Ethnicity and maternal and child health outcomes and service coverage in western China: a systematic review and meta-analysis

Yuan Huang, David Shallcross*, Li Pi, Fan Tian, Jay Pan, Carine Ronsmans*

Summary

Background There is a dearth of accurate information about health outcomes and health service coverage among ethnic minorities in China. We assessed maternal and child health (MCH) outcomes and service coverage among ethnic minorities compared with Han populations in western China.

Methods We did a systematic review searching English (Embase, MEDLINE, Web of Science) and Chinese (China National Knowledge Infrastructure [CNKI], VIP, Wanfang) databases for population-based studies comparing MCH indicators between ethnic minorities between Jan 1, 1990, and Nov 9, 2016, in any language. For studies making individual comparisons we used the odds ratio (OR) and corresponding 95% CIs as the primary measure to assess the association between MCH indicators and ethnicity. We used a random-effects model to pool odds ratios.

Findings We included 29 Chinese and 16 English language studies, providing 31 individual comparisons and 15 ecological comparisons. Ethnic minority women had lower odds of antenatal care use (pooled crude OR 0·60 [95% CI 0·48–0·75]) and birth in health facilities (0·50 [0·39–0·64]) than did Han women; and their children had higher odds of mortality (2·02 [1·23–3·32]) and lower immunisation (0·34 [0·24–0·47]) than did Han children. After taking account of the potential confounding effects of socioeconomic factors, ethnic minority women were less likely to use antenatal care (pooled adjusted OR 0·54 [0·42–0·71]) or to immunise their children (0·57 [0·44–0·74]) compared with Han women.

Interpretation China has a wealth of primary data that could further our understanding of why ethnic minority populations are lagging behind. As MCH outcomes continue to improve nationally, ethnic minorities will take a greater share of the overall burden of adverse outcomes, requiring strategic investments to address the specific challenges faced by people living in remote areas.

Funding China Medical Board.

Lancet Glob Health 2017; 6: e39–56

Published Online November 16, 2017 http://dx.doi.org/10.1016/S2214-109X(17)30445-X

See Comment page e2

*First authors

West China School of Public Health, Sichuan University, Chengdu, China (Y Huang, D Shallcross, L Pi, F Tian, J Pan, Prof C Ronsmans); **West China Research Center for Rural Health Development, Sichuan University, Chengdu, China** (D Shallcross, J Pan, C Ronsmans); **and London School of Hygiene & Tropical Medicine, London, UK** (Y Huang, D Shallcross, Prof C Ronsmans)

Correspondence to: Prof Carine Ronsmans, Department of Infectious Disease Epidemiology, Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, London WC1E 7HT, UK **carine.ronsmans@lshtm.ac.uk**

Introduction

Ethnic minority populations across the world often have worse social and health outcomes than non-ethnic minority populations, though the pattern is by no means constant.[1–3] Some ethnic minority populations fare better than others in the same society, and where ethnic variation has been documented the size of effect varies greatly.[1] The factors underlying health inequalities between ethnic and non-ethnic minority populations are complex and varied, but aspects related to employment, income, education, food security, health-care policies and systems, social policies, social structures, health behaviours, and cultural norms are all thought to play a part.[2]

China's 55 ethnic minority groups represent one of the largest ethnic minority populations in the world.[2] The 2010 China census estimated that 114 million people belonged to ethnic minorities, representing 8·5% of the total population.[4] Nearly three-quarters (71·4%) of all ethnic minorities in China live in the Western Region.[5] The Zhuang (17 million), Hui (11 million), Manchus (10 million), Uyghur (10 million), and Miao (9 million) are the dominant ethnic groups.[4] Collectively, China's 55 ethnic minority groups represent highly heterogeneous socioeconomic positions, languages, religions, and cultural and geographical contexts.[4,5]

Over the past 50 years, the Chinese Government has made substantial efforts to improve the rights and opportunities of its ethnic minorities.[6] At a collective level, the Government designated regions with large ethnic minority populations as "autonomous", giving them the right to self-government, including special legislative power and the right to develop and control local economies and finances. Today, there are five autonomous provinces (Tibet, Xinjiang, Inner Mongolia, Guangxi, and Ningxia), 30 autonomous prefectures, and 120 autonomous counties.[5] Many autonomous counties have also benefited from national poverty alleviation efforts that provided the poorest counties with extra funding.[7] At an individual level, ethnic minorities have some privileges such as looser family planning restrictions and educational benefits. Fertility controls

have been less stringent for people living in autonomous regions and many ethnic minority couples were allowed a second or third child under the one child policy.[8] In education, some minority students have benefited from subsidies and preferential admittance into colleges and universities, and bilingual education has been offered to ethnic groups with a language and writing system.

