

Systematic Error in measures of induced abortion related post-abortion care in Zanzibar, Tanzania: A multiple bias analysis

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Background

In Tanzania, as in much of Sub-Saharan Africa, abortion is prohibited except in cases in which the mother's life is in danger.¹ Though rarely enforced, laws exist in Tanzania with penalties of seven years in prison for a woman attempting to induce abortion, and abortion providers can face a penalty of fourteen years in prison.² Contraceptive use in Tanzania is low; in the most recent Demographic and Health Survey in 2010, only 27% of women reported using a modern method of family planning. Unmet need for contraception is high with 25% of women in Tanzania reporting unmet need for family planning.³ According to the same DHS, in Zanzibar, a low-resource, predominantly Muslim archipelago in Tanzania, contraceptive prevalence is an even lower 12%, and unmet need for contraception is 34%.³

Without reliable access to modern methods of contraception, unintended pregnancy is common in Tanzania.¹ Despite potential legal penalties for inducing abortion, and social stigma surrounding the procedure, induced abortion is widely practiced in Tanzania, with an estimated abortion rate of 39/1000 women.^{4,5-8} Because abortion is illegal, however, most of the abortions performed in Tanzania are thought to be unsafe.⁹ The WHO defines unsafe abortion as a procedure for terminating an

unwanted pregnancy either by persons lacking the necessary skills or in an environment lacking the minimal medical standards, or both. The consequences of unsafe abortion can be severe, include hemorrhage, sepsis, chronic reproductive tract infections, infertility, and death.^{10,11} Unsafe abortion is one of the most preventable causes of maternal mortality and morbidity worldwide,¹² and yet unsafe abortion now accounts for more than half of the worlds 20 million induced abortions each year.¹³ Such high global incidence of unsafe abortion speaks to the need to understand the determinants and consequences of unsafe abortion in local and regional settings, for the creation of evidence-based policies and interventions to reduce the negative consequences of unsafe abortion. Unfortunately, valid and accurate data can be difficult to capture.

Most data on unsafe abortion in Tanzania are collected from hospital-based registries and reports of post-abortion complications identified through post-abortion care (PAC) services. PAC services are intended to provide care for women who experience complications from both induced and spontaneous abortions. Correctly attributing abortion-related complications as resulting from induced or spontaneous abortion can, however, be challenging, as complications from induced and spontaneous abortions are often clinically indistinguishable.¹⁴ Additionally, given the restrictive legal status and social stigma around abortion in Tanzania, women themselves may intentionally misclassify PAC cases resulting from induced abortion as spontaneous abortions. Facility-based data are therefore likely to underestimate the true proportion of PAC cases that result from induced abortion and overestimate those resulting from spontaneous abortion. Data collected through the use of empathic interviewing techniques designed specifically for abortion related research, however, suggests that up to 60% of women

presenting to hospitals in mainland Tanzania for post abortion care may have attempted to induce abortion.^{7,15-17}

Studies that seek to measure complications from induced abortion in settings where abortion is illegal or highly restricted ultimately seek to present valid, precise, and generalizable estimates of the underlying ‘burden of disease’. To achieve these goals, attention must be given to the potential for both random and systematic error in the data. Researchers have focused a great deal of attention on the development of accessible and interpretable methods for reporting random error, but the equally prevalent sources of systematic error (otherwise known as bias) have received far less attention. Due to the necessity (ethical or practical) of non-randomized study designs, and imperfect measurement tools, some systematic error is present in most epidemiologic studies. Techniques for the quantitative assessment of systematic error have existed for decades,¹⁸ and range from simple sensitivity analyses¹⁹ to complex Bayesian uncertainty analyses.²⁰ These techniques, known broadly as bias analysis techniques, allow researchers to identify potential sources of systematic error in their data, use published literature and expert knowledge to assign probability distributions for the magnitude of that systematic error, and draw repeated random samples from those distributions to “correct” for the error that is likely to exist in their data. The technique ultimately produces a range and distribution of probable estimates for the desired measure (e.g., point estimates, odds ratios, and risk ratios) had no bias existed in the data to begin with. Applying these techniques to examine systematic error in studies, we argue, is preferable to ignoring potential biases and presenting data we know to be flawed.

