Health & Place 79 (2023) 102942

Contents lists available at ScienceDirect

Health and Place

journal homepage: www.elsevier.com/locate/healthplace

The impacts of profound gender discrimination on the survival of girls and women in son-preference countries - A systematic review

Andy Pennington [*], Gillian Maudsley, Margaret Whitehead

Department of Public Health, Policy, and Systems, Institute of Population Health, University of Liverpool, Whelan Building, Liverpool, L69 3GB, UK

ABSTRACT

Amartya Sen first used the phrase 'missing women' to describe a survival disadvantage for women exposed to extreme gender discrimination in son-preference countries. In 1989 he estimated that, despite a biological survival advantage for females, there were 100 million fewer women in Asia and north Africa than expected. He blamed corrosive gender discrimination restricting the resources needed for survival. This systematic review examined demographic evidence on the impacts of profound gender discrimination on the survival of girls and women in son-preference countries. Thirty-four included studies provided consistent evidence of lower-than-expected female survival in 15 societies. Male-to-female sex ratios rose particularly in China and India between the 1980s and 2010s, despite general improvements in female mortality. High sex ratios in South Korea, however, returned to biologically normal levels. The number of 'missing women' rose steadily from 61 million in 1970 to 126 million in 2010 and was predicted to continue to rise until 2035. The number of 'missing women' in the world increased in relative and absolute terms between 1980 and 2020. Profound discrimination reduces female survival at every stage of life. Future research is needed to understand the complete pathways and mechanisms leading to poorer survival and the major policy drivers of these trends to devise the best possible ways of preventing the tragedy of 'missing women'.

1. Introduction

In 1986, the Nobel Laureate in Economics, Amartya Sen, first drew attention to the phenomenon that he termed 'missing women' (Sen, 1986). As he explained in 1990:

> "In West Asia and North Africa a great many more than a hundred million women are simply not there … they are 'missing' … because women are neglected compared with men … These numbers tell us, quietly, a terrible story of inequality and neglect leading to the excess mortality of women" (Sen, 1990).

Sen's concern was sparked by suspiciously skewed population sex ratios (PSRs) in countries with profound gender discrimination. Population sex ratio refers to the total number of males for every 100 females in the population, which is compared in countries with and without extreme forms of gender discrimination. From these comparisons, an estimate can be made of the 'number of females who would be alive, in the absence of profound gender discrimination', referred to as the number of 'missing women'.

Sen and many others after him have maintained that profound gender discrimination threatens women's very survival and fundamental right to live (Sen, 1989, 1999; Coale, 1991; Klasen and Wink, 2002, 2003; Banister, 2004; Guilmoto, 2012a). Theory postulates two main, inter-connected pathways from such discrimination to poorer survival chances for women worldwide (depicted in Fig. 1, Whitehead et al., 2016). The first is the impact of corrosive gender discrimination affecting women from when they are born and right throughout their lives. In particular societies, the gender discrimination that accompanies women's low status and lack of decision-making powers in their society lead to reduced autonomy for women, and a form of relative neglect, with poorer access than their male counterparts to: household resources, food and nutrition, health services, schooling and employment/economic opportunities, as well as legal resources such as property, fertility, and reproductive rights. This relative neglect leads on to excess mortality and reduced survival of women and girls and is a longstanding, historical pathway, explaining much of the reduced survival reflected in the 'missing women' numbers until recent decades (Bongaarts and Guilmoto, 2015b).

The second pathway is through particular consequences of son preference (depicted at the lower part of Fig. 1). Son preference refers to the entrenched cultural preference for sons over daughters, which is a pervasive social norm in some societies and which leads on to discriminatory practices and behaviours. It leads not only to the excess mortality of women and girls through the first pathway described above, but

* Corresponding author. Department of Public Health, Policy and Systems, Institute of Population Health, University of Liverpool, Whelan Building, Liverpool, L69 3GB, UK.

E-mail addresses: ajpenn@liverpool.ac.uk (A. Pennington), mmw@liverpool.ac.uk (M. Whitehead).

https://doi.org/10.1016/j.healthplace.2022.102942
Received 27 July 2022; Received in revised form 17 October 2022; Accepted 15 November 2022
Available online 2 January 2023
1353-8292/

also, more directly, to a shortfall of newborn girls, through prenatal sex selection and female infanticide. Although there have been reports of female infanticide over the centuries, this practice has not been on a scale that changed the sex ratio at birth (SRB). For most of human history, right up until 1980, the SRB has been fairly stable at 105 to 107 males for every 100 female newborns (median 105.9) in all populations, with the exception of a few known ethnic variations (Hesketh and Xing, 2006). This ratio is therefore taken to be the biologically natural level and the median of 105.9 is widely used as the norm for calculating deviations in the SRB. Slightly more boys than girls are born, which appears to be nature's way of compensating for women being hardier than men and surviving better at all ages – provided they are given similar care and attention (Zarulli et al., 2018). From the 1980s onwards, however, the SRB has risen in many son-preference countries as new technologies to detect the sex of a fetus were introduced and became more affordable, leading to the practice of sex-selective abortion on a wide scale. This second pathway, through prenatal sex selection leading to a shortfall of newborn girls, is estimated to have made an increasing contribution to the numbers of missing women and girls in son-preference countries in recent decades.

To contextualise these practices, there are several cultural reasons why sons are preferred over daughters, related to entrenched gender norms, particularly in agrarian economies. First, sons are considered to have a higher wage-earning capacity. Second, they continue the family line in patriarchal societies, which includes receiving any inheritance. Third, they are expected to have responsibility for their parents in illness and old age. In contrast, daughters are often seen as an economic burden rather than a resource, because their earning power is low, their parents would have to pay out a marriage dowry to the husband's family, and the daughter would then move to be part of her husband's family, ceasing to have responsibility for caring for her own parents (Hesketh and Xing, 2006). The thrust of many development and health strategies over the past 40 years has, therefore, been to challenge such gender norms through the empowerment of girls and women, by improving their access to education and employment opportunities, the theory being that such empowerment would in turn improve their economic independence and hence status in society (Sen, 1999).

It is becoming increasingly clear, though, that the new contemporary technological advances and their ensuing impact on the numbers of 'missing women' also need urgent attention if empowerment strategies are to work. A body of literature has accumulated on the phenomenon of 'missing women' since Sen first coined the phrase in the 1980s, but it has yet to be comprehensively synthesised. The aim of our systematic review is to synthesise the empirical evidence on the impacts of profound gender discrimination on the survival of girls and women in son-preference countries. This is the first systematic review of its kind, encompassing up-to-date empirical evidence on both the impact of prenatal sex selection and postnatal excess mortality in women and girls. It employs a logic model on the son-preference pathway, drawn from a critical review of theory published in Health & Place, which was itself the first of its kind (Whitehead et al., 2016).

2. Methods

2.1. Search strategy and identification of evidence

Six electronic databases (OVID Medline, OVID Medline In-Process and Other Non-Indexed Citations, American Psychological Association (APA) PsycINFO, Web of Science Social Science Citation Index, Web of Science Conference Proceedings Citation Index - Social Sciences and Humanities, and CINAHL Plus [via EbscoHOST]) were searched for articles published in English between 1980 and 2020 on son preference, sex selection, and 'missing women'.

A theory-based logic model (Fig. 1) informed development of the search strategy and interrogation of the evidence. Systematic review approaches followed the Centre for Reviews and Dissemination's guide to undertaking systematic reviews, and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (CRD, 2009; Moher et al., 2009; Page et al., 2021). Search terms were identified through relevant sample papers in results from three related, preceding reviews (Whitehead et al., 2016; Orton et al., 2016; Pennington et al., 2018). Pilots of the database searches identified that a single-tier search ('a broad net') using a range of highly relevant (specific) terms would provide the best balance of sensitivity and specificity. Search

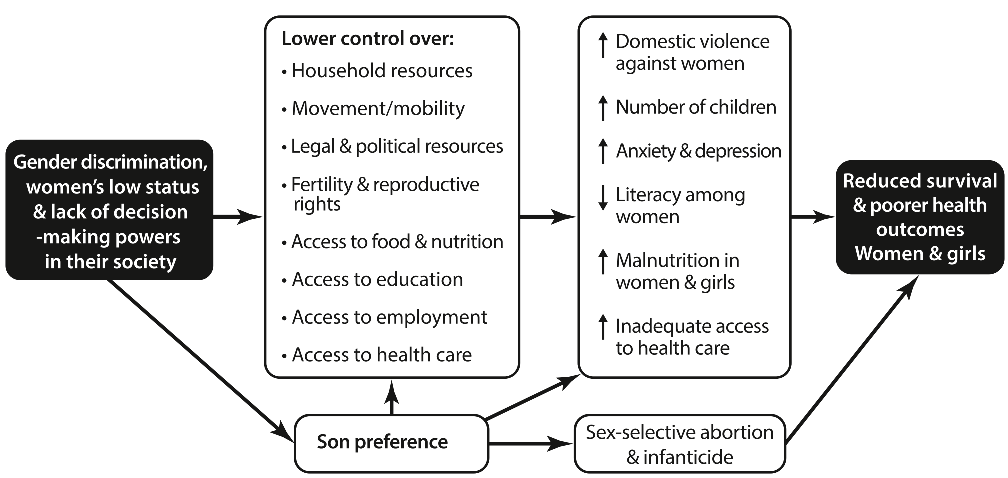

Fig. 1. Theoretical pathways and mechanisms between gender discrimination, women's low status and lack of decision-making powers in son-preference societies, and reduced survival and poorer health outcomes for women and girls.
Source: Adapted from Whitehead et al. (2016).

Table 1
Inclusion/exclusion criteria for systematic review of evidence on relative survival outcomes for girls and women in son-preference countries.

	Included	Excluded
Population & Setting	Populations in established son-preference countries. At national level.	Sub-national populations.
Studies and data of interest	Quantitative empirical representative population-level studies, including demographic studies of observed and expected sex ratios at birth and in adulthood.	Non-empirical studies (including evidence reviews). Qualitative studies. Studies on populations not representative of societal level. Opinion/discussion pieces not providing empirical data.
Outcomes	Sex-specific survival indicated by sex ratios at birth and other ages; estimates of shortfalls of women ('missing women') in the population of son-preference countries, derived from sex ratio data.	Studies not measuring survival outcomes.
Time coverage	1980–2020	–
Language	English-language studies.	–

syntaxes were tailored and ran on specific appropriate databases. Dates of searches, search terms and syntaxes, databases searched, number of hits, keywords, and other comments were recorded, so the searches were transparent, systematic, and replicable (an example of the MEDLINE search strategy is in Appendix 1).

The results of the searches were deduplicated in Endnote reference manager before export into EPPI Reviewer 4 systematic review management software. Reference lists of included studies were scanned for any additional relevant articles (backward citation searching or 'citation snowballing'). We also ran advanced (Boolean and date-limited) Google searches to identify any publications that may have been missed by the database searches (but no further papers were identified). Finally, we contacted authors (experts in the field) to request missing or unpublished data for key papers and any additional relevant publications (but no further papers were identified).

2.2. Study selection

2.2.1. Study inclusion and exclusion criteria

Study inclusion and exclusion criteria focused on sex ratios in son-preference countries (Table 1).

Demographic studies reporting empirical data from quantitative investigations in low- and middle-income countries (LMICs) with a culture of strong gender discrimination and son preference were included. Studies that measured survival outcomes for females at any stage of life compared with males were included. Studies were only included if they used data from representative national population-level samples.

2.2.2. Screening for inclusion/exclusion

Studies were selected for inclusion through two stages (title and abstract screening and full-text screening). Titles and abstracts of all records retrieved from the searches were independently screened by two reviewers to identify potentially eligible studies based on the inclusion/exclusion criteria (Table 1). All potentially eligible papers were retrieved in full text. Two reviewers then screened the full text of the articles in EPPI-reviewer 4 (Thomas et al., 2010). Reasons for exclusion were recorded (Appendix 2). Any queries or disagreements in the

Table 2
National level evidence on trends in male-to-female Sex Ratios at Birth (SRBs) in son-preference countries, 1982–2017.

