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Falling Sex Ratios and Emerging Evidence of Sex Selective Abortion in Nepal: Evidence from Nationally Representative Survey Data

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Article Summary

Article focus

- Little evidence exists concerning whether the legal status of abortion is related to incidence of prenatal sex selection; Nepal provides an interesting case study.
- Sex ratios at birth in Nepal before and after abortion was legalised in 2002 are calculated in order to test for evidence of sex-selective abortions.
- This study seeks to identify characteristics of women experiencing the lowest sex ratios and thus those who are most likely to have a sex-selective abortion.

Key messages

- There is clear evidence of a substantial increase in sex selection since 2002, even though this remains strictly prohibited.
- The sex ratio for second and third born children where previous births were female fell substantially in almost all regions of Nepal, indicating widespread usage of sex-selective abortions.
- Women who are wealthier, better educated and living in urban areas are most likely to use prenatal sex selection.

Strengths and limitations of this study

- This is the first study to show that sex-selective abortions are becoming increasingly common in Nepal and that this problem is nationwide.
- The survey data used did not allow for a more detailed geographic breakdown, which would be useful for policymakers.

Abstract

Objectives: To quantify trends and patterns in changing sex ratios since the legalisation of abortion in Nepal. While sex-selective abortion is common in some Asian countries it is not clear if the legal status of abortion can have an effect on the prevalence of sex-selection when sex-selection is illegal. In this context, Nepal provides an interesting case study. Abortion was legalised in Nepal in 2002 and prior to that there was no evidence of sex-selective abortion. Changes in the sex ratio at birth since legalisation would indicate that this may have been caused by legalisation, even though sex-selection itself remains prohibited.

Design: Analysis of data from four Nepal Demographic and Health Surveys, conducted in 1996, 2001, 2006 and 2011.

Setting: Nepal.

Participants: 31,842 women aged 15-49.

Main outcome measure: Conditional sex ratios (CSRs) were calculated, specifically the CSR for second-born children where the first born was female. This CSR is where evidence of sex-selective abortion will be most visible. CSRs were looked at over time to assess the impact of legalisation as well as for population sub-groups in order to assess trends and identify characteristics of women using sex selection.

Results: From 2007 to 2010 the CSR for second-order births where the first born was a girl was found to be 742 (95% confidence interval 599 to 913). Before abortion was legalised (1998 to 2000) the same CSR was 1021 (906 to 1150). After legalisation the CSR dropped most amongst educated and richer women, especially in urban areas. Indeed, just 325 girls were born for every 1,000 boys amongst the richest urban women.

Conclusions: The abrupt fall in CSRs witnessed post legalisation indicates that sex-selective abortion has become common. This research also indicates that legalising abortion can have a substantial effect on sex ratios, even if sex-selection is specifically prohibited.

Introduction

Selective abortion of females has been found to occur extensively in several Asian countries. Estimates suggest that between 3.1 and 6.0 million sex-selective abortions took place in India in the 2000s.[1] China has a well-documented history of so-called "missing girls" resulting from a combination of the one child policy and son preference, with as few as 847-877 girls born for every 1,000 boys.[2 3] Both China and India have well-established abortion services provided by national and regional governments.[4 5]

An interesting question is the extent to which state provision of abortion services is associated with the selective abortion of females. Assessing this using data from China and India is difficult as the provision of abortion services has increased gradually.[4 6] However the neighbouring country of Nepal saw an abrupt change between 2002 and 2004 which provides the opportunity to measure the impact of state provision of abortion services on sex-selective behaviour. Abortion was legalised in Nepal in 2002 and Comprehensive Abortion Care (CAC) services were provided by the government from 2004 onwards.[7] Sex determination is expressly prohibited and anyone found performing (or facilitating) an abortion on this basis can be punished with one year's imprisonment, but otherwise the law is now extremely liberal. Before 2002 unsafe abortion was the third largest cause of maternal mortality and it was not uncommon for women living in the south of the country to visit India if they wanted an abortion, though the scale of this is not known.[7] Studies of post-abortion care at 10 major hospitals showed that between 20% and 60% of the women admitted as obstetric and gynaecological patients were abortion complication cases.[8]

Nepal has revealed high levels of son preference since the World Fertility Surveys first documented the phenomenon in the 1980s.[9] Daughters are often considered to be an economic burden because of the dowry system and the fact that a girl will join her husband's family after marriage. Sons are highly prized because they continue the family name, are deemed crucial to perform funeral rites, are likely to bring in a daughter-in-law into the family and are expected to provide support for their parents in old age.[10-12]

Before 2002, son preference in Nepal was mainly evidenced through differential stopping behaviour (i.e. the decision to have another child depended upon the sex composition of previous children). It has been estimated that such behaviour caused the fertility rate to be at least 6% higher and contraceptive use to be as much as 24% lower than it would otherwise have been.[9 10] It therefore seems possible that, despite the strict prohibition of abortion on the grounds of the sex of the child, Nepalis will have taken advantage of the opportunities provided by legalisation of abortion to influence the sex composition of their children.

Previous research suggests that sex-selective abortions do occur in Nepal, but the evidence is either qualitative or based on small scale data.[13] A study in Kathmandu recorded the sex and parity of all babies born in a single hospital during a five year period (2003-2007) and found that, while for first born children the sex ratio was relatively normal at 106 males to 100 females, the sex ratio for second order births was 118 and for higher order births it was 177.[14] Unfortunately the sample sizes were too small to draw any significant conclusions. A rapid assessment of sex ratios at birth in 1991 and 2001 consistently found more male than female babies being born in a number of districts of Nepal bordering India.[15] A study conducted in 2007 revealed that legal sanctions against pre-natal sex determination and sex-selective

abortion had not stopped medical practitioners and Sonographers in Nepal from providing such services.[16]

The aim of this paper, therefore, is to examine sex ratios of births before and after the introduction of Comprehensive Abortion Care in 2004 to assess whether, given the religious and socio-economic value given to sons, the legalisation of abortion, and the availability of pre-natal sex-determination technologies and abortion clinics, was associated with a change in the proportion of babies which were male.

Methods

Data

Over 40,000 women were interviewed in four rounds of the Nepal Demographic and Health Survey (NDHS), conducted in 1996, 2001, 2006 and 2011. All four surveys were nationally representative and used a two stage stratified sampling scheme. All women were asked about their fertility and full birth histories were obtained from the 31,842 women aged 15-49; these birth histories included information on over 111,000 births. Full details of the NDHSs used can be found elsewhere.[17-20]

A module on induced abortion was included in the 2011 NDHS for the first time. This included questions to ascertain the prevalence of abortion as well as the reasons for it. Overall 7.5% of pregnancies were reported to have ended in abortion in the five years before the survey was conducted. This varied substantially depending on the woman's socioeconomic characteristics with 17.5% of pregnancies ending in abortion for women in the highest wealth quintile. Of 506 women who gave a reason for their abortion 3.16% reported that it was due to the child's sex, but the subject area tends to have a high incidence of misreporting so indirect methods are likely to be the best method of studying the phenomenon.[21]

Statistical Analysis

In the absence of intervention, the sex ratio at birth in human populations is essentially a biological constant with relatively little variation. For every 1,000 males born, there will generally be between 950 and 975 females.[22 23]

Abnormal sex ratios can be the result of mechanisms other than sex-selective abortion: the most obvious example is through Hepatitis B, though there are other biological explanations. Moreover, even when sex-selective abortion is occurring, changes in its prevalence can occur for reasons related to the demand for, rather than the supply of, abortion services. Where fertility is declining rapidly the preference for sons may be intensified since the overall desired number of children will fall faster than the desire for sons, and pressure on couples to balance the sex composition of their children may contribute to further demand for pre-natal sex selection at low parities.[12 24] Nepal has seen one of the most dramatic fertility declines in history, with the total fertility rate (TFR) falling from 4.1 to 2.6 in just 10 years.[20]

To control for these effects, we use conditional sex ratios (CSRs) in our analysis, specifically the CSR for second-born children where the first born was female. This sex ratio is generally held to be where evidence of sex-selective abortion will be most visible, since the motivation for sex-selection will probably be at its highest; it has been used frequently to provide evidence for the

widespread use of sex-selective abortion in India. If a woman is sufficiently motivated (or pressured) to have a son that she is prepared to have an abortion to achieve that end it is unlikely that she will wait until a much higher parity than two or three.

The sex ratios presented in this paper are the number of female births per 1,000 male births, calculated as $(P_f / P_m) * 1000$, where P_f is the proportion of total births that are female and P_m is the proportion of total births that are male. The sex ratios are weighted to account for the sampling scheme used in the NDHS. We only included births reported to have happened within ten years of the survey date, since extremely long recall periods tend to be less accurate, and misreporting may differ by sex of the baby. For time periods where more than one survey was available a weighted average of the different surveys was used.

Wealth tertiles were produced using principal components analysis; this was done separately for urban and rural areas in order to be able to look at the relative contribution of women at different wealth levels in diverse environments. Tertiles were used, rather than the more traditional quintiles, due to sample size considerations.

All analyses were conducted in STATA (version 12.0).

Results

Sex ratios at birth were found to vary substantially by parity, the sex of previous offspring and the time period during which the births occurred. Table 1 shows the trends in different CSRs over the 18-years 1992-2010. Years were grouped as the sample sizes for single years were small. The overall sex ratio is never significantly different from the expected range of 950-975; neither is the sex ratio of first-born children. However, for second-born children where the first born was female, the sex ratio shows a substantial decline after the legalisation of abortion. In 2001-2003 it was 947, in 2004-2006(when government abortion services became available in most district headquarters and urban and semi-urban areas) it dropped to 830 and by 2007-2010 it had plummeted to just 742, despite the overall sex ratio being 933. For third-born children where the first two children had both been female the sex ratio was also extremely low at 767, compared to 892 if the first two children had both been male or 935 if one was male and one was female. The sex ratio for second-born children in 2007-2010 was low even for mothers whose first born was male at 822. Of the 4,521 births recorded in the NDHS 2011 during 2007-2010, 1,247 of them were second order births and just 559 (44.8%) of these were female. Assuming the biologically expected sex ratio at birth we would have expected at least around 650 females to have been born given the number of males.