To date there are no population-level data on induced abortion in Zanzibar, and very little is known about Zanzibari young women's experiences with sexuality or contraceptive use. One recent study, however, suggests that complications from unsafe abortion in mainland Tanzania are among the top five causes of hospital admissions¹⁵. Another report estimates that unsafe abortion in Tanzania contributes upwards of 17% of maternal mortality⁴, and post abortion care has been recorded as the leading cause of admission to the gynecologic ward at Mnazi Mmoja Hospital, the sole tertiary care facility in Zanzibar.²¹

The purpose of our study was three fold: 1) to establish a “bias framework” for the identification of systematic error in hospital-based, post-abortion care data in settings where abortion is illegal; 2) to employ the bias framework to examine the reported cases of induced abortion as a proportion of all cases of post abortion care among women seeking post abortion care services at Mnazi Mmoja Hospital in Zanzibar, Tanzania; and 3) to employ multiple bias analysis techniques²⁰ to “correct” for potential selection bias and misclassification in our data and generate a range of potential values for the true proportion of induced abortion related PAC, had no bias existed.

Subjects and Methods

Setting:

Zanzibar's population of approximately 1.2 million is served by an established network of health facilities at the district and local level. The sole tertiary-level facility in Zanzibar is the Mnazi Mmoja Hospital.

Survey and Study Population:

Between July 2010 and November 2010, all women 15 years and older who presented to Mnazi Mmoja Hospital seeking care for an incomplete abortion (induced or spontaneous) between 6 a.m. and 6 p.m. Monday through Friday, were approached, after they had received care and were determined to be clinically stable, by hospital staff nurses and informed about this study. Approximately ninety percent of PAC cases arriving at Mnazi Mmoja Hospital during the study period (194 women) consented to participate and were enrolled in the study. Informed consent was given by the women themselves, and IRB approval was granted by the Johns Hopkins School of Public Health. Zanzibari field workers – trained in the empathic interview methods – conducted a one-hour interview with each participant in a private space adjacent to the gynecological ward. The 183-item Swahili-language questionnaire included questions about: basic demographic information; reproductive and contraceptive history; fertility intentions; and reproductive health decision-making.

The large majority of women seeking post abortion care at Mnazi Mmoja Hospital reported ambiguous or negative feelings (indifferent, worried, scared, bad, ashamed, miserable, sad or regretful) about the pregnancy for which they were seeking care (158 out of 194 women). It has repeatedly been shown that women who experience wanted pregnancies behave in systematically different ways towards their pregnancies than women who experience unwanted pregnancies. Including women in our sample who had positive feelings towards their pregnancies would not have yielded a valid comparison group for the abortion seeking behaviors of women with unwanted pregnancies. For the purposes of this study, we defined negative or ambiguous feelings about pregnancy as

unwanted pregnancy, and restricted the analysis to those 158 women who reported that the pregnancy for which they were seeking post-abortion care had been unwanted.

Statistical Analysis:

Bias Framework

Figure 1: Framework for identification of bias in the study of induced abortion among women with unwanted pregnancies reporting for PAC at Mnazi Mmoja Hospital