Study	Data sources	Results	
Country, Author/s, year *(number of included studies)*		Year/s	Sex Ratio at Birth (number of males born per 100 females born)
EAST AND SOUTHEAST ASIA			
China *(n=9)*		*1982–2017*	*Highest = 121.2 (2010)*
Zeng et al. (1993)	1982–87: Fertility and Contraception Survey; 1989: 10 Percent Sample 1990 Census	1982	107.2
		1983	107.7
		1984	108.3
		1985	111.2
		1986	112.1
		1987	110.8
		1989	113.8
Huang et al. (2016)	National Maternal Near Miss Surveillance System	2012	111.0
		2013	110.2
		2014	108.8
		2015	109.5
Jiang et al. (2017)	Censuses; sample	1981	107.8
	Censuses; survey data	1986	113.1
		1989	113.9
		1993	114.1
		2000	119.9
		2005	120.5
		2010	121.2
Jiang et al. (2012)	Censuses	2000	119.9
		2010	121.2
Bongaarts (2013)	United Nations (2011) World Population Prospects: The 2010 Revision ("author's calculations")	2011	119
Guilmoto (2012a)	Annual estimate	2011	117.8
Rahm (2020, p23)	National statistics UNFPA (United Nations Population Fund)	2014–15	114.7
Tufuro & Guilmoto (2020)	2015 Inter-Census, National Statistical Office	2015	113.5
Chao et al. (2019)	Various sources (including Census, vital registration, population surveys), identified in Chao et al. (2019)	1981	107.3
		1990	111.9
		2000	117.1
		2004	117.9
		2010	117.4
		2017	114.3
Taiwan *(n=1)*		*1982–2017*	*Highest = 110.0 (2004)*
Chao et al. (2019)	Vital Registration (Demographic Fact Book)	1982	106.9
		1990	109.8
		2000	109.3
		2004	110.0
		2010	108.6
		2017	107.6
South Korea *(n=8)*		*1980–2017*	*Highest = 116.5 (1990)*
Chun & Das Gupta (2009)	Vital statistics: Korea Statistical Information System (KOSIS), Korea National Statistical Office	1980	105.3
		1981	107.2
		1982	106.8
		1983	107.4
		1984	108.3
		1985	109.5
		1986	111.7
		1987	108.8
		1988	113.3
		1989	111.7
		1990	116.5
		1991	112.1
		1992	113.6
		1993	115.3
		1994	115.2

(continued on next page)

Table 2 (*continued*)

Study: Country, Author/s, year *(number of included studies)*	Data sources	Results: Year/s	Results: Sex Ratio at Birth (number of males born per 100 females born)
		1995	113.2
		1996	111.6
		1997	108.2
		1998	110.1
		1999	109.6
		2000	110.2
		2001	109.0
		2002	110.0
		2003	110.7
		2004	108.2
		2005	107.7
Guilmoto (2012a)	Birth registration	2010	106.7
Yoo et al. (2017)	National Survey on Fertility, Family Health & Welfare (NFFHS)	1990	116.5
		2013	105.3
Jiang et al. (2017)	Vital statistics	1990	116.5
Den Boer & Hudson (2017)	Korea Statistical Information Service	1981	107.1
		1985	109.4
		1990	116.5
		2000	110.2
		2007	106.2
		2014	105.3
Rahm (2020, p23)	National statistics UNFPA	2015–16	105.1
Chao et al. (2019)	Vital Registration (United Nations Demographic Yearbook)	1982	107.2
		1990	115.1
		2000	109.9
		2010	106.5
		2017	105.6
Tufuro & Guilmoto (2020)	Birth registration, National Statistical Office	2017	106.2
Singapore *(n=2)*		*1990–2017*	*Highest = 107.6 (2000)*
Guilmoto (2012a)	Birth registration	2009	107.5
Chao et al. (2019)	Vital registration (United Nations Demographic Yearbook)	1990	107.2
		2000	107.6
		2010	106.8
		2017	106.5
Vietnam *(n=6)*		*1989–2017*	*Highest = 112.6 (2012)*
Guilmoto et al. (2009)	Annual population survey	1989	107
		1999	105.5
		2000	109
		2001	107
		2002	104
		2003	108
		2004	106
		2005	108
		2006	111.6
Guilmoto (2012b)	Censuses; National Family Health Surveys (NFHS); annual population surveys (including state-level analysis)	2005	110.0
		2009	110.6
		2010	111.2
Guilmoto (2012a)	Annual demographic survey	2010	111.2
Rahm (2020, p23)	National statistics UNFPA	2013–14	112.2
Chao et al. (2019)	Vital Registration (United Nations Demographic Yearbook)	1990	106.5
		2000	107.6
		2001	107.6
		2010	112.4
		2012	112.6
		2017	112.2
Tufuro & Guilmoto (2020)	Annual Population Survey	2016–17	112.1
SOUTH ASIA			
India *(n=7)*		*1975–2017*	*Highest = 113.1 (1994-96)*
Bhat & Zavier (2007)	Census	2001	110.4
Guilmoto (2012a)	Sample registration	2008–10	110.5
Bongaarts (2013)	United Nations (2011) World Population Prospects: The 2010 Revision ("author's calculations")	2010	108
Condorelli (2015)	Sample registration system	1982–1984	109.8
		1984–1986	109.5
		1986–1988	109.6
		1988–1990	109.8
		1990–1992	111.1
		1992–1994	113.0
		1994–1996	113.1
		1996–1998	110.9
		1998–2000	111.1
		2000–2002	112.1
		2005–2007	109.4
		2006–2008	110.6
		2007–2009	110.4
		2008–2010	110.5
		2009–2011	110.4
		2010–2012	110.1
Rahm (2020, p23)	National statistics UNFPA	2013–14	110.0
Tufuro & Guilmoto (2020)	Sample registration system, National Statistical Office	2014–16	111.3
Chao et al. (2019)	Demographic and Health Survey (DHS) – Full Birth Histories	1975	106.1
		1990	109.6
		1995	111.3
		2000	111.3
		2010	109.8
		2017	109.8
Pakistan *(n=1)*		*2007*	*Highest = 109.9 (2007)*
Guilmoto (2012a)	Population and demographic survey	2007	109.9
Nepal *(n=1)*		*2012–2016*	*Highest = 110.6 (2012-16)*
Tufuro & Guilmoto (2020)	DHS sample	2012–16	110.6
WEST ASIA			
Azerbaijan *(n=6)*		*1990–2017*	*Highest = 119 (2001-06)*
Duthé et al. (2012)	Censuses; demographic surveys	1999	112
		2001–06	119
		2011	117
Michael et al. (2013)	DHSs; vital statistics	2005–09	116
Guilmoto (2012a)	Birth registration	2011	116.5
Rahm (2020, p23)	National statistics UNFPA	2014–15	114.6
Chao et al. (2019)	Vital Registration (United Nations Demographic Yearbook)	1990	106.6
		1991	106.8
		2000	115.5
		2003	117.1
		2010	116.6
		2017	113.4
Tufuro & Guilmoto (2020)	Birth registration, National Statistical Office	2017	113.5

(*continued on next page*)

Table 2 (*continued*)

Study	Data sources	Results	
Country, Author/s, year *(number of included studies)*		Year/s	Sex Ratio at Birth (number of males born per 100 females born)
Armenia *(n=6)*		*2000–2017*	*Highest = 126 (2000-05)*
Duthé et al. (2012)	Census Demographic surveys	2001 2000–05	116 126
Michael et al. (2013)	DHSs; vital statistics	2005–09	117
Guilmoto (2012a)	Birth registration	2010	114.9
Rahm (2020, p23)	National statistics UNFPA	2014–15	113.3
Chao et al. (2019)	Vital Registration (United Nations Demographic Yearbook)	1990 1992 2000 2010 2017	106.6 105.9 117.6 116.6 111.7
Tufuro & Guilmoto (2020)	Birth registration, National Statistical Office	2017	109.8
Georgia *(n=6)*		*1990–2017*	*Highest = 122 (2000-05)*
Duthé et al. (2012)	Census Demographic surveys	2002 2000–05	110 122
Michael et al. (2013)	DHSs; vital statistics	2005–09	121
Guilmoto (2012a)	Birth registration (provisional)	2009–11	113.6
Rahm (2020, p23)	National statistics UNFPA	2010–16	108.0
Chao et al. (2019)	Vital Registration (United Nations Demographic Yearbook)	1990 1992 2000 2003 2010 2017	106.2 106.3 111.4 111.5 108.1 106.5
Tufuro & Guilmoto (2020)	Birth registration, National Statistical Office	2017	107.9
SOUTHEAST EUROPE			
Albania *(n=4)*		*2008–2017*	*Highest = 111.7 (2008-10)*
Guilmoto (2012a)	Birth registration (provisional)	2008–10	111.7
Rahm (2020, p23)	National statistics UNFPA	2012–13	109.0
Chao et al. (2019)	Vital Registration (United Nations Demographic Yearbook)	2017	108.3
Tufuro & Guilmoto (2020)	Birth registration, National Statistical Office	2017	110.6
Montenegro *(n=4)*		*1980–2017*	*Highest = 109-9 (1997 & 2012-14)*
Guilmoto (2012a)	Birth registration	2009–11	109.8
Rahm (2020, p23)	National statistics UNFPA	2012–14	109.9
Chao et al. (2019)	Vital Registration (United Nations Demographic Yearbook)	1980 1990 1997 2000 2010 2017	105.6 109.0 109.9 109.8 109.0 107.2
Tufuro & Guilmoto (2020)	Birth registration, National Statistical Office	2015–17	107.4
Kosovo *(n=2)*		*2014–2017*	*Highest = 111.2 (2017)*
Rahm (2020, p23)	National statistics UNFPA	2014–16	110.9
Tufuro & Guilmoto (2020)	Birth registration, National Statistical Office	2017	111.2

Notes: *n* = in column 1 shows the number of included studies with data for that country. The range of years with available data is shown in column 3. SRB results in columns 3 and 4 are rounded to one decimal place where possible. "Highest" in column 4 refers to the highest observed/recorded SRB, for the most recent year/s recorded.

screening process were resolved by discussion or recourse to a third reviewer.

In practice, the (n = 20) studies excluded as not being conducted in son-preference countries but otherwise meeting the remaining inclusion criteria were studies of diasporas from son-preference countries (India, China, etc.) that had migrated to high-income countries such as the USA and UK; these studies were set aside for a subsequent review.

2.3. Data extraction, harmonisation, and synthesis

Reviewers extracted data from studies into pre-designed and piloted forms. Extractions were checked for accuracy and completeness by a second reviewer. Extracted data included: study aims, study design, setting/country, and main findings related to the review question.

Data on population sex ratios from individual studies were harmonised/converted to the international convention of presenting the Sex Ratio at Birth (SRB) as the number of male births per 100 female births, so a population sex ratio of 106 would represent 106 males for every 100 females (Table 2).

Results were synthesised narratively (Mays et al., 2005; Popay et al., 2006; Whitehead et al., 2014).

2.4. Measurement of survival outcomes

2.4.1. Note on estimating the number of 'missing women' in son-preference countries

The concept of 'missing women' refers to the females who would otherwise be alive but for profound sex discrimination. This is a *shortfall* in the actual number of women in a specified population compared with an expected norm derived from a reference population without such profound discrimination against girls and women, i.e. how many girls and women would have to be added to the existing population to eliminate this shortfall? (Bongaarts and Guilmoto, 2015b).

To derive the number of 'missing women', the studies in this review use the population sex ratio (PSR), i.e. the total number of males for every 100 females in the population as a whole (all ages). The observed (actual) PSR in a country is compared with an 'expected' PSR that would prevail if both sexes were treated equally in their access to resources (e.g. nutrition, healthcare, education) that influence survival. "If the actual ratio exceeds the expected, the additional females that would have to be alive in order to equate the actual with the expected PSRs, would then be the number of 'missing women' at this point in time" (Klasen and Wink, 2003).