The sex ratio for second-born children where the first was female is thought to be the strongest evidence for sex selective abortion available, short of direct data. If this particular CSR also varies by socioeconomic characteristics then this is even stronger evidence that sex-selective abortion is being used, since knowledge of, access to, and uptake of abortion will not be equal in all parts of society. Figure 1 shows how the CSR has varied over the four NDHSs by mother's education. The sex ratios shown are those experienced during the five years prior to each survey. Table 2 shows the CSR before and after 2004 (when CAC services first became available), the percentage change in the CSR and the significance of the fall using a one sided *t*-test. A dramatic decline in the sex ratio is evident for those women who have at least a secondary leaving certificate or above. In the five years before the NDHS 2006 the CSR for this

group of women was just 653 females for every 1,000 males, and the NDHS 2011 showed a CSR of just 368, while the CSR was almost 50% lower after 2004. The fall in the CSR after 2004 was significant at the 5% level for all educational groups except those with no education.

Table 1: Conditional sex ratios at birth (females per 1000 males), by birth order, 1992-2010

Birth order	All		First born		Second born			
Sex of previous children	*NA*		*NA*		*first born male*		*first born female*	
Year	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI
1992-1994	975	*(945 ,1007)*	964	*(892 ,1041)*	1063	*(949 ,1191)*	951	*(852 ,1061)*
1995-1997	952	*(920 ,985)*	878	*(807 ,954)*	856	*(760 ,963)*	967	*(858 ,1090)*
1998-2000	973	*(938 ,1009)*	920	*(850 ,995)*	902	*(799 ,1018)*	1021	*(906 ,1150)*
2001-2003	928	*(887 ,971)*	907	*(812 ,1011)*	818	*(688 ,969)*	947	*(810 ,1106)*
2004-2006	962	*(915 ,1012)*	975	*(872 ,1090)*	971	*(816 ,1157)*	830	*(702 ,978)*
2007-2010	933	*(880 ,989)*	1010	*(907 ,1124)*	822	*(689 ,979)*	742	*(599 ,913)*

Birth order	Third born						Fourth or above	
Sex of previous children	*both male*		*both female*		*one male, one female*		*NA*	
Year	mean	95% CI	mean	95% CI	mean	95% CI	mean	95% CI
1992-1994	811	*(681 ,964)*	1027	*(864 ,1221)*	984	*(870 ,1113)*	963	*(912 ,1016)*
1995-1997	922	*(763 ,1112)*	975	*(814 ,1167)*	1131	*(995 ,1287)*	951	*(897 ,1008)*
1998-2000	1005	*(806,1254)*	849	*(699 ,1027)*	954	*(827 ,1099)*	1011	*(948 ,1078)*
2001-2003	933	*(713,1218)*	872	*(689 ,1099)*	888	*(726 ,1084)*	972	*(893 ,1057)*
2004-2006	930	*(650 ,1325)*	846	*(629 ,1130)*	1041	*(845 ,1282)*	994	*(900 ,1097)*
2007-2010	892	*(637 ,1241)*	767	*(556 ,1046)*	935	*(707 ,1233)*	1100	*(973 ,1244)*

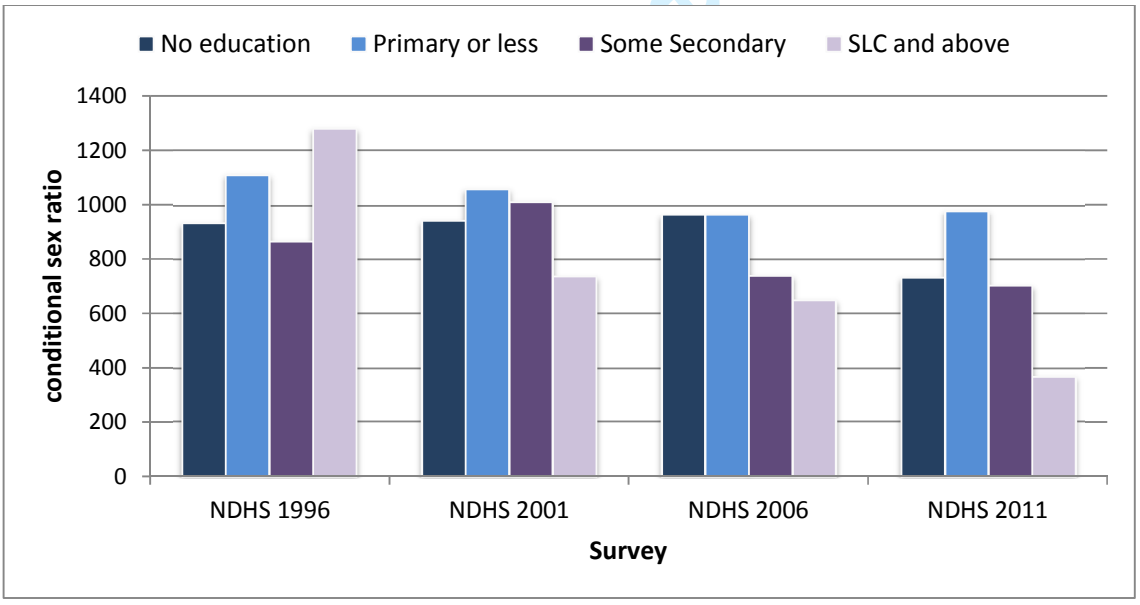

Figure 1: Conditional sex ratio of second order births where the first born was female, by educational level of the mother, over time

Figure 2 shows the same CSR split by wealth tertile in urban and rural areas. Figures are also shown in Table 2. Perhaps unexpectedly, by the 2011 NDHS rural women in all wealth tertiles display lower sex ratios than would be expected, with the sex ratio in all wealth groups below 800. A wealth gradient is visible, with the richest women being least likely to have a girl, but it seems that even poorer women are finding ways of manipulating the sex composition of their children. For urban women in the 2011 NDHS the wealth gradient is dramatic, with the poorest urban women having a higher sex ratio than rural women, but the richest urban women exhibiting the lowest sex ratio of all at just 326, indicating where sex-selective abortion is likely to be most prevalent. That the CSR is lowest among richer urban women is unsurprising, as they would be expected to be able to access abortion services most easily and have the greatest knowledge about the availability of abortion services; that said, the extent of the shortfall in female births is remarkable. Table 2 shows that the fall in the sex ratio was significant for all wealth groups in rural areas, but only for the richest in urban areas. Nonetheless, the CSR post-2004 was substantially less than 900 for all wealth groups of urban women.

Table 2: Conditional sex ratio of second order births where the first born was female, before and after 2004

		Pre-2004	Post-2004	% change	Sig.
Wealth of urban women	*Poorest*	956	843	*11.8*	
	Middle	915	864	*5.6*	
	Richest	1019	794	*22.1*	*
Wealth of rural women	*Poorest*	1074	911	*15.2*	*
	Middle	939	795	*15.3*	**
	Richest	916	786	*14.2*	†
Woman's education	*No education*	957	895	*6.5*	
	Primary or less	1046	969	*7.4*	*
	Some secondary	958	730	*23.8*	**
	SLC or above	1001	501	*49.9*	**
Region	Eastern Mountain	789	945	*-19.8*	
	Central Mountain	1194	1011	*15.4*	
	Western Mountain	901	833	*7.5*	
	Eastern Hill	1023	792	*22.6*	†
	Central Hill	964	761	*21.0*	
	Western Hill	997	847	*15.0*	
	Mid-Western Hill	869	691	*20.5*	†
	Far-Western Hill	1105	872	*21.1*	
	Eastern Terai	911	700	*23.1*	*
	Central Terai	989	701	*29.1*	†
	Western Terai	1023	1000	*2.3*	
	Mid-Western Terai	1020	761	*25.4*	*
	Far-Western Terai	956	835	*12.6*	†

NB: † p<0.1 * p<0.05 **p<0.01 ***p<0.001

There were also substantial regional differences in the CSR and how much it changed after the legalisation of abortion. Table 2 shows the conditional sex ratio for 13 sub-regions of Nepal for the 10 years before 2004 and the period post-2004. The regions are defined on the basis of altitude ('mountain', 'hill' and 'Terai' or plains), and longitude ('far western', 'western', 'mid-western', 'central' and 'eastern'). The CSR declines between the two periods in every region but

one (the Eastern Mountain, where the CSR before 2004 was below 800). Seven regions show declines that are significant at the 10% level: these regions account for around two thirds of the population of Nepal. The most substantial decline was visible in the Central Terai where the CSR fell by almost 30% from 989 to 701, though both the Mid-Western Hill and the Eastern Terai had lower sex ratios after 2004. Before 2004 just one region had a CSR below 800 and 11 out of 13 had CSRs of over 900. In the period after abortion services became available the CSRs of 10 regions dropped below 900, with six falling below 800 and one below 700.