Despite an increasing focus on ethnic minority culture and identity in China, there is a dearth of accurate demographic, health outcome, and health service coverage data for ethnic minorities. An international review bringing together experts in indigenous health data systems from across the world reported only two studies from China, one from Tibet and one from the Dai minority group in Yunnan Province.[1] Similarly, a literature review examining socioeconomic variation in maternal health care and maternal mortality in China found three studies showing lower uptake of antenatal and delivery care among ethnic minority populations, but no studies reporting on maternal mortality.[9] Repeated calls have been made to improve the information base about ethnic minorities in China.[1,2,6,9,10]

The aim of this systematic review is to examine whether maternal and child health (MCH) outcomes and service coverage vary by ethnic affiliation in western China. We focus on MCH because this is a priority area for the Chinese Government and great success has been achieved over the past 20 years.[11] The areas of MCH that we include are maternal and child mortality, antenatal and delivery care, and immunisation coverage. Our review focuses on western China not only because ethnic minorities are overwhelmingly concentrated in this region, but also because the region is economically deprived and performs poorly compared with eastern and central China.[11] Because ethnic minority groups in China are highly heterogeneous,[4,5] we aim to report variation in MCH outcomes and service coverage between the Han and individual ethnic groups.

Methods

Search strategy and selection criteria

We searched English (Embase, MEDLINE, Web of Science) and Chinese (China National Knowledge Infrastructure [CNKI], VIP, Wanfang) databases between Jan 1, 1990, and Nov 9, 2016, using the search terms "health care utilisation", "ethnic minorities", and "western China" (see appendix pp 1–8 for the full search strategy). We only included papers published in peer-reviewed journals, but there were no language restrictions. All English titles and abstracts were reviewed by one author (DS); the Chinese titles and abstracts were reviewed by two authors (LP, FT). The two Chinese authors read all titles and abstracts independently, and agreed the final selection of papers. Whenever the Chinese authors disagreed or were uncertain, they consulted one of the authors (DS) for clarification. Where uncertainty persisted for English or Chinese papers, questions were referred to the senior author (CR), who made a final decision. We obtained full text copies of potentially relevant articles and the reference lists were searched for further relevant publications.

See Online for appendix

Studies were eligible for inclusion if they compared MCH indicators between Han populations and ethnic minorities, or between particular ethnic minorities in western China. Western China consists of 12 provinces: Tibet, Qinghai, Xinjiang, Gansu, Shaan'xi, Sichuan, Guizhou, Guangxi, Yunnan, Chongqing, Ningxia, and Inner Mongolia. We included studies reporting data from 1990 onwards to coincide with the Millennium Development Goals. Both facility-based studies and any studies that did not sample from western China were excluded. MCH indicators included neonatal, infant, child or maternal mortality and MCH service coverage, specifically antenatal visits (≥1, ≥3, ≥5, and first visit in first trimester), birth in hospital, caesarean section, and one of the five traditional childhood vaccines (Bacillus Calmette–Guérin [BCG], oral polio vaccine [OPV], diphtheria, tetanus, and pertussis [DTP], measles vaccine [MV], and hepatitis B vaccine [hepatitis B]).

We included two types of studies: (1) studies comparing individual ethnicities and (2) studies making ecological comparisons between geographically defined groups. Studies making individual comparisons were included if the paper reported crude, adjusted, or both odds ratios (ORs) with 95% CIs comparing individuals with different ethnic affiliations (ie, Han compared with ethnic minorities or comparisons between ethnic minorities); or if the paper provided the data that allowed us to calculate these effect estimates with 95% CIs. Ethnic groups with a sample size of less than 30 were excluded from the analysis. For ecological studies we included papers that made comparisons between prefectures, counties, or villages with a stated ethnic composition. Studies comparing autonomous prefectures, counties, or villages without stating the ethnic composition were excluded, as were studies comparing autonomous provinces. Ecological studies were included regardless of the statistical methods used to compare the geographically defined groups.