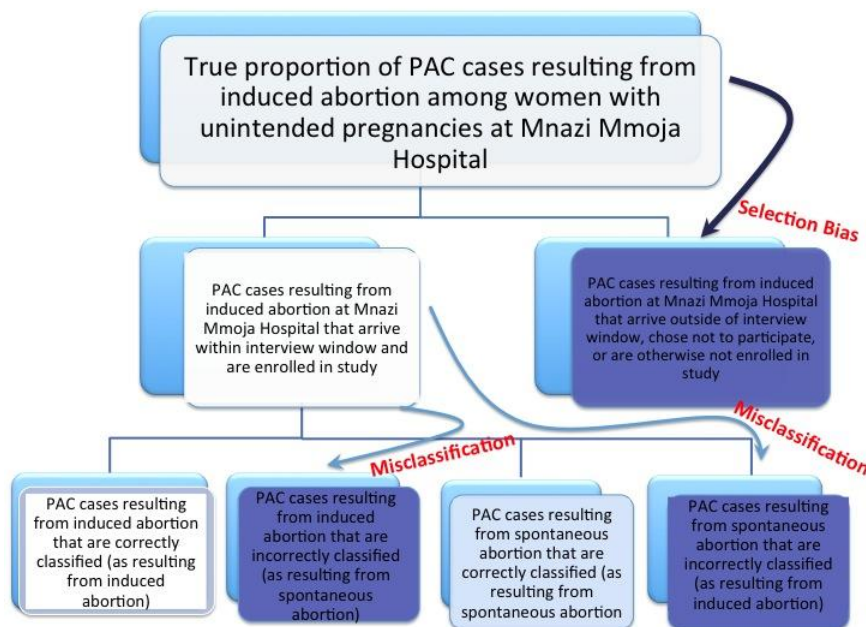


Figure 1 represents the framework for potential systematic error in our study. The target population for this study has been defined as all women arriving at Mnazi Mmoja Hospital seeking post abortion care services who reported an unwanted pregnancy. If PAC cases resulting from induced abortion are more or less likely than PAC cases resulting from spontaneous abortion to arrive at Mnazi Mmoja Hospital during the interview window (Monday-Friday 6am-6pm) than outside of the interview window, bias will arise (eg, the proportion of induced abortions among the women we interviewed

would be different from the proportion of induced abortions among all PAC cases at Mnazi Mmoja Hospital). This bias can be identified as selection bias. Another form of selection bias could occur if women who had an induced abortion arrive at the hospital seeking post abortion care, but opt not to participate in the study. If PAC cases are more or less likely to be correctly classified as resulting from induced abortion than those resulting from spontaneous abortion, bias will again arise (eg, the sensitivity and specificity of PAC classification will differ for induced and spontaneous abortions, and the proportion of PAC cases resulting from induced abortion in the study population will differ from the true proportion in the enrolled population). This bias can be identified as misclassification.

Proportion of PAC cases attributable to Induced Abortion

To determine the proportion of PAC cases that resulted from induced abortion, we divided the number of women who reported having induced abortion by the total number of women in the sample. In our survey, only 4.5% of participants (7 women) reported having induced abortion before seeking post-abortion care. The remaining 95.5% reported having experienced a spontaneous abortion. This proportion of induced abortion related PAC is likely to be a substantial underestimate of the true proportion of induced abortion related PAC, given the evidence supporting the proportion of induced abortion related PAC to be 10-60%^{6, 7, 11} in Eastern Africa and other countries where abortion is considered unsafe.

Multiple Bias Analysis of proportion of PAC cases resulting from induced abortion

Due to the high likelihood for misclassification of induced abortion related PAC, and the possibility that some selection bias may have occurred, we chose to employ probabilistic multiple bias analysis techniques to evaluate the impact of potential selection bias and misclassification. Multiple bias analysis techniques are an extension of basic sensitivity analyses^{15, 16} which allow investigators to address multiple, non-independent, threats to a study's validity in one analysis¹³. This analysis employed Monte-Carlo based, probabilistic, multiple bias-analysis techniques^{13, 14, 16-21} to evaluate the influence of selection bias and misclassification in the current study. The full methodology has been described elsewhere in detail²². Briefly, we followed an eight-step process:

1. Using recruitment and retention data from studies of post abortion care in East Africa, we modeled the range of possible values for selection probabilities for induced and spontaneous abortion related PAC using trapezoidal distributions.
2. Using data from validation studies of PAC diagnoses in Eastern Africa, we modeled the range of possible values for the sensitivity and specificity of diagnosis of induced and spontaneous abortion related PAC using trapezoidal distributions.
3. We calculated the reported proportion of PAC cases resulting from induced abortion in our study (Table 1).
4. We constructed a 95% confidence interval around the reported proportion of PAC cases resulting from induced abortion in our study (Table 1).
5. We adjusted the proportion of PAC resulting from induced abortion in the order in which the biases would have occurred.¹⁵ Given that subjects were selected into

- the study before misclassification could occur, we first adjusted for selection bias in the study using the trapezoidal distributions established in *step 1*.
6. We next used the proportion of induced abortion PAC cases that had been adjusted for selection bias as the baseline for adjustment for misclassification, and adjusted for misclassification using the trapezoidal distributions established in *step 2*.
 7. After adjusting for both sources of bias (selection bias and misclassification), and accounting for random error in the new estimate, we constructed 95% confidence intervals for the proportion of induced abortion related PAC in our study.
 8. Three iterations of trapezoidal modes were modeled for each selection probability, sensitivity, and specificity, with varying widths between the modal values (narrow, medium, and wide), to test the implications of modal value selection on the final results. Twenty-one different simulation experiments were modeled. The trapezoidal distributions used for each scenario are presented in Table 2. 50,000 Monte Carlo simulation trials were run for each simulation experiment.

