex worker's clients who last had sex with her. If 0.1% of women are sex workers, each sex worker has 200 clients, and 50% of those clients last had sex with the sex worker, then [.5*.001*200]*100 = 10% of men will have last had sex with a sex worker.[11] The equation for the proportion of men who report condom use at last sex, then, is

$$c_m = (1-\rho\mu_s s)c_w + \rho\mu_s sc_s \tag{4}$$

the weighted average of the proportion of wives and sex-workers reporting condom use at last sex, where the weights capture the fraction of men who last have sex with a sex-worker or a with a wife.

An important point in comparing the expression for women in Equation (3) with the expression for men in Equation (4) is the very different role of sex workers. Sex workers only have a weight of s in Equation (3), reflecting their weight in the female population. In Equation (4) their importance gets multiplied by $\rho\mu_s$, which is the number of men who last had sex with each sex worker. Continuing with the previous example, if there are 100 men who last had sex with each sex worker (ρ=.5,μ_s=200), the impact of sex workers on average male condom use is effectively multiplied by 100. A proportion of sex workers that is relatively inconsequential in generating the weighted condom use for women becomes important enough to significantly affect

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[11] We assume that there is no overlap in the clients of sex workers. We also continue to assume that there are equal numbers of men and women.

the mean condom use of men. We can write the true ratio of male to all female reports of condom use as:

$$\frac{c_m}{c_f} = \frac{(1-\rho\mu_s s)c_w + \rho\mu_s s c_s}{(1-s)c_w + s c_s} \tag{5}$$

From this expression, we can see that even if there is no sampling bias and no reporting bias, this ratio will only be 1 if condom use is the same between partners ($c_w=c_s$) or if $\rho=1/\mu_s$. The latter case would imply, for example, that if sex workers have 200 clients, only 1/200 of those clients, which is to say one man, last had sex with the sex worker. In this case, sex workers have the same weight in men's average condom use as they have in women's average condom use.

If we assume that sex workers are not included in the sample, as was assumed in the analysis of the mean number of partners, the relevant reporting ratio is c_m/c_w, the proportion of men reporting condom use at last sex as a fraction of the proportion of wives reporting condom use at last sex. This corresponds to the proportions reported in Table 1.[12] Defining $\lambda = c_m/c_w$ and using Equation (4),

$$\lambda = \left[\frac{c_m}{c_w}\right] = 1 + \rho\mu_s s\left[\frac{c_s - c_w}{c_w}\right] \tag{6}$$

From (6), we can see that the reporting ratio is a function of the difference in condom use behavior between different types of partnerships, and is larger when ρ, μ_s, or s are larger. That is, the larger the fraction of men who last have sex with a sex worker, the larger λ will be, conditional on $c_s>c_w$. Note also that if condom use is very unlikely with wives, c_w is close to 0 and λ is likely to be very large conditional on $\rho\mu_s s$. Continuing with the example in which ρ=0.5, μ_s=200, and s=0.001 (implying that 10% of men last had sex with a sex worker), assume that c_s=0.8 and c_w=0.1. Then λ=1.8, implying that the %age of men reporting condom use at last sex is 80% higher than for women.

The DHS data illustrate why we would not expect λ=1. First, Table 1 indicates that between 4% and 31% of men and up to 7% of women report more than one partner in the last year. This means that reports about condom use at last sex by men or women with multiple partners could be different than the last sex report given by each of their multiple partners. Second, Table 4 shows clearly that condom use behavior is different across different partner types, for men and women. Men typically report higher condom use at last sex compared to

[12] As is clear from Equation (3), the difference between c_w and c_f will in practice be very small, since s is presumably small and since both c_w and c_s are bounded by 0 and 1. If c_w itself is close to small, this ratio will be very large. This is in contrast to the calculation of mean number of partners, where the mean for sex workers is presumably many times greater than the mean for other women, making their exclusion from the sample critical to the calculation of the overall mean.

women, regardless of whether the last partner was a regular or non-regular partner. For example, almost one in four men in Burkina Faso report using a condom at last sex with a regular partner while only 8% of women do; almost three-quarters of men in this country report using a condom at last sex with a non-regular partner while 42% of women do. Across countries, men and women are more likely to report condom use at last sex with a non-regular partner, compared with a regular partner. Heterogeneity in condom use behavior across partner types makes it even more likely that condom use reports at last sex for men and women do not balance.

