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Risk factors for vaginal fistula symptoms in Sub-Saharan Africa: a pooled analysis of national household survey data

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Abstract

Background: Vaginal fistula (VF) is one of the most severe maternal morbidities with the immediate consequence of chronic urinary and/or fecal incontinence. The epidemiological evidence regarding risk factors for VF is dominated by facility-based studies. Our aim is to estimate the effect size of selected risk factors for VF using population-based survey data.

Methods: We pooled all available Demographic and Health Surveys and Multiple Indicators Cluster Surveys carried out in sub-Saharan Africa that collected information on VF symptoms. Bayesian matched logistic regression models that accounted for the imperfect sensitivity and specificity of self-reports of VF symptoms were used for effect size estimation.

Results: Up to 27 surveys were pooled, including responses from 332,889 women. Being able to read decreased the odds of VF by 13% (95% Credible Intervals (CrI): 1% to 23%), while higher odds of VF symptoms were observed for women of short stature (<150 cm) (Odds Ratio (OR) = 1.31; 95% CrI: 1.02-1.68), those that had experienced intimate partner sexual violence (OR = 2.13; 95% CrI: 1.60-2.86), those that reported sexual debut before the age of 14 (OR = 1.41; 95% CrI: 1.16-1.71), and those that reported a first birth before the age of 14 (OR = 1.39; 95% CrI: 1.04-1.82). The effect of post-primary education, female genital mutilation, and having problems obtaining permission to seek health care were not statistically significant.

Conclusions: Increasing literacy, delaying age at first sex/birth, and preventing sexual violence could contribute to the elimination of obstetric fistula. Concomitant improvements in access to quality sexual and reproductive healthcare are, however, required to end fistula in sub-Saharan Africa.

Keywords: Obstetric fistula, vesicovaginal fistula, rectovaginal fistula, reproductive health, sexual health, women’s health

Background

In sub-Saharan Africa, maternal disorders are the second most important cause of death among women of reproductive age (15–49 years old) [1]. Disease burden attributable to maternal complications still remains important despite the significant declines in maternal mortality observed in this region since the mid-2000s [2, 3]. In fact, it is estimated that for every woman dying from maternal complications, another 20 women will have to withstand serious maternal morbidity [4]. Of all maternal morbidities, obstetric fistula is one of the most debilitating conditions with the immediate consequence of chronic urinary and/or fecal incontinence. Physical comorbidities, psychological distress, and social stigmatization usually follow [5–9].

The etiology of vaginal fistula (VF), an abnormal hole between the bladder (vesico-vaginal fistula) and/or rectum (recto-vaginal fistula) and the reproductive tract of a woman, is divided into two main categories: obstetric and traumatic. VF of obstetric origin are
caused by an intertwined set of biological, socio-economic, and cultural factors that favor obstructed labor and triggered by insufficient or delayed access to quality emergency obstetric care [7]. VF of traumatic origin mostly results from sexual violence. The vast majority of VF in sub-Saharan Africa are of obstetric origins and prevalence of this condition in this region was recently estimated to be between 1.0 and 1.6 per 1,000 women of reproductive age depending on methodology [10, 11].

The epidemiological evidence regarding risk factors for VF is dominated by facility-based studies [12]. The numerous clinical series usually report socio-demographic characteristics of VF patients (age of marriage, marital status, literacy, parity, etc.) as well as circumstances of fistula occurrence (duration of labor, type of birth attendance, mode and place of delivery, etc.) [13–21]. This accumulation of hospital-based studies contributed to highlight the diverse characteristics of fistula sufferers who present to facilities [12]. A few case-control studies tackle individual determinants with the aim to confirm risk factors [22–24] or develop a fistula prevention index [25]. Other studies, often qualitative, reflect on cultural or health system factors to reduce the three delays causative of obstetric fistula and maternal mortality [21, 26–28]: delay in decision to seek care, delay in reaching care, and delay in receiving adequate care once in the health facility.

Population-based studies could be less susceptible to selection bias than case series from facility and case-control studies but are rarely carried-out [11, 29]. In sub-Saharan Africa, the main sources of nationally representative health data are Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS). Since 2004, these surveys progressively began to include questions about VF symptoms. These data sources were recently used to estimate the prevalence of VF in sub-Saharan Africa [10], while adjusting for the imperfect accuracy of self-reports, but a thorough and systematic examination of individual risk factors has yet to be completed. We are aware of four population-based studies that examined determinants of VF [30–33]. These studies only included a small number of surveys, assumed that self-reports of VF symptoms were perfectly accurate, and none pooled surveys together, severely limiting their statistical power.

The primary objective of this paper is thus to examine the association between selected individual risk factors and lifetime prevalence of self-reported VF symptoms, such as literacy status, education level, female genital mutilation (FGM), sexual violence, short stature, age at first sexual intercourse, age at first birth, and women’s ability to get permission to seek health care. By pooling surveys from different countries, we hope to improve the representativeness and precision of the effect size measures for those risk factors.

Methods

Data sources

DHS and MICS surveys conducted in sub-Saharan Africa that included questions about VF symptoms were considered for this analysis. A comprehensive overview of DHS and MICS surveys can be found elsewhere [34]. Briefly, both DHS and MICS are household-based surveys that use a multistage stratified cluster sampling design to select a nationally representative sample of women of reproductive age (15-49 years old). Socio-demographic characteristics and information on selected health indicators are collected through face-to-face interviews by trained personnel and recorded in standard questionnaires. The majority of surveys administered the VF questions to all women of reproductive age but some restricted it to women that were ever married (Mauritania MICS 2011), ever pregnant (Swaziland MICS 2010 and Guinea-Bissau MICS 2010), or that had a live birth in the previous five years (Rwanda DHS 2005).