All statistical analyses were conducted using R (R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>).

Results

Multiple Bias Analysis: proportion of PAC cases resulting from induced abortion

Table 1 presents the results of multiple bias analysis illustrating adjustment of selection bias, misclassification, and incorporation of random error for the proportion of induced

abortion related PAC cases in our study. The proportion of PAC resulting from induced abortion in our sample was 0.045 (95% CI: 0.01,0.08). After adjustment for selection bias alone, under three distribution scenarios, no substantial change in the median was observed (median: 0.043), and because random error was not incorporated into these estimates, the range of possible values was narrow (2.5th percentile: 0.04, 97.5th percentile: 0.05). However, after adjustment for selection bias and misclassification, the median value of the proportion of PAC resulting from unsafe abortion increased, on average, to 0.258, and the range of possible values increased substantially as well (2.5th percentile: 0.13, 97.5th percentile: 0.40). After incorporating random error in the multiple bias analysis, the median was, on average, 0.243; more than 5 times greater than the observed proportion of PAC cases resulting from induced abortion, and the range of possible values, with the incorporation of random error, increased quite dramatically (2.5th percentile: 0.20, 97.5th percentile: 0.557).

Table 1 Multiple bias analysis results: proportion of PAC cases related to induced abortion adjusted for selection bias, misclassification, and random error, after 50,000 simulation trials per scenario.

Bias Model	Scenario (probability distribution/s)	Median	2.5, 97.5 percentiles	Ratio of limits
None (conventional, with estimate of precision)	NA	0.045	0.012, 0.076	6.3
Adjusted for selection only, no random error	1 (W_1 & W_2 narrow)	0.043	0.039, 0.046	1.2
	2 (W_1 & W_2 medium)	0.042	0.039, 0.046	1.2
	3 (W_1 & W_2 wide)	0.042	0.039, 0.047	1.2
Adjusted for misclassification and selection bias, no random error	4 (W_1 & W_2 narrow, W_3 & W_4 narrow)	0.248	0.133, 0.379	2.8
	5 (W_1 & W_2 narrow, W_3 & W_4 medium)	0.256	0.136, 0.387	2.8
	6 (W_1 & W_2 narrow, W_3 & W_4 wide)	0.271	0.126, 0.412	3.2
	7 (W_1 & W_2 medium, W_3 & W_4 narrow)	0.248	0.133, 0.379	3.5
	8 (W_1 & W_2 medium, W_3 & W_4 medium)	0.256	0.134, 0.387	2.9
	9 (W_1 & W_2 medium, W_3 & W_4 wide)	0.272	0.127, 0.411	2.3
	10 (W_1 & W_2 wide, W_3 & W_4 narrow)	0.248	0.133, 0.379	2.8
	11 (W_1 & W_2 wide, W_3 & W_4 medium)	0.257	0.134, 0.388	2.9
	12 (W_1 & W_2 wide, W_3 & W_4 wide)	0.271	0.127, 0.412	3.2
	Adjusted for misclassification and selection bias, random error included	13 (W_1 & W_2 narrow, W_3 & W_4 narrow)	0.236	0.020, 0.520
14 (W_1 & W_2 narrow, W_3 & W_4 medium)		0.240	0.023, 0.530	23.0
15 (W_1 & W_2 narrow, W_3 & W_4 wide)		0.244	0.017, 0.558	32.8
16 (W_1 & W_2 medium, W_3 & W_4 narrow)		0.236	0.021, 0.519	24.7
17 (W_1 & W_2 medium, W_3 & W_4 medium)		0.239	0.023, 0.529	23.0
18 (W_1 & W_2 medium, W_3 & W_4 wide)		0.272	0.021, 0.411	19.6
19 (W_1 & W_2 wide, W_3 & W_4 narrow)		0.236	0.014, 0.519	37.1
20 (W_1 & W_2 wide, W_3 & W_4 medium)		0.239	0.023, 0.530	23.0
21 (W_1 & W_2 wide, W_3 & W_4 wide)		0.245	0.018, 0.557	30.9