In Table 5, we present one final set of simulations. We use plausible parameter values for s, μ_s, c_s and c_w from the literature and the DHS data to check whether we can produce estimates of λ that fall within the range [1.9, 3.6], and we do this for a high and a low value of ρ. We begin with the more conservative estimates of s (0.002) and μ_s (208) from the literature and use the cross-country average proportion of women reporting condom use at last sex Table 1 to represent c_w (0.069). This is consistent with what Foss et al (2003) find in a review of studies measuring reported condom use across the world: these studies indicate that under 7% of wives report condom use at last sex. In the same article, Foss et al (2003) report rates of condom use among sex workers in sub-Saharan African to be between 30% and 90%. We use their estimates in Table 5, letting c_s be either 0.3 or 0.9.

In the first row of the table, 75% of sex-worker clients last have sex with a sex worker. Since sex workers make up 0.2 % of the population and each have on average 208 partners, this translates into 31 % of men having last sex with a sex worker. The proportional difference in condom use behavior across sex workers and wives (3.35) is scaled up by this large fraction of men, contributing to a large value of λ=2.04. This is in the middle of the range of gender discrepancies in condom use in DHS data reported in column 9 of Table 1. λ is even larger when each sex worker has more clients (row 2) or when condom use behavior between sex workers and wives differs even more dramatically (row 3). These latter two examples produce estimates of λ that are substantially higher than we observed in the DHS data. However, when we adjust ρ downwards to 0.25 (that is, 25 % of sex-worker clients last have sex with a sex worker), then the fraction of men who have last sex with a sex worker falls to 10% and λ falls to within the range of the DHS reports.[13] With a large number of sex worker clients (row 5), λ=2.16 and when there is more heterogeneity in condom use behavior across partner types (row 6), λ=2.25.

[13] Carael et al (2006) use cross-country national household survey data to estimate the proportion of all men who are clients of sex workers. They estimate the median %age of female sex-worker clients to be between 9 and 10 %. This corresponds to rows 4 and 6 in the simulations of Table 5.

Summarizing the results in Table 5, we see that plausible assumptions about the percentage of sex workers in the population, number of clients per sex worker, and differential condom use by partner status generate gender gaps in reported condom use that are highly consistent with the gaps measured in DHS survey data. This would be true even if sex workers are included in the survey, since they would have a negligible impact on the average condom use of women.

6. Conclusions

Using recent DHS data from nine African countries, we describe the gender gap in reports of number of sex partners and condom use at last sex. These gaps are large in all countries: men report on average 40% more partners than women do, and report condom use at last sex 2.6 times more often than women. We propose two sets of equilibrium equations to describe the adding up constraints on male and female reporting behavior, in order to highlight which parameters drive gender gaps in reporting. We learn three things from this exercise: first, that under-sampling of a small fraction of female sex workers, each with a large number of clients, can account for the entire male/female reporting gap in average number of sex partners.[14] Second, that condom use at last sex reports do not have to balance across men and women in a population in which some fraction of people have multiple partners and condom use behavior differs across these partners. Third, sex workers play a different role in each of the two reported behaviors. For the number of partners equation, they raise the average number of partners for women by a small amount since they constitute only a very small fraction of the population. However, precisely because they have a large number of partners, they contribute a substantial amount to the proportion of men reporting condom use at last sex. Just how much depends on ρ, the fraction of sex worker clients who have last sex with a sex worker. Because of the multiplier effect that ρ has, we should always expect the male/female condom use gap to be larger than the male/female gap in number of sex partners, and for the former gap to persist even if female sex workers are accurately represented in national surveys.