Choosing a comparable reference population to calculate the 'expected' PSR is crucial and must consider factors influencing the population sex ratio in addition to the profound sex discrimination under study. These factors include the age structure of the population (determined mostly by fertility patterns) and the overall mortality level (and biological differences in survival by sex over the lifecourse, resulting in female survival advantage in infancy and older age groups, as men suffer higher mortality rates than females at various ages). The PSR is also influenced by the natural sex ratio at birth (as described below), which exhibits a slight male excess in all populations, including non-discriminating societies.

The studies in this review (Table 3) took variations in population age structure and mortality level into account by applying modelling and model life tables to a reference group of countries with a wide range of mortality levels but presumedly without profound gender discrimination. The resulting expected age-specific sex ratios by age, country, and year can then be applied in comparing observed versus expected PSRs in

Table 3
Studies estimating the numbers and percentages of 'missing women' in son-preference countries and globally (in millions and percentages of total female population[a]), 1989–2015.

	Sen (1989) [b]		Coale (1991)		Klasen (1994)		Klasen and Wink (2003)		Guilmoto (2012a)		Kahlert (2014) [d]		Bongaarts and Guilmoto (2015a)	
	Millions	%[c]	Millions	%	Millions	%	Millions	%	Millions	%	Millions	%	Millions	%
China	50.0	9.1	29.1	5.3	40.1	7.3	40.9	6.7	66.2	10.3	35.1	5.4	62.3	9.5
India	41.6	10.2	22.8	5.6	35.9	8.8	39.1	7.9	43.3	7.3	32.4	5.5	43.3	7.4
Pakistan	5.2	13.1	3.1	7.8	4.1	10.2	4.9	7.8	2.9	3.4	4.8	5.6	4.4	5.2
Bangladesh	3.8	8.9	1.6	3.8	4.1	9.8	2.7	4.2	2.0	2.8	0.8	1.0	2.4	3.2
Nepal	0.6	7.5	0.2	2.4	0.5	7.1	0.1	0.5	0.1	–	−0.9	−6.3	–	–
Indonesia	–	–	–	–	–	–	–	–	–	–	–	–	1.7	1.5
West Asia[e]	4.7	8.5	1.7	3.0	3.0	5.5	3.8	4.2	–	–	9.7	8.4	–	–
Egypt	1.7	7.2	0.6	2.6	1.2	5.1	1.3	4.5	–	–	1.4	3.9	–	–
Nigeria	–	–	–	–	–	–	–	–	–	–	–	–	1.9	2.5
Sub-Saharan Africa	–	–	–	–	–	–	5.5	1.8	–	–	15.6	3.6	–	–
'Rest of world'	–	–	–	–	–	–	–	–	–	–	–	–	9.6	0.5
Total in 'comparable' son-preference countries[f]	107.5	9.6	59.1	–	89.0	7.9	92.8	6.8	–	–	83.3	5.3	–	–
Global total in son-preference countries[g]	–	–	–	–	–	–	101.3	5.7	116.7	7.7	99.6	4.7	125.6	3.7

Notes.
[a] Figures are rounded. Subtotals include some countries not listed (for brevity and clarity). Estimates by Sen (1986), Klasen and Wink (2002), Organisation for Economic Co-operation and Development (OECD, 2014) are omitted to allow for easier comparison and to prevent duplication. Papers used latest United Nations Population Division and/or national level Census data, for example, Coale's 1991 estimates were based on Census data from between 1981 and 1991, depending on country.
[b] Figures as reported in Klasen (1994) paper.
[c] Percentage of the total population of women in specified territory.
[d] Data time-points, sources, and data time-gaps (a minimum of 10 years for each country/region) between Klasen and Wink (2003) and Kahlert (2014) are shown in Appendix 4.
[e] Turkey and Syria are included in West Asia.
[f] A set of 'comparable' countries (including China, India, Pakistan, Bangladesh, Nepal, West Asia, and Egypt) were used in studies by Sen, Coale, Klasen/Klasen & Wink, and Kahlert to allow for comparisons between studies and over time.
[g] In addition to the 'comparable' son-preference countries (note vi), some later studies also included a larger set of newly recognised son-preference countries in their analyses, adding: Taiwan, South Korea, Iran, Algeria, Tunisia, and Afghanistan, to estimate the 'global total' of 'missing women'.

countries with gender discrimination.

2.4.2. Note on estimating the number of 'missing newborn girls' in son-preference countries

Estimates are derived from comparing observed and expected sex ratios at birth. The 'expected' ratio is based on the level that was observed in all countries pre-1980 and in countries without profound discrimination since then, i.e. in the range between 105 and 107, commonly taken as 105.9 in non-African countries. A slight adjustment is made for a lower natural SRB in sub-Saharan Africa.

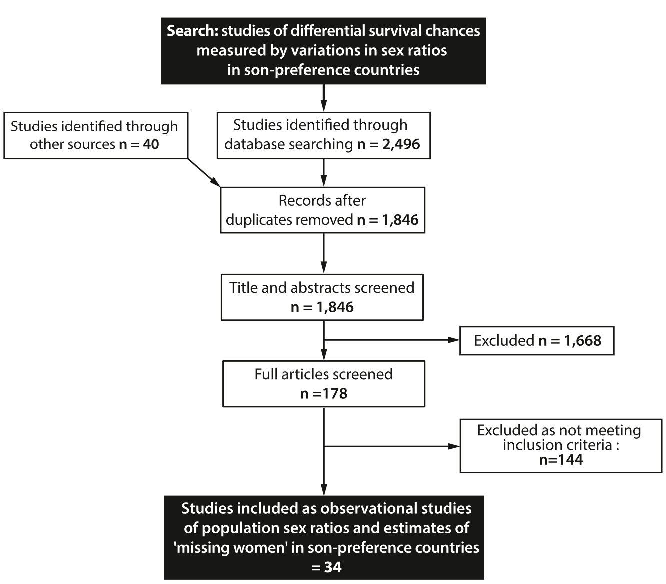

Fig. 2. PRISMA flow chart illustrating the progression of studies through the systematic review of evidence on relative survival outcomes for girls and women in son-preference countries, compared with boys and men.

3. Results

3.1. Included studies

From an initial 1846 unique records, 34 demographic studies (listed in Appendix 3) on the relative survival impacts of discrimination against girls and women, compared with boys and men, at national level in son-preference countries were included (Fig. 2).

3.2. Evidence of lower-than-expected female survival

3.2.1. Sex ratios at birth

Sex ratios at birth (SRBs) may be influenced by sex-selective abortions, infanticide, and under-reporting of newborn girls.

Eighteen studies found evidence of elevated levels of male births in records of ratios of male-to-female births at national levels in 14 countries in East and Southeast Asia (China, Taiwan, South Korean Singapore, Vietnam), South Asia (India, Pakistan, Nepal), West Asia (Azerbaijan, Armenia, Georgia), and Southeast Europe (Albania, Montenegro, Kosovo). Elevated SRBs were up to 126, against a naturally occurring SRB of 105.9 (Table 2).

3.2.2. Trends in SRBs over time

SRBs varied within countries over time. Most studies, including all in China and India (Figs. 3 and 4, respectively), indicated that male-to-female SRBs rose rapidly between the 1980s and 2000s. Although

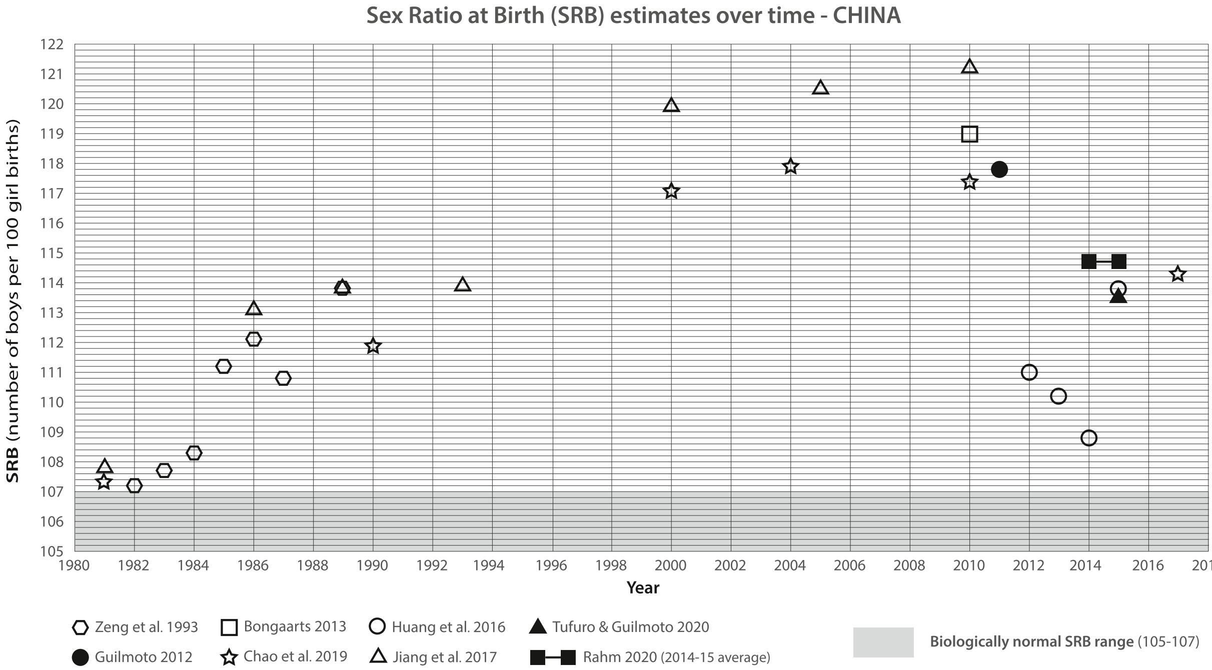

Fig. 3. Findings of included studies giving estimates of male-to-female Sex Ratios at Birth over time in China, compared with biologically normal (reference) range.

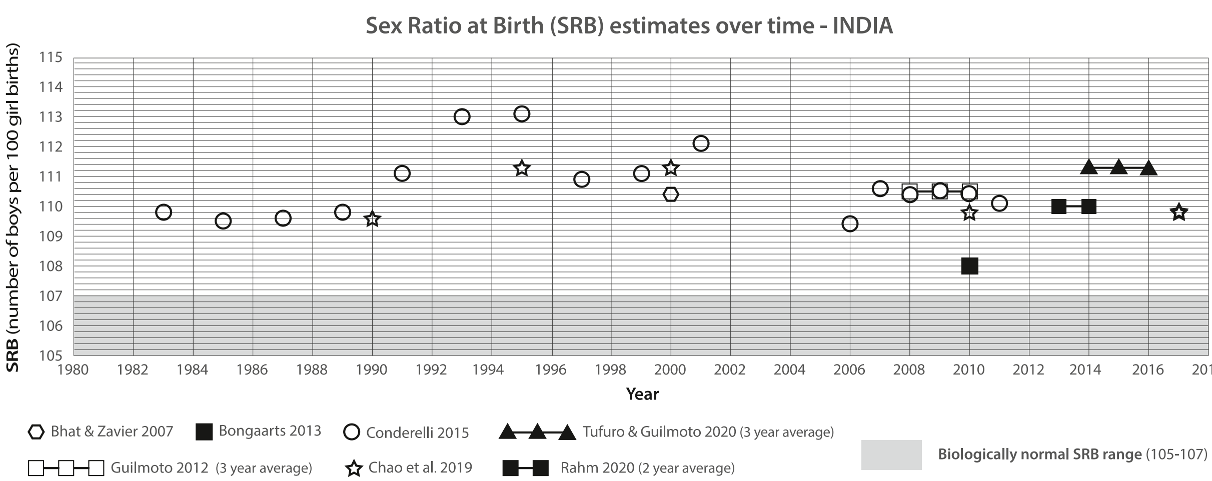

Fig. 4. Findings of included studies giving estimates of male-to-female Sex Ratios at Birth over time in India, compared with biologically normal (reference) range.

estimates differed across data sources, looking across the studies, levels appeared to have peaked in South Korea in the mid-to-late 1990s, in India in the late 1990s, in China in the late 2000s, and in Vietnam in the mid-2010s (Table 2).