Data for study location, dates, design and population, sample size, definition, and ascertainment of MCH indicators and ethnic groups, the type of denominator and the numerator for each indicator were extracted by five authors (DS, LP, FT, YH, and CR). Study populations described in more than one paper were included only once, using data from the paper with the most detailed information. When more than one MCH indicator was assessed in a single study, these were extracted and treated as separate datasets.

The risk of bias for each dataset was assessed using the component approach adopted by the Cochrane Collaboration.[12] All datasets were assessed on the rigour of the study design (eg, whether the sampling strategy for a cross-sectional survey was clearly described and data sources stated), the completeness of data, the definition and ascertainment of the MCH indicator, the definition of

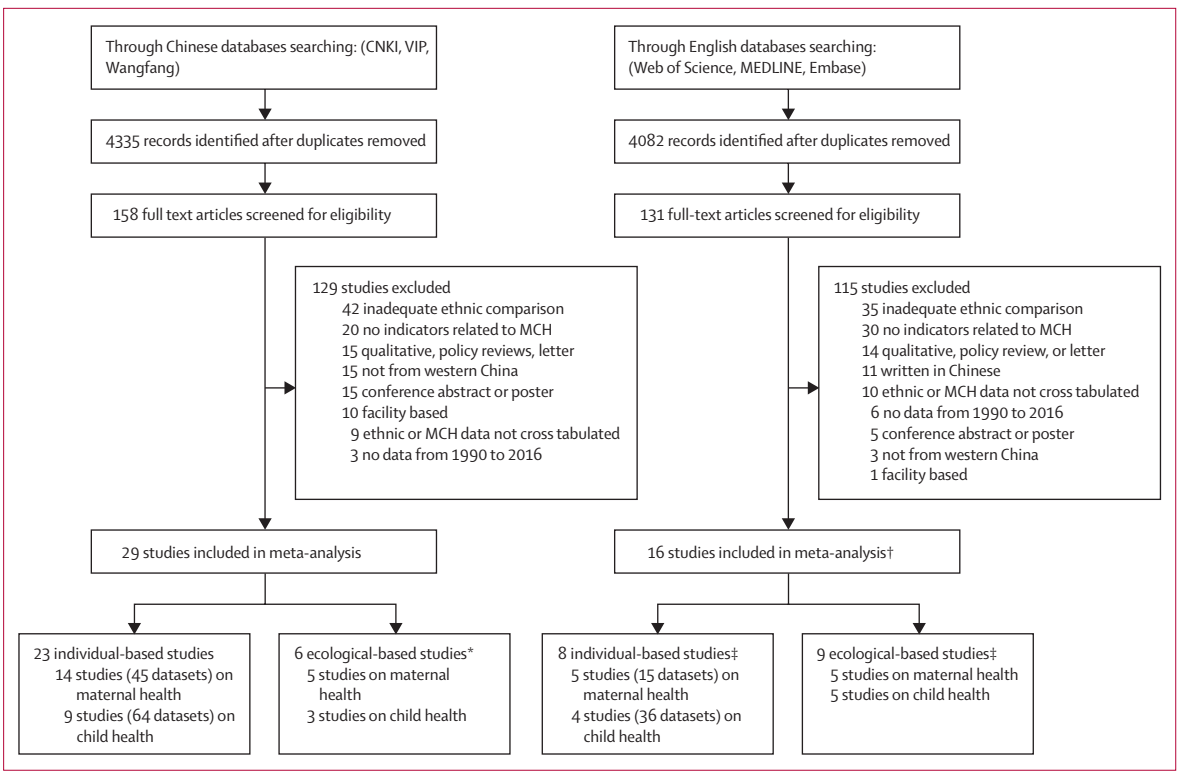

Figure 1: **Flow chart of study selection for inclusion in the systematic review**
CNKI=China National Knowledge Infrastructure. MCH=maternal and child health. *Two studies reported both maternal health and child health datasets. †One study reported both individual and ecological comparisons. ‡One study reported both maternal health and child health datasets.

ethnicity, the statistical analysis (eg, whether survey design had been accounted for in the analysis), and adjustment for confounding. Each of the quality criteria were classified as having a low risk or high risk of bias for each dataset. For example, a dataset was classified as having a high risk of bias for study design if a cross-sectional survey was said to be based on "stratified multistage random sampling" but no further details were given. Similarly, cross-sectional surveys reportedly using random sampling but without information about the data from which children were sampled were considered at high risk of bias for study design. Where there was insufficient information to assess the risk of bias, the dataset was classified as at an unclear risk of generating bias.