Procedures

The specific questions related to vaginal fistula symptoms varied slightly from survey to survey and a contingency question about knowledge of vaginal fistula was sometime incorporated. A full description of the VF and contingency questions (if any), their probes, and the coding of the outcome can be found elsewhere [10].

Based on previous studies and the information available from DHS/MICS surveys, we estimated the effect of the following risk factors: illiteracy, education level, whether the respondent has experienced female genital mutilation (FGM), short stature, experience of intimate partner sexual violence, young age at first sexual intercourse, young age at first birth, and women’s difficulty to get permission to access health care. Literacy status was ascertained in the surveys by asking the interviewee to read a sentence on a card that was handed out to her. If the woman was able to read only part of the sentence, she was considered not being able to read properly. Women who reported having had some secondary education or higher were de facto assumed to be literate. For genital mutilation, we did not stratify our analysis by FGM type as a validation study of the DHS FGM questions in Sierra Leone demonstrated that they were accurate to determine FGM prevalence but inaccurate for determining cutting extent [35]. Not all surveys recorded information for these risk factors and the list of countries for which such data was collected is presented in Tables 1 and 2. As for women’s anthropometric measurements, this information is not collected by MICS.
| Country, Survey, and Year | VF (N)/Literate (N) | VF (N)/Illiterate (N) | VF (N)/Post-primary (N) | VF (N)/No Post-primary (N) | VF (N)/FGM (N) | VF (N)/No FGM (N) | VF (N)/Short (N) | VF (N)/Tall (N) |
|--------------------------|---------------------|----------------------|------------------------|--------------------------|----------------|------------------|----------------|----------------|
| Benin DHS 2011-12        | 36/4182             | 91/12417             | 31/3450                | 96/13149                 | 10/1370        | 117/15229        | 12/1115        | 111/15061      |
| Burkina Faso DHS 2010    | 6/3063              | 14/13982             | 6/2201                 | 14/14854                 | 17/12884       | 3/4176           | 0/243          | 10/8202        |
| Cameroon DHS 2011        | 32/9212             | 24/6163              | 27/7148                | 29/8271                  | Not Measured   | 1/411            | 25/7473        |
| Chad MICS 2010          | 6/2334              | 34/13437             | 5/1857                 | 35/14000                 | 24/7218        | 16/8569          | Not Measured   |
| Comoros DHS 2012        | 50/2974             | 59/2319              | 49/2761                | 60/2547                  | Not Measured   | 16/590           | 92/4593        |
| Congo (Brazz.) DHS 2011-12 | 17/6740           | 10/4052              | 14/6299                | 13/4519                  | Not Measured   | 2/513            | 12/5134        |
| DRC DHS 2007            | 22/5015             | 22/4954              | 19/4107                | 25/5879                  | Not Measured   | 3/782            | 12/3949        |
| Ethiopia DHS 2005       | 21/3937             | 82/10103             | 10/2650                | 93/11405                 | 69/10012       | 32/3603          | 1/852          | 44/5798        |
| Guinea DHS 2012         | 10/1812             | 52/7306              | 10/1703                | 53/7432                  | 63/8935        | 0/194            | 4/256          | 27/4457        |
| Kenya DHS 2008-09       | 54/5809             | 24/2609              | 21/2796                | 57/5640                  | 19/2539        | 59/5891          | 5/569          | 72/7742        |
| Malawi DHS 2010         | 59/13471            | 73/9500              | 14/4289                | 118/18721                | Not Measured   | 7/1136           | 28/6496        |
| Mali DHS 2006           | 0/1809              | 18/12730             | 0/1546                 | 18/13034                 | 18/11740       | 0/2827           | 17/13808       | 17/13808       |
| Mali DHS 2012-13        | 12/1810             | 59/8614              | 9/1689                 | 62/8735                  | 69/9480        | 2/944            | 0/138          | 28/5134        |
| Mauritania DHS          | 4/3459              | 3/5537               | 2/1539                 | 5/7557                   | 4/6702         | 3/2377           | Not Measured   |
| Niger DHS 2006          | 2/1185              | 18/7985              | 1/967                  | 19/8822                  | 2/209          | 18/8952          | 0/179          | 12/4351        |
| Niger DHS 2012          | 0/1672              | 16/9432              | 0/1373                 | 16/9759                  | 1/209          | 15/10924         | 0/214          | 7/4912         |
| Nigeria DHS 2008        | 55/14345            | 86/18804             | 51/13527               | 91/19790                 | 37/8452        | 102/24709        | 20/3853        | 120/28572      |
| Rwanda DHS 2005         | 80/3041             | 84/2332              | 12/519                 | 152/4867                 | Not Measured   | 6/273            | 66/2422        |
| Senegal DHS 2010-11     | 3/3983              | 15/11705             | 1/2802                 | 17/12886                 | 11/5689        | 7/9999           | 0/126          | 8/5633         |
| Sierra Leone DHS 2013   | 23/5415             | 89/11085             | 22/5206                | 90/11337                 | 105/14773      | 6/1760           | 4/764          | 46/7185        |
| Swaziland MICS 2010    | 48/2005             | 9/395                | 36/2195                | 21/1123                  | Not Measured   | Not Measured     |
| Tanzania DHS 2010       | 32/6903             | 18/3205              | 7/2360                 | 44/7776                  | 9/1322         | 42/8807          | 13/1636        | 37/8408        |
| Togo MICS 2010         | 4/2255              | 19/4108              | 4/1744                 | 19/4631                  | 0/393          | 23/5970          | Not Measured   |
| Togo DHS 2013-2014      | 35/3579             | 58/5874              | 27/3070                | 66/6404                  | 6/602          | 87/8861          | 2/314          | 50/4517        |
| Uganda DHS 2006        | 80/3867             | 121/4606             | 27/1823                | 174/6653                 | 2/61          | 199/8403         | 11/248         | 63/2596        |
| Uganda DHS 2011        | 76/4298             | 88/4307              | 32/2509                | 132/6097                 | 7/156          | 156/8423         | 8/194          | 51/2493        |
| Zambia DHS 2013-2014   | 41/9554             | 49/6774              | 34/7386                | 57/9001                  | Not Measured   | 12/1677         | 79/14562       |