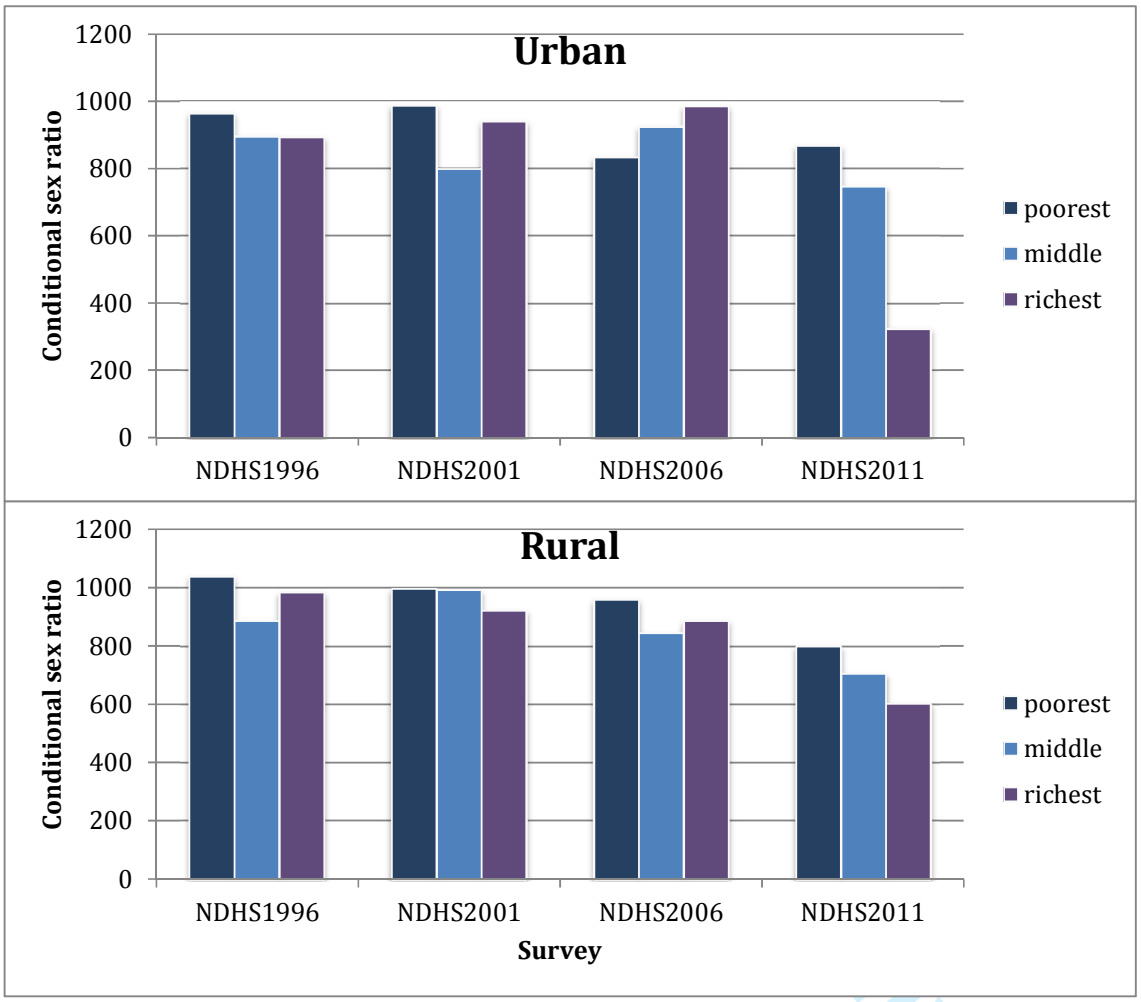

Figure 2: Conditional sex ratio of second order births where first born was female, by wealth tertile of the household in urban and rural areas, over time

Discussion

These findings suggest that since abortion was legalised in Nepal sex-selective abortion has become more common. Sex ratios are lowest for richer, more educated women, especially in urban areas and differ substantially by parity and the sex composition of previous children. There is currently no evidence that the sex ratio of first-born children is significantly different from the biological norm. However, for second-born children, especially where the first-born was female, there has been a sharp fall in the number of girls compared with boys. The sex ratio of third-born children where the first two were female has also fallen substantially in recent

years, while for children of higher parities the sex ratio remains within the expected range indicating a tendency for those women having more than four children not to use contraception or abortion services.[25]

The data we have used were collected over the course of 16 years and covering over 40,000 Nepali women, but are still not sufficient to allow the identification of all of the sub-populations experiencing low sex ratios. Regional estimates of sex ratios were limited to relatively large areas. Census data may yet prove fruitful for achieving a finer level of aggregation. The 2001 census indicated that no district had an abnormal sex ratio for infants. It will be interesting to find out if almost ten years after abortion was legalised, the infant sex ratios in any particular districts show a decline. The survey data analysed here indicates that this may well be the case, but it should be remembered that the extremely low CSRs are masked by a relatively normal overall sex ratio at birth.

Apart from the fact that the results reported in this paper are based on a relatively small number of births, some underreporting of girls in full birth histories is a possibility. However, it seems improbable that the underreporting would be greater than average for second order and third order births, or among rich, urban, or better educated women in more recent surveys.

Although we have been able to suggest that sex-selective abortion has increased in Nepal since 2004, we have not been able to enumerate the size of the problem. It is hoped that census data will allow the number of sex-selective abortions in recent years to be estimated. However, some of the sex ratios we report are as low as those seen in parts of India where sex-selective abortion is widespread.[1 21] It seems likely that sex-selective abortion is becoming common phenomenon in Nepal, a trend which mirrors that in India and China.

The timing and abruptness of the change in CSRs suggests that it is associated with the legalisation of abortion and the state provision of abortion services in the country. CAC services have only been available since 2004, but in some regions the CSR of second-born children where the first born was male has fallen by well over 200 in that time. Clearly there are policy implications in terms of education about the long term social and demographic consequences of sex-selective abortion. While educating medical practitioners is one important step, previous research has shown that medical practitioners believe that if a woman wishes to have a sex-selective abortion she can easily obtain one in India. It may also be hard for practitioners to judge a woman's reasons for wanting an abortion. For these reasons it is also paramount to educate wider members of the community about the illegality of sex determination tests for the sole purpose of selective abortion and the health risks associated with second trimester abortions.

Advocacy and educational campaigns amongst groups with particularly low sex ratios will be important; literate, urban women are one target group. Those living in the Terai with easy access to the Indian border are another. It is also important to remember that the use of sex-selective abortion has risen not only because of socio-cultural preferences for sons, but also because girls are seen as an economic burden. Ultimately, combating sex-selective abortion will require the empowerment of women throughout Nepali society. Programmes benefiting female children would be a start; these might include maternity incentives to mothers who give birth to a girl, education scholarships and free vocational training for girls, and economic incentives for the parents of girls.

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Contributors

MF conducted the data analysis. All authors were involved with data interpretation, writing the paper, and approved the final version. MF is the guarantor.

Conflicts of Interest

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Ethics

Ethics approval was not required as this paper was produced using secondary data analysis.

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Dr. Andrew “Amos” Channon provided the wealth indices used within this paper.

Data sharing

The full datasets are available at www.measuredhs.com. Consent was not obtained for this study, but participants gave informed consent for the original survey; the presented data are anonymised and there is no risk of identification.

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- Little evidence exists concerning whether the legal status of abortion is related to incidence of prenatal sex selection; Nepal provides an interesting case study.
- Sex ratios at birth in Nepal before and after abortion was legalised in 2002 are calculated in order to test for evidence of sex-selective abortions.
- This study seeks to identify characteristics of women experiencing the lowest sex ratios and thus those who are most likely to have a sex-selective abortion.

Key messages

- There is clear evidence of a substantial increase in sex selection since 2002, even though this remains strictly prohibited.
- The sex ratio for second and third born children where previous births were female fell substantially in almost all regions of Nepal, indicating increasing usage of sex-selective abortions.
- Women who are wealthier, better educated and living in urban areas are most likely to use prenatal sex selection.

Strengths and limitations of this study

- This is the first study to show that sex-selective abortions are becoming increasingly common in Nepal at the national level.
- The survey data used did not allow for a more detailed geographical breakdown, which would be useful for policymakers.

Abstract

Objectives: To quantify trends in changing sex ratios of births before and after the legalisation of abortion in Nepal. While sex-selective abortion is common in some Asian countries it is not clear whether the legal status of abortion is associated with the prevalence of sex-selection when sex-selection is illegal. In this context, Nepal provides an interesting case study. Abortion was legalised in 2002 and before that there was no evidence of sex-selective abortion. Changes in the sex ratio at birth since legalisation would suggest an association with legalisation, even though sex-selection is expressly prohibited.

Design: Analysis of data from four Demographic and Health Surveys, conducted in 1996, 2001, 2006 and 2011.

Setting: Nepal.

Participants: 31,842 women aged 15-49.

Main outcome measure: Conditional sex ratios (CSRs) were calculated, specifically the CSR for second-born children where the first born was female. This CSR is where evidence of sex-selective abortion will be most visible. CSRs were looked at over time to assess the impact of legalisation as well as for population sub-groups in order to identify characteristics of women using sex-selection.

Results: From 2007 to 2010 the CSR for second-order births where the first born was a girl was found to be 742 girls per 1,000 boys (95% CI 599-913). Before abortion was legalised (1998-2000) the same CSR was 1021 (906-1150). After legalisation the CSR dropped most amongst educated and richer women, especially in urban areas. Just 325 girls were born for every 1,000 boys amongst the richest urban women.

Conclusions: The fall in CSRs witnessed post legalisation indicates that sex-selective abortion is becoming more common. This change is likely driven by both supply and demand factors. Falling fertility has intensified the need to bear a son sooner, while legal abortion services have reduced the costs and risks associated with obtaining an abortion.

Introduction

Selective abortion of females has been found to occur extensively in several Asian countries. Estimates suggest that between 3.1 and 6.0 million sex-selective abortions took place in India in the 2000s.[1] China has a well-documented history of so-called "missing girls" resulting from a combination of the one child policy and son preference, with as few as 847-877 girls born for every 1,000 boys.[2 3] Both China and India have well-established abortion services provided by national and regional governments; sex-selective abortion is illegal in both countries.[4 5]

An interesting question is the extent to which state provision of abortion services is associated with the selective abortion of females. Assessing this using data from China and India is difficult as the provision of abortion services has increased gradually.[4 6] However the neighbouring country of Nepal saw an abrupt change between 2002 and 2004 which provides the opportunity to measure the impact of state provision of abortion services on sex-selective behaviour. Abortion was legalised in Nepal in 2002 and Comprehensive Abortion Care (CAC) services were provided by the government from 2004 onwards.[7] Sex determination is expressly prohibited and anyone found performing (or facilitating) an abortion on this basis can be punished with one year's imprisonment, but otherwise the law is now liberal. Before 2002 unsafe abortion was the third largest cause of maternal mortality and it was not uncommon for women living in the south of the country to visit India if they wanted an abortion, though the scale of this is not known.[7] Studies of post-abortion care at 10 major hospitals showed that between 20% and 60% of the women admitted as obstetric and gynaecological patients were abortion complication cases.[8]

Nepal has revealed high levels of son preference since the World Fertility Surveys first documented the phenomenon in the 1980s.[9] Daughters are often considered to be an economic burden because of the dowry system and the fact that a girl will join her husband's family after marriage. Sons are highly prized because they continue the family name, are deemed crucial to perform funeral rites, are likely to bring in a daughter-in-law into the family and are expected to provide support for their parents in old age.[10-12]

Before 2002, son preference in Nepal was mainly evidenced through differential stopping behaviour (i.e. the decision to have another child depended upon the sex composition of previous children). It has been estimated that such behaviour caused the fertility rate to be at least 6% higher and contraceptive use to be as much as 24% lower than it would otherwise have been.[9 10] It therefore seems possible that, despite the strict prohibition of abortion on the grounds of the sex of the child, Nepalis will have taken advantage of the opportunities provided by the legalisation of abortion to influence the sex composition of their children.