Data analysis

All meta-analyses were carried out using Stata 14.0. The association between ethnicity and each MCH indicator was estimated using ORs and 95% CIs. Both the crude ORs (either provided in the paper or calculated by us) and the adjusted estimates were included, but pooled separately for each MCH indicator. If a study provided findings from several time periods, only the effect estimates from the latest period were included. The weighted summary measure of effect for each MCH indicator was obtained by conducting a random-effects model and represented with a forest plot. The presence of statistical heterogeneity across studies was assessed by applying an I^2 value (<25% interpreted as no heterogeneity, 25–49% as low heterogeneity, 50–74% as moderate heterogeneity, and ≥75% as high heterogeneity) and a χ^2 test with a threshold p value of 0·10 to determine significance. We used funnels plots and Begg's test[13] ($p<0·05$ to determine significance) to assess if there was any potential publication bias. Additionally, sensitivity analyses and meta-regressions were done to assess the effect of calendar effect and small-study bias on the pooled results. We used year of publication rather than year of data collection to test for calendar effect because some studies did not report the latter. This review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[14]

Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The Chinese search initially identified 4335 titles and abstracts; 158 of these were retained for full text review and 129 were excluded because they did not contain

relevant data (figure 1). The English search identified 4082 titles and abstracts; 131 of these were retained for review and 115 were subsequently excluded. 29 Chinese language studies and 16 English language studies, providing 31 individual comparisons and 15 ecological comparisons, were included.

Table 1 describes the 31 eligible studies based on individual comparisons.[15–45] 19 studies reported on maternal health indicators (two maternal mortality, 11 antenatal care, ten facility births, and one caesarean section) and 13 on child health indicators (three child mortality, one infant mortality, one neonatal mortality, and ten immunisation). One study reported on both maternal and child health indicators.[19] Most studies described data collected during 2000–09, and the most commonly represented provinces were Guizhou (n=12), Ningxia (n=7), and Xinjiang (n=7). Most studies (n=28 [90%]) relied on data from cross-sectional surveys, and the most commonly reported comparisons were between Han Chinese and other (n=25), Hui (n=9), Zhang (n=6), or Uyghur (n=6) ethnic groups.

Only four studies were judged to be at low risk of bias across all of the quality criteria (table 2).[19,26,32,39] Sampling strategies for cross-sectional surveys were generally well described, but only half (17 of 31) reported the data sources from which the sample was drawn. Only ten of 31 studies provided data for response rates and 16 of 31 studies reported the definition of outcomes. For the ten studies reporting immunisation coverage, the source of information varied: four studies relied on mother's report only, one on blood tests only, and five on at least two sources (mother's report, household certificate, health facility card, blood tests, or immunisation scars). Most (21 of 31) studies used logistic regression, but it was not always clear whether adjustment for survey design had been taken into account in the analysis. Two studies reported regression analyses but data could not be used because the ethnicity was treated as a continuous variable.[15,16] 17 studies adjusted the analysis for confounders, including sociodemographic factors, geographic accessibility, and health-related knowledge.

	Study design (period)	Study setting	Study population	Sample size	Indicators	Ethnic minority: number				
						Han	Hui	Uyghur	Tibetan	Other ethnicities
Maternal health										
Lu et al, 2000 (C)[15]	Cross-sectional survey (1999)	40 counties in Gansu, Guizhou, Ningxia, Qinghai, and Xinjiang Provinces	Women with a child younger than 3 years	6069	Antenatal visits (1st visit in 1st trimester, ≥5), facility birth	3928	759	1088	321	..
An et al, 2002 (C)[16]	Cross-sectional survey (period unclear)	40 counties in Gansu, Guizhou, Ningxia, Qinghai, and Xinjiang Provinces	Women with a child younger than 3 years	7152	Facility birth	3728	751	1054	..	Other (no name): 1619
Yan et al, 2003 (C)[17]	Cross-sectional survey (2000)	24 counties in Xinjiang Uygur Autonomous Province	Women with a child younger than 5 years	2441	Facility birth	461	87	1392	..	Kazak: 387, Mongolian: 45, other (no name): 69
An et al, 2004 (C)[18]	Cross-sectional survey (period unclear)	40 counties in Xinjiang, Gansu, Qinghai, Ningxia, and Guizhou Provinces	Women with a child younger than 3 years	7259	Antenatal visits (≥3)	3789	762	1067	..	Other (no name): 1641
Li, 2004 (E)[19]	Cross-sectional survey (1994)	51 villages in Diandong County, Yunnan Province	Women who gave birth during 1991–93	1062	Antenatal visits (≥1)	892	..	..	..	Other (no name): 170
Fang et al, 2005 (C)[20]	Cross-sectional survey (2001)	China	Women who gave birth in the 3 years before the survey	1206	Antenatal visit (≥1)	Not stated	..	..	..	Other (no name): not stated
Li et al, 2008 (C)[21]	Cross-sectional survey (2003)	Guangxi Province	Rural women with a livebirth since January 1998	407	Facility birth	188	..	..	..	Other (no name): 219
Chang et al, 2009 (C)[22]	Cross-sectional survey (2006)	Tekesi County in Xinjiang Yili Kazak Autonomous Prefecture	Women with a child born in 2000-06	862	Facility birth	..	102	72	..	Kazak: 474, Kyrgyz: 163, other (Han/Mongolian): 51