VF = Vaginal Fistula; FGM = Female genital mutilation; DHS = Demographic and Health Survey; MICS = Multiple Indicators Cluster Survey

The survey-specific total sample sizes can vary by risk factor depending on the number of missing observations and eligibility criteria.
| Country, Survey, and Year | IPSV<sup>a</sup> | Young age at 1<sup>st</sup> intercourse<sup>b</sup> | Young age at 1<sup>st</sup> birth<sup>c</sup> | Permission to seek health care |
|--------------------------|------------------|------------------|------------------|------------------|
| Benin DHS 2011-12        | Not Measured     | 17/1250          | 5/604             | 55/5797          |
| Burkina Faso DHS 2010    | 0/142            | 81/11681         | 83/11681          | 72/10802         |
| Cameroon DHS 2011         | 5/574            | 9/11148          | 3/1396            | 7/7251           |
| Chad MICS 2010           | 1/844            | 33/11283         | 5/2165            | 22/5195          |
| Comoros DHS 2012         | 2/36             | 31/3128          | 75/243            | 15/4752          |
| Congo (Brazz.) DHS 2011-12| Not Measured   | 5/1510           | 22/8405           | 12/6056          |
| DRC DHS 2007             | 7/764            | 10/2082          | 9/958             | Not Measured     |
| Ethiopia DHS 2005        | Not Measured     | 22/1892          | 72/8172           | 34/2405          |
| Guinea DHS 2012          | Not Measured     | 18/1415          | 41/6383           | 65/10049         |
| Kenya DHS 2008-09        | 18/626           | 39/4273          | 10/597            | Not Measured     |
| Malawi DHS 2010          | 7/842            | 19/4531          | 22/1904           | Not Measured     |
| Mali DHS 2006            | 0/307            | 13/8613          | 0/1554            | Not Measured     |
| Mali DHS 2012-13         | 1/378            | 19/2742          | 7/1108            | Not Measured     |
| Mauritania MICS 2011     | Not Measured     | Not Measured     | Not Measured      | Not Measured     |
| Niger DHS 2006           | Not Measured     | 2/1294           | 15/6225           | 15/6929          |
| Niger DHS 2012           | Not Measured     | 5/1160           | 10/8356           | 189/53270        |
| Nigeria DHS 2008         | 5/688            | 88/18509         | 21/3221           | Not Measured     |
| Rwanda DHS 2005          | 14/257           | 33/1822          | 0/88              | Not Measured     |
| Senegal DHS 2010-11      | Not Measured     | 4/1505           | 12/9717           | Not Measured     |
| Sierra Leone DHS 2013    | 3/248            | 39/4027          | 11/1358           | Not Measured     |
| Swaziland MICS 2010     | Not Measured     | 5/118            | 52/3198           | 57/3270          |
| Tanzania DHS 2010        | 7/695            | 25/4991          | 2/498             | Not Measured     |
| Togo MICS 2010           | Not Measured     | 1/299            | 22/5417           | 50/9899          |
| Togo DHS 2013-14         | 12/420           | 52/4949          | 6/490             | Not Measured     |
| Uganda DHS 2006          | 17/516           | 25/1225          | 32/769            | Not Measured     |
| Uganda DHS 2011          | 15/423           | 21/1271          | 22/822            | Not Measured     |
| Zambia DHS 2013-14       | 18/1502          | 53/7896          | 4/894             | Not Measured     |

VF = Vaginal Fistula; IPSV = Intimate Partner Sexual Violence; DHS = Demographic and Health Survey; MICS = Multiple Indicators Cluster Survey

<sup>a</sup>Among married and/or ever married women (or those in a union)
<sup>b</sup>Among sexually active women
<sup>c</sup>Among primi/multiparous women

The survey-specific total sample sizes can vary by risk factor depending on the number of missing observations and eligibility criteria.
surveys and the women’s height was recorded from a sub-sample of participants in most DHS surveys. Similarly, questions on domestic violence were often administered to a subsample of women, depending on the survey, and the questions about ever having experienced intimate partner sexual violence were only asked to ever married women (or those in a union). As for age at first sexual intercourse, inconsistent responses were disregarded and considered as missing (e.g., a women reporting never having had sexual intercourse but having given birth). Finally, most DHS surveys asked women if getting permission to seek health care was a problem. Those who responded that it was a big problem were considered as having limited ability to seek the care they need.

