PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	Determinants of imbalanced sex ratio at birth in Nepal: evidence from secondary analysis of a large hospital-based study, and a nationally representative survey data
AUTHORS	Pradhan, Elina; Pearson, Erin; Puri, Mahesh; Maharjan, Manju; Maharjan, Dev; Shah, Iqbal

VERSION 1 – REVIEW

REVIEWER	Reviewer name: Duong Minh Duc Institution and Country: Hanoi University of Public Health Competing interests: No
REVIEW RETURNED	13-Jul-2018

GENERAL COMMENTS	The paper is well written with novel methods. However, Table 2 with step-wise methods should be explain in more details since it is very difficult to follow the process and understand this table from what is now written in Methods section.

REVIEWER	Reviewer name: Dr Gwinyai Masukume Institution and Country: The Irish Centre for Fetal and Neonatal Translational. Research, Department of Obstetrics and. Gynaecology, University College Cork, Cork T12 YE02,Ireland Competing interests: None declared
REVIEW RETURNED	22-Jul-2018

GENERAL COMMENTS	Thank you for the opportunity you have afforded me to peer review this very interesting manuscript. Strong evidence for selective abortion of female fetuses, facilitated by the use of antenatal ultrasound sex determination, in Nepal is provided. The authors employ robust statistical analyses to arrive at this conclusion. Their contribution is very valuable and timely. Please find herein some comments and suggestions related mainly to domain specific aspects of sex ratios at birth that can help to refine the statistical analysis and interpretation of their data. Page 1, Line 8, Title I would suggest that the authors avoid using the abbreviation RCT in the title. The hospital-based sample was obtained from a primary study that was a cluster-randomised stepped-wedge trial. Using the term RCT solely in my view incorrectly creates the notion that the unit of randomisation was the individual. Perhaps the article's title should speak to the design of this secondary study, in keeping with the Strengthening the reporting of observational studies in epidemiology (STROBE) statement provided.

	Page 2, Line 19 and 26 I suggest a consistent numbering style, for example, one finds 75428 and 75,428. The background and/or discussion could be enhanced by migrant study data which further supports this paper's main conclusion. For example son preference persists in some Asian migrant communities in Canada. The following study, using a related methodology to the authors', finds evidence of sex-selective abortion of female fetuses resulting in skewed secondary sex ratios. Urquia ML, Moineddin R, Jha P, et al. Sex ratios at birth after induced abortion. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne 2016;188(9):E181-90. https://www.ncbi.nlm.nih.gov/pubmed/27067818 I draw attention to a contemporary review on the subject of gendercide which has valuable nuggets that would bolster this manuscript and would also be worthwhile citing: Grech V. Gendercide and femineglect. Early human development 2015;91(12):851-4. https://www.ncbi.nlm.nih.gov/pubmed/26542255 In April 2015 there was a devastating earthquake which struck Nepal and was accompanied by major aftershocks https://en.wikipedia.org/wiki/April_2015_Nepal_earthquake. Recruitment of some of the participants in this study occurred in 2015. Now, earthquakes in their aftermath have been found to perturb sex ratios at birth significantly: Fukuda M, Fukuda K, Mason S, et al. The sex ratio at birth after recent major earthquakes in Japan. Early human development 2018. https://www.ncbi.nlm.nih.gov/pubmed/29958723 How was the 2015 earthquake factored into the analysis? At a minimum I would suggest that the authors discuss the potential implications of the 2015 Nepal earthquake on their analysis and results. A concept not touched on is the Trivers-Willard effect which is relevant to this paper. Women in a relatively good health condition e.g. nutritionally replete, tend to have proportionately more male offspring, in short a comparatively higher sex ratio at birth. Cameron EZ, Dalerum F. A Trivers-Willard effect in contemporary humans: male-biased sex ratios among billionaires. PLoS One 2009;4(1):e4195. https://www.ncbi.nlm.nih.gov/pubmed/19142225 From the Nepal 2011 Demographic and Health Survey (DHS) page 125, Table 9.5 https://dhsprogram.com/pubs/pdf/FR257/FR257[13April2012].pdf women in the highest wealth quintiles (likely with the best nutritional status, etc.) were the most likely to deliver in a health facility (where the hospital-based sample was recruited from). It thus seems possible, in addition, to sex-selective abortion that these women had an inherent tendency to have more live male births than the rest of the female Nepalese population of reproductive age. Now, in Nepal "57% of deliveries take place in a health facility" DHS 2016 page 151

	https://www.dhsprogram.com/pubs/pdf/fr336/fr336.pdf. Please may the authors mention the proportion of women that deliver in a health facility in Nepal so that the reader can appreciate, to a better extent, the degree of selection in their sample? I suggest consistent use of abbreviations e.g. there is both DHS and NDHS. I recommend disambiguation of an abbreviation at first use and then use of the abbreviation from then onwards.

REVIEWER	Reviewer name: Sanjay K Mohanty Institution and Country: International Institute for Population Sciences, Mumbai, India Competing interests: None delared
REVIEW RETURNED	09-Aug-2018

GENERAL COMMENTS	This is an interesting manuscript and can contribute to literature. The increasing SRB is in many Asian countries including Nepal and India. It is associated with falling fertility, increasing use of health services and more prevalent among educated and economically better of households. These results are amply clear from the analyses. I have few minor sugegstions 1. Appendix Table 1 is confusing. It need to be written differently for each of the variable. For example, it would be better to present in terms of percentage of birth, educational attainment in % etc than descriptive 2. Table 1, if possible give estimates of SRB (unadjusted at the beginning , an additional column) 3. Would be better to present the graphs to a single table and estimating the SRB. This can be done for last five years, 5-10 years to see how these are changing 4. From census or DHS, a graph depicting child sex ratio and sex ratio at birth may be presented (these data are usually available for last 20 years in interval of time) 5. A descriptive statistics on number of births, sex and other features from each hospital may be presented 6. Policy implication need to be improved. What is present law in Nepal? For example in india, sex identification is strictly prohibited and it intact has been implemented

VERSION 1 – AUTHOR RESPONSE

Reviewer: 1

Reviewer Name: Duong Minh Duc
Institution and Country: Hanoi University of Public Health
Please state any competing interests or state ‘None declared’: No
Please leave your comments for the authors below

2. The paper is well written with novel methods. However, Table 2 with step-wise methods should be explain in more details since it is very difficult to follow the process and understand this table from what is now written in Methods section.