Previous research suggests that sex-selective abortions occur in Nepal, but the evidence is either qualitative or based on small scale data.[13] A study in Kathmandu recorded the sex and parity of all babies born in a single hospital during a five year period (2003-2007) and found that, while for first born children the sex ratio was relatively normal at 943 females per 1,000 males, the sex ratio for second order births was 847 and for higher order births it was 565.[14] Unfortunately the sample sizes were too small to draw any significant conclusions. A rapid assessment of sex ratios at birth in 1991 and 2001 consistently found more male than female babies being born in a number of districts of Nepal bordering India.[15] A study conducted in 2007 revealed that legal sanctions against pre-natal sex determination and sex-selective abortion had not stopped medical practitioners and sonographers in Nepal from providing such services.[16]

Abnormal sex ratios can be the result of mechanisms other than sex-selective abortion: one example is through Hepatitis B, which can cause the sex ratio to be skewed towards males, though this is somewhat controversial; [17] there are also other biological explanations, but none of these would operate differentially across birth orders. If sex ratios vary substantially across birth orders then the explanation for this is almost certainly the use of sex-selective abortion. In India, for example, recent research indicates that the sex ratio of first born children has not changed significantly since 1990, while the sex ratio of second born children where the first was female was as low as 786 in the year 2000 and has not been above 900 since 1992.[1] Research from China has also found that sex ratios differ by parity – in 2004-05 the sex ratio of first born children was 925, while for second born children it was 699.[3]

It should be noted that even when sex-selective abortion is occurring, changes in its prevalence can occur for reasons related to the demand for, rather than the supply of, abortion services. Where fertility is declining rapidly the preference for sons may be intensified since the overall desired number of children will fall faster than the desire for sons, and pressure on couples to balance the sex composition of their children may contribute to further demand for pre-natal sex selection at low parities.[12 18] Nepal has seen one of the most dramatic fertility declines in history, with the total fertility rate (TFR) falling from 4.1 to 2.6 in just 10 years.[19]

The aim of this paper, therefore, is to examine sex ratios of births before and after the introduction of Comprehensive Abortion Care in 2004 to assess whether, given the religious and socio-economic value given to sons, the legalisation of abortion, and the availability of pre-natal sex-determination technologies and abortion clinics, was associated with a change in the proportion of babies which were male.

Methods

Data

Over 40,000 women were interviewed in four rounds of the Nepal Demographic and Health Survey (NDHS), conducted in 1996, 2001, 2006 and 2011. All four surveys were nationally representative and used a two stage stratified sampling scheme. All women were asked about their fertility and full birth histories were obtained from the 31,842 women aged 15-49; these birth histories included information on over 111,000 births. Full details of the NDHSs can be found elsewhere.[19-22]

A module on induced abortion was included in the 2011 NDHS for the first time. This included questions to ascertain the prevalence of abortion as well as the reasons for it. Overall 7.5% of pregnancies were reported to have ended in abortion in the five years before the survey was conducted. This varied substantially depending on the woman's socioeconomic characteristics with 17.5% of pregnancies ending in abortion for women in the highest wealth quintile. Of 506 women who gave a reason for their abortion 3.16% reported that it was due to the child's sex, but the subject area tends to have a high incidence of misreporting so indirect methods are likely to be the best method of studying the phenomenon.[23]

Statistical Analysis

In the absence of intervention, the sex ratio at birth in human populations is essentially a biological constant with relatively little variation. For every 1,000 males born, there will generally be between 950 and 975 females.[24 25] This should not vary by birth order.

To control for the fact that demand for sex-selective abortions will vary by birth order and sex of previous children conditional sex ratios (CSRs) are used in our analysis, specifically the CSR for second-born children where the first born was female. This sex ratio is generally held to be where evidence of sex-selective abortion will be most visible, since the motivation for sex-selection will probably be at its highest; it has been used frequently to provide evidence for the widespread use of sex-selective abortion in India.[1 23] If a woman is sufficiently motivated (or pressured) to have a son that she is prepared to have an abortion to achieve that end it is unlikely that she will wait until a much higher parity than two or three.

The sex ratios presented in this paper are the number of female births per 1,000 male births, calculated as $(P_f / P_m) * 1000$, where P_f is the proportion of total births that are female and P_m is the proportion of total births that are male. The sex ratios are weighted to account for the sampling scheme used in the NDHS. We only included births reported to have happened within ten years of the survey date, since extremely long recall periods tend to be less accurate, and misreporting may differ by sex of the baby. For time periods where more than one survey was available a weighted average of the different surveys was used.

Wealth tertiles were produced using principal components analysis; this was done separately for urban and rural areas in order to be able to look at the relative contribution of women at different wealth levels in diverse environments. Tertiles were used, rather than the more traditional quintiles, due to sample size considerations.

All analyses were conducted in STATA (version 12.0).

Results

Sex ratios at birth were found to vary substantially by parity, the sex of previous offspring and the time period during which the births occurred. Table 1 shows the trends in different conditional sex ratios over the 18-years 1992-2010. Years were grouped as the sample sizes for single years were small. The overall sex ratio is never significantly different from the expected range of 950-975 and does not show significant change over time; the same is true of the sex ratio of first-born children. However, for second-born children where the first born was female, the sex ratio shows a substantial decline after the legalisation of abortion. In 2001-2003 it was 947, in 2004-2006 (when government abortion services became available in most district headquarters and urban and semi-urban areas) it dropped to 830 and by 2007-2010 it had fallen further to just 742, despite the overall sex ratio being 933. For third-born children where the first two children had both been female the sex ratio was also very low at 767, compared to 892 if the first two children had both been male or 935 if one was male and one was female. The sex ratio for second-born children in 2007-2010 was low even for mothers whose first born was male at 822. Of the 4,521 births recorded in the NDHS 2011 during 2007-2010, 1,247 were second order births and just 559 (44.8%) of these were female. Assuming the biologically expected sex ratio at birth we would have expected at least around 650 females to have been born given the number of males.

It should be noted that in 2007-2010 only 14% of all births in Nepal were second order after a first-born girl. This explains why the overall sex ratio at birth is not greatly affected even by substantial changes in the sex ratio for this subset of births.

The sex ratio for second-born children where the first was female is thought to be the strongest evidence for sex selective abortion available, short of direct data. If this particular CSR also varies by socioeconomic characteristics then this is even stronger evidence that sex-selective abortion is being used, since knowledge of, access to, and uptake of abortion will not be equal in all parts of society. Figure 1 shows how the CSR has varied over the four NDHSs by mother's education. The sex ratios shown are those experienced during the five years prior to each survey. Table 2 shows the CSR and overall sex ratio before and after 2004 (when CAC services first became available), the percentage change in the CSR and the significance of the fall using a one sided *t*-test. A dramatic decline in the sex ratio is evident for those women who have at least a secondary leaving certificate or above. In the five years before the NDHS 2006 the CSR for this group of women was just 653 females for every 1,000 males, and the NDHS 2011 showed a CSR of just 368, while the CSR was almost 50% lower after 2004. The fall in the CSR after 2004 was significant at the 5% level for all educational groups except those with no education.

Table 1: Conditional sex ratios at birth (females per 1000 males), by birth order, 1992-2010

Birth order	All			First born			Second born					
Sex of previous children	*NA*			*NA*			*first born male*			*first born female*		
Year	mean	95% CI	n	mean	95% CI	n	mean	95% CI	n	mean	95% CI	n
1992-1994	975	(945 ,1007)	14963	964	(892 ,1041)	3642	1063	(949 ,1191)	1580	951	(852 ,1061)	1685
1995-1997	952	(920 ,985)	13050	878	(807 ,954)	3295	856	(760 ,963)	1474	967	(858 ,1090)	1439
1998-2000	973	(938 ,1009)	11553	920	(850 ,995)	3136	902	(799 ,1018)	1386	1021	(906 ,1150)	1340
2001-2003	928	(887 ,971)	7586	907	(812 ,1011)	2187	818	(688 ,969)	966	947	(810 ,1106)	968
2004-2006	962	(915 ,1012)	6044	975	(872 ,1090)	1864	971	(816 ,1157)	812	830	(702 ,978)	788
2007-2010	933	(880 ,989)	4521	1010	(907 ,1124)	1489	822	(689 ,979)	633	742	(599 ,913)	614

Birth order	Third born									Fourth or above		
Sex of previous children	*both male*			*both female*			*one male, one female*			*NA*		
Year	mean	95% CI	n	mean	95% CI	n	mean	95% CI	n	mean	95% CI	n
1992-1994	811	(681 ,964)	662	1027	(864 ,1221)	719	984	(870 ,1113)	1327	963	(912 ,1016)	5348
1995-1997	922	(763 ,1112)	530	975	(814 ,1167)	640	1131	(995 ,1287)	1163	951	(897 ,1008)	4509
1998-2000	1005	(806,1254)	449	849	(699 ,1027)	553	954	(827 ,1099)	948	1011	(948 ,1078)	3741
2001-2003	933	(713,1218)	300	872	(689 ,1099)	392	888	(726 ,1084)	620	972	(893 ,1057)	2153
2004-2006	930	(650 ,1325)	198	846	(629 ,1130)	313	1041	(845 ,1282)	490	994	(900 ,1097)	1579
2007-2010	892	(637 ,1241)	169	767	(556 ,1046)	215	935	(707 ,1233)	372	1100	(973 ,1244)	1029

ways of manipulating the sex composition of their children. For urban women in the 2011 NDHS the wealth gradient is dramatic, with the poorest urban women having a higher sex ratio than rural women, but the richest urban women exhibiting the lowest sex ratio of all at just 326, indicating where sex-selective abortion is likely to be most prevalent. That the CSR is lowest among richer urban women is unsurprising, as they would be expected to be able to access abortion services most easily and have the greatest knowledge about the availability of abortion services; that said, the extent of the shortfall in female births is remarkable. Table 2 shows that the fall in the sex ratio was significant for all wealth

groups in rural areas, but only for the richest in urban areas. Nonetheless, the CSR post-2004 was substantially less than 900 for all wealth groups of urban women.