Male-to-female SRBs remained elevated in all son-preference countries in the most recent data (typically 2017), with the notable exception of South Korea (and Singapore, although levels there were never particularly high). Studies in South Korea showed male-to-female SRBs declining to, and remaining around, a biologically 'normal' level since 2007 (Jiang et al., 2017) (Fig. 5).

3.3. *Estimates of the number of 'missing girls' at birth in son-preference countries*

Extrapolating from the skewed SRBs, four studies presented estimates of the number of 'missing newborn girls' within and across son-preference countries (Bongaarts, 2013; Grech, 2015; Bongaarts and Guilmoto, 2015b; Chao et al., 2019).

3.3.1. *Single year estimates of 'missing girls' at birth*

Bongaarts (2013) estimated that in 2010 alone 12.7 percent of girls were 'missing' at birth in China and 1.9 percent of girls in India. Bongaarts and Guilmoto (2015a) estimated that approximately 1.7 million girls were missing at birth across son-preference countries annually by 2010.

3.3.2. *Cumulative estimates over time of population effects of 'missing newborn girls'*

Annual numbers of 'missing newborn girls' accumulate over time. Based on data from 1985 to 2005, Grech (2015) estimated that a total of 48,734,993 girls were 'missing' at birth in low- and middle-income countries. The most recent global cumulative estimate of 'missing newborn girls' was based on data from vital registration systems, censuses, and surveys from 202 countries (Chao et al., 2019). They identified 11 countries (China, India, Albania, Montenegro, Tunisia, Armenia, Azerbaijan, Georgia, Vietnam, South Korea, Taiwan) with strong evidence of skewed SRBs resulting in an estimated cumulative total of 45 million 'missing newborn girls' globally between 1970 and 2017 (95%

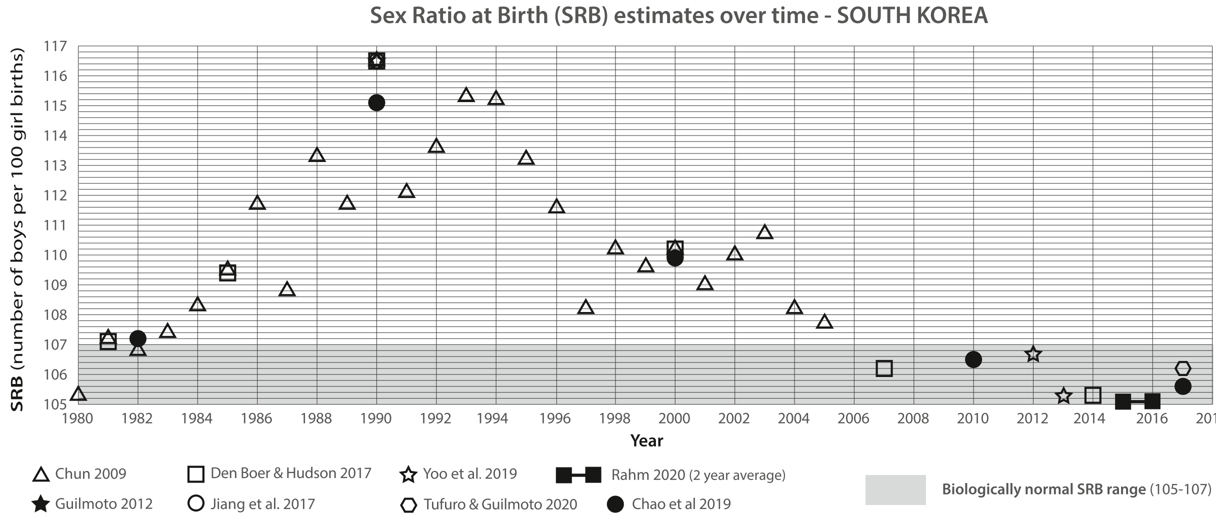

Fig. 5. Findings of included studies giving estimates of male-to-female Sex Ratios at Birth over time in South Korea, compared with biologically normal (reference) range.

confidence interval (CI): 36.4–54.8 million). Most were 'missing' from China (23.1 million, 95% CI: 16.5–30.7 million) and India (20.7 million, 95% CI: 15.5–26.6 million).

3.4. Multinational and global estimates of total numbers of 'missing women'

Estimates of 'missing women' include prenatal shortfall in newborn girls plus postnatal shortfall in girls and women throughout the life-course. Discrimination against girls and women in son-preference countries reduces their survival chances at all stages of life, prenatally and from birth, through childhood, adolescence, and into adulthood and older ages. This relative survival disadvantage, compared with males, accumulates over time in populations and leads to the whole-population phenomenon of 'missing women'.

Ten included studies estimated the number of 'missing women' (within and across son-preference countries) (Sen, 1986, 1989; Coale, 1991; Klasen, 1994; Klasen and Wink, 2002; Klasen and Wink, 2003; Guilmoto, 2012a; OECD, 2014; Kahlert, 2014; Bongaarts and Guilmoto, 2015b). Sen's (1989) 'crude estimate' of over 100 million 'missing women' in son-preference countries was followed by studies that used more sophisticated demographic models (Table 3) (Coale, 1991; Klasen and Wink, 2003).

Multinational estimates of 'missing women' across whole populations (all ages combined) ranged from 59 to 108 million across son-preference countries in 1989-94 (Sen, 1989; Coale, 1991; Klasen and Wink 2003), and from 100 to 126 million globally in 2010 (Kahlert, 2014; Bongaarts and Guilmoto, 2015b). Bongaarts and Guilmoto (2015a) found, based on time-series estimates, that the world total of 'missing women' rose steadily from 61 million in 1970 to 125.6 million in 2010. The rate of increase in 'missing women' between 1970 and 2010 was faster than global population growth, with 3.3 and 3.7 percent of women 'missing' in 1970 and 2010, respectively (Table 3) (Bongaarts and Guilmoto, 2015b). They projected that the numbers would rise to 136.2 million in 2015, peak at 149.9 million in 2035, before levelling off and gradually reducing to 142 million in 2050 (Table 4).

3.5. Misreporting the number of girls born

Misreporting of the number of girls being born leading to 'hidden girls' is another factor that potentially contributes to male-to-female population figures. Self-reported birth data (including Census, survey, and vital registration data) may be deliberately misreported (or subject to errors in reporting or recording). Underreporting of girl births may be a factor in China, where some authors attribute a proportion of 'missing newborn girls' to under-reporting by parents attempting to avoid heavy penalties under the (former) One-Child-policy (Johansson and Nygren, 1991; Zeng et al., 1993). In included studies that investigated differential underreporting (Zeng et al., 1993; Cai and Lavely, 2003; Banister, 2004; Cai, 2017; Goodkind, 2011; Shi and Kennedy, 2016, 2017), the extent is contested.

Shi and Kennedy (2016) argued that, in addition to explanations that include sex-selective abortion, '*the story of 'missing girls' is also an administrative one*' (p1018). They compared the SRBs for younger and older children in Census data from 1990, 2000, and 2010 and found evidence of dramatic increases in the number of reported females after the age of 10 (particularly after age 15). They originally estimated that 15 million of the girls 'missing' between 1990 and 2010 (of over 20 million) were not 'missing' but underreported (or 'hidden') by parents and local officials attempting to avoid penalties under the One-Child-Policy. Following criticisms by Cai (2017) who identified '*oversights in Shi and Kennedy's numeric analysis*' (p797), they revised the estimate to around 10 million 'hidden girls' (Shi and Kennedy, 2017).

4. Discussion

4.1. Summary of findings

There is consistent empirical evidence to support the direct son-preference pathway through prenatal sex selection leading to a

Table 4
Estimates of the total number and percent of 'missing women' across son-preference countries over time (1970–2010) and predictions to 2050.

	Number 'missing' (millions)					Predicted (millions)		
	1970	1980	1990	2000	2010	2015	2035	2050
Total 'missing' across son-preference countries	61.0	72.2	87.6	105.9	125.6	136.2	149.9	142.0

Source: Bongaarts and Guilmoto, 2015b

shortfall in newborn girls. Eighteen studies showed male-skewed SRBs in 14 son-preference countries in East and Southeast Asia, South Asia, West Asia, and Southeast Europe, with elevated SRBs up to 126, against a naturally occurring SRB of 105.9. Male-to-female SRBs rose in son-preference countries from the 1980s onwards (consistent with the spread of the technology) and appear to have peaked in most of these countries during the 1990s and 2000s, before gradually reducing somewhat, but still remaining at high levels in the 2010s. The rapid rise in SRBs in Vietnam during the 2010s is a notable exception. In contrast, male-to-female SRBs in South Korea declined rapidly to reference (biologically normal) levels after 2000. From the SRB data, four studies estimated numbers of 'missing newborn girls' in son-preference countries. One estimate found that approximately 1.7 million newborn girls were missing across son-preference countries annually by 2010. The most recent estimate of the cumulative total over the years 1970–2017 identified 11 countries with strong evidence of skewed SRBs resulting in an estimated cumulative total of 45 million missing newborn girls across these countries.

There is also firm evidence for the operation of the postnatal pathway through corrosive gender discrimination affecting women from when they are born and right throughout their lives, leading to relative neglect and excess mortality across the lifecourse. Ten studies estimated the survival impacts of these two pathways combined, to produce figures for 'missing women' overall. Estimates of the number of 'missing women' across son-preference countries rose steadily from 61 million in 1970 to 126 million in 2010. The total number 'missing women' was predicted to continue increasing to a peak of 150 million in 2035. China accounted for 50 per cent (62.3 million) of the 'missing women' in the world, followed by India at 34 per cent (43.3 million).

4.2. Limitations of the reviewed studies

Besides known problems with data quality in low- and middle-income countries such as India and Pakistan (Hesketh and Xing, 2006; Bongaarts and Guilmoto, 2015b; Chao et al., 2019), demographic studies of SRBs were subject to difficulties in attributing differences in aggregate sex ratios to specific causes (sex-selective abortion, infanticide, or sex-selective under-reporting of girl births). The remarkably stable SRBs for most of human history until 1980 and the onset of increasing SRBs in son-preference countries coinciding with the advent of prenatal sex selection technologies argue for a dominant role for sex-selective abortion rather than a sudden upturn in infanticide. There is debate about the possibility of under-reporting of girl births in China as a consequence of the One-Child policy, but studies of births reported by doctors in healthcare settings indicated skewed SRBs of similar magnitudes. There was no evidence that sex-selective underreporting of girl births was important other than in China (Bongaarts, 2013).

Calculation of skewed population sex ratios (PSRs) to estimate the number of 'missing women' rely on the selection of an appropriate comparison population without profound gender discrimination and son preference to derive an 'expected' population sex ratio. Potential bias can be introduced if a study failed to take account of three types of differences between populations that affect the level of PSR: the differing population age structure; the impact of the overall mortality level (and mortality differentials by sex); and the natural sex ratio at birth, which exhibits a slight male excess in all populations, including in societies without profound discrimination. All the studies in this review took account of these biases in the estimation of numbers of 'missing women' to varying levels of refinement and produced estimates that indicate the huge scale of the problem.

4.3. Limitations of this systematic review

The review only included English language studies. It is possible that some non-English language studies were missed by the searches. We are confident that this restriction would have had only a minimal effect on our ability to pick up relevant studies in relation to 'missing women' for two main reasons. First, we excluded sub-national studies from the review, which are sometimes published in the language of the study country, and only included national and multi-country studies, which are almost invariably published in English in the health field. Second, even though there is a burgeoning literature from China, it is common for Chinese academics to be incentivised to publish in English language peer-reviewed journals, reinforcing the convention of publishing national studies in English.