Authors’ response: Thank you very much! We have adjusted the methods section describing this process as below:

Finally, we perform stepwise linear regression using NDHS data to understand whether boys born in the last five years were more likely to be delivered in hospitals, adjusting for women's socio-demographic characteristics (equation (4)). This stepwise method adds each of the potentially relevant socioeconomic variables such as woman's education, parity, age and household wealth tertile (X_i) to the model in addition to male child as explanatory variables, and could allow us to identify any models where male births were significantly related to hospital-based deliveries. We could potentially assert the dominance of female foeticide as the primary season behind skewed SRBs if we did not find a significant relationship between hospital-based deliveries and male births in these models.

$$hospital - based\ delivery_i = \alpha + \beta male\_child_i + \gamma X_i + \epsilon_i \quad — \quad (4)$$

Reviewer: 2

Reviewer Name: Dr Gwinyai Masukume
Institution and Country: The Irish Centre for Fetal and Neonatal Translational
Research, Department of Obstetrics and
Gynaecology, University College Cork, Cork T12 YE02,
Ireland
Please state any competing interests or state 'None declared': None declared
Please leave your comments for the authors below

3. Thank you for the opportunity you have afforded me to peer review this very interesting manuscript. Strong evidence for selective abortion of female fetuses, facilitated by the use of antenatal ultrasound sex determination, in Nepal is provided. The authors employ robust statistical analyses to arrive at this conclusion. Their contribution is very valuable and timely.

Authors' response: Thank you!

Please find herein some comments and suggestions related mainly to domain specific aspects of sex ratios at birth that can help to refine the statistical analysis and interpretation of their data.

Page 1, Line 8, Title
4. I would suggest that the authors avoid using the abbreviation RCT in the title.
The hospital-based sample was obtained from a primary study that was a cluster-randomised stepped-wedge trial. Using the term RCT solely in my view incorrectly creates the notion that the unit of randomisation was the individual. Perhaps the article's title should speak to the design of this secondary study, in keeping with the Strengthening the reporting of observational studies in epidemiology (STROBE) statement provided.

Authors' response: Thank you, and understood. We agree—the RCT is not central to the analysis of this study, and we have modified the title as below:

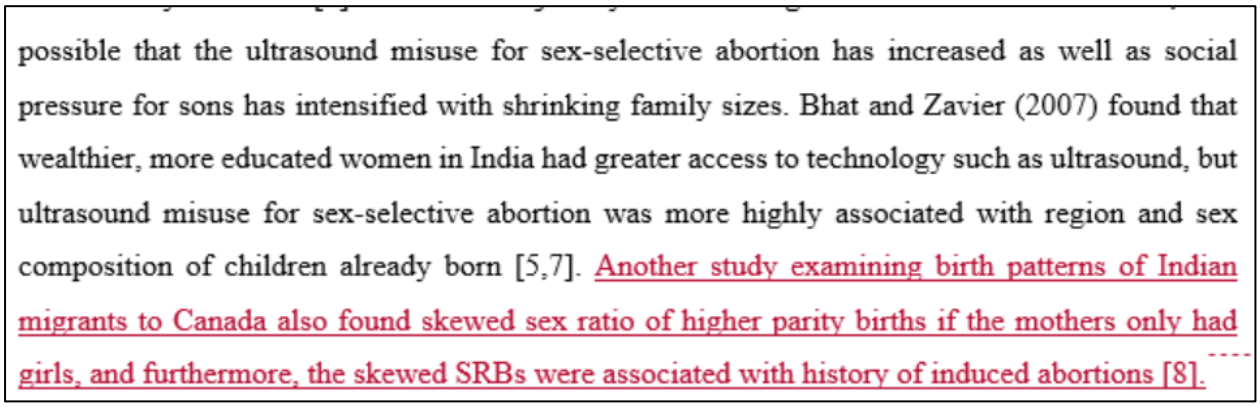
Determinants of imbalanced sex ratio at birth in Nepal: evidence from secondary analysis of a large hospital-based ~~RCT~~study, and a nationally representative survey data

5. Page 2, Line 19 and 26
I suggest a consistent numbering style, for example, one finds 75428 and 75,428.

Authors' response: Thank you—modified accordingly!

6. The background and/or discussion could be enhanced by migrant study data which further supports this paper's main conclusion. For example son preference persists in some Asian migrant communities in Canada. The following study, using a related methodology to the authors', finds evidence of sex-selective abortion of female fetuses resulting in skewed secondary sex ratios.
Urquia ML, Moineddin R, Jha P, et al. Sex ratios at birth after induced abortion. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne 2016;188(9):E181-90. https://www.ncbi.nlm.nih.gov/pubmed/27067818

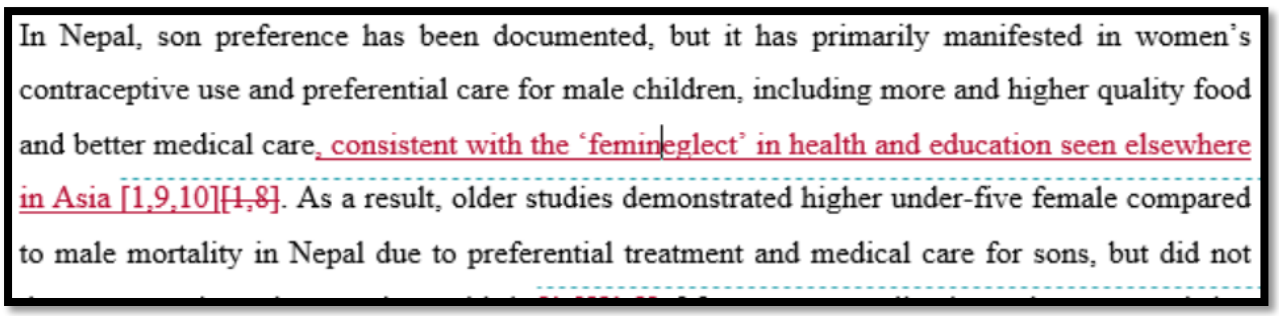
Authors' response: Thank you for the reference—we have modified our background section to include this very relevant study!