Table 2: Conditional sex ratios of second order births where the first born was female and overall sex ratios, before and after the introduction of CAC services

		1992-2003				2004-2010				% fall in CSR	Sig.
		Overall sex ratio	n	CSR	n	Overall sex ratio	n	CSR	n		
Wealth of urban women	*Poorest*	949	3963	**956**	952	953	1014	**843**	129	*11.8*	
	Middle	952	2789	**915**	772	971	749	**864**	139	*5.6*	
	Richest	943	1263	**1019**	480	872	279	**794**	57	*22.1*	*
Wealth of rural women	*Poorest*	990	13256	**1074**	2706	989	3642	**911**	544	*15.2*	*
	Middle	954	15852	**939**	3657	912	2845	**795**	538	*15.3*	**
	Richest	939	8811	**916**	2463	897	1476	**786**	330	*14.2*	†
Woman's education	*No education*	956	34496	**957**	8758	988	5433	**895**	567	*6.5*	
	Primary or less	998	6539	**1046**	1517	937	2059	**969**	321	*7.4*	*
	Some secondary	945	5416	**958**	1219	899	2598	**730**	440	*23.8*	**
	SLC or above	991	699	**1001**	166	863	475	**501**	74	*49.9*	**
Region	Eastern Mountain	978	2194	**789**	477	930	635	**945**	83	*-19.8*	
	Central Mountain	961	2330	**1194**	534	828	468	**1011**	53	*15.4*	
	Western Mountain	897	2953	**901**	591	965	863	**833**	101	*7.5*	
	Eastern Hill	1024	3310	**1023**	793	1002	855	**792**	120	*22.6*	†
	Central Hill	925	4056	**964**	1207	996	701	**761**	112	*21.0*	
	Western Hill	969	4152	**997**	1136	1004	809	**847**	118	*15.0*	
	Mid-Western Hill	928	3485	**869**	737	867	945	**691**	99	*20.5*	†
	Far-Western Hill	979	3356	**1105**	712	929	872	**872**	99	*21.1*	
	Eastern Terai	991	4557	**911**	1298	969	882	**700**	133	*23.1*	*
	Central Terai	969	5823	**989**	1412	980	1113	**701**	139	*29.1*	†
	Western Terai	941	3983	**1023**	992	964	821	**1000**	110	*2.3*	
	Mid-Western Terai	921	3370	**1020**	844	941	852	**761**	119	*25.4*	*
	Far-Western Terai	1001	3583	**956**	928	923	749	**835**	116	*12.6*	†

NB: † p<0.1 * p<0.05 **p<0.01 ***p<0.001

There were regional differences in the CSR and how much it changed after the legalisation of abortion. Table 2 shows the conditional sex ratio for 13 sub-regions of Nepal for the 10 years before 2004 and the period post-2004. The regions are defined on the basis of altitude ('mountain', 'hill' and 'Terai' or plains), and longitude ('far western', 'western', 'mid-western', 'central' and 'eastern'). The CSR declines between the two periods in every region but one (the Eastern Mountain, where the CSR before 2004 was below 800). Two regions show declines which are significant at the 5% level, and six regions (accounting for around two thirds of the population of Nepal) show declines that are significant at the 10% level. The most substantial decline was visible in the Central Terai where the CSR fell by almost 30% from 989 to 701, though both the Mid-Western Hill and the Eastern Terai had lower sex ratios after 2004. Before 2004 just one region had a CSR below 800 and 11 out of 13 had CSRs of over 900. In the period after abortion services became available the CSRs of 10 regions dropped below 900, with six falling below 800 and one below 700.

Discussion

These findings suggest that since abortion was legalised in Nepal sex-selective abortion has become more common. We have found no evidence that the natural sex ratio of births (unaffected by human intervention) is outside the normal range for human populations; in particular the sex ratio of first-born does not differ significantly from the expected level of 950-975 females per 1,000 males. However, for second-born children, especially where the first-born was female, there has been a sharp (and significant) fall in the number of girls compared with boys. The sex ratio of third-born children where the first two were female has also fallen substantially in recent years, while for children of higher parities the sex ratio remains within the expected range; this may indicate a tendency for those women having more than four children not to use contraception or abortion services.[26] Sex ratios of births are lowest for richer, more educated women, especially in urban areas and differ substantially by parity and the sex composition of previous children.

The data we have used were collected over the course of 16 years and include over 40,000 Nepali women, but are still not sufficient to allow the identification of all the sub-populations experiencing low sex ratios. Regional estimates of sex ratios were limited to relatively large areas. Census data may yet prove fruitful for achieving a finer level of aggregation. The 2001 census indicated that no district had an abnormal population sex ratio for infants. It will be interesting to find out if almost ten years after abortion was legalised, the infant sex ratios in any particular districts show a decline. The survey data analysed here indicates that this may well be the case, but it should be remembered that the extremely low CSRs are masked by a relatively normal overall sex ratio at birth.

Apart from the fact that the results reported in this paper are based on a relatively small number of births, some underreporting of girls in full birth histories is a possibility. However, it seems improbable that the underreporting would be greater than average for second order and third order births, or among rich, urban, or better educated women in more recent surveys.

Although we have been able to suggest that sex-selective abortion has increased in Nepal since 2004, we have not been able to enumerate the size of the problem. It is hoped that census data will allow the number of sex-selective abortions in recent years to be estimated. However, the CSR we report for second order births where the first born was female is just 742, which is as low as the same CSRs found in India, where sex-selective abortion is known to be widespread.[1 23] It seems likely that sex-selective abortion is becoming a more common phenomenon in Nepal, a trend which mirrors that in India and

China. Recent evidence from DHS data suggests that the proportion of pregnancies aborted increases with birth order and is higher for urban, richer and better-educated women.[19]

The timing and abruptness of the change in CSRs suggests that it is associated with the legalisation of abortion and the state provision of abortion services in the country. CAC services have only been available since 2004, but in some regions the CSR of second-born children where the first born was male has fallen by well over 200 in that time. However, we do not mean to suggest a simple relationship between the introduction of CAC services and the change in the CSRs. It is more likely that both demand and supply factors have been at work. The decline in fertility has increased the importance that at least one son is born among the first three children. This has intensified the demand for abortions on the grounds of the sex of the foetus. Before 2004, Nepali women desiring abortions had to be prepared to incur either substantial health risks (from illegal services) or costs (from going to India) or both. The effect of the introduction of CAC services in 2004 was to reduce both the risks and the costs, and hence to increase the number of abortions in Nepal. The reduction in risks/costs applied to all abortions, but since a major (and increasingly important) reason for demanding an abortion in Nepal is the sex of the foetus there has been a rise in the number of abortions performed for this reason. It is interesting to note that the change in the CSR for second births following a first-born girl was greatest among urban educated women, who would have been most able to afford abortions even before 2004. The decline in fertility has been most acute among this group; if cultural forces leading to a strong desire for at least one son remain universal in Nepal, their demand for sex-selective abortions may have increased more rapidly than that of rural and less well educated women.

Clearly there are policy implications in terms of education about the long term social and demographic consequences of sex-selective abortion. While educating medical practitioners is one important step, previous research has shown that medical practitioners believe that if a woman wishes to have a sex-selective abortion she can easily obtain one in India; it may also be hard for practitioners to judge a woman's reasons for wanting an abortion.[13 27] For these reasons it is also paramount to educate wider members of the community about the illegality of sex determination tests for the sole purpose of selective abortion and the health risks associated with second trimester abortions.

Advocacy and educational campaigns amongst groups with particularly low sex ratios will be important; literate, urban women are one target group. Those living in the Terai with easy access to the Indian border are another. It is also important to remember that the use of sex-selective abortion has risen not only because of socio-cultural preferences for sons, but also because girls are seen as an economic burden. Ultimately, combating sex-selective abortion will require the empowerment of women throughout Nepali society. Programmes benefiting female children would be a start; these might include maternity incentives to mothers who give birth to a girl, education scholarships and free vocational training for girls, and economic incentives for the parents of girls.

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Contributors

MF conducted the data analysis. All authors were involved with data interpretation, writing the paper, and approved the final version. MF is the guarantor.

Conflicts of Interest

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Ethics

Ethics approval was not required as this paper was produced using secondary data analysis.

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Data sharing

The full datasets are available at www.measuredhs.com. Consent was not obtained for this study, but participants gave informed consent for the original survey; the presented data are anonymised and there is no risk of identification.

Figure legends:

Figure 1: Conditional sex ratio of second order births where the first born was female, by educational level of the mother, over time

Figure 2 shows the same CSR split by wealth tertile in urban and rural areas for the five year period before each NDHS. In the 2011 NDHS rural women in all wealth tertiles display lower sex ratios than would be expected, with the sex ratio in all wealth groups below 800. A wealth gradient is visible, with the richest women being least likely to have a girl, but it seems that even poorer women are finding

Article Summary

Article focus

- Little evidence exists concerning whether the legal status of abortion is related to incidence of prenatal sex selection; Nepal provides an interesting case study.
- Sex ratios at birth in Nepal before and after abortion was legalised in 2002 are calculated in order to test for evidence of sex-selective abortions.
- This study seeks to identify characteristics of women experiencing the lowest sex ratios and thus those who are most likely to have a sex-selective abortion.