We used appropriate quality assurance tools in our systematic reviewing whenever available, but, unfortunately, no international standard has been developed for 'scoring' the types of demographic evidence in this review for risk of bias. Demographic studies present a layer of complexity for such scoring even beyond the tricky issues raised by more common types of observational study. Although the ROBINS-E tool (Risk of Bias in Non-randomised Studies of Exposures) was developed for use with observational studies of exposures, it built upon tools for risk of bias assessment in randomised trials, diagnostic test accuracy studies, and observational studies of *interventions*. It has been shown to be inappropriate for the task of evaluating observational studies of exposures for questions of *harm relevant to public and environmental health* (Bero et al., 2018). In the absence of a suitable tool for 'scoring' demographic evidence, the approach we used for quality-assuring the evidence entailed selecting those studies employing good quality national data sources (vital statistics, Census, high quality population surveys) and removing single-centre studies and those using non-representative population samples.

4.4. Implications for research and policy

Several plausible mechanisms for the lower female survival in son-preference countries are postulated in the literature, which require further investigation. These include the growing effectiveness, affordability, and use of new technologies for prenatal sex selection and sex-selective abortion (Devaney et al., 2011; Karabinus et al., 2014), neglect of girls in relation to health care and nutrition, underreported or otherwise 'hidden girls', and the impact of mandatory population control/birth reduction policies.

The studies in this review consistently show large increases in male-to-female SRBs following the introduction and diffusion of prenatal diagnostic technologies in son-preference countries in the 1980s and 1990s. New pre-conception (e.g. sperm-sorting), pre-implantation (e.g. in vitro pre-implantation genetic diagnosis), and abortion technologies (including inexpensive pharmaceutical drugs to induce abortion) may pose additional threats to female survival in son-preference countries as they become increasingly affordable and accessible. The impacts of emerging technologies for sex selection on relative female survival are currently unknown and need to be carefully studied.

The broad searches we conducted before this review identified a very large body of literature on the general health and wellbeing impacts of discrimination and neglect in the distribution of health care and nutrition to girls and women. This body of evidence requires review and synthesis.

Government population control policies introduced in China since 1980 are considered to be major contributors to the toll of 'missing women' in the country. In particular, the One-Child policy, rigorously enforced from 1980 to 2015, has led to far-reaching consequences, some unintended and unforeseen. These include being implicated in the rise of sex-selective abortions and abandonment of girl babies, the development of a thriving trade in commercial adoption services offering girl babies to overseas adoptive parents, and a shortage of women available for marriage (Bhattacharjya et al., 2008; Hesketh and Xing, 2006; Hesketh et al., 2011). On the other side of the same coin are the large cohorts of 'surplus' young men in India as well as China now reaching adulthood who lack available women to marry and therefore may face marginalisation in society with long-term social consequences.

Chakravarty et al. (2022) list some of those consequences as increased migration, bride trafficking, and bride-abduction. There are some indications that the introduction of the Two-Child policy in China from 2015 might soften the effect of the earlier One-Child policy, but it is too early to judge (Jiang and Zhang, 2021; Fan et al., 2020; Tang et al., 2022). Further evidence is needed on the impacts of such mandatory population control policies, including studies over time on SRBs by birth order and on the relative health and survival impacts on girls compared with boys over time.

Other countries, including India, have introduced policies to tackle son preference, including laws banning the use of prenatal sex selection technologies (Kumar and Sunha, 2019), but to date these have proved ineffective or relatively easy to bypass. For example, physicians might hint at the sex of the fetus to parents by using certain descriptors, without actually calling it male or female. Regulatory measures that aim to address the rise in prenatal sex selection need to be evaluated for their effectiveness in tackling the problem, including any unintended side-effects. More promising, according to Kumar and Sinha's policy analysis, are policies that indirectly raise the value of daughters, and there are good examples of such policies, including initiatives in Bangladesh. There is a paucity of causal studies in this field though and these policies need to be subjected to rigorous evaluation (Kumar and Sunha, 2019).

There are also lessons to be learnt from the favourable trends in South Korea. How did the country manage to reverse the trends and bring down the SRBs to normal levels?

4.5. *The paradox of opposing forces affecting female survival?*

Above all, the findings of this systematic review serve to highlight the tension that has built up between two opposing forces that appear to have been at work in maintaining the high numbers of 'missing women' in the world today. On the one hand, there has been a near universal improvement in female mortality in low- and middle-income countries over recent decades, influenced by improvements in the social determinants of health: reduction in poverty and improvements in nutrition and access to effective healthcare, aided by progress in access to schooling for girls and greater employment/economic empowerment of women. This has improved the survival chances of women throughout the lifecourse. On the other hand, this progress in female mortality rates has been counterbalanced by the widespread adoption of technological innovations, such as ultrasound scans in pregnancy, which have led to the rise of a new phenomenon in son-preference societies - the human manipulation of sex ratios at birth by prenatal sex selection and sex-selective abortions. This adverse trend affecting the sex ratio at birth is not picked up by tools such as the Gender Inequality Index, which continues to show favourable changes in social norms towards women in many son-preference countries (UNDP, 2015). Paradoxically, the influence of the ancient tradition of son preference has become stronger, not weaker, over recent decades as a result of the new technological tools we have at our disposal. These opposing forces need to be considered together to make sense of the population trends and to devise the best possible ways of preventing the tragedy of 'missing women'.

5. Conclusions

There is consistent evidence of a survival disadvantage for girls and women in son-preference countries. There are over 126 million girls and women 'missing' from the world today. The survival disadvantage of girls increased significantly after the introduction of sex-selection technologies, which greatly compounded existing structural inequalities. Despite some improvements over time, male-skewed population sex ratios in many countries are still of concern. Time-series data and projections suggest the problem is getting worse in absolute terms as population levels increase in son-preference countries, which include the most populous nations of the world. New sex-selection technologies and economic downturns pose additional threats. This review highlights, above all, that the phenomenon of 'missing women' is still one of the great inequalities of our time. Profound gender discrimination in son-preference countries has severe and large-scale adverse impacts on the survival of girls and women at every stage of life.

Role of the funding source

The work was undertaken by the authors as part of the Public Health Research Consortium (now the NIHR Public Health Policy Research Unit (PHPRU)), funded by the Department of Health and Social Care Policy Research Programme (www.phpru.online). The views expressed in the publication are those of the authors and not necessarily those of the Department of Health and Social Care. The Department of Health and Social Care Policy Research Programme (the funding source) played no role in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

Appendix 1. Example, MEDLINE search strategy for systematic review of evidence on relative survival outcomes for of girls and women in son-preference countries

MEDLINE, and MEDLINE In-Process & other Non-Indexed Citations <1980 to 2020>
Searched via OVID 17/11/20. Restricted to English language and human.
Syntax:
1 Son preference.ti,ab.
2 Gender preference.ti,ab.
3 Sex select*.ti,ab.
4 Sex-select*.ti,ab.
5 Gender select*.ti,ab.
6 Gender-select*.ti,ab.
7 Missing women.ti,ab.
8 Lost girls.ti,ab.
9 OR 1 to 8
10 Limit 9 to Humans, English language and 1980 to 2020

Appendix 2. Studies excluded during full text screening, and reasons for exclusion in systematic review of evidence on relative survival outcomes for of girls and women in son-preference countries

Article	Reasons for exclusion (Number of articles)
Agrawal S (2012) The sociocultural context of family size preference, ideal sex composition, and induced abortion in India: Findings from India's National Family Health Surveys. Health Care Women Int. 33:986-1019.	Outcome - Not survival / 'missing girls or women' (as population ratios) (n=77)
Altindag O (2016) Son preference, fertility decline, and the nonmissing girls of Turkey. Demography. 53:541-566.	
Ambel A (2008) Essays on intrahousehold allocation and the family: Fertility, child education, and nutrition. Doctoral dissertation, Harvard University.	
Amin R, Mariam A (1987) Son preference in Bangladesh - an emerging barrier to fertility regulation. J Biosoc Sci, 19:221-228.	
Arulampalam W, Bhalotra S (2008) The linked survival prospects of siblings: Evidence for the Indian states. Popul Stud (Camb). 62:171-190.	
Bharadwaj P, Lakdawala L (2013) Discrimination begins in the womb Evidence of sex-selective prenatal investments. J Hum Resour. 48:71-113.	
Bhaskar V (2011) Sex selection and gender balance. Am Econ J Microecon. 3:252-253.	
Bose S (2012) A contextual analysis of gender disparity in education in India: The relative effects of son preference, women's status, and community. Sociol Perspect. 55:67-91.	
Bose S, Trent K (2006) Socio-demographic determinants of abortion in India: A north-south comparison. J Biosoc Sci. 38:261-282.	
Chamarbagwala R (2011) Sibling composition and selective gender-based survival bias. J Popul Econ. 24:935-955.	
Chamarbagwala R, Ranger M (2010) A multinomial model of fertility choice and offspring sex ratios in India. J Dev Stud. 46:417-438.	
Chaturvedi S, Chhabra P, Bharadwaj S, Smanla S, Kannan A T, Students Study Group (2007) Fetal sex-determination in Delhi: a population-based investigation. Trop Doct. 37:98-100.	
Chen Y (2008) The significance of cross-border marriage in a low fertility society: Evidence from Taiwan. J Comp Fam Stud. 39:331.	
Chen Y, Li H, Meng L (2013) Prenatal sex selection and missing girls in China: Evidence from the diffusion of diagnostic ultrasound. J Hum Resour. 48:36-70.	
Chun H, Das Gupta M (2009) Gender discrimination in sex selective abortions and its transition in South Korea. Womens Stud Int Forum. 32:89-97.	
Chung W, Das Gupta M (2011) Factors influencing 'missing girls' in South Korea. Appl Econ. 43:3365-3378.	
Clark S (2000) Son preference and sex composition of children: Evidence from India. Demography. 37:95-108.	
Cronk L (1991) Intention versus behaviour in parental sex preferences among the Mukogodo of Kenya. J Biosoc Sci. 23:229-40.	
Dama M (2011) Sex ratio at birth and mortality rates are negatively related in humans. Plos One. 6(8):e23792.	
Das Gupta M (2005) Explaining Asia's "missing women": A new look at the data. Popul Dev Rev. 31:529. den Boer A, Hudson V (2017) Patrilineality, son preference, and sex selection in South Korea and Vietnam. Popul Dev Rev. 43:119-147.	
Detray D (1980) Son preference in Pakistan - an analysis of intentions versus behavior. Popul Index. 46:382-382.	
Dharmalingam A, Rajan S, Morgan S (2014) The determinants of low fertility in India. Demography. 51:1451-1475.	
Dinh T, Borjesson L, Nga N, Johansson A, Malqvist M (2012) Sex of newborns associated with place and mode of delivery: A population-based study in Northern Vietnam. Gend Med. 9:418-423.	
Dreze J, Murthi M (2001) Fertility, education, and development: Evidence from India. Popul Dev Rev. 27:33.	
Ebenstein A (2011) Estimating a dynamic model of sex selection in China. Demography. 48:783-811.	
Echavarri R A, Ezcurra R (2010) Education and gender bias in the sex ratio at birth: evidence from India. Demography. 47:249-268.	
Edlund L (1999) Son preference, sex ratios, and marriage patterns. J Polit Econ. 107:1275-1304.	
Edmeades J, Rohini P, MacQuarrie K, Falle T, Malhotra A (2012) Two sons and a daughter: Sex composition and women's reproductive behaviour in Madhya Pradesh, India. J Biosoc Sci. 44:749-764.	
Eliason S, Baiden F, Tuoyire D, Awusabo-Asare K (2018) Sex composition of living children in a matrilineal inheritance system and its association with pregnancy intendedness and postpartum family planning intentions in rural Ghana. Reprod. 15(1)187.	
Erfani A, McQuillan K (2014) The changing timing of births in Iran: An explanation of the rise and fall in fertility after the 1979 Islamic Revolution. Biodemogr. Soc. Biol. 60:67-86.	
Gangadharan L, Maitra P (2003) Testing for son preference in South Africa. J Afr Econ. 12:371-416.	
Guilmoto C (2017) Gender bias in reproductive behaviour in Georgia, Indonesia, and Vietnam: An application of the own-children method. Popul Stud (Camb). 71:265-279.	
Hamoudi A (2010) Exploring the causal machinery behind sex ratios at birth: Does hepatitis B play a role? Econ Dev Cult Change. 59(1):1-21.	
Haque I, Patel P (2016) Assessing Hindu-Muslim fertility differentials in West Bengal: Insights from the National Family Health Survey-3 Data. J Fam Hist. 41:192-224.	
Hatlebakk M (2017) Son preference, number of children, education and occupational choice in rural Nepal. Rev Dev Econ. 21:1-20.	
Hesketh T, Lu L, Xing Z (2011) The consequences of son preference and sex-selective abortion in China and other Asian countries. CMAJ. 183:1374-1377.	
Hossain M, Phillips J, Legrand T (2007) The impact of childhood mortality on fertility in six rural thanas of Bangladesh. Demography. 44:771-784.	
Hu L, Schlosser A (2012) Trends in prenatal sex selection and girls' nutritional status in India. CESifo Econ Stud. 58:348-372.	
Jayaraj D, Subramanian S (2004) Women's wellbeing and the sex ratio at birth: Some suggestive evidence from India. J Dev Stud. 40:91-119.	
Jha P, Kumar R, Vasa P, Dhingra N, Thiruchelvam D, Moineddin R (2006) Low male-to-female sex ratio of children born in India: National survey of 1.1 million households. Lancet. 367:211-218.	
Jiang Q, Li S, Feldman M (2011) Demographic consequences of gender discrimination in China: Simulation analysis of policy options. Popul Res Policy Rev. 30:619-638.	