The principal threat to the internal validity of our analyses is confounding of the exposure-outcome relationship. The main potential confounders for which information was collected by the survey questionnaires are age, literacy status, location of residence (rural versus urban), gravidity status, and religion. Socio-economic status and marital status were not considered in this analysis because these variables are likely both a cause and an effect of VF. That is, due to the cross-sectional nature of data collection, we do not have information on the temporal sequence in which changes in socio-economic status or marital status occurred. Three surveys (Chad MICS 2010, Mauritania MICS 2011, and Togo MICS 2010) did not record information on gravidity status and we assumed that all nulliparous women were also nulligravid – a reasonable assumption giving the high correlation observed between these two variables. Finally, four surveys did not record information on religion and these were coded using a missing variable indicator to retain them in the analyses (Mauritania MICS 2011, Niger DHS 2012, Swaziland MICS 2010, and Tanzania DHS 2010).

Statistical analyses

To circumvent the lack of balance and overlap for some of the covariates, matching was used to make the group with the selected risk factor (i.e., exposed) as similar as possible to the group without (i.e., unexposed). By reducing model dependency through this semi-parametric data preprocessing, we aim to produce more robust inferences that are less sensitive to modeling assumptions [36]. Three of our risk factors are continuous and were dichotomized. Respondents with a height less than 150 cm, a commonly used threshold [12, 15], were defined as having a short stature. For age at first birth, visual inspection of the exposure-outcome relationship suggested that this variable could be dichotomized at less than 14 years of age at first delivery. This corresponds roughly to the 4th percentile of the distribution of age at first birth. The same threshold of less than 14 years was used to define young age at first sexual intercourse.

All country datasets were pooled together as the low number of VF cases precludes data analysis at the country level for many surveys (i.e., all cases were either exposed or unexposed in these surveys). For the selected risk factors, a nearest neighbor algorithm was used to match women on sampling weight (for sexual violence, the sampling weight from the domestic violence questionnaire was used), age (continuous), and survey identifier. For this latter variable, exact matching was used for risk factors that consistently had more unexposed than exposed observations across surveys: short stature, intimate partner sexual violence, young age at first sexual intercourse, young age at first birth, and problem obtaining permission to seek care (otherwise, nearest neighbor matching was used). The matching ratio of exposed to unexposed units varied for each risk factor and was chosen as to minimize unbalance and maximize statistical power. Matching was implemented using the ‘MatchIt’ package [37] in R. Unmatched women were excluded from the analyses.

Logistic regression models were used on the matched data to estimate the effect of the selected risk factors on lifetime prevalence of VF. Missing values for the selected risk factors and covariates were always less than 1 %, except for height (2.0 %) and age at first sexual intercourse (6.1 % of inconsistent or missing values). Observations with missing values were excluded from the analyses (with the exception of those for religion which were retained using a missing indicator). To provide for additional control of potential confounders, we adjusted for the following covariates: age (15-19, 20-29, and 30-49 years), literacy status (this covariate was not included for literacy status and education level risk factors), gravidity status (not included for age at first birth), location of residence (urban/rural), religion (Christian, Muslim, others, missing), and the survey’s country. Such analyses have been described as doubly-robust because statistically consistent inferences can be made “if either the matching analysis or the analysis model is correct (but not necessarily both)” [37]. Surveys that had a different design of surveys as our preliminary analyses have shown that clustering the standard errors had no impact on our conclusions (also discussed in [10]).

Importantly, women’s self-report of vaginal fistula symptoms do not have perfect sensitivity and specificity, as compared to the gold standard of a pelvic examination. In order to account for non-differential misclassification of the self-reported outcome, we used a latent-class Bayesian statistical model [10, 38, 39]. The underlying assumption being that all surveys have a
common sensitivity and specificity (see [10] for details). This model takes the following form:

\[
\text{Likelihood:} \\
\gamma_i \sim \text{Binomial}(\pi_i, N_i) \\
p_i = \pi_i(Se) + (1-\pi_i)(1-Sp) \\
\logit(\pi_i) = a + \beta X_i
\]

Because of our very large sample sizes and the computing-intensive nature of Bayesian calculations, we grouped observations with the same covariate patterns and used a binomial likelihood instead of the standard Bernoulli (i.e., grouped logistic regression). In this model, \( \gamma_i \) is the total number of women reporting VF symptoms with covariate pattern \( i \); \( N_i \) is the total number of women with covariate pattern \( i \); \( p_i \) is the observed probability of reporting VF symptoms, \( \pi_i \) is the true probability of women having ever had VF symptoms; \( Se \) and \( Sp \) are the sensitivity and specificity of the survey instrument, respectively; \( a \) is the model’s intercept; \( \beta \) is a vector of coefficients for the covariates included in \( X_i \). The model’s specification is completed using the following prior distributions:

Prior distributions for model parameters:

\[
\begin{align*}
\alpha &\sim \text{Normal}(0, 20) \\
\beta &\sim \text{Normal}(0, 20) \\
Se &\sim \text{Uniform}(95.10\%, 99.90\%) \\
Sp &\sim \text{Uniform}(99.85\%, 99.95\%)
\end{align*}
\]

Both \( \alpha \) and \( \beta \) are given non-informative priors that follow a normal distribution with a mean of zero and standard deviation of 20. For sensitivity and specificity, we used uniform distributions that match the 95% credible intervals of the posterior distributions of these quantities, as estimated previously [10]. Posterior distributions were obtained using Markov Chain Monte Carlo sampling, implemented in R using the ‘rstan’ package [40]. Samples are obtained using the no-U-turn sampler, a computationally efficient variant of Hamiltonian Monte Carlo [41]. Inferences were based on three chains of 30,000 samples after an initial warm-up period of 2,500 samples per chain (total of 90,000 iterations used for inferences). Convergence was examined using traceplots and ensuring that the potential scale reduction factor was equal to one. All analyses were performed using the R statistical software [42].