Key messages

- There is clear evidence of a substantial increase in sex selection since 2002, even though this remains strictly prohibited.
- The sex ratio for second and third born children where previous births were female fell substantially in almost all regions of Nepal, indicating increasing~~widespread~~ usage of sex-selective abortions.
- Women who are wealthier, better educated and living in urban areas are most likely to use prenatal sex selection.

Strengths and limitations of this study

- This is the first study to show that sex-selective abortions are becoming increasingly common in Nepal at the national level~~and that this problem is nationwide~~.
- The survey data used did not allow for a more detailed geographical~~geographic~~ breakdown, which would be useful for policymakers.

Abstract

Objectives: To quantify trends ~~and patterns~~ in changing sex ratios of births before and after~~since~~ the legalisation of abortion in Nepal. While sex-selective abortion is common in some Asian countries it is not clear whether~~if~~ the legal status of abortion is associated with~~can have an effect on~~ the prevalence of sex-selection when sex-selection is illegal. In this context, Nepal provides an interesting case study. Abortion was legalised ~~in Nepal~~ in 2002 and before~~prior to~~ that there was no evidence of sex-selective abortion. Changes in the sex ratio at birth since legalisation would suggest an association with~~indicate that this may have been caused by~~ legalisation, even though sex-selection is expressly~~itself remains~~ prohibited.

Design: Analysis of data from four ~~Nepal~~ Demographic and Health Surveys, conducted in 1996, 2001, 2006 and 2011.

Setting: Nepal.

Participants: 31,842 women aged 15-49.

Main outcome measure: Conditional sex ratios (CSRs) were calculated, specifically the CSR for second-born children where the first born was female. This CSR is where evidence of sex-selective abortion will be most visible. CSRs were looked at over time to assess the impact of legalisation as well as for population sub-groups in order to ~~assess trends and~~ identify characteristics of women using sex-selection.

Results: From 2007 to 2010 the CSR for second-order births where the first born was a girl was found to be 742 girls per 1,000 boys (95% CI~~confidence interval~~ 599~~ to~~-913). Before abortion was legalised (1998~~ to~~-2000) the same CSR was 1021 (906~~ to~~-1150). After legalisation the CSR dropped most amongst educated and richer women, especially in urban areas. Just~~Indeed, just~~ 325 girls were born for every 1,000 boys amongst the richest urban women.

Conclusions: The ~~abrupt~~ fall in CSRs witnessed post legalisation indicates that sex-selective abortion is becoming more common. This change is likely driven by both supply and demand factors. Falling fertility has intensified the need to bear a son sooner, while legal abortion services have reduced the costs and risks associated with obtaining an abortion. ~~has become common. This research also indicates that legalising abortion can have a substantial effect on sex ratios, even if sex-selection is specifically prohibited.~~

Introduction

Selective abortion of females has been found to occur extensively in several Asian countries. Estimates suggest that between 3.1 and 6.0 million sex-selective abortions took place in India in the 2000s.[1] China has a well-documented history of so-called "missing girls" resulting from a combination of the one child policy and son preference, with as few as 847-877 girls born for every 1,000 boys.[2 3] Both China and India have well-established abortion services provided by national and regional governments; sex-selective abortion is illegal in both countries.[4 5]

An interesting question is the extent to which state provision of abortion services is associated with the selective abortion of females. Assessing this using data from China and India is difficult as the provision of abortion services has increased gradually.[4 6] However the neighbouring country of Nepal saw an abrupt change between 2002 and 2004 which provides the opportunity to measure the impact of state provision of abortion services on sex-selective behaviour. Abortion was legalised in Nepal in 2002 and Comprehensive Abortion Care (CAC) services were provided by the government from 2004 onwards.[7] Sex determination is expressly prohibited and anyone found performing (or facilitating) an abortion on this basis can be punished with one year's imprisonment, but otherwise the law is now ~~extremely~~ liberal. Before 2002 unsafe abortion was the third largest cause of maternal mortality and it was not uncommon for women living in the south of the country to visit India if they wanted an abortion, though the scale of this is not known.[7] Studies of post-abortion care at 10 major hospitals showed that between 20% and 60% of the women admitted as obstetric and gynaecological patients were abortion complication cases.[8]

Nepal has revealed high levels of son preference since the World Fertility Surveys first documented the phenomenon in the 1980s.[9] Daughters are often considered to be an economic burden because of the dowry system and the fact that a girl will join her husband's family after marriage. Sons are highly prized because they continue the family name, are deemed crucial to perform funeral rites, are likely to bring in a daughter-in-law into the family and are expected to provide support for their parents in old age.[10-12]

Before 2002, son preference in Nepal was mainly evidenced through differential stopping behaviour (i.e. the decision to have another child depended upon the sex composition of previous children). It has been estimated that such behaviour caused the fertility rate to be at least 6% higher and contraceptive use to be as much as 24% lower than it would otherwise have been.[9 10] It therefore seems possible that, despite the strict prohibition of abortion on the grounds of the sex of the child, Nepalis will have taken advantage of the opportunities provided by the legalisation of abortion to influence the sex composition of their children.

Previous research suggests that sex-selective abortions occur in Nepal, but the evidence is either qualitative or based on small scale data.[13] A study in Kathmandu recorded the sex and parity of all babies born in a single hospital during a five year period (2003-2007) and found that, while for first born children the sex ratio was relatively normal at ~~106 males to 100 females~~943 females per 1,000 males, the sex ratio for second order births was 847~~118~~ and for higher order births it was 565~~177~~.[14] Unfortunately the sample sizes were too small to draw any significant conclusions. A rapid assessment of sex ratios at birth in 1991 and 2001 consistently found more male than female babies being born in a number of districts of Nepal bordering India.[15] A study conducted in 2007 revealed that legal sanctions against pre-natal sex determination and sex-selective abortion had not stopped medical practitioners and sonographers in Nepal from providing such services.[16]

Abnormal sex ratios can be the result of mechanisms other than sex-selective abortion: one example is through Hepatitis B, which can cause the sex ratio to be skewed towards males, though this is somewhat controversial;[17] there are also other biological explanations, but none of these would operate differentially across birth orders. If sex ratios vary substantially across birth orders then the explanation for this is almost certainly the use of sex-selective abortion. In India, for example, recent research indicates that the sex ratio of first born children has not changed significantly since 1990, while the sex ratio of second born children where the first was female was as low as 786 in the year 2000 and has not been above 900 since 1992.[1] Research from China has also found that sex ratios differ by parity – in 2004-05 the sex ratio of first born children was 925, while for second born children it was 699.[3]

It should be noted that even when sex-selective abortion is occurring, changes in its prevalence can occur for reasons related to the demand for, rather than the supply of, abortion services. Where fertility is declining rapidly the preference for sons may be intensified since the overall desired number of children will fall faster than the desire for sons, and pressure on couples to balance the sex composition of their children may contribute to further demand for pre-natal sex selection at low parities.[12 18] Nepal has seen one of the most dramatic fertility declines in history, with the total fertility rate (TFR) falling from 4.1 to 2.6 in just 10 years.[19]

The aim of this paper, therefore, is to examine sex ratios of births before and after the introduction of Comprehensive Abortion Care in 2004 to assess whether, given the religious and socio-economic value given to sons, the legalisation of abortion, and the availability of pre-natal sex-determination technologies and abortion clinics, was associated with a change in the proportion of babies which were male.

Methods

Data

Over 40,000 women were interviewed in four rounds of the Nepal Demographic and Health Survey (NDHS), conducted in 1996, 2001, 2006 and 2011. All four surveys were nationally representative and used a two stage stratified sampling scheme. All women were asked about their fertility and full birth histories were obtained from the 31,842 women aged 15-49; these birth histories included information on over 111,000 births. Full details of the NDHSs can be found elsewhere.[19-22]

A module on induced abortion was included in the 2011 NDHS for the first time. This included questions to ascertain the prevalence of abortion as well as the reasons for it. Overall 7.5% of pregnancies were reported to have ended in abortion in the five years before the survey was conducted. This varied substantially depending on the woman's socioeconomic characteristics with 17.5% of pregnancies ending in abortion for women in the highest wealth quintile. Of 506 women who gave a reason for their abortion 3.16% reported that it was due to the child's sex, but the subject area tends to have a high incidence of misreporting so indirect methods are likely to be the best method of studying the phenomenon.[23]

Statistical Analysis

In the absence of intervention, the sex ratio at birth in human populations is essentially a biological constant with relatively little variation. For every 1,000 males born, there will generally be between 950 and 975 females.[24 25] This should not vary by birth order.

~~Abnormal sex ratios can be the result of mechanisms other than sex-selective abortion: the most obvious example is through Hepatitis B, though there are other biological explanations. Moreover,~~ [3] ~~even when sex-selective abortion is occurring, changes in its prevalence can occur for reasons related to the demand for, rather than the supply of, abortion services. Where fertility is declining rapidly the preference for sons may be intensified since the overall desired number of children will fall faster than the desire for sons, and pressure on couples to balance the sex composition of their children may contribute to further demand for pre-natal sex selection at low parities.~~[12 18] ~~Nepal has seen one of the most dramatic fertility declines in history, with the total fertility rate (TFR) falling from 4.1 to 2.6 in just 10 years.~~[19]

To control for the fact that demand for sex-selective abortions will vary by birth order and sex of previous children~~se effects, we use~~ conditional sex ratios (CSRs) are used in our analysis, specifically the CSR for second-born children where the first born was female. This sex ratio is generally held to be where evidence of sex-selective abortion will be most visible, since the motivation for sex-selection will probably be at its highest; it has been used frequently to provide evidence for the widespread use of sex-selective abortion in India.[1 23] If a woman is sufficiently motivated (or pressured) to have a son that she is prepared to have an abortion to achieve that end it is unlikely that she will wait until a much higher parity than two or three.