(*continued on next page*)

(*continued*)

Article	Reasons for exclusion (Number of articles)
Jiang Q, Li Y, Sanchez-Barricarte J (2016) Fertility intention, son preference, and second childbirth: Survey findings from Shaanxi Province of China. Soc Indic Res. 125:935-953.	
Kabeer N, Huq L, Mahmud S (2014) Diverging stories of "Missing women" in South Asia: Is son preference weakening in Bangladesh? Fem Econ. 20:138-163.	
Karki Y (1988) Sex preference and the value of sons and daughters in Nepal. Stud Fam Plann. 19:169-178.	
Kastor A, Chatterjee S (2018) Impact of sex composition of living children and couples' agreement on subsequent fertility in India. J Biosoc Sci. 50:666-682.	
Kaul T (2018) Intra-household allocation of educational expenses: Gender discrimination and investing in the future. World Dev. 104:336-343.	
Knight J, Shi L, Deng Q (2010) Son preference and household income in rural China. J Dev Stud. 46:1786-1805.	
Kureishi W, Wakabayashi M (2011) Son preference in Japan. J Popul Econ. 24:873-893.	
Leung S (1994) Will sex selection reduce fertility. J Popul Econ. 7:379-392.	
Lhila A, Simon K (2008) Prenatal health investment decisions: Does the child's sex matter? Demography. 45:885-905.	
Li J, Cooney R (1993) Son preference and the one child policy in China - 1979-1988. Popul Res Policy Rev. 12:277-296.	
Li J, Lavely W (2003) Village context, women's status, and son preference among rural Chinese women. Rural Sociol. 68:87-106.	
Lipatov M, Li S, Feldman M (2008) Economics, cultural transmission, and the dynamics of the sex ratio at birth in China. Proc Natl Acad Sci USA. 105:19171-19176.	
Mishra S, Ram B, Singh A, Yadav A (2018) Birth order, stage of infancy and infant mortality in India. J Biosoc Sci. 50:604-625.	
Mwageni E, Ankomah A, Powell R (2001) Sex preference and contraceptive behaviour among men in Mbeya region, Tanzania. J Fam Plann Reprod Health Care. 27:85-89.	
Nie L (2009) Essays on son preference in China during modernization. Doctoral thesis, University of California, Berkeley.	
Nosaka A (2000) Effects of child gender preference on contraceptive use in rural Bangladesh. J Comp Fam Stud. 31:485.	
Park C (1983) Preference for sons, family size, sex ratio: An empirical study in Korea. Demography. 20:333-352.	
Park C, Cho N (1995) Consequences of son preference in a low-fertility society - imbalance of the sex-ratio at birth in Korea. Popul Dev Rev. 21:59-84.	
Pham B, Hall W, Hill P, Rao C (2008) Analysis of socio-political and health practices influencing sex ratio at birth in Viet Nam. Reprod Health Matters. 16:176-184.	
Pulver A, Ramraj C, Ray J, O'Campo P, Urquia M (2016) A scoping review of female disadvantage in health care use among very young children of immigrant families. Soc Sci Med. 152:50-60.	
Puri S, Adams V, Ivey S, Nachtigall R (2011) "There is such a thing as too many daughters, but not too many sons": A qualitative study of son preference and fetal sex selection among Indian immigrants in the United States. Soc Sci Med. 72:1169-1176.	
Ren X (1995) Sex differences in infant and child mortality in three provinces in China. Soc Sci Med (1982). 40:1259-69.	
Ren Y (1995) Sex-differences in infant and child-mortality in 3 provinces in China. Soc Sci Med. 40:1259-1269.	
Schwekendiek D (2010) Why has son-preference disappeared in North Korea? North Korean Rev. 6:65-73.	
Short S, Zhai F, Xu S, Yang M (2001) China's one-child policy and the care of children: An analysis of qualitative and quantitative data. Soc Forces. 79:913-943.	
Srinivasan S, Bedi A (2007) Domestic violence and dowry: Evidence from a south Indian village. World Dev. 35:857-880.	
Tang Z, Sharp P (2011) Interactions of socioeconomic determinants, offspring sex preference, and fertility behaviour. Can Stud Popul. 38:99-113.	
Tucker C, Van Hook J (2013) Surplus Chinese men: Demographic determinants of the sex ratio at marriageable ages in China. Popul Dev Rev. 39:209-229.	
Weeks J, Rumbaut R, Brindis C, Korenbrot C, Minkler D (1989) High fertility among Indochinese refugees. Public Health Rep. 104:143-150.	
Wong G, Leung W, Chin R (2010) Recent dramatic increase in the male-to-female sex ratio of babies born in Hong Kong. J Perinat Med. 38:209-213.	
Xu B, Pak M (2015) Gender ratio under China's two-child policy. J Econ Behav Organ. 119:289-307.	
Yount K, Langsten R, Hill K (2000) The effect of gender preference on contraceptive use and fertility in rural Egypt. Stud Fam Plann. 31:290-300.	
Zavier A, Jejeebhoy S, Kalyanwala S (2012) Factors associated with second trimester abortion in rural Maharashtra and Rajasthan, India. Glob Public Health. 7:897-908.	
Zhai F, Gao Q (2010) Center-based care in the context of One-Child Policy in China: Do child gender and siblings matter? Popul Res Policy Rev. 29:745-774.	
Zhang C, Li T (2017) Culture, fertility and the socioeconomic status of women. China Economic Review. 45:279-288.	
Almond D, Edlund L, Milligan K (2013) Son preference and the persistence of culture: Evidence from South and East Asian immigrants to Canada. Popul Dev Rev. 39(1):75.	
Almond D, Sun Y X (2017) Son-biased sex ratios in 2010 US Census and 2011-2013 US natality data. Soc Sci Med. 176:21-24.	Country – not son-preference (n=20)
Blau F, Kahn L, Brummund P, Cook J, Larson-Koester M (2020) Is there still son preference in the United States? J Popul Econ. 33(3):709-750.	
Carol S, Hank K (2020) Natives' and immigrants' gender preferences for children in Germany. Eur J Popul. 36(2):235-246.	
Colls P, Silver L, Olivera G, Weier J, Escudero T, Goodall N, Tomkin G, Munne S (2009) Preimplantation genetic diagnosis for gender selection in the USA. Reprod Biomed Online. 19(S2):16-22.	
Dhillon N, MacArthur C (2010) Antenatal depression and male gender preference in Asian women in the UK. Midwifery. 26:286-293.	
Edvardsson K, Axmon A, Powell R, Davey M (2018) Male-biased sex ratios in Australian migrant populations: A population-based study of 1 191 250 births 1999-2015. Int J Epidemiol. 47(6):2025-2037.	
Filho A, Kawachi I (2013) Are sex-selective abortions a characteristic of every poor region? Evidence from Brazil. Int J Public Health. 58:395-400.	
Gonzalez L (2018) Sex selection and health at birth among Indian immigrants. Econ Hum Biol. 29:64-75.	
Grech V (2017) Further evidence of male offspring preference for certain subgroups in the United States (2007-2015) Early Hum Dev. 110:9-12.	

(*continued on next page*)

(*continued*)