(Table 1 continues on next page)

	Study design (period)	Study setting	Study population	Sample size	Indicators	Ethnic minority: number				
						Han	Hui	Uyghur	Tibetan	Other ethnicities
(Continued from previous page)										
Cui et al, 2009 (C)[23]	Cross-sectional survey (2005)	46 counties in ten western provinces: Gansu, Qinghai, Jiangxi, Sichuan, Guizhou, Inner Mongolia, Guangxi, Xinjiang, Ningxia, and Chongqing	Rural women with a child younger than 3 years	13 532	Antenatal visit (≥1, ≥5, 1st visit in 1st trimester)	8458	..	..	..	Other (no name): 5074
Zhu et al, 2009 (C)[24]	Cross-sectional survey (2007)	Five ethnic minority autonomous counties in Guizhou Province	Married women aged 20-49 years	520	Antenatal visits (≥1), facility birth	..	..	..	..	Dong: 104, Buyei: 98, Qilao: 01, Sui: 100, Miao: 117
Lei et al, 2010 (C)[25]	Cross-sectional survey (period unclear)	Counties in Ningxia, Sichuan and Shaanxi Province	Women with a livebirth during 2002–06	1658	Antenatal visits (≥5)	938	..	..	..	Other (no name): 720
Long et al, 2010 (E)[26]	Cross-sectional survey (2003, 2008)	300 rural townships in 10 western provinces	Women aged 15–49 years, who gave birth in the previous year	2002: 917, 2007: 801	Antenatal visits (≥1, ≥5, 1st visit in 1st trimester), facility birth	2002: 510, 2007: 424	..	..	..	Other (no name): 407 (2002) and 377 (2007)
Feng, 2011 (C)[27]	Routine data from MCH hospitals and death report cards (1996– 2007)	Haibei Tibetan Autonomous Prefecture in Qinghai Province	Livebirths	44 838	Maternal mortality ratio	15 000	10 206	..	19 632	..
Liu et al, 2011 (E)[28]	Cross-sectional survey (2005)	867 villages in 45 counties in 10 western provinces	Women with a child younger than 3 years	14 111	Antenatal visits (≥5), facility birth	9003	..	..	..	Other (no name): 5108
Ren, 2011 (E)[29]	Cross-sectional survey (2006)	Four counties in Ningxia Province	Women with a child younger than 5 years	553	Antenatal visits (≥1, ≥5, 1st visit in 1st trimester, ≥5 and 1st visit in 1st trimester)	151	402	..	..	..
Rong et al, 2011 (C)[30]	Cross-sectional survey (period unclear)	Six ethnic minority counties: Nongchuan and Luxi (Yunnan); Congjiang and Leishan (Guizhou); Hualong (Qinghai); Gongbujiangda (Tibet)	(1) Married women of childbearing age (15–49 years); (2) Guardians of children aged 0–5 years	455	Facility birth	122	..	..	..	Other (no name): 333
Chen et al, 2013 (C)[31]	Cross-sectional survey (2011)	12 counties in Tibet Province and Liangshan Prefecture of Sichuan Province	Women with a child younger than 3 years	1351	Antenatal visit (≥1, ≥5, 1st visit in 1st trimester)	98	..	..	..	Other (Zang, Yi, Miao, or others): 1253
Jiang XX et al, 2014 (C)[32]	Cross-sectional survey (period unclear)	12 counties in Tibet Province and Liangshan Prefecture of Sichuan Province	Women with a child younger than 3 years	624	Caesarean section	77	..	..	145	Yi: 399, other (no name): 3
Du et al, 2015 (E)[33]	National maternal and child health reporting system (1996–2009)	Guizhou Province	Livebirths	1996–2002: 3 481 640; 2003–09: 2 825 212	Facility births, maternal mortality ratio	1996–2002: 1 806 971; 2003–09: 1 449 334	..	..	..	Other (no name): 1 674 669 (1996–2002); 1 375 878 (2003–09)