**Results**

**Surveys characteristics**

A total of 31 surveys collected information on VF symptoms in sub-Saharan Africa. Of these, individual data records were not available for two surveys (Equatorial Guinea DHS 2011 and Guinea-Bissau MICS 2010), and two other surveys were excluded because the incontinence questions were considered to be non-specific (Côte d’Ivoire DHS 2011-12 and Malawi DHS 2004). Hence, 27 surveys, conducted between 2005 and 2014, informed our analyses. The main characteristics of the interviewees can be found in Additional file 1: Table S1.

These 27 surveys pooled self-reports from 334,606 eligible women and 2,048 reported having ever experienced VF symptoms (742 had missing information on the outcome (0.2 %)). The specific sample size used in the regression models varied, depending on the considered risk factors, from 332,889 for literacy to 102,928 for intimate partner sexual violence (before matching). Detailed information on the risk factors and number of women reporting VF symptoms, stratified by surveys, can be found in Table 1 and Table 2. Briefly, a little over a third of women were able to read (38.6 %), a quarter had completed post-primary education (26.8 %), 42.2 % had experienced FGM, 8.7 % had a height below 150 cm, 9.0 % of ever married women had experienced intimate partner sexual violence, 11.0 % of sexually active women had their first sexual intercourse before the age of 14, 3.8 % of primi/multiparous women had their first birth before the age of 14, and 18.3 % of women reported that obtaining permission to seek health care was a big problem for them.

**Risk factors for vaginal fistula**

The sample size of the pooled datasets before and after matching are presented for each risk factors in a supplementary appendix (Additional file 1: Table S2). One-to-one matching was used for the risk factors that were most prevalent: being able to read, having a post-primary education, female genital mutilation, and degree of difficulty in obtaining permission to seek health care. For the other risk factors, the ratio was chosen as to minimize imbalances while retaining sufficient statistical power: one-to-two matching for intimate partner sexual violence, one-to-three for young age at first sexual intercourse, one-to-four for short stature, and one-to-eight for young age at first birth.

Results from the matched logistic regressions are presented in Table 3. Preliminary results from the Bayesian models for young age at 1st birth and problem getting permission to seek healthcare suggest convergence issues with the country fixed effects. Since matched logistic regressions with and without country fixed effects for these two risk factors gave very similar results (data not shown), they were omitted from the Bayesian model.

Being able to read decreased the odds of VF by 13 % (95 % Credible Intervals (CrI): 1 % to 23 %). The impact of having completed some post-primary education also reduced the odds of VF by 10 % (95 % CrI: -6 % to 24 %) but the effect did not reach statistical significance. For these two determinants, it is likely that gravidity
Table 3 Matched logistic regression results for the different risk factors for vaginal fistula symptoms

| Risk Factors                        | Bayesian matched logistic regressions adjusting for outcome misclassification | OR (95 % CrI) |
|------------------------------------|--------------------------------------------------------------------------------|----------------|
| Being able to read                 |                                                                               | 0.87 (0.77-0.99) |
| Post-primary education             |                                                                               | 0.90 (0.76-1.06) |
| Female genital mutilation          |                                                                               | 1.04 (0.82-1.30) |
| Short stature (<150 cm)            |                                                                               | 1.31 (1.02-1.68) |
| Intimate partner sexual violencea  |                                                                               | 2.13 (1.60-2.86) |
| Young age at 1st intercourse (<14 years)b |                                                                           | 1.41 (1.16-1.71) |
| Young age at 1st birth (<14 years)c |                                                                               | 1.39 (1.04-1.82) |
| Problem with permission to seek care|                                                                               | 1.20 (0.99-1.47) |

OR = Odds ratio; 95 % CI = 95 % Confidence Interval; 95 % CrI = 95 % Credible Intervals.
Statistically significant results at the alpha = 0.05 level are bolded.

The matched logistic regression models adjust for the following covariates: age, literacy status (except for ‘Being able to read’ and ‘Post-primary education’), location of residence (urban/rural), gravidity status (except for ‘Young age at 1st birth’), religion, and country (country fixed effects were omitted from the Bayesian regressions for ‘Young age at 1st birth’ and ‘Problem getting permission to seek healthcare’).

aAmong married and/or ever married women (or those in a union).
bAmong sexually active women.
cAmong primi/multiparous women.

status lies on the causal pathway between literacy/education and occurrence of VF. If that is the case, the effect size measures reported above should be interpreted as the direct effect of literacy/education on VF (i.e., the effect not mediated through gravidity). By not controlling for gravidity status, we can calculate the total effect of literacy/education. The total effect of being literate is a 20 % reduction in the odds of VF (95 % CrI: 10 % to 30 %). For post-primary education, the total effect is a 21 % reduction in the odds of VF (95 % CrI: 7 % to 34 %).