Article	Reasons for exclusion (Number of articles)
Grech V (2017) Evidence of socio-economic stress and female foeticide in racial disparities in the gender ratio at birth in the United States (1995-2014) Early Hum Dev. 106:63-65.	
Grech Victor (2017) Further evidence of male offspring preference for certain subgroups in the United States (2007–2015) Early Hum Dev. 110:9-12.	
Howell E Zhang H, Poston D (2018) Son preference of immigrants to the United States: Data from US birth certificates, 2004-2013. J Immigr Minor Health. 20(3):711-716.	
Joseph K, Lee L, Williams K (2016) Sex ratios among births in British Columbia, 2000-2013. J Obstet Gynaecol Can. 38 (10):919.	
Liu P, Rose G (1995) Social aspects of > 800 couples coming forward for gender selection of their children. Hum Reprod. 10:968-71.	
Park C, Braun K, Horiuchi B, Tottori C, Onaka A (2009) Longevity disparities in multiethnic Hawaii: An analysis of 2000 life tables. Public Health Rep. 124:579-584.	
Singh N, Pripp A, Brekke T, Stray-Pedersen B (2010) Different sex ratios of children born to Indian and Pakistani immigrants in Norway. BMC Pregnancy Childbirth. 10:5.	
Takaku R (2018) First daughter effects in Japan. J Jpn Int Econ. 50:48-59.	
Tang Z (2013) Sex preference for children and Chinese fertility in America. In: Chan Kwok-bun, ed., International handbook of Chinese families. New York: Springer Science & Business Media: 263-275.	
Tonnessen M, Aalandslid V, Skjerpen T (2013) Changing trend? Sex ratios of children born to Indian immigrants in Norway revisited. BMC Pregnancy Childbirth. 13:6.	
Agrawal A (2018) Women's human rights and migration: sex selective abortion laws in the United States and India. Int Fem J Polit. 20:284-285.	
Belanger D (2015) Son preference, science, and modernity. Asian Popul Stud. 11:211-213.	Not empirical (n=4)
Mackenzie D (2019) 23 million girls are 'missing' worldwide. New Sci. 242:10.	
Vogel Lauren (2012) Sex selection migrates to Canada. CMAJ. 184:E163-4.	
Bhattacharjya H, Baidya S (2017) Determinants of child sex ratio in West and South Districts of Tripura, India. Indian J Public Health. 61:112-117.	
Brooks R (2012) "Asia's missing women" as a problem in applied evolutionary psychology? Evol Psychol. 10:910-925.	Not a primary-level study (review level) (n=13)
Chun H, Doyal L, Payne S, Il-Cho S, Kim I (2006) Understanding women, health, social change: the case of South Korea. Int J Health Serv. 36:575-592.	
Das Gupta M (2006) Cultural versus biological factors in explaining Asia's "missing women": Response to Oster. Popul Dev Rev, 32:328-332.	
Das Gupta M, Jiang Z, Li B, Xie Z, Chung W, Hwa-Ok B (2003) Why is son preference so persistent in East and South Asia? A cross-country study of China, India and the Republic of Korea. J Dev Stud. 40:153-187.	
Das Gupta M, Bhat P (1997) Fertility decline and increased manifestation of sex bias in India. Popul Stud (Camb). 51(3) 307-315.	
Dyson T (2012) Causes and consequences of skewed sex ratios. Annu Rev Sociol. 38:443-461.	
Guo Z, Das Gupta M, Li S (2016) 'Missing girls' in China and India: Trends and policy challenges. Asian Popul Stud. 12:135-155.	
Hesketh T, Xing Z (2006) Abnormal sex ratios in human populations: Causes and consequences. Proc Natl Acad Sci U S A. 103:13271-13275.	
Loh C, Remick E (2015) China's skewed sex ratio and the One-Child Policy. China Q. 222:295-319.	
Murphy R (2014) Sex ratio imbalances and China's Care for Girls Programme: A case study of a social problem. China Q. 219:781-807.	
Oldenburg P (1992) Sex-ratio, son preference and violence in India - a research note. Econ Polit Wkly. 27:2657-2662.	
Sen A (1992) Missing women. BMJ. 304:587-588.	
Basten S, Verropoulou G (2013) 'Maternity migration' and the increased sex ratio at birth in Hong Kong SAR. POP STUD-J DEMOG. 67(3):323-334.	
Belanger D, Oanh K (2009) Second-trimester abortions and sex-selection of children in Hanoi, Vietnam. Popul Stud (Camb). 63:163-171.	Not population-level, or not national level (n=17)
Chhetri U D, Ansari I, Bandary S, Adhikari N (2011) Sex preferences among mothers delivering at Patan Hospital. Kathmandu Univ Med J. 9:229-32.	
Chu J (2001) Prenatal sex determination and sex-selective abortion in rural central China. Popul Dev Rev. 27:259.	
Graham M J, Larsen U, Xu X (1998) Son preference in Anhui Province, China. Int Fam Plan Perspect. 24:72-77.	
Guha A, Rai A, Gupta D, Mondal R (2019) Abandoned babies at Tertiary Care Rural Medical College Hospital: The Indian scenarios. Indian J Pediatr. 86:335-339.	
Kant S, Srivastava R, Rai S, Misra P, Charlette L, Pandav C (2015) Induced abortion in villages of Ballabgarh HDSS: rates, trends, causes and determinants. Reprod. 12:51.	
Le V, Duong D, Nguyen A, Nguyen C, Bui H, Pham C, Le T, Tran B (2017) Sex ratio at birth in Vietnam: Results from data in CHILILAB HDSS, 2004 to 2013. Asia Pac J Public Health. 29:25S-34S.	
Lee I, Lai Y, Kuo P, Chang C (2012) Human sex ratio at amniocentesis and at birth in Taiwan. Taiwan J Obstet Gynecol. 1:572-575.	
Mohanty S, Rajbhar M (2014) Fertility transition and adverse child sex ratio in districts of India. J Biosoc Sci 46(6):753-771.	
Qian Z (1997) Progression to second birth in China: A study of four rural counties. POP STUD-J DEMOG. 51:221-228..	
Rai P, Paudel I, Ghimire A, Pokharel P, Rijal R, Niraula S (2014) Effect of gender preference on fertility: Crosssectional study among women of Tharu community from rural area of eastern region of Nepal. Reprod. 11:1-11.	
Sahni M, Verma N, Narula D, Varghese R, Sreenivas V, Puliyel J (2008) Missing girls in India: Infanticide, feticide and made-to-order pregnancies? Insights from hospital-based sex-ratio-at-birth over the last century. Plos One. 3(5):e2224.	
Sharma M, Kumar S, Vats K (2018) Disappearing of daughters or failure to perforate the Chakravyuha of favoritism from womb to tomb. Med Legal Update. 18(2):211-218.	
Srinivasan S, Bedi A (2008) Daughter elimination in Tamil Nadu, India: A tale of two ratios. J Dev Stud. 44(7):961-990.	
Tse W, Leung K, Hung B (2013) Trend of sex ratio at birth in a public hospital in Hong Kong from 2001 to 2010. Hong Kong Med J. 19:305-310.	

(*continued on next page*)

(*continued*)

Article	Reasons for exclusion (Number of articles)
Varghese J, Aruldas V, Jeemon P (2008) Beyond the numbers: Factors distorting sex ratio at birth. Indian J Gend Stud. 15:115-125.	
Seth S (2007) Sex selective feticide in India. J Assist Reprod Genet. 24:153-154.	Not a full published study (n=1)
Almond D, Li H, Zhang S (2019) Land reform and sex selection in China. J Polit Econ. 127:560-585. Bhalotra S, Chakravarty A, Mookherjee D, Pino F (2019) Property rights and gender bias: Evidence from land reform in West Bengal. Am Econ J Appl Econ. 11:205-237. Bhattacharjya D, Sudarshan A, Tuljapurkar S, Shachter R, Feldman M (2008) How can economic schemes curtail the increasing sex ratio at birth in China? Demogr Res. 19:1831-1850. Chakraborty T (2015) Trade Liberalization in a traditional society: Implications for relative female survival. World Dev. 74:158-170. Chakravarty A (2010) Supply shocks and gender bias in child health investments: Evidence from the ICDS Programme in India. B E J Econ Anal Policy. 10(1):88. Frost M, Puri M, Hinde P (2013) Falling sex ratios and emerging evidence of sex-selective abortion in Nepal: Evidence from nationally representative survey data. BMJ Open. 3:e002612. Kalsi P (2017) Seeing is believing- can increasing the number of female leaders reduce sex selection in rural India? J Dev Econ. 126:1-18. Li H, Zheng H (2009) Ultrasonography and sex ratios in China. Asian Econ Policy Rev. 4:121-137. Li J (1995) China One-Child Policy - How and how well has it worked - a case-study of Hebei-Province, 1979-88. Popul Dev Rev. 21(3):563-585. Lin M, Liu J, Qian N (2014) More missing women, fewer dying girls: the impact of sex-selective abortion on sex at birth and relative female mortality in Taiwan. J Eur Econ Assoc. 12:899-926. Nandi A, Deolalikar A (2013) Does a legal ban on sex-selective abortions improve child sex ratios? Evidence from a policy change in India. J Dev Econ. 103:216-228. Sharma B, Gupta N, Relhan N (2007) Misuse of prenatal diagnostic technology for sex-selected abortions and its consequences in India. Public Health. 121:854-860.	Interventional study (for other review) (n=12)
Total excluded at full text screening	N=144

Appendix 3. List of included studies for systematic review of evidence on relative survival outcomes for of girls and women in son-preference countries

1. Banister J (2004) Shortage of girls in China today. J Popul Res. 21(1):19–45.
2. Bhat P, Zavier A (2007) Factors influencing the use of prenatal diagnostic techniques and the sex ratio at birth in India. Econ Polit Wkly. 42 (24):2292–2303.
3. Bongaarts J, Guilmoto C (2015a) How many more missing women? Excess female mortality and prenatal sex selection, 1970–2050. Popul Dev Rev. 41(2):241–269.
4. Bongaarts J, Guilmoto C (2015b) How many more missing women? Lancet. 386(9992):427.
5. Cai Y, Lavely W (2003) China's missing girls: Numerical estimates and effects on population growth. China Rev. 3(2):13–29.
6. Cai Y (2017) Missing girls or hidden girls? A comment on Shi and Kennedy's "Delayed registration and identifying the 'missing girls' in China". China Q. 231:797–803.
7. Chao F, Gerland P, Cook A, Alkema L (2019) Systematic assessment of the sex ratio at birth for all countries and estimation of national imbalances and regional reference levels. Corrected June 26, 2019. Proc Natl Acad Sci USA. 116(19):9303–9311.
8. Chun H, Das Gupta M (2009) Gender discrimination in sex selective abortions and its transition in South Korea. Womens Stud Int Forum. 32 (2):89–97.
9. Coale A (1991), Excess female mortality and the balance of the sexes in the population: An estimate of the number of 'missing females'. Popul Dev Rev. 17(3):517–523.
10. Condorelli A (2015) An emergentist vs a linear approach to social change processes: A gender look in contemporary India between modernity and Hindu tradition. SpringerPlus. 4:156.
11. Den Boer A, Hudson V (2017) Patrilineality, son preference, and sex selection in South Korea and Vietnam. Popul Dev Rev. 43(1):119–147.
12. Duthé G, Meslé F, Vallin J, Badurashvili I, Kuyumjyan K (2012) High sex ratios at birth in the Caucasus: Modern technology to satisfy old desires. Popul Dev Rev. 38(3):487–501.
13. Goodkind D (2011) Child underreporting, fertility, and sex ratio imbalance in China. Demography. 48(1):291–316.
14. Grech V (2015) Evidence of economic deprivation and female foeticide in a United Nations global births by gender data set. Early Hum Dev, 91 (12):855-858.
15. Guilmoto C, Hoang X, Van T (2009) Recent increase in sex ratio at birth in Viet Nam. PLoS ONE. 4(2): e4624.
16. Guilmoto C (2012a) Sex imbalances at birth. Current trends, consequences and policy implications. Bangkok: UNFPA (United Nations Population Fund) Asia and the Pacific Regional Office.
17. Guilmoto C (2012b) Son preference, sex selection, and kinship in Vietnam. Popul Dev Rev. 38(1):31–54.
18. Huang Y, Tang W, Mu Y, Li X, Liu Z, Wang Y et al. (2016) The sex ratio at birth for 5,338,853 deliveries in China from 2012 to 2015: A facility-based study. PLoS ONE 11(12): e0167575.
19. Jiang Q, Li S, Feldman M (2012) China's missing girls in the three decades from 1980 to 2010. Asian Women. 28(3):53–73.
20. Jiang Q, Yu Q, Yang S, Sánchez-Barricarte J (2017) Changes in sex ratio at birth in China: a decomposition by birth order. J Biosoc Sci. 49 (6):826–841.
21. Kahlert M (2014) Trends in missing women in the 2000s. MA dissertation. Göttingen University.
22. Klasen S (1994) "Missing women" reconsidered. World Dev. 22(7):1061-1071.

23. Klasen S, Wink C (2002) A turning point in gender bias in mortality? An update on the number of missing women. Popul Dev Rev. 28 (2):285–312.
24. Klasen S, Wink C (2003) "Missing women": Revisiting the debate. Fem Econ. 9(2–3):263-299.
25. Michael M, King L, Guo L, McKee M, Richardson E, Stuckler D (2013) The mystery of missing female children in the Caucasus: an analysis of sex ratios by birth-order. Int Perspect Sex Reprod Health. 39(2):97–102.
26. Organisation for Economic Cooperation and Development (OECD) (2014) SIGI (Social Institutions and Gender Index) Methodological Background Paper. Paris: OECD. http://genderindex.org/sites/default/files/Backgroundpaper.pdf
27. Rahm L (2020) Gender-biased sex selection in South Korea, India and Vietnam - Assessing the influence of public policy. Switzerland: Springer Nature.
28. Sen A (1986) Africa and India: What do we have to learn from each other? In: Proceedings of the Eighth World Congress of the International Economic Association New Delhi (December 1986). London: Macmillan.
29. Sen A (1989) Women's survival as a development problem. Am Acad Arts Sci Bull. 43(2):14–29.
30. Shi Y, Kennedy J (2016) Delayed registration and identifying the "missing girls" in China. China Q. 228:1018–1038.
31. Shi Y, Kennedy J (2017) Missing girls, indirect measures and critical assumptions: A response to Yong Cai's comments. China Q. 231:804–810.
32. Tufuro S, Guilmoto C (2020) Skewed sex ratios at birth: A review of global trends. Early Hum Dev. 141:104868.
33. Yoo S, Hayford S, Agadjanian V (2017) Old habits die hard? Lingering son preference in an era of normalizing sex ratios at birth in South Korea. Popul Res Policy Rev. 36(1):25–54.
34. Zeng Y, Tu P, Gu B, Xu Y, Li B, Li Y (1993) Causes and implications of the recent increase in the reported sex-ratio at birth in China. Popul Dev Rev. 19(2):283–302.