[14] Note that throughout, we assume there is no misreporting either due to recall bias or social desirability bias. If we allow for the possibility of gender-specific misreporting, we would able to explain gaps in the number of partners with even smaller values of s and for μ_s.

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Table 1: Gaps in male/female reporting of number of sex partners and condom use at last sex

	Mean number of sex partners in past 12 months[a]			More than 1 partner in past year[b]			Condom use at last sex[c]		
	Male (1)	Female (2)	M/F (3)	Male (4)	Female (5)	M/F (6)	Male (7)	Female (8)	M/F (9)
Burkina Faso 2003	1.2	0.8	1.5	21%	1%	19.7	27%	9%	3.2
Cameroon 2004	1.7	1.0	1.8	36%	7%	5.5	30%	15%	2.0
Ghana 2003	1.0	0.8	1.3	13%	1%	10.5	18%	9%	2.1
Guinea 2005	1.3	0.8	1.7	29%	2%	12.9	17%	5%	3.6
Kenya 2003	1.1	0.9	1.2	14%	2%	6.6	17%	5%	3.0
Malawi 2004	1.0	0.9	1.2	10%	1%	11.1	15%	5%	2.9
Mozambique 2003	1.5	0.9	1.6	31%	5%	6.0	12%	6%	2.0
Nigeria 2003	1.3	0.9	1.4	19%	2%	10.6	16%	5%	3.3
Rwanda 2005	0.8	0.8	1.1	4%	0%	8.9	5%	3%	1.9
Range in male/female ratio:			[1.1,1.8]			[2.7,19.7]			[1.9,3.6]

Notes:

Statistics are calculated from raw Demographic Health Survey data. Proportions are for sample of sexually active females (ages 15-49) and males (15-59). In Malawi and Kenya, the male sample is aged 15-54, in Mozambique the male sample is 15-64.

[a.] From the question "How many partners have you had in the last 12 months?", asked of all men and women who have ever had sex.

[b] From the question "How many partners have you had in the last 12 months?". The variable 'multiple partners'=1 if a person reports two or more partners, and =0 if the person reports 0 or 1 partner.

[c] From the question "Did you use a condom the last time you had sex with this partner?" which refers to the most recent partnership. This question is asked of all men and women with at least one sex partner in the past 12 months.

Table 2: Balancing number of partner reports: illustrations from the high-school prom

		High-activity girls		Low-activity girls		All girls	High-activity boys	Low-activity boys	All boys	Male/female ratio	
	N_f=N_m	fraction *(s)*	mean partners (μ_s)	fraction *(1-s)*	mean partners	mean partners	fraction who dance with 2 partners	fraction who dance with 1 partner	mean partners	True ratio: μ_m/μ_f	Reporting ratio: k $=\mu_m/\mu_w$
Balancing equation		s *	μ_s +	$(1-s)$ *	μ_w =	μ_f			μ_m		
Homogeneous behavior for boys											
1. Baseline case	100	0.02	51	0.98	1	2	1	0	2	1	2.0
2. Larger population	1000	0.02	51	0.98	1	2	1	0	2	1	2.0
3. Fewer high-activity girls, more partners	1000	0.002	501	0.998	1	2	1	0	2	1	2.0
4. More high-activity girls, fewer partners	1000	0.1	11	0.9	1	2	1	0	2	1	2.0
Heterogeneous behavior for boys											
5. Fewer high-activity girls	1000	0.002	51	0.998	1	1.1	0.1	0.9	1.1	1	1.1
6. Fewer partners	1000	0.02	11	0.98	1	1.2	0.2	0.8	1.2	1	1.2
7. High-activity boys have 3 partner, low-activity boys have 1 partner	1000	0.02	51	0.98	1	2	0.5	0.5	2	1	2.0

Notes:

1. The reporting ratio k=1-s[(ms-mw)/mw]

2. For rows 1-4, all boys dance with 2 partners

3, For rows 5 and 6, some fraction of boys dance with 2 partners while the remainder dance with 1 partner

4. In the final row, half of the boys dance with 3 partners, and half of the boys dance with 1 partner.

Table 3: Is the sex-worker effect negligible?