possible that the ultrasound misuse for sex-selective abortion has increased as well as social pressure for sons has intensified with shrinking family sizes. Bhat and Zavier (2007) found that wealthier, more educated women in India had greater access to technology such as ultrasound, but ultrasound misuse for sex-selective abortion was more highly associated with region and sex composition of children already born [5,7]. Another study examining birth patterns of Indian migrants to Canada also found skewed sex ratio of higher parity births if the mothers only had girls, and furthermore, the skewed SRBs were associated with history of induced abortions [8].

7. I draw attention to a contemporary review on the subject of gendercide which has valuable nuggets that would bolster this manuscript and would also be worthwhile citing:
Grech V. Gendercide and femineglect. Early human development 2015;91(12):851-4. https://www.ncbi.nlm.nih.gov/pubmed/26542255

Authors' response: Thank you! This is another useful reference that we have added to the paper.



In Nepal, son preference has been documented, but it has primarily manifested in women's contraceptive use and preferential care for male children, including more and higher quality food and better medical care, consistent with the 'femineglect' in health and education seen elsewhere in Asia [1,9,10]~~[1,8]~~. As a result, older studies demonstrated higher under-five female compared to male mortality in Nepal due to preferential treatment and medical care for sons, but did not

8. In April 2015 there was a devastating earthquake which struck Nepal and was accompanied by major aftershocks https://en.wikipedia.org/wiki/April_2015_Nepal_earthquake. Recruitment of some of the participants in this study occurred in 2015. Now, earthquakes in their aftermath have been found to perturb sex ratios at birth significantly:
Fukuda M, Fukuda K, Mason S, et al. The sex ratio at birth after recent major earthquakes in Japan. Early human development 2018. https://www.ncbi.nlm.nih.gov/pubmed/29958723
How was the 2015 earthquake factored into the analysis? At a minimum I would suggest that the authors discuss the potential implications of the 2015 Nepal earthquake on their analysis and results.

Authors' response: Thank you for this comment. The month-fixed effects in the adjusted regression should adjust for any impact of the earthquake on SRBs. We have modified the methods section to note this.

Linear regression models with hospital and month fixed effects are used to estimate the association between women's socio-demographic characteristics and male birth. The hospital and month fixed effects control for any hospital-specific or time-specific changes to the outcomes unrelated to the intervention, including any potential impact of the April 2015 earthquakes in Nepal [19]. Equation (1) below represents the multivariate model, where we interact women's education and parity to understand any multiplier effects of these two variables on male preference for woman i, hospital h and month t. We also control for region, ethnicity, woman's age, abortion history (X_i), hospital fixed effects and month fixed effects.

$$male\ birth_{iht} = \alpha + \beta schooling_i + \psi Parity_i + \boldsymbol{\omega} schooling_i * Parity_i + \gamma X_i + \sum_{h=1}^{5} \delta_h H_h + \sum_{t=1}^{11} \tau_t T_t + \epsilon_{iht} \quad — \quad (1)$$

9. A concept not touched on is the Trivers-Willard effect which is relevant to this paper. Women in a relatively good health condition e.g. nutritionally replete, tend to have proportionately more male offspring, in short a comparatively higher sex ratio at birth.
Cameron EZ, Dalerum F. A Trivers-Willard effect in contemporary humans: male-biased sex ratios among billionaires. PLoS One 2009;4(1):e4195. https://www.ncbi.nlm.nih.gov/pubmed/19142225

Authors' response: This is an interesting and relevant point. In figure 5, we present conditional SRB of second child, and compare SRBs for children with an older brother versus an older sister. On average, the Trivers-Willard effect holds when you look at SRBs of children with an older brother [105 for educated women versus 99 for women without any formal schooling—difference not statistically significant]. However, the difference in SRBs of second births among those with male sibling versus those with no male siblings strongly suggests sociological son preference as primary pathway rather than biological selection. Amended the discussion as follows:

births with facility deliveries using the nationally representative sample further support the sex-selection abortion pathway.