FGM had little effect on the odds of VF, after adjusting for outcome misclassification. Women with a short stature had odds of VF that were 31 % (95 % CrI: 2 % to 68 %) higher than their taller counterparts. Among the sample of ever married women (or in a union), the odds of having had VF for those that experienced intimate partner sexual violence were 2.13 times higher than those that never had (95 % CrI: 1.60-2.86). This finding was confirmed in the subsample of 13 surveys that asked all women (never married and ever/currently married) if they had ever experienced sexual violence (from anyone) with an odds ratio of 2.22 (95 % CrI: 1.72-2.90). Among sexually active women, the odds of VF for those that had sexual intercourse before the age of 14 were 41 % (95 % CrI: 16 % to 71 %) higher than those that had a sexual debut at an older age. Expanding our sample by including women that have not begun their sexually active life had little impact on this effect size estimate (odds ratio (OR) = 1.38; 95 % CrI: 1.14-1.66). Both of these findings are in line with the one from age at first birth. Indeed, having had a first live birth before the age of 14 was associated with odds of VF that were 39 % higher (95 % CrI: 1.04-1.82) than those that had their first birth at older ages. Finally, having difficulty obtaining permission to seek health care was associated with increased odds of reporting VF symptoms but this effect did not reach statistical significance (OR = 1.20; 95 % CrI: 0.99-1.47).

Discussion
Main findings
Pooling data from up to 27 population-based surveys conducted in sub-Saharan Africa, we identified the following risk factors for VF: illiteracy, short stature, sexual violence, young age at first sexual intercourse, and young age at first birth. These results corroborate findings from previous studies on the importance of some individual-level risk factors for obstetric fistulas [12, 13, 15, 43]. Short stature, early sexual debut and young age at first birth are risk factors that are related, among other things (e.g., cultural practices, women’s status, access to family planning), to a woman’s anthropometry. Women that were young at first sex/birth, with immature pelvic bones, and women of short stature have increased incidence of cephalo-pelvic disproportion, which is a known risk for obstructed labor [44]. Illiteracy has been found to significantly increase the odds of VF and its effect went beyond that mediated by gravidity status. In contrast, we found no significant direct effect of post-primary education on VF occurrence. This could be explained by the fact that literacy was objectively measured whereas the quality of primary education in sub-Saharan Africa varies widely, even within the same geographical region [45]. Alternatively, it is possible that education beyond primary school has no impact on VF incidence, suggesting that fistula sufferers are the most disadvantaged of the disadvantaged. We did not evidence any relationship between FGM and VF. The DHS/MICS questionnaire, however, did not enable us to investigate if the most severe forms of FGM, such as infibulation and gishiri cutting, are risk factors for VF. Experience of intimate partner violence had a large effect on VF occurrence, as reported previously [31]. Taken together, these results suggest that empowerment and improvement of women’s status could play a key role in reducing the burden of VF in sub-Saharan Africa.

Strengths and limitations
A number of strengths characterize this study. First, we have conducted what is believed to be the largest population-based analysis of risk factors for VF, pooling data from up to 23 countries (27 surveys) in sub-Saharan Africa. Second, we explicitly modeled uncertainty of self-
Characteristics of the study population, et al. BMC Pregnancy and Childbirth (2016) 16:82

The number of surveys included in the Table S2. fistula in sub-Saharan Africa. barriers to the prevention and elimination of obstetric risk factors such as access to health services, quality of health services, and coverage of maternal health interventions, coupled with potentially important within-country migration, prohibited us from examining the effect of a number of other risk factors have changed since the occurrence of VF symptoms. Hence, it is possible that women with VF have a higher probability of being affected by intimate partner sexual violence as VF impacts their status within marriage and community [46], for example by creating financial stress and/or affecting women’s economic productivity. Living with fistula was found to interfere with sexual activity for 85.2 % of patients in a multi-country study [18]. Some physical and psychological consequences of VF persist after repair [47] and this could influence risk of sexual violence [18]. Second, we could not exclude from our sample fistulas that were not of obstetric origins as many surveys did not record the cause of VF symptoms. Since more than 90 % of VF in sub-Saharan Africa are from obstetric origins [10, 13], inclusion of VF from other causes should have little impact on our estimated effect size measures. Third, risk factors like intimate sexual violence, the degree of difficulty of obtaining permission to seek health care, and literacy were measured at the time of interview and we assumed these to be time-invariant. This assumption could be violated if these risk factors have changed since the women’s onset of VF symptoms. Finally, the cross-sectional nature of the surveys, coupled with potentially important within-country migration, prohibited us from examining the effect of a number of other risk factors such as access to health services, quality of health services, and coverage of maternal health interventions that may ultimately represent important barriers to the prevention and elimination of obstetric fistula in sub-Saharan Africa.

Interpretation
VF embodies many of the challenges of the post-2015 agenda, and, more specifically, of the unfinished reproductive health agenda. Despite a decade of maternal health improvements [2, 3], poor access to and quality of health services is the norm in most low and middle income countries with antenatal and perinatal care being the least equitable interventions [48]. The third sustainable development goal (SDG) aims at reducing the maternal mortality ratio to less than 70 per 100,000 live birth and to ensure universal access to sexual and reproductive health-care services, including family planning [49]. The fifth goal also calls for achieving gender equality and women empowerment, with the elimination of all form of violence against women and girls and of harmful practices such as early and forced marriage [49]. Attaining these objectives could have important synergistic impacts to reduce incidence of obstetric fistula [50], but quality of care should be emphasized as poor vulnerable women are often attended by “the most disenfranchised members of the health-care system” [4]. The importance of family planning and antenatal care should also be stressed. Indeed, universal access to sexual and reproductive health is emphasized in both the third and fifth SDG. Alongside, access to comprehensive emergency obstetric care should be viewed as a form of prevention [51, 52]. Yet, our study highlighted that fistula prevention could be most effective if accompanied with enhanced efforts on education and women empowerment.