The sex ratios presented in this paper are the number of female births per 1,000 male births, calculated as $(P_f / P_m) * 1000$, where P_f is the proportion of total births that are female and P_m is the proportion of total births that are male. The sex ratios are weighted to account for the sampling scheme used in the NDHS. We only included births reported to have happened within ten years of the survey date, since extremely long recall periods tend to be less accurate, and misreporting may differ by sex of the baby. For time periods where more than one survey was available a weighted average of the different surveys was used.

Wealth tertiles were produced using principal components analysis; this was done separately for urban and rural areas in order to be able to look at the relative contribution of women at different wealth levels in diverse environments. Tertiles were used, rather than the more traditional quintiles, due to sample size considerations.

All analyses were conducted in STATA (version 12.0).

Results

Sex ratios at birth were found to vary substantially by parity, the sex of previous offspring and the time period during which the births occurred. Table 1 shows the trends in different conditional sex ratios~~CSRs~~ over the 18-years 1992-2010. Years were grouped as the sample sizes for single years were small. The overall sex ratio is never significantly different from the expected range of 950-975 and does not show significant change over time; the same is true of~~, neither is~~ the sex ratio of first-born children. However, for second-born children where the first born was female, the sex ratio shows a substantial decline after the legalisation of abortion. In 2001-2003 it was 947, in 2004-2006 (when government abortion services became available in most district headquarters and urban and semi-urban areas) it dropped to 830 and by 2007-2010 it had fallen further~~plummeted~~ to just 742, despite the overall sex ratio being 933. For third-born children where the first two children had both been female the sex ratio was also very~~extremely~~ low at 767, compared to 892 if the first two children had both been male or 935 if one was male and one was female. The sex ratio for second-born children in 2007-2010 was low even

for mothers whose first born was male at 822. Of the 4,521 births recorded in the NDHS 2011 during 2007-2010, 1,247 ~~of them~~ were second order births and just 559 (44.8%) of these were female. Assuming the biologically expected sex ratio at birth we would have expected at least around 650 females to have been born given the number of males.

It should be noted that in 2007-2010 only 14% of all births in Nepal were second order after a first-born girl. This explains why the overall sex ratio at birth is not greatly affected even by substantial changes in the sex ratio for this subset of births.

The sex ratio for second-born children where the first was female is thought to be the strongest evidence for sex selective abortion available, short of direct data. If this particular CSR also varies by socioeconomic characteristics then this is even stronger evidence that sex-selective abortion is being used, since knowledge of, access to, and uptake of abortion will not be equal in all parts of society. Figure 1 shows how the CSR has varied over the four NDHSs by mother's education. The sex ratios shown are those experienced during the five years prior to each survey. Table 2 shows the CSR and overall sex ratio before and after 2004 (when CAC services first became available), the percentage change in the CSR and the significance of the fall using a one sided *t*-test. A dramatic decline in the sex ratio is evident for those women who have at least a secondary leaving certificate or above. In the five years before the NDHS 2006 the CSR for this group of women was just 653 females for every 1,000 males, and the NDHS 2011 showed a CSR of just 368, while the CSR was almost 50% lower after 2004. The fall in the CSR after 2004 was significant at the 5% level for all educational groups except those with no education.

Table 1: Conditional sex ratios at birth (females per 1000 males), by birth order, 1992-2010

Birth order	All			First born			Second born					
Sex of previous children	*NA*			*NA*			*first born male*			*first born female*		
Year	mean	95% CI	n	mean	95% CI	n	mean	95% CI	n	mean	95% CI	n
1992-1994	975	*(945 ,1007)*	14963	964	*(892 ,1041)*	3642	1063	*(949 ,1191)*	1580	951	*(852 ,1061)*	1685
1995-1997	952	*(920 ,985)*	13050	878	*(807 ,954)*	3295	856	*(760 ,963)*	1474	967	*(858 ,1090)*	1439
1998-2000	973	*(938 ,1009)*	11553	920	*(850 ,995)*	3136	902	*(799 ,1018)*	1386	1021	*(906 ,1150)*	1340
2001-2003	928	*(887 ,971)*	7586	907	*(812 ,1011)*	2187	818	*(688 ,969)*	966	947	*(810 ,1106)*	968
2004-2006	962	*(915 ,1012)*	6044	975	*(872 ,1090)*	1864	971	*(816 ,1157)*	812	830	*(702 ,978)*	788
2007-2010	933	*(880 ,989)*	4521	1010	*(907 ,1124)*	1489	822	*(689 ,979)*	633	742	*(599 ,913)*	614

Birth order	Third born									Fourth or above		
Sex of previous children	*both male*			*both female*			*one male, one female*			*NA*		
Year	mean	95% CI	n	mean	95% CI	n	mean	95% CI	n	mean	95% CI	n
1992-1994	811	*(681 ,964)*	662	1027	*(864 ,1221)*	719	984	*(870 ,1113)*	1327	963	*(912 ,1016)*	5348
1995-1997	922	*(763 ,1112)*	530	975	*(814 ,1167)*	640	1131	*(995 ,1287)*	1163	951	*(897 ,1008)*	4509
1998-2000	1005	*(806,1254)*	449	849	*(699 ,1027)*	553	954	*(827 ,1099)*	948	1011	*(948 ,1078)*	3741
2001-2003	933	*(713,1218)*	300	872	*(689 ,1099)*	392	888	*(726 ,1084)*	620	972	*(893 ,1057)*	2153
2004-2006	930	*(650 ,1325)*	198	846	*(629 ,1130)*	313	1041	*(845 ,1282)*	490	994	*(900 ,1097)*	1579
2007-2010	892	*(637 ,1241)*	169	767	*(556 ,1046)*	215	935	*(707 ,1233)*	372	1100	*(973 ,1244)*	1029

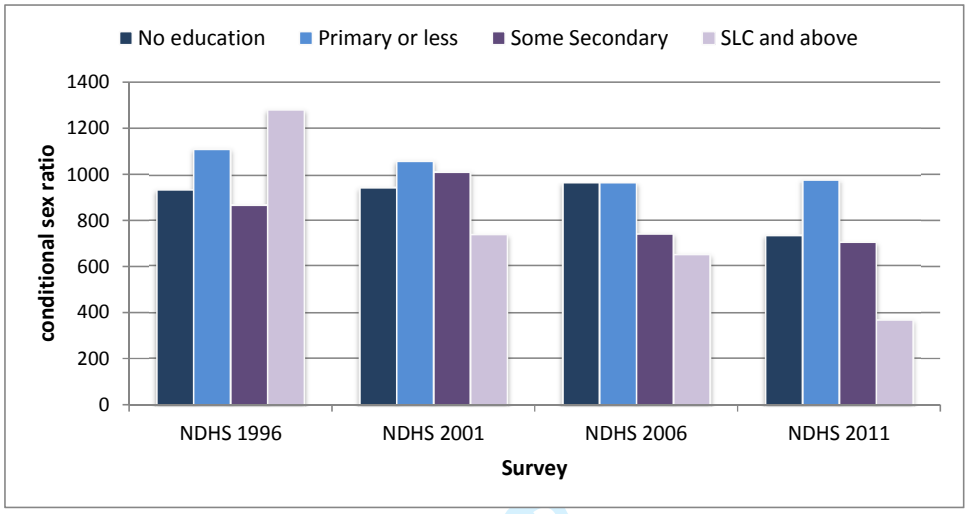

Figure 1: Conditional sex ratio of second order births where the first born was female, by educational level of the mother, over time

Figure 2 shows the same CSR split by wealth tertile in urban and rural areas for the five year period before each NDHS. ~~Figures are also shown in Table 2.~~ In~~Perhaps unexpectedly, by~~ the 2011 NDHS rural women in all wealth tertiles display lower sex ratios than would be expected, with the sex ratio in all wealth groups below 800. A wealth gradient is visible, with the richest women being least likely to have a girl, but it seems that even poorer women are finding ways of manipulating the sex composition of their children. For urban women in the 2011 NDHS the wealth gradient is dramatic, with the poorest urban women having a higher sex ratio than rural women, but the richest urban women exhibiting the lowest sex ratio of all at just 326, indicating where sex-selective abortion is likely to be most prevalent. That the CSR is lowest among richer urban women is unsurprising, as they would be expected to be able to access abortion services most easily and have the greatest knowledge about the availability of abortion services; that said, the extent of the shortfall in female births is remarkable. Table 2 shows that the fall in the sex ratio was significant for all wealth groups in rural areas, but only for the richest in urban areas. Nonetheless, the CSR post-2004 was substantially less than 900 for all wealth groups of urban women.

Table 2: Conditional sex ratios of second order births where the first born was female and overall sex ratios, before and after the introduction of CAC services

		1992-2003				2004-2010				% fall in CSR	Sig.
		Overall sex ratio	n	CSR	n	Overall sex ratio	n	CSR	n		
Wealth of urban women	*Poorest*	949	3963	**956**	952	953	1014	**843**	129	*11.8*	
	Middle	952	2789	**915**	772	971	749	**864**	139	*5.6*	
	Richest	943	1263	**1019**	480	872	279	**794**	57	*22.1*	*
Wealth of rural women	*Poorest*	990	13256	**1074**	2706	989	3642	**911**	544	*15.2*	*
	Middle	954	15852	**939**	3657	912	2845	**795**	538	*15.3*	**
	Richest	939	8811	**916**	2463	897	1476	**786**	330	*14.2*	†
Woman's education	*No education*	956	34496	**957**	8758	988	5433	**895**	567	*6.5*	
	Primary or less	998	6539	**1046**	1517	937	2059	**969**	321	*7.4*	*
	Some secondary	945	5416	**958**	1219	899	2598	**730**	440	*23.8*	**
	SLC or above	991	699	**1001**	166	863	475	**501**	74	*49.9*	**
Region	Eastern Mountain	978	2194	**789**	477	930	635	**945**	83	*-19.8*	
	Central Mountain	961	2330	**1194**	534	828	468	**1011**	53	*15.4*	
	Western Mountain	897	2953	**901**	591	965	863	**833**	101	*7.5*	
	Eastern Hill	1024	3310	**1023**	793	1002	855	**792**	120	*22.6*	†
	Central Hill	925	4056	**964**	1207	996	701	**761**	112	*21.0*	
	Western Hill	969	4152	**997**	1136	1004	809	**847**	118	*15.0*	
	Mid-Western Hill	928	3485	**869**	737	867	945	**691**	99	*20.5*	†
	Far-Western Hill	979	3356	**1105**	712	929	872	**872**	99	*21.1*	
	Eastern Terai	991	4557	**911**	1298	969	882	**700**	133	*23.1*	*
	Central Terai	969	5823	**989**	1412	980	1113	**701**	139	*29.1*	†
	Western Terai	941	3983	**1023**	992	964	821	**1000**	110	*2.3*	
	Mid-Western Terai	921	3370	**1020**	844	941	852	**761**	119	*25.4*	*
	Far-Western Terai	1001	3583	**956**	928	923	749	**835**	116	*12.6*	†