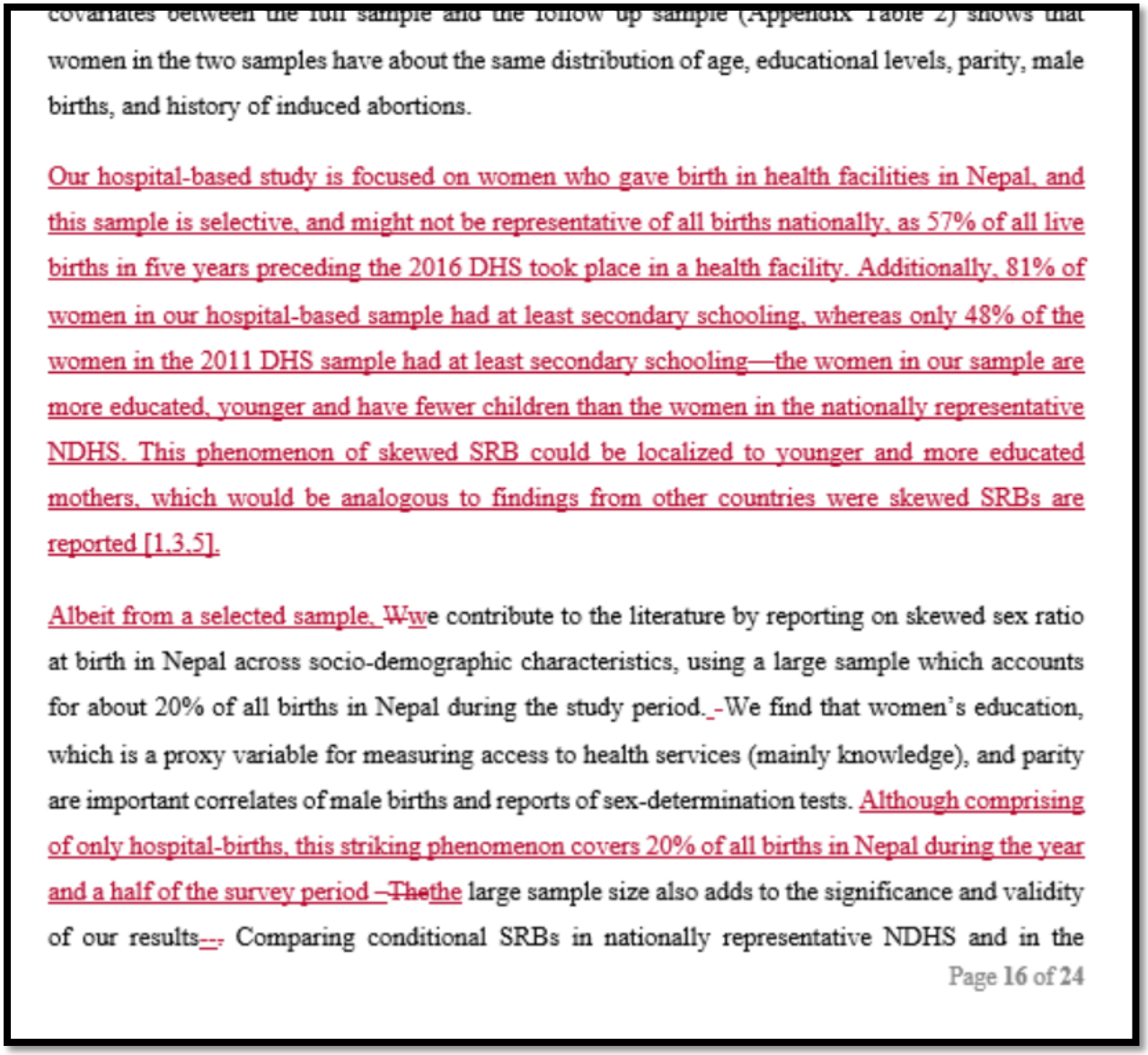
The Trivers-Willard effect would be consistent with more educated and wealthy women having more sons as they are generally in better health condition [21]. However, Figure 5, which illustrates SRBs for second order births differentially among those with male siblings and no male siblings suggest that sociological son preference is still overwhelmingly the primary reason for skewed sex ratio at births among educated women—the conditional SRB of second order births with male siblings among women with at least secondary schooling is 105, as compared to 176 for those without any male siblings.

Nepal has seen a rapid decline in actual and desired fertility rates over the last forty years.

10. From the Nepal 2011 Demographic and Health Survey (DHS) page 125, Table 9.5 https://dhsprogram.com/pubs/pdf/FR257/FR257[13April2012].pdf women in the highest wealth quintiles (likely with the best nutritional status, etc.) were the most likely to deliver in a health facility (where the hospital-based sample was recruited from).

It thus seems possible, in addition, to sex-selective abortion that these women had an inherent tendency to have more live male births than the rest of the female Nepalese population of reproductive age. Now, in Nepal “57% of deliveries take place in a health facility” DHS 2016 page 151 https://www.dhsprogram.com/pubs/pdf/fr336/fr336.pdf. Please may the authors mention the proportion of women that deliver in a health facility in Nepal so that the reader can appreciate, to a better extent, the degree of selection in their sample?

Authors’ response: Thank you for this comment! We agree, and we have modified the discussion section as below:



covariates between the full sample and the follow up sample (Appendix Table 2) shows that women in the two samples have about the same distribution of age, educational levels, parity, male births, and history of induced abortions.

Our hospital-based study is focused on women who gave birth in health facilities in Nepal, and this sample is selective, and might not be representative of all births nationally, as 57% of all live births in five years preceding the 2016 DHS took place in a health facility. Additionally, 81% of women in our hospital-based sample had at least secondary schooling, whereas only 48% of the women in the 2011 DHS sample had at least secondary schooling—the women in our sample are more educated, younger and have fewer children than the women in the nationally representative NDHS. This phenomenon of skewed SRB could be localized to younger and more educated mothers, which would be analogous to findings from other countries were skewed SRBs are reported [1,3,5].

Albeit from a selected sample, ~~W~~we contribute to the literature by reporting on skewed sex ratio at birth in Nepal across socio-demographic characteristics, using a large sample which accounts for about 20% of all births in Nepal during the study period. -We find that women’s education, which is a proxy variable for measuring access to health services (mainly knowledge), and parity are important correlates of male births and reports of sex-determination tests. Although comprising of only hospital-births, this striking phenomenon covers 20% of all births in Nepal during the year and a half of the survey period –~~T~~hethe large sample size also adds to the significance and validity of our results--. Comparing conditional SRBs in nationally representative NDHS and in the

Page 16 of 24

11. I suggest consistent use of abbreviations e.g. there is both DHS and NDHS. I recommend disambiguation of an abbreviation at first use and then use of the abbreviation from then onwards.

Authors’ response: Noted—we have changed all references to DHS as NDHS, and clarified the abbreviation at the first mention of this survey.