W_1 : Selection probability for abortion related deaths

W_2 : Selection probability for non-abortion related deaths

W_2 : Sensitivity of cause of death classification

W_2 : Specificity of cause of death classification

Table 2 Descriptions of trapezoidal probability distributions used for multiple-bias analysis of the proportion of induced abortion related PAC cases

Scenario	W ₁ *	W ₂ *	W ₃ *	W ₄ *	RE
1	0.85, 0.93, 0.94, 1.0	0.85, 0.93, 0.94, 1.0	None	None	None
2	0.85, 0.9, 0.95, 1.0	0.85, 0.9, 0.95, 1.0	None	None	None
3	0.85, 0.87, 0.97, 1.0	0.85, 0.87, 0.97, 1.0	None	None	None
4	0.85, 0.93, 0.94, 1.0	0.85, 0.93, 0.94, 1.0	0.1, 0.14, 0.15, 0.2	0.91, 0.96, 0.97, 0.99	None
5	0.85, 0.93, 0.94, 1.0	0.85, 0.93, 0.94, 1.0	0.1, 0.12, 0.17, 0.2	0.91, 0.95, 0.97, 0.99	None
6	0.85, 0.93, 0.94, 1.0	0.85, 0.93, 0.94, 1.0	0.1, 0.11, 0.19, 0.2	0.91, 0.92, 0.98, 0.99	None
7	0.85, 0.9, 0.95, 1.0	0.85, 0.9, 0.95, 1.0	0.1, 0.14, 0.15, 0.2	0.91, 0.96, 0.97, 0.99	None
8	0.85, 0.9, 0.95, 1.0	0.85, 0.9, 0.95, 1.0	0.1, 0.12, 0.17, 0.2	0.91, 0.95, 0.97, 0.99	None
9	0.85, 0.9, 0.95, 1.0	0.85, 0.9, 0.95, 1.0	0.1, 0.11, 0.19, 0.2	0.91, 0.92, 0.98, 0.99	None
10	0.85, 0.87, 0.97, 1.0	0.85, 0.87, 0.97, 1.0	0.1, 0.14, 0.15, 0.2	0.91, 0.96, 0.97, 0.99	None
11	0.85, 0.87, 0.97, 1.0	0.85, 0.87, 0.97, 1.0	0.1, 0.12, 0.17, 0.2	0.91, 0.95, 0.97, 0.99	None
12	0.85, 0.87, 0.97, 1.0	0.85, 0.87, 0.97, 1.0	0.1, 0.11, 0.19, 0.2	0.91, 0.92, 0.98, 0.99	None
13	0.85, 0.93, 0.94, 1.0	0.85, 0.93, 0.94, 1.0	0.1, 0.14, 0.15, 0.2	0.91, 0.96, 0.97, 0.99	Standard
14	0.85, 0.93, 0.94, 1.0	0.85, 0.93, 0.94, 1.0	0.1, 0.12, 0.17, 0.2	0.91, 0.95, 0.97, 0.99	Standard
15	0.85, 0.93, 0.94, 1.0	0.85, 0.93, 0.94, 1.0	0.1, 0.11, 0.19, 0.2	0.91, 0.92, 0.98, 0.99	Standard
16	0.85, 0.9, 0.95, 1.0	0.85, 0.9, 0.95, 1.0	0.1, 0.14, 0.15, 0.2	0.91, 0.96, 0.97, 0.99	Standard
17	0.85, 0.9, 0.95, 1.0	0.85, 0.9, 0.95, 1.0	0.1, 0.12, 0.17, 0.2	0.91, 0.95, 0.97, 0.99	Standard
18	0.85, 0.9, 0.95, 1.0	0.85, 0.9, 0.95, 1.0	0.1, 0.11, 0.19, 0.2	0.91, 0.92, 0.98, 0.99	Standard
19	0.85, 0.87, 0.97, 1.0	0.85, 0.87, 0.97, 1.0	0.1, 0.14, 0.15, 0.2	0.91, 0.96, 0.97, 0.99	Standard
20	0.85, 0.87, 0.97, 1.0	0.85, 0.87, 0.97, 1.0	0.1, 0.12, 0.17, 0.2	0.91, 0.95, 0.97, 0.99	Standard
21	0.85, 0.87, 0.97, 1.0	0.85, 0.87, 0.97, 1.0	0.1, 0.11, 0.19, 0.2	0.91, 0.92, 0.98, 0.99	Standard