(Table 1 continues on next page)

	Study design (period)	Study setting	Study population	Sample size	Indicators	Ethnic minority: number				
						Han	Hui	Uyghur	Tibetan	Other ethnicities
(Continued from previous page)										
Child health										
Long, 1996 (C)[34]	Cross-sectional survey (1992)	Longsheng County in Guangxi Province	Livebirths and under-5 deaths in 1992	761	Mortality of children younger than 5 years	..	..	..	..	Zhuang or Han: 275; Miao or Yao or Dong: 486
Li, 2004 (E)[19]	Cross-sectional survey (1994)	51 villages in Diandong County, Yunnan Province	Children born during 1991–93	1300	Childhood immunisation coverage	Not stated	..	..	..	Other (Yi, Buyei, Miao, or others): not stated
Wei et al, 2005 (C)[35]	Cross-sectional survey (2003)	Qiandongnan Prefecture in Guizhou Province	Children aged 0–2 years	1377	Hepatitis B: coverage	163	..	..	..	Dong: 757; Miao: 431; other (no name): 26
Zhou et al, 2007 (C)[36]	Cross-sectional survey (period unclear)	Puding County in Guizhou Province	Children born in 2003	Full coverage: 213; timely first dose coverage: 169	Hepatitis B: full and timely first does coverage	Full coverage: 175; timely first does coverage: 140	..	..	..	Other (no name): 38; (full coverage) and 29 (timely first does coverage)
Yang, 2008 (C)[37]	Routine data from MCH hospitals and death report cards (2003–07)	Yuanjiang County in Yunnan Province	Livebirths	10 976	Mortality of children younger than 5 years; infant mortality; neonatal mortality	2289	..	..	..	Hani: 4842; Dai: 1164; Bai: 287; Yi: 2328; other (no name): 66
Gao et al, 2009 (C)[38]	Routine data from MCH hospitals and death report cards (2003–07)	10 townships in Mengla County in Yunnan Province	Livebirths and under-5 deaths during 2003–07	2003: 1546; 2004: 1577; 2005: 1625; 2006: 1741; 2007: 1903	Mortality of children younger than 5 years	2003: 451; 2004: 454; 2005: 453; 2006: 478; 2007: 515	..	..	..	Dai: 447 (2003), 457 (2004), 465 (2005), 495 (2006), and 543 (2007); Hani: 361 (2003), 379 (2004), 409 (2005), 444 (2006), and 484 (2007); Yao: 127 (2003), 124 (2004), 128 (2005), 138 (2006), and 153 (2007); Yi: 160 (2003), 163 (2004), 170 (2005), 186 (2006), and 208 (2007)
Liang et al, 2009 (E)[39]	Cross-sectional survey (2006)	160 counties in 31 provinces	Children aged 1–14 years	40 129	Hepatitis B: full and timely birth dose coverage	34 668	583	599	1138	Zhuang: 244; Mongolian: 336; other (no name): 2561
Zhou et al, 2009 (E)[40]	Cross-sectional survey (2006)	16 counties in Guangxi, Guizhou, Tibet, and Shaanxi Province	Children born in 2004	3390	Hepatitis B: timely birth dose coverage and coverage	1126	..	..	842	Zhuang: 942; other (Mongolian, Miao, or Hui): 480
Wang et al, 2012 (C)[41]	Cross-sectional survey (2009–10)	Six investigation points within the migrant population area in Urumqi, Xinjiang Province	Migrant children aged 1–4 years old	341	Childhood immunisation coverage	166	..	..	..	Other (no name): 175
Ding et al, 2014 (C)[42]	Cross-sectional survey (2009 and 2012)	Tongxin County in Ningxia Hui Autonomous Province	Children younger than 5 years	2009: 425; 2012: 479	Hepatitis B: timely first dose coverage, coverage