Appendix 4. Data time points, sources, and data time gaps between Klasen and Wink (2003) and Kahlert (2014) studies of 'missing women'

Appendix 4
Data time points, sources, and data time gaps between Klasen & Wink (2003) and Kahlert (2014) studies of 'missing women'

	Klasen and Wink (2003)	Kahlert, 2014*	Data sources (Kahlert, 2014)	Data time gap
China	2000	2010	National Census data	10 years
Taiwan	1999	2012	Statistical Yearbook of the Republic of China 2012	13 years
South Korea	1995	2010	National Census data	15 years
India	2001	2011	National Census data	10 years
Pakistan	1998	2011	United Nations (UN) Population Division	13 years
Bangladesh	2001	2011	National Census data	10 years
Nepal	2001	2011	National Census data	10 years
Sri Lanka	1991	2012	National Census data	21 years
West Asia	2000	2012	Demographic Yearbook 2012	12 years
Egypt	1996	2006	National Census data	10 years
Algeria	1998	2008	National Census data	10 years
Tunisia	1994	2004	National Census data	10 years
Sub-Saharan Africa	2000	2012	Demographic Yearbook 2012	12 years

Note: *Kahlert's 2014 study was supervised by Stephan Klasen. It used similar methods, which allow for comparison between the studies over time. The 2014 study data were graciously provided by Mirjam Kahlert.

References

Banister, J., 2004. Shortage of girls in China today. J. Popul. Res. 21 (1), 19–45.
Bero, L., Chartres, N., Diong, J., Fabbri, A., Ghersi, D., Lam, J., et al., 2018. The risk of bias in observational studies of exposures (ROBINS-E) tool: concerns arising from application to observational studies of exposures. Syst. Rev. 7 (1), 242.
Bhat, P., Zavier, A., 2007. Factors influencing the use of prenatal diagnostic techniques and the sex ratio at birth in India. Econ. Polit. Wkly. 42 (24), 2292–2303.
Bhattacharjya, D., Sudarshan, A., Tuljapurkar, S., Shachter, R., Feldman, M., 2008. How can economic schemes curtail the increasing sex ratio at birth in China? Demogr. Res. 19 (54), 1831–1850.
Bongaarts, J., 2013. The implementation of preferences for male offspring. Popul. Dev. Rev. 39 (2), 185–208.
Bongaarts, J., Guilmoto, C., 2015a. How many more missing women? Excess female mortality and prenatal sex selection, 1970-2050. Popul. Dev. Rev. 41 (2), 241–269.
Bongaarts, J., Guilmoto, C., 2015b. How many more missing women? Lancet 386 (9992), 427.
Cai, Y., Lavely, W., 2003. China's missing girls: Numerical estimates and effects on population growth. China Rev. 3 (2), 13–29.
Cai, Y., 2017. Missing girls or hidden girls? A comment on Shi and Kennedy's "Delayed registration and identifying the 'Missing girls' in China". China Q. 231, 797–803.
Chakravarty, N., Dabla, V., Sagar, M., Neogi, S., Markan, M., Segan, M., et al., 2022. Cultural and social bias leading to prenatal sex selection: India perspective. Front. Global Women's Health 3, 903930.
Chao, F., Gerland, P., Cook, A., Alkema, L., 2019. Systematic assessment of the sex ratio at birth for all countries and estimation of national imbalances and regional reference levels. Corrected June 26, 2019 Proc. Natl. Acad. Sci. USA 116 (19), 9303–9311.
Chun, H., Das Gupta, M., 2009. Gender discrimination in sex selective abortions and its transition in South Korea. Womens Stud. Int. Forum 32 (2), 89–97.
Coale, A., 1991. Excess female mortality and the balance of the sexes in the population: an estimate of the number of 'missing females'. Popul. Dev. Rev. 17 (3), 517–523.
Condorelli, R., 2015. An emergentist vs a linear approach to social change processes: a gender look in contemporary India between modernity and Hindu tradition. SpringerPlus 4, 156.
CRD, 2009. Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care. University of York: Centre for Reviews and Dissemination. www.york.ac.uk/media/crd/Systematic_Reviews.pdf.
Den Boer, A., Hudson, V., 2017. Patrilineality, son preference, and sex selection in South Korea and Vietnam. Popul. Dev. Rev. 43 (1), 119–147.
Devaney, S., Palomaki, G., Scott, J., Bianchi, D., 2011. Noninvasive fetal sex determination using cell-free fetal DNA: a systematic review and meta-analysis. JAMA 306 (6), 627–636.
Duthé, G., Meslé, F., Vallin, J., Badurashvili, I., Kuyumjyan, K., 2012. High sex ratios at birth in the Caucasus: Modern technology to satisfy old desires. Popul. Dev. Rev. 38 (3), 487–501.
Fan, S., Xiao, C., Zhang, Y., Li, Y., Wang, X., Wang, L., 2020. How does the two-child policy affect the sex ratio at birth in China? A cross-sectional study. BMC Publ. Health 20 (1), 789.
Goodkind, D., 2011. Child underreporting, fertility, and sex ratio imbalance in China. Demography 48 (1), 291–316.
Grech, V., 2015. Evidence of economic deprivation and female foeticide in a United Nations global births by gender data set. Early Hum. Dev. 91 (12), 855–858.
Guilmoto, C., Hoang, X., Van, T., 2009. Recent increase in sex ratio at birth in Viet Nam. PLoS One 4 (2), e4624.
Guilmoto, C., 2012a. Sex imbalances at birth. Current trends, consequences and policy implications. Bangkok: UNFPA (United Nations Population Fund) Asia and the Pacific Regional Office.
Guilmoto, C., 2012b. Son preference, sex selection, and kinship in Vietnam. Popul. Dev. Rev. 38 (1), 31–54.
Hesketh, T., Xing, Z., 2006. Abnormal sex ratios in human populations: causes and consequences. Proc. Natl. Acad. Sci. USA 103 (36), 13271–13275.

Hesketh, T., Lu, L., Xing, Z., 2011. The consequences of son preference and sex-selective abortion in China and other Asian countries. CMAJ (Can. Med. Assoc. J.) 183 (12), 1374–1377.
Huang, Y., Tang, W., Mu, Y., Li, X., Liu, Z., Wang, Y., et al., 2016. The sex ratio at birth for 5,338,853 deliveries in China from 2012 to 2015: a facility-based study. PLoS One 11 (12), e0167575.
Jiang, Q., Li, S., Feldman, M., 2012. China's missing girls in the three decades from 1980 to 2010. Asian Women 28 (3), 53–73.
Jiang, Q., Yu, Q., Yang, S., Sánchez-Barricarte, J., 2017. Changes in sex ratio at birth in China: a decomposition by birth order. J. Biosoc. Sci. 49 (6), 826–841.
Jiang, Q., Zhang, C., 2021. Recent sex ratio at birth in China. BMJ Global Health 6, e005438.
Johansson, S., Nygren, O., 1991. The missing girls of China: a new demographic account. Popul. Dev. Rev. 17 (1), 35–51.
Kahlert, M., 2014. Trends in Missing Women in the 2000s. MA Dissertation. Göttingen University.
Karabinus, D., Marazzo, D., Stern, H., Potter, D., Opanga, C., Cole, M., et al., 2014. The effectiveness of flow cytometric sorting of human sperm for influencing a child's sex. Reprod. Biol. Endocrinol. 12 (106), 1–12.
Klasen, S., 1994. "Missing women" reconsidered. World Dev. 22 (7), 1061–1071.
Klasen, S., Wink, C., 2002. A turning point in gender bias in mortality? An update on the number of missing women. Popul. Dev. Rev. 28 (2), 285–312.
Klasen, S., Wink, C., 2003. "Missing women": Revisiting the debate. Fem. Econ. 9 (2–3), 263–299.
Kumar, S., Sinha, N., 2019. Preventing more "missing girls": a review of policies to tackle son preference. World Bank Res. Obs. 35 (1), 87–121.
Mays, N., Pope, C., Popay, J., 2005. Systematically reviewing qualitative and quantitative evidence to inform management and policy-making in the health field. J. Health Serv. Res. Policy 10 (1). S1:6-S1:20.
Michael, M., King, L., Guo, L., McKee, M., Richardson, E., Stuckler, D., 2013. The mystery of missing female children in the Caucasus: an analysis of sex ratios by birth-order. Int. Perspect. Sex. Reprod. Health 39 (2), 97–102.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D., The PRISMA Group, 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 6 (7), 1–6: e1000097.
Organisation for Economic Cooperation and Development (OECD), 2014. SIGI (Social Institutions and Gender Index) Methodological Background Paper. OECD, Paris. http://genderindex.org/sites/default/files/Backgroundpaper.pdf.
Orton, L., Pennington, A., Nayak, S., Sowden, A., White, M., Whitehead, M., 2016. Group-based microfinance for collective empowerment: a systematic review of health impacts. Bull World Health Organ 94 (9), 694–704A.
Page, M., McKenzie, J., Bossuyt, P., Boutron, I., Hoffmann, T., Mulrow, C., et al., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372, n71.
Pennington, A., Orton, L., Nayak, S., Ring, A., Petticrew, M., Sowden, A., et al., 2018. The health impacts of women's low control in their living environment: a theory-based systematic review of observational studies in societies with profound gender discrimination. Health Place 51, 1–10.
Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., et al., 2006. Guidance on the Conduct of Narrative Synthesis in Systematic Reviews. A Product from the ESRC Methods Programme. Institute for Health Research, Lancaster University, Lancaster.
Rahm, L., 2020. Gender-Biased Sex Selection in South Korea, India and Vietnam - Assessing the Influence of Public Policy. Springer Nature, Switzerland.
Sen, A., 1986. Africa and India: what do we have to learn from each other?. In: Proceedings of the Eighth World Congress of the International Economic Association New Delhi (December 1986). Macmillan, London.
Sen, A., 1989. Women's survival as a development problem. Am. Acad. Arts Sci. Bull. 43 (2), 14–29.
Sen, A., 1990. More than a 100 Million Women Are Missing. New York Review of Books, 20 December 1990.
Sen, A., 1999. Development as Freedom. Oxford University Press, New York.
Shi, Y., Kennedy, J., 2016. Delayed registration and identifying the "missing girls" in China. China Q. 228, 1018–1038.
Shi, Y., Kennedy, J., 2017. Missing girls, indirect measures and critical assumptions: a response to Yong Cai's Comments. China Q. 231, 804–810.
Tang, D., Gao, X., Cai, J., Coyte, P., 2022. The effect of China's Two-Child Policy on the child sex ratio: evidence from Shanghai, China. Inquiry 59, 1–9: 469580211067933.
Thomas, J., Brunton, J., Graziosi, S., 2010. EPPI-reviewer 4: Software for Research Synthesis, EPPI-Centre Software. Social Science Research Unit, UCL Institute of Education, London.
Tufuro, S., Guilmoto, C., 2020. Skewed sex ratios at birth: a review of global trends. Early Hum. Dev. 141, 104868.
UNDP, 2015. United Nations Development Programme Gender Inequality Index Human Development Reports [online]. http://hdr.undp.org/en/content/gender-inequality-index-gii.
Whitehead, M., Orton, L., Pennington, A., Nayak, S., Ring, A., Petticrew, M., et al., 2014. Is control in the living environment important for health and wellbeing, and what are the implications for public health interventions?. Public Health Research Consortium, London.
Whitehead, M., Pennington, A., Orton, L., Nayak, S., Petticrew, M., Sowden, A., et al., 2016. How could differences in 'control over destiny' lead to socio-economic inequalities in health? A synthesis of theories and pathways in the living environment. Health Place 39, 51–61.
Yoo, S., Hayford, S., Agadjanian, V., 2017. Old habits die hard? Lingering son preference in an era of normalizing sex ratios at birth in South Korea. Popul. Res. Pol. Rev. 36 (1), 25–54.
Zarulli, V., Barthold Jones, J., Oksuzyan, A., Lindahl-Jacobsen, R., Christensen, K., Vaupel, J., 2018. Women live longer than men even during severe famines and epidemics. Proc. Natl. Acad. Sci. USA E832-E840. https://www.pnas.org/doi/pdf/10.1073/pnas.1701535115.
Zeng, Y., Tu, P., Gu, B., Xu, Y., Li, B., Li, Y., 1993. Causes and Implications of the recent increase in the reported sex-ratio at birth in China. Popul. Dev. Rev. 19 (2), 283–302.