Parameters from the literature	fraction of sex workers *(s)*	number of sex worker clients (μ_s)	$k = 1+s(\mu_s - \mu_w)/\mu_w$ $\mu_w = 1$	$\mu_w = 0.85$
U.S.				
Potterat et al (1990), Brewer et al (2000)	0.0002	694	1.16	1.19
suppose fewer partners	0.0002	*200*	1.04	1.05
suppose fewer sex workers	*0.0001*	694	1.07	1.08
Kenya				
Elmore-Meegan et al (2004)	0.0690	208	15.28	17.82
suppose fewer partners	0.0690	*12*	1.76	1.91
suppose fewer sex workers	*0.0002*	208	1.05	1.06
Various countries, sub-Saharan Africa				
Vandepitte et al (2006)				
capital cities	0.0040	*100*	1.40	1.47
urban areas	0.0070	*50*	1.34	1.40
high-end estimate for *s*	0.0400	*10*	1.36	1.43

Notes:

1. Numbers in plain type are taken from the cited articles.
2. Numbers in italics are hypothesized values, manipulated from reported values to test sensitivity of k.

Table 4: Male and female reported condom use by partner type

	Condom use at last sex with a regular partner?			Condom use at last sex with a non-regular partner?		
	Male (1)	Female (2)	M/F (3)	Male (4)	Female (5)	M/F (6)
Burkina Faso 2003	24%	8%	2.9	72%	42%	1.7
Cameroon 2004	27%	14%	1.9	56%	47%	1.2
Ghana 2003	16%	8%	1.9	41%	24%	1.7
Guinea 2005	16%	5%	3.5	21%	14%	1.5
Kenya 2003	13%	5%	2.5	47%	18%	2.7
Malawi 2004	14%	5%	2.7	37%	16%	2.2
Mozambique 2003	10%	6%	1.7	23%	15%	1.6
Nigeria 2003	13%	5%	2.8	46%	14%	3.4
Rwanda 2005	4%	3%	1.7	36%	31%	1.2
Range in male/female ratio:			[1.7,3.5]			[1.2,3.4]

Notes:

1. Statistics are calculated from raw Demographic Health Survey data.
Proportions are for sample of sexually active females (ages 15-49) and males (15-59).
In Malawi and Kenya, the male sample is aged 15-54, in Mozambique the male
sample is 15-64.

2. Percentages are calculated over the set of sexually-active men and women who
have had at least 1 partner in the past 12 months.

Table 5: Simulating gaps in condom use reports of men and women

	multiplier	fraction sex-workers	mean sex worker clients	weight	condom use reported by sex workers	condom use reported by wives	female condom use gap	male/wives reporting ratio: c_m/c_w
Cases	ρ	s	μ_s	$\rho * s * \mu_s$	c_s	c_w	$(c_s - c_w)/c_w$	$\lambda = 1 + s\rho\mu_s[(c_s - c_w)/c_w]$
1. High ρ	0.75	0.002	208	0.31	0.3	0.069	3.35	2.04
2. High ρ, higher μ_s	0.75	0.002	694	1.04	0.3	0.069	3.35	4.49
3. High ρ, higher c_s	0.75	0.002	208	0.31	0.9	0.069	12.04	4.76
4. Low ρ	0.25	0.002	208	0.10	0.3	0.069	3.35	1.35
5. Low ρ, higher μ_s	0.25	0.002	694	0.35	0.3	0.069	3.35	2.16
6. Low ρ, higher c_s	0.25	0.002	208	0.10	0.9	0.069	12.04	2.25

Notes:

1. The male/wife reporting ratio is the fraction of men who report condom use at last sex as a ratio of the fraction of women who report condom use at last sex, conditional on men and women who have had at least one partner in the last 12 months.