NB: † p<0.1 * p<0.05 **p<0.01 ***p<0.001

There were ~~also substantial~~ regional differences in the CSR and how much it changed after the legalisation of abortion. Table 2 shows the conditional sex ratio for 13 sub-regions of Nepal for the 10 years before 2004 and the period post-2004. The regions are defined on the basis of altitude ('mountain', 'hill' and 'Terai' or plains), and longitude ('far western', 'western', 'mid-western', 'central' and 'eastern'). The CSR declines between the two periods in every region but one (the Eastern Mountain, where the CSR before 2004 was below 800). Two~~Seven~~ regions show declines which~~that~~ are significant at the 5~~10~~% level, and six~~: these~~ regions (accounting~~account~~ for around two thirds of the population of Nepal) show declines that are significant at the 10% level. The most substantial decline was visible in the Central Terai where the CSR fell by almost 30% from 989 to 701, though both the Mid-Western Hill and the Eastern Terai had lower sex ratios after 2004. Before 2004 just one region had a CSR below 800 and 11 out of 13 had CSRs of over 900. In the period after abortion services became available the CSRs of 10 regions dropped below 900, with six falling below 800 and one below 700.

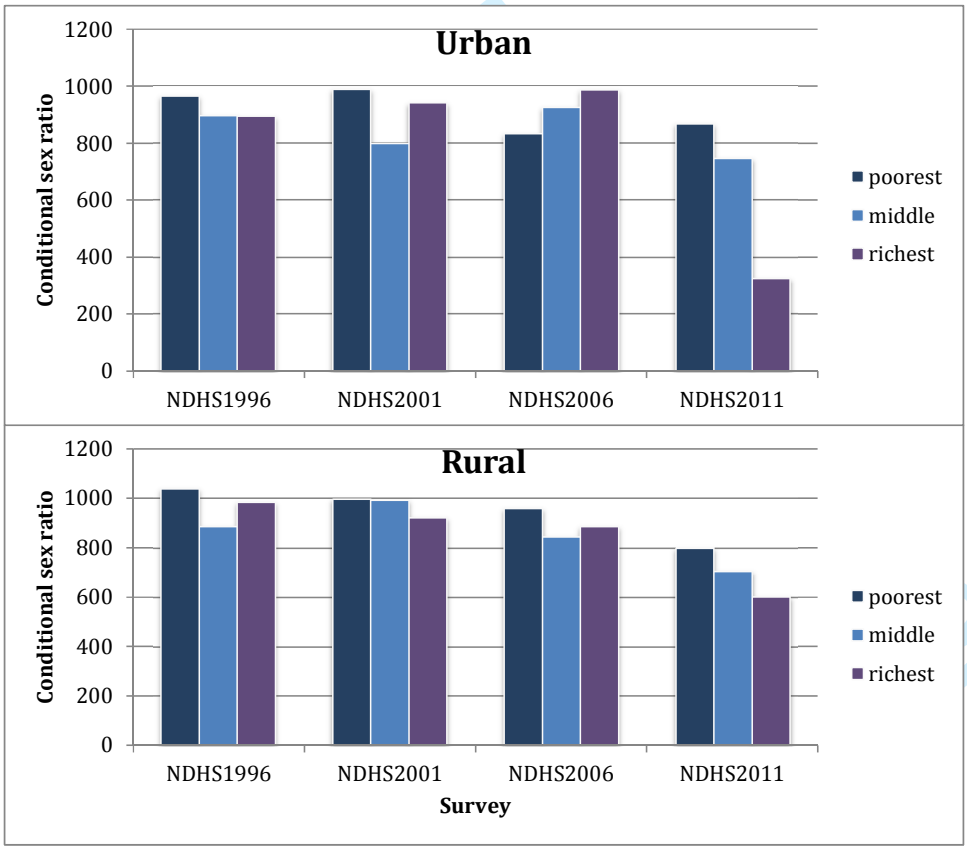

Figure 2: Conditional sex ratio of second order births where first born was female, by wealth tertile of the household in urban and rural areas, over time

Discussion

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These findings suggest that since abortion was legalised in Nepal sex-selective abortion has become more common. We have found ~~Sex ratios are lowest for richer, more educated women, especially in urban areas and differ substantially by parity and the sex composition of previous children. There is currently~~ no evidence that the natural sex ratio of births (unaffected by human intervention) is outside the normal range for human populations; in particular the sex ratio of first-born does not differ ~~children is~~ significantly ~~different~~ from the expected level of 950-975 females per 1,000 males~~biological norm~~. However, for second-born children, especially where the first-born was female, there has been a sharp (and significant) fall in the number of girls compared with boys. The sex ratio of third-born children where the first two were female has also fallen substantially in recent years, while for children of higher parities the sex ratio remains within the expected range; this may indicate a tendency for those women having more than four children not to use contraception or abortion services.[26] Sex ratios of births are lowest for richer, more educated women, especially in urban areas and differ substantially by parity and the sex composition of previous children. ~~indicating a tendency for those women having more than four children not to use contraception or abortion services.[25]~~

The data we have used were collected over the course of 16 years and include~~covering~~ over 40,000 Nepali women, but are still not sufficient to allow the identification of all ~~of~~ the sub-populations experiencing low sex ratios. Regional estimates of sex ratios were limited to relatively large areas. Census data may yet prove fruitful for achieving a finer level of aggregation. The 2001 census indicated that no district had an abnormal population sex ratio for infants. It will be interesting to find out if almost ten years after abortion was legalised, the infant sex ratios in any particular districts show a decline. The survey data analysed here indicates that this may well be the case, but it should be remembered that the extremely low CSRs are masked by a relatively normal overall sex ratio at birth.

Apart from the fact that the results reported in this paper are based on a relatively small number of births, some underreporting of girls in full birth histories is a possibility. However, it seems improbable that the underreporting would be greater than average for second order and third order births, or among rich, urban, or better educated women in more recent surveys.

Although we have been able to suggest that sex-selective abortion has increased in Nepal since 2004, we have not been able to enumerate the size of the problem. It is hoped that census data will allow the number of sex-selective abortions in recent years to be estimated. However, ~~some of~~ the CSR~~sex ratios~~ we report for second order births where the first born was female is just 742, which is~~are~~ as low as the same CSRs found~~those seen~~ in ~~parts of~~ India, where sex-selective abortion is known to be widespread.[1 23] It seems likely that sex-selective abortion is becoming a more common phenomenon in Nepal, a trend which mirrors that in India and China. Recent evidence from DHS data suggests that the proportion of pregnancies aborted increases with birth order and is higher for urban, richer and better-educated women.[19] ~~It seems likely that sex-selective abortion is becoming common phenomenon in Nepal, a trend which mirrors that in India and China.~~

The timing and abruptness of the change in CSRs suggests that it is associated with the legalisation of abortion and the state provision of abortion services in the country. CAC services have only been available since 2004, but in some regions the CSR of second-born children where the first born was male has fallen by well over 200 in that time. However, we do not mean to suggest a simple relationship between the introduction of CAC services and the change in the CSRs. It is more likely that both demand and supply factors have been at work. The decline in fertility has increased the importance that at least one son is born among the first three children. This has intensified the demand for abortions on the grounds of the sex of the foetus. Before 2004, Nepali women desiring abortions

had to be prepared to incur either substantial health risks (from illegal services) or costs (from going to India) or both. The effect of the introduction of CAC services in 2004 was to reduce both the risks and the costs, and hence to increase the number of abortions in Nepal. The reduction in risks/costs applied to all abortions, but since a major (and increasingly important) reason for demanding an abortion in Nepal is the sex of the foetus there has been a rise in the number of abortions performed for this reason. It is interesting to note that the change in the CSR for second births following a first-born girl was greatest among urban educated women, who would have been most able to afford abortions even before 2004. The decline in fertility has been most acute among this group; if cultural forces leading to a strong desire for at least one son remain universal in Nepal, their demand for sex-selective abortions may have increased more rapidly than that of rural and less well educated women.

Clearly there are policy implications in terms of education about the long term social and demographic consequences of sex-selective abortion. While educating medical practitioners is one important step, previous research has shown that medical practitioners believe that if a woman wishes to have a sex-selective abortion she can easily obtain one in India; it may also be hard for practitioners to judge a woman's reasons for wanting an abortion.[13 27] For these reasons it is also paramount to educate wider members of the community about the illegality of sex determination tests for the sole purpose of selective abortion and the health risks associated with second trimester abortions.

Advocacy and educational campaigns amongst groups with particularly low sex ratios will be important; literate, urban women are one target group. Those living in the Terai with easy access to the Indian border are another. It is also important to remember that the use of sex-selective abortion has risen not only because of socio-cultural preferences for sons, but also because girls are seen as an economic burden. Ultimately, combating sex-selective abortion will require the empowerment of women throughout Nepali society. Programmes benefiting female children would be a start; these might include maternity incentives to mothers who give birth to a girl, education scholarships and free vocational training for girls, and economic incentives for the parents of girls.

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Contributors

MF conducted the data analysis. All authors were involved with data interpretation, writing the paper, and approved the final version. MF is the guarantor.

Conflicts of Interest

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Ethics

Ethics approval was not required as this paper was produced using secondary data analysis.

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Data sharing

The full datasets are available at www.measuredhs.com. Consent was not obtained for this study, but participants gave informed consent for the original survey; the presented data are anonymised and there is no risk of identification.