Conclusions
Our study confirms a number of important individual-level risk factors for VF, while adding precision to the effect size estimates, using population-based data from a large number of countries in sub-Saharan Africa. Increasing literacy, delaying age at first sex/birth, and preventing sexual violence could contribute to the elimination of obstetric fistula if concomitant improvements in access to quality sexual and reproductive healthcare are ensured.

Ethics approval and consent to participate
Informed consent was provided by all survey participants (or their guardian) before questionnaire administration. Further, all DHS survey protocols have been approved by the Internal Review Board of ICF International in Calverton (USA) and by the relevant country authorities for both DHS and MICS. Further information on the ethics approval can be found in the individual country reports published by DHS and MICS.

Consent for publication
Not applicable.

Availability of data and materials
Datasets containing individual-level records are in the public domain and can be obtained from The DHS Program (DHS surveys) and UNICEF (MICS surveys).

Additional file
Additional file 1: Table S1. Characteristics of the study population, stratified by survey. Table S2. Number of surveys included in the analyses, sample size in the un-matched datasets, matching ratio, and matched sample size for the selected risk factors. (DOCX 22 kb)
Abbreviations
CrI: credible intervals; DHS: Demographic and Health Survey; FGM: female genital mutilation; MICS: Multiple Indicators Cluster Survey; OR: odds ratio; SDG: Sustainable Development Goals; VF: vaginal fistula.

Competing interests
The authors declare that they have no competing interests.

Authors’ contributions
FKS developed the original research idea with contributions by SS and MMG. FKS, MMG, and NMa performed the background literature review for this paper. MMG assembled and managed the databases. MMG also performed the analyses with inputs from VF, MCC, MP and FKS. MMG wrote the manuscript with contributions by FKS and NMa. VF, NMa, SS, MCC, NMa, MP, and FKS contributed intellectual content to the paper and critically reviewed it. All authors have read and approved the final version of this manuscript.