* Trapezoidal distribution (minimum value, mode 1 value, mode 2 value, maximum value).

W₁: Selection probability for abortion related deaths

W₂: Selection probability for non-abortion related deaths

W₂: Sensitivity of cause of death classification

W₂: Specificity of cause of death classification

RE: Random Error

Discussion

Our quantitative analysis of selection bias and misclassification in the proportion of PAC cases resulting from unsafe abortion showed substantial increases in the proportion of abortion related PAC when adjusted for biases known to be present in the data. While our results showed some sensitivity to the effects of adjustment for selection bias, the most notable increases in the proportion of PAC cases were observed after adjustment for misclassification. Given the relatively high participation rate for our study (90% of PAC cases arriving at the hospital during the study period), it is likely that selection factors were not a major source of bias in the study. However, the proportion of PAC cases that were self-reported as having resulted from induced abortion in our study (4.5%) is substantially lower than would be expected in an East African context. It is unsurprising, given the legal status and strong social and religious stigma against abortion, that women in Zanzibar would be unlikely to admit having had an abortion. Additionally, because our study population was restricted to women experiencing an unwanted pregnancy, many of whom were young and poor, their unwillingness to disclose having induced abortion may have been compounded by additional social, economic, and relationship factors. Plummer et al (2008) found that most women in mainland Tanzania who wanted to prevent pregnancy were not willing to reveal their use of contraceptives to their partners; because of the social importance of having many children, they feared their partners would oppose it.⁵ In a subsequent study by the same researchers, women who expressed a desire to terminate an unwanted pregnancy faced hostility from sexual partners, sexual exploitation from health practitioners, and broad reaching social stigma.⁶ The dramatic increase in the proportion of PAC cases resulting from induced abortion in

our study, when adjusted for misclassification, likely reflects a widespread trend of women seeing post abortion care for complications of unsafe abortion but reporting them as complications from spontaneous abortion.

It is widely acknowledged that bias is present in the current estimates of PAC cases that result from unsafe induced abortion, and the causes and consequences thereof. Little, however, is known about the extent of those biases, and to date there have been no attempts to identify the specific biases in epidemiologic terms or to quantify the role of those errors in studies of PAC and unsafe abortion. Our framework for the examination of systematic error in the proportion of PAC cases resulting from unsafe abortion among women with unintended pregnancies at Mnazi Mmoja Hospital in Zanzibar provides a structure through which authors can identify biases that exist in their studies. Even if authors cannot directly quantify the impact of those biases, such a framework allows investigators to provide some guidance for their readers in their interpretation of the studies results vis a vis the potential role those biases might play.

Limitations:

In order to adjust for selection bias and misclassification in our study, we established probability distributions (bias parameters) within which we believed the true magnitude of bias to exist. While those parameters were based on existing literature, and validation studies, where possible, it is possible that the bias parameters were too wide, too narrow, or altogether misspecified. Were the bias parameters incorrectly specified, the results of our multiple bias analyses would, themselves, be biased. However, because we have explicitly identified the parameters used (Table 2), it would be relatively simple

to recreate our analyses and test its sensitivity using a different set of parameters. While imperfect, specifying the assumptions made about the magnitude of the systematic error we believe to be present in our study is a vast improvement on the common practice of simply describing the possibility of systematic error's existence, or, worse, ignoring it.

Conclusion

In restrictive legal environments such as Tanzania, it will be increasingly important for abortion researchers to identify the potential sources of error in their data surrounding unsafe abortion, employ empathic interview techniques to attempt to minimize misclassification, and when possible, quantify systematic error. Such efforts will help to instill confidence in the results we produce, and encourage their use for true evidence based policy and program planning.

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