Reviewer: 3
Reviewer Name: Sanjay K Mohanty

Institution and Country: International Institute for Population Sciences, Mumbai, India

Please state any competing interests or state ‘None declared’: None delared

Please leave your comments for the authors below

12. This is an interesting manuscript and can contribute to literature. The increasing SRB is in many Asian countries including Nepal and India. It is associated with falling fertility, increasing use of health services and more prevalent among educated and economically better of households. These results are amply clear from the analyses. I have few minor sugegstions

Authors’ response: Thank you!

13. Appendix Table 1 is confusing. It need to be written differently for each of the variable. For example, it would be better to present in terms of percentage of birth, educational attainment in % etc than descriptive

Authors’ response: Thank you for the comment. We have tried to clarify the different samples by ensuring that the columns are distinct, labeling the table title more precisely and updating the description of total sample size in the last row.

Appendix Table 1: Descriptive statistics for study data—proportions and sample size

	Full Sample	Follow-up Sample	DHS sample
Male birth	0.54	0.54	0.51
Mother's age			
<20	0.14	0.13	0.09
20-24	0.45	0.45	0.37
25-29	0.28	0.29	0.30
Region			
Terai	0.71	0.76	
Hill	0.28	0.24	
Mountain	0.01	0.00	
Number of induced abortions			
0	0.96	0.96	
1	0.04	0.04	
2+	0.01	0.01	
Conducted ultrasound during antenatal period of current birth		0.93	
Knew sex of current child		0.13	
Total sample size for each data sample~~N~~	**75,428**	**14,015**	~~4,047~~

14. Table 1, if possible give estimates of SRB (unadjusted at the beginning, an additional column)

Authors’ response: Thank you for this suggestion. We tried this, and just makes the table too busy. Additionally, we are already maxed out on the number of tables/ figures that we can include as suggested by BMJ open. Since the raw SRBs at the hospital level, followed by regression model results, and adjusted estimates of SRB by women’s characteristics seem more critical to present, we have opted to keep the tables and figures the same. I hope you agree, since you suggest this as a possibility.

15. Would be better to present the graphs to a single table and estimating the SRB. This can be done for last five years, 5-10 years to see how these are changing

Authors' response: A previous paper (Frost et al.) shows the trends in SRBs, and conditional SRBs. Since our primary data source collects data from 2015-2017, showing trends for last five/ five-ten years would not be possible.

16. From census or DHS, a graph depicting child sex ratio and sex ratio at birth may be presented (these data are usually available for last 20 years in interval of time)

Authors' response: Thank you for this suggestion. We have noted in the background that the historical trend so far has not been different from the norm. This is one of the reasons why this would be one of the first studies from the country that shows skewed SRBs in hospitals. A previous paper, as mentioned above, has already shown trends in Conditional SRBs in Nepal.

17. A descriptive statistics on number of births, sex and other features from each hospital may be presented

Authors' response: Thank you—we have included descriptive statistics in Appendix Table 1, and described the sample in data section.

18. Policy implication need to be improved. What is present law in Nepal?
For example in india, sex identification is strictly prohibited and it intact has been implemented

Authors' response: Indeed we agree that noting the present law and context is critical for policy discussion. We note the present law in Nepal in the background section as the analysis needs to rest on the present context.

(1) We present the background on Nepal as follows in the background section:

> became skewed after abortion law was liberalized in 2002 [11]~~[9]~~. Though sex-determination tests and sex-selective abortion are illegal in Nepal, punishable by imprisonment from 3 to 6 months [12,13]~~[10,11]~~, evidence suggests that it does occur [11,14]~~[9,12]~~. Abortion providers report difficulty ascertaining whether families are seeking abortion for sex-selection purposes, and fear that women will resort to unsafe abortion if they are under pressure to bear sons but unable to access safe abortion services [14]~~[12]~~. A comparison of two districts in Nepal found that many conditions led to higher SRB in one district compared to the other, including greater access to ultrasound due to more facilities offering diagnostic services and greater purchasing power, less enforcement of the law barring sex-selective abortion, desire for fewer children, and fewer community-based programs on gender equity [12]~~[10]~~.

2. We discuss our finding of women reporting knowing the sex of their child, despite this practice being illegal in Nepal, here in the results section:

> As discussed before, facilitating or conducting sex determination tests is illegal in Nepal. However, we find that 13% of the women in our follow-up sample report knowing the sex of their child before birth. Similar to correlates of male birth, women reporting knowledge of the sex of their fetus before birth is also correlated with women's education and parity with significant interactions

3. And finally, we discuss the policy implications/ lessons learned/ policy avenues for Nepal here in the discussion section:

Nepal has seen a rapid decline in actual and desired fertility rates over the last forty years. However, the reduction in desired fertility exists in a society with persistent preferences for a son, because of cultural and religious norms, and economic rationale. Aside from the religious norms such as sons being necessary to perform death rituals in Hinduism, parents have an economic incentive to have sons in an environment where (1) strong filial (social and financial) ties exist between parents and children, (2) women are not able to realize their full economic earning potential, and (3) daughters are considered to "belong" to another family after marriage. The marginalized status of women, coupled with increasing access to sex-selection technology and lack or weak enforcement of the law is further skewing sex ratio at births in Nepal.

Imbalanced sex ratios at birth (SRB) are not immutable as evidenced from South Korea. SRBs in South Korea rose from 109 in 1985 to 115 in 1994, but then declined reaching 105 in 2016 [25][~~22~~]. Most remarkable are the 2016 SRB figures by birth order –104 for the first order births, 105 for the second, and 107 for the (fewer) third or higher order births. This transition to balanced SRB has been achieved by a combination of factors resulting in raising the status and empowerment of women [26][~~23~~]. Increased opportunities for higher education and better employment contributed to women's autonomy coupled with laws and policies addressing

women's rights. The law recognizing women's inheritance and other rights within their birth family following marriage contributed to redressing the traditional gender imbalance that existed in Korea. Media campaigns such as "Love your daughters" and other measures such as strict enforcement of laws prohibiting the misuse of technology for sex determination, increased exposure to mass media, weakening of traditional patrilineal norms with increasing urbanization and industrialization and expansion of nuclear families all contributed to bringing down SRB to the normal biological level in the country [27–29][~~24–26~~]. As exemplified by the South Korean experience, it is possible to bring down the skewed SRB to the normal level by systematic and multi-pronged efforts.

Bongaarts and Guilmoto (2015) predict that the preference for sons and gender discriminations faced by the female sex from before birth that continues over a lifetime has manifested as three million excess female deaths every year globally, or 150 million missing women by 2035 [30][~~27~~]. Our findings highlight the marginalized status of women in Nepal, and stress the urgent need for research and implementation of policies that reduce son preference and ultimately, skewed sex ratios. National strategies to prevent misuse of ultrasound services and gender-biased sex selection that do not hinder women's access to safe abortion services are needed. Most importantly, comprehensive interventions with a mix of laws, policies and advocacy campaigns that aim to improve the status of women and eliminate gender-based discrimination are needed to achieve a balanced sex ratio at birth and subsequent survival and quality of life.

Date Sent:

15-Aug-2018

APPENDIX 1:
Decision Letter (bmjopen-2018-023021)

BMJ Open - Decision on Manuscript ID bmjopen-2018-023021

15-Aug-2018

Dear Dr. Pradhan:

Manuscript ID bmjopen-2018-023021 entitled "Determinants of imbalanced sex ratio at birth in Nepal: evidence from secondary analysis of a large hospital-based RCT, and a nationally representative survey data" which you submitted to BMJ Open, has been reviewed. The comments of the reviewer(s) are included at the bottom of this letter. The Editorial Office have also checked your manuscript for any minor formatting issues and these will be listed at the end of this email.

The reviewer(s) have recommended revisions to your manuscript. Therefore, I invite you to respond to the reviewer(s)' comments and revise your manuscript. Please remember that the reviewers' comments and the previous drafts of your manuscript will be published as supplementary information alongside the final version.

To revise your manuscript, log into https://mc.manuscriptcentral.com/bmjopen and enter your Author Center, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision.

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https://mc.manuscriptcentral.com/bmjopen?URL_MASK=4b3ab217be994f0d9ec56d7ca4a770e5

You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript using a word processing program and save it on your computer. Please also highlight the changes to your manuscript within the document by using the track changes mode in MS Word or by using bold or coloured text. Once the revised manuscript is prepared, you can upload it and submit it through your Author Center.

When submitting your revised manuscript, you will be able to respond to the comments made by the reviewer(s) in the space provided. You can use this space to document any changes you make to the original manuscript. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response to the reviewer(s).

You will receive a proof if your article is accepted, but you will be unable to make substantial changes to your manuscript, please take this opportunity to check the revised submission carefully.

IMPORTANT: Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

Because we are trying to facilitate timely publication of manuscripts submitted to BMJ Open, your revised manuscript should be submitted within 28 days. If it is not possible for you to submit your revision by this date, we may have to consider your paper as a new submission.

Once again, thank you for submitting your manuscript to BMJ Open and I look forward to receiving your revision.

VERSION 2 – REVIEW

REVIEWER	Reviewer name: Gwinyai Masukume Institution and Country: The Irish Centre for Fetal and Neonatal Translational Research (INFANT), Department of Obstetrics and Gynaecology, University College Cork, Cork, Ireland Competing interests: None declared
REVIEW RETURNED	22-Sep-2018

GENERAL COMMENTS	Thanks for inviting me to review the revised version of this very interesting manuscript which will contribute valuable information to the literature. The authors have adequately addressed all the comments that I raised. I nonetheless draw attention to a possible minor typographical error in a new sentence and make related comments: Page 16 of 25. Line 36. “This phenomenon of skewed SRB could be localized to younger and more educated mothers, which would be analogous to findings from other countries were skewed SRBs are reported” Please consider ‘where’ instead of ‘were’. Page 15 of 25. Line 12. “Consistent with the literature on determinants of son-preference…” Son preference is hyphenated unlike elsewhere in the manuscript. I suggest removing the hyphen. Page 16 of 25. Line 30. “Our hospital-based study is focused on women who gave birth in health facilities in Nepal, and this sample is selective, and might not be representative of all births nationally, as 57% of all live births in five years preceding the 2016 DHS took place in a health facility.” I would suggest that, here, the authors provide a formal citation to the 2016 Nepal Demographic and Health Survey (NDHS) like they did for the 2011 NDHS elsewhere. The following relevant article was published after the authors submitted their paper to BMJ Open. I thus appreciate why it was not included. It might however be useful to consider/cite it where applicable: Preference for Sex of Children Among Women in Nepal: https://doi.org/10.1007/s40609-018-0117-9

REVIEWER	Reviewer name: Sanjay K Mohanty Institution and Country: International Institute for Population Sciences, Mumbai Competing interests: Competing Interest -None
REVIEW RETURNED	27-Sep-2018

GENERAL COMMENTS	Thank you for revising the manuscript. A minor suggestion; do mention a sentence on R square i.e., predictive power of the regression model.

	It would be beneficial if policy option are elaborates mentioned in last line of the paper (text)

VERSION 2 – AUTHOR RESPONSE

Reviewer(s)' Comments to Author:
: 2 Reviewer Name: Gwinyai Masukume

Institution and Country: The Irish Centre for Fetal and Neonatal Translational Research (INFANT), Department of Obstetrics and Gynaecology, University College Cork, Cork, Ireland

Please state any competing interests or state ‘None declared’: None declared

Please leave your comments for the authors below
22 September 2018, bmjopen-2018-023021.R1

Thanks for inviting me to review the revised version of this very interesting manuscript which will contribute valuable information to the literature. The authors have adequately addressed all the comments that I raised. I nonetheless draw attention to a possible minor typographical error in a new sentence and make related comments:

Thank you very much for your careful read and review!

Page 16 of 25. Line 36. “This phenomenon of skewed SRB could be localized to younger and more educated mothers, which would be analogous to findings from other countries were skewed SRBs are reported” Please consider ‘where’ instead of ‘were’.
Thank you—amended as below.

NDHS. This phenomenon of skewed SRB could be localized to younger and more educated mothers, which would be analogous to findings from other countries where skewed SRBs are reported [1,3,5].

Page 15 of 25. Line 12. “Consistent with the literature on determinants of son-preference…” Son preference is hyphenated unlike elsewhere in the manuscript. I suggest removing the hyphen.
Thank you—amended as below.

Our analysis shows evidence of skewed sex ratio of deliveries in six large public hospitals in Nepal. Consistent with the literature on determinants of son-preference and sex-selective abortion, we show that male birth in the study hospitals is correlated with higher parity births and higher

Page 16 of 25. Line 30. “Our hospital-based study is focused on women who gave birth in health facilities in Nepal, and this sample is selective, and might not be representative of all births nationally, as 57% of all live births in five years preceding the 2016 DHS took place in a health facility.” I would suggest that, here, the authors provide a formal citation to the 2016 Nepal Demographic and Health Survey (NDHS) like they did for the 2011 NDHS elsewhere.
Thank you—amended as below.

Our hospital-based study is focused on women who gave birth in health facilities in Nepal, and this sample is selective, and might not be representative of all births nationally, as 57% of all live births in five years preceding the 2016 DHS took place in a health facility [25]. Additionally, 81%

The following relevant article was published after the authors submitted their paper to BMJ Open. I thus appreciate why it was not included. It might however be useful to consider/cite it where applicable: Preference for Sex of Children Among Women in Nepal: https://doi.org/10.1007/s40609-018-0117-9
Thank you for this reference. We read this paper with interest, however found the methodology lacking in eliciting son preference. The methods section of this paper states the following:
“The main concept of this study came from the woman’s questionnaire. For women with children, the following question was asked: If you returned to a time when you did not have any

children and could choose the number of children that you would have during your lifetime, how many would that be? For women without children, the questionnaire asked the following question: If you could choose the number of children that you would have during your lifetime, how many would that be? Then, they were further asked to answer the following question: How many of these children would you like to be boys, how many would you like to be girls and how many would it be no matter if it were a boy or a girl?^ Therefore, the responses were operationalized as multinomial with three different values: **a preference for more sons (1), a preference for more daughters (2), and indifference between sons and daughters or a preference for an equal number of sons and daughters (0).**

Background literature and theory suggests that although more number of sons are desirable for economic reasons, at least one son is important to the household for religious/cultural perspective (to perform funeral rites in Hindu tradition for example). This paper does not take the religious/cultural pathway into account because in each of the options, the respondent could have preference for at least one son, which is the dominant pathway in a country where the total fertility rate hovers around 2. It does not seem possible to add a mere reference to this study without discussing at length the differences in the definition of "son preference", hence we prefer not to reference this study and go into lengthy discussion of the differences in definition. Please also see this excellent discussion by Professor Seema Jayachandran on why these questions in DHS that the authors used have some methodological issues: https://blogs.worldbank.org/impactevaluations/odds-are-you-re-measuring-son-preference-incorrectly

We stand advised by the editor on *BMJ Open's* preference.

Yours sincerely, Dr. Gwinyai Masukume MB ChB(UZ), Dip Obst(SA), MSc(Wits) Reviewer: 3 Reviewer Name: Sanjay K Mohanty Institution and Country: International Institute for Population Sciences, Mumbai Please state any competing interests or state 'None declared': Competing Interest -None Please leave your comments for the authors below Thank you for revising the manuscript. A minor suggestion; do mention a sentence on R square i.e., predictive power of the regression model. It would be beneficial if policy option are elaborates mentioned in last line of the paper (text)

Thank you—The tables did have R2 and we have described the policy options in the South Korea example before (see below) and summarized it in the last sentence. We hope this is acceptable.

Table 1: Association of socio-demographic factors with male births, ultrasound during ANC and knowledge of sex of current child before birth in study hospitals

	Male Birth		Ultrasound during ANC		Knew the sex of the current child before birth	
	Est.	95% CI	Est.	95% CI	Est.	95% CI
Mother's Age (Ref: <20)						
20-24	0.006	[-0.002 - 0.014]	0.014**	[0.000 - 0.028]	-0.009	[-0.026 - 0.008]
25-29	0.010	[-0.009 - 0.025]	0.030***	[0.015 - 0.044]	0.002	[-0.017 - 0.021]
≥30	0.014**	[0.007 - 0.032]	0.043***	[0.025 - 0.061]	0.040***	[0.014 - 0.067]
Mother's Education (Ref: Secondary or higher)						
Primary	0.009	[-0.006 - 0.035]	-0.052***	[-0.079 - -0.024]	0.032**	[0.001 - 0.063]
No schooling	0.025	[-0.012 - 0.058]	-0.130***	[-0.169 - -0.089]	0.049***	[0.015 - 0.083]
Parity (Ref: 1)						
2	0.049***	[0.014 - 0.078]	-0.020***	[-0.029 - -0.011]	0.056***	[0.041 - 0.072]
≥3	0.178***	[0.136 - 0.210]	-0.028***	[-0.045 - -0.011]	0.252***	[0.217 - 0.289]
Mother's Education*Parity						
Primary*2	-0.038*	[-0.090 - 0.000]	0.001	[-0.040 - 0.042]	-0.070***	[-0.112 - -0.026]
Primary*≥3	-0.113***	[-0.151 - -0.054]	-0.006	[-0.056 - 0.043]	-0.131***	[-0.204 - -0.058]
No schooling*2	-0.065**	[-0.124 - -0.011]	0.007	[-0.049 - 0.064]	-0.109***	[-0.153 - -0.064]
No schooling*≥3	-0.139***	[-0.198 - -0.074]	-0.050*	[-0.104 - 0.004]	-0.219***	[-0.278 - -0.159]
Ethnicity (Ref: Janajati)						
Chhetri	0.013**	[0.002 - 0.034]	0.028***	[0.017 - 0.038]	-0.0001	[-0.018 - 0.018]
Hill Brahmin	0.011	[-0.002 - 0.025]	0.022***	[0.014 - 0.030]	0.007	[-0.008 - 0.022]
Madhesi	0.005	[-0.068 - 0.049]	-0.024**	[-0.047 - -0.001]	-0.005	[-0.027 - 0.018]
Dalit	-0.005	[-0.018 - 0.009]	-0.015**	[-0.030 - -0.001]	0.002	[-0.016 - 0.020]
Muslim	-0.028**	[-0.068 - -0.007]	0.014	[-0.021 - 0.049]	-0.028*	[-0.058 - 0.002]
Others	0.025*	[-0.003 - 0.049]	0.032**	[0.003 - 0.060]	0.045*	[-0.002 - 0.091]
Region (Ref: Terai)						
Hill	0.003	[-0.020 - 0.011]	-0.006	[-0.022 - 0.010]	-0.016	[-0.043 - 0.012]
Mountain	0.003	[-0.090 - 0.042]	-0.295	[-51.884 - 51.213]	-0.105	[-102.651 - 103.068]
Number of Abortions (Ref: 0)						
1	0.0003	[-0.022 - 0.035]	0.019**	[0.003 - 0.035]	0.0363**	[0.002 - 0.070]
2+	0.050	[-0.006 - 0.100]	0.055***	[0.024 - 0.084]	0.068	[-0.031 - 0.164]
Constant	0.518***	[0.474 - 0.551]	0.951***	[0.932 - 0.970]	0.245***	[0.217 - 0.274]
Observations	75,428		14,015		13,113	
R-squared	0.009		0.111		0.077	

Note: Difference from null tested using wild cluster bootstrap method.
All regression models adjusted for hospital and month fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

Table 2: Association between hospital-based delivery and male births in NDHS, stepwise regression

	Dependent variable: Hospital-based delivery						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Male child	0.003		-0.005	-0.025	-0.023	-0.022	-0.014
	[-0.025 - 0.030]		[-0.031 - 0.021]	[-0.077 - 0.026]	[-0.074 - 0.027]	[-0.072 - 0.028]	[-0.063 - 0.034]
Mother's Education (Ref: Secondary or higher)							
Primary		-0.231***	-0.231***	-0.256***	-0.218***	-0.200***	-0.081**
		[-0.282 - -0.180]	[-0.282 - -0.180]	[-0.322 - -0.191]	[-0.284 - -0.152]	[-0.266 - -0.133]	[-0.147 - -0.016]
No schooling		-0.335***	-0.335***	-0.347***	-0.253***	-0.247***	-0.101***
		[-0.381 - -0.288]	[-0.382 - -0.288]	[-0.402 - -0.292]	[-0.310 - -0.196]	[-0.303 - -0.191]	[-0.156 - -0.045]
Male child*Mother's education							
Male child, Primary				0.048	0.049	0.045	0.048
				[-0.024 - 0.120]	[-0.023 - 0.121]	[-0.027 - 0.116]	[-0.022 - 0.118]
Male child, No schooling				0.023	0.012	0.011	0.011
				[-0.034 - 0.080]	[-0.043 - 0.068]	[-0.044 - 0.067]	[-0.042 - 0.065]
Parity (Ref: 1)							
2					-0.096***	-0.129***	-0.121***
					[-0.143 - -0.050]	[-0.175 - -0.083]	[-0.163 - -0.079]
≥3					-0.210***	-0.277***	-0.227***
					[-0.253 - -0.167]	[-0.327 - -0.228]	[-0.276 - -0.178]
Mother's Age (Ref: <20)							
20-24						0.078**	0.047
						[0.016 - 0.140]	[-0.011 - 0.106]
25-29						0.157***	0.100***
						[0.089 - 0.225]	[0.036 - 0.165]
>=30						0.151***	0.110***
						[0.076 - 0.226]	[0.040 - 0.181]
Household wealth tertile (Ref: Poor)							
Middle							0.104***
							[0.065 - 0.144]
Rich							0.353***
							[0.299 - 0.407]
Constant	0.281***	0.484***	0.487***	0.498***	0.573***	0.493***	0.258***
	[0.248 - 0.313]	[0.441 - 0.528]	[0.441 - 0.533]	[0.447 - 0.549]	[0.521 - 0.625]	[0.423 - 0.564]	[0.186 - 0.331]
Observations	4,047	4,047	4,047	4,047	4,047	4,047	4,047
R-squared	0.000	0.108	0.109	0.109	0.137	0.146	0.225

Note: Standard errors clustered at the primary sampling unit level.

Imbalanced sex ratios at birth (SRB) are not immutable as evidenced from South Korea. SRBs in South Korea rose from 109 in 1985 to 115 in 1994, but then declined reaching 105 in 2016 [26][~~25~~]. Most remarkable are the 2016 SRB figures by birth order –104 for the first order births, 105 for the second, and 107 for the (fewer) third or higher order births. This transition to balanced SRB has been achieved by a combination of factors resulting in raising the status and empowerment of women [27][~~26~~]. Increased opportunities for higher education and better employment contributed to women's autonomy coupled with laws and policies addressing women's rights. The law recognizing women's inheritance and other rights within their birth family following marriage contributed to redressing the traditional gender imbalance that existed in Korea. Media campaigns such as "Love your daughters" and other measures such as strict enforcement of laws prohibiting the misuse of technology for sex determination, increased exposure to mass media, weakening of traditional patrilineal norms with increasing urbanization and industrialization and expansion of nuclear families all contributed to bringing down SRB to the normal biological level in the country [28–30][~~27–29~~]. As exemplified by the South Korean experience, it is possible to bring down the skewed SRB to the normal level by systematic and multi-pronged efforts.