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References
1. IHME. GBD Heatmap. 2013 [cited 2015 August 12]; Available from: http://vizhub.healthdata.org/gbd-compare/heatmap.
2. Kassebaum NJ et al. Global, regional, and national levels and causes of maternal mortality during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9497):980–1004.
3. WHO. Trends in maternal mortality: 1990 to 2013. Estimates by WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division. Geneva, Switzerland: World Health Organization; 2014. p. 56.
4. Langer, A., et al. Women and health: the key for sustainable development. Lancet. 2015;386(9999):1162–1210.
5. Wilson, S.M., et al. Psychological Symptoms Among Obstetric Fistula Patients Compared to Gynecology Outpatients in Tanzania. Int J Behav Med. 2015;22(5):605–613.
6. Siddle K et al. Psychosocial impact of obstetric fistula in women presenting for surgical care in Tanzania. Int Urogynecol J. 2013;24(7):1215–20.
7. Wall LL et al. The obstetric vesicovaginal fistula in the developing world. Obstet Gynecol Surv. 2005;60(7 Suppl 1):S53–S51.
8. Arrosmith S, Hamlin EC, Wall LL. Obstructed labor injury complex: obstetric fistula formation and the multifaceted morbidity of maternal birth trauma in the developing world. Obstet Gynecol Surv. 1996;51(9):568–74.
9. Goh JT et al. Mental health screening in women with genital tract fistulae. BJOG. 2006;112(9):1328–30.
10. Maheu-Giroux M et al. Prevalence of symptoms of vaginal fistula in 19 sub-Saharan Africa countries: a meta-analysis of national household survey data. Lancet Glob Health. 2015;3(5):e271–8.
11. Adler AJ et al. Estimating the prevalence of obstetric fistula: a systematic review and meta-analysis. BMC Pregnancy Childbirth. 2013;13:246.
12. Zheng AX, Anderson FW. Obstetric fistula in low-income countries. Int J Gynaecol Obstet. 2009;104(2):85–9.
13. Muleta M, Rasmussen S, Kiserud T. Obstetric fistula in 14,928 Ethiopian women. Acta Obstet Gynecol Scand. 2010;89(7):945–51.
14. Hawkins L et al. Characteristics and surgical success of patients presenting for repair of obstetric fistula in western Kenya. Int J Gynaecol Obstet. 2013;120(2):178–82.
15. Tebeu PM et al. Risk factors for obstetric fistula: a clinical review. Int Urogynecol J. 2012;23(4):387–94.
16. Ijaiya MA et al. Vesicovaginal fistula: a review of nigerian experience. West Afr J Med. 2010;29(5):293–8.
17. Holme A, Breen M, MacArthur C. Obstetric fistulae: a study of women managed at the Monze Mission Hospital, Zambia. BJOG. 2007;114(8):1010–7.
18. Landry E et al. Profiles and experiences of women undergoing genital fistula repair: findings from five countries. Glob Public Health. 2013;8(8):926–42.
19. Wall LL et al. The obstetric vesicovaginal fistula: characteristics of 899 patients from Jos, Nigeria. Am J Obstet Gynecol. 2004;190(4):1011–9.
20. Tahzib F. Epidemiological determinants of vesicovaginal fistula. J Obstet Gynaecol. 1983;90(3):387–91.
21. Mewlè LT et al. Waiting for attention and care: birthing accounts of women in rural Tanzania who developed obstetric fistula as an outcome of labour. BMC Pregnancy Childbirth. 2011;11:75.
22. Melah GS et al. Risk factors for obstetric fistulae in north-eastern Nigeria. J Obstet Gynaecol. 2007;27(8):819–23.
23. Roka ZG et al. Factors associated with obstetric fistula occurrence among patients attending selected hospitals in Kenya, 2010: a case control study. BMC Pregnancy Childbirth. 2013;13:56.
24. Baraèigne JK et al. Risk factors for fistula in Western Uganda: a case control study. PLoS One. 2014;9(11):e112299.
25. Browning A, Lewis A, Whiteside S. Predicting women at risk for developing obstetric fistula: a fistula index? An observational study comparison of two cohorts. BJOG. 2014;121(5):604–9.
26. Norman AM, Breen M, Richter HE. Prevention of obstetric urogenital fistulae: some thoughts on a daunting task. Int Urogynecol J Pelvic Floor Dysfunct. 2007;18(5):485–91.
27. Wall LL. Overcoming phase 1 delays: the critical component of obstetric fistula prevention programs in resource-poor countries. BMC Pregnancy Childbirth. 2012;12:68.
28. Turan JM, Johnson K, Polan ML. Experiences of women seeking medical care for obstetric fistula in Entebbe: implications for prevention, treatment, and social reintegration. Glob Public Health. 2007;2(1):64–77.
29. Cowgill KD et al. Obstetric fistula in low-resource countries: an under-valued and under-studied problem–systematic review of its incidence, prevalence, and association with stillbirth. BMC Pregnancy Childbirth. 2015;15:193.
30. Sagna M, Hoque N, Sunil T. Are some women more at risk of obstetric fistula in Uganda? Evidence from the Uganda Demographic and Health survey. Journal of Public Health in Africa. 2011;2(2):108–11.
31. Peterman A, Johnson K. Incontinence and trauma: sexual violence, female genital cutting and proxy measures of gynaecological fistula. Soc Sci Med. 2009;68(5):971–9.
32. Badgill SJ et al. A population based survey in Ethiopia using questionnaire as proxy to estimate obstetric fistula prevalence: results from demographic and health survey. Reprod Health. 2013;10:14.
33. Johnson, K. and A. Peterman, Incontinence data from the Demographic and Health surveys: comparative analysis of a proxy measure of vaginal fistula and recommendations for future population-based data collection, in DHS Analytical Studies No. 17. 2008, Macro International Inc: Calverton, MD.
34. Hancioğlu A, Arnold F. Measuring coverage in MNCH: tracking progress in MNCH and association with stillbirth. Acta Obstet Gynecol Scand. 2010;89(7):945–51.
35. Bjälkander O et al. Female genital mutilation in Sierra Leone: forms, reliability of reported status, and accuracy of related demographic and health survey questions. Obstet Gynecol Int. 2013;2013:680926.
36. Stuart EA. Matching methods for causal inference. A review and a look forward. Stat Sci. 2010;25(1):1–21.
37. Ho D et al. MatchIt: Nonparametric preprocessing for parametric causal inference. Journal of Statistical Software. 2011;42(8):1–28.
38. Maheu-Giroux M, Casapia M, Gyorros T. On the validity of self-reports and indirect reports to ascertain malarial prevalence in settings of hypoen demicity. Soc Sci Med. 2011;72(5):633–40.
39. McInturff P et al. Modelling risk when binary outcomes are subject to error. Stat Med. 2004;23(7):1095–109.
40. Stan Development Team, RStan: the R interface to Stan, Version 2.5.0. 2014. http://mc-stan.org.
41. Hoffman M, Gelman A. The no-U-turn sampler: adaptively setting path lengths in Hamiltonian Monte Carlo. J Machine Learning Res. 2014;15:1593–623.
42. R Development Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing; 2013.
43. Muleta M. Obstetric fistula in developing countries: a review article. J Obstet Gynaecol Can. 2006;28(11):962–6.
44. Neillson JP et al. Obstructed labour. Br Med Bull. 2003;67:191–204.
45. Murtin F. Improving Education Quality in South Africa. Paris, France: Organisation for Economic Co-operation and Development; 2013.
46. Mwini-Nyaledzigbor PP, Agana AA, Pilkington FB. Lived experiences of Ghanaian women with obstetric fistula. Health Care Women Int. 2013;34(6):440–60.
47. Mselle LT et al. “Hoping for a normal life again”: reintegration after fistula repair in rural Tanzania. J Obstet Gynaecol Can. 2012;34(10):927–38.
48. Barros AJ et al. Equity in maternal, newborn, and child health interventions in Countdown to 2015: a retrospective review of survey data from 54 countries. Lancet. 2012;379(9822):1225–33.
49. UN. Open Working Group proposal for Sustainable Development Goals. 2014, Open Working Group of the General Assembly on Sustainable Development Goals: http://undocs.org/A/68/970.
50. Wall LL. Preventing obstetric fistulas in low-resource countries: insights from a Haddon matrix. Obstet Gynecol Surv. 2012;67(2):111–21.
51. Higashi H et al. Surgically avertable burden of obstetric conditions in low- and middle-income regions: a modelled analysis. BJOG. 2015;122(2):228–36.
52. ICES, Vision & Priorities for the Sustainable Development Goals and the Post-2015 Development Agenda - Women’s Equity and Essential Surgery Recommendations for Action. 2014, The International Collaboration for Essential Surgery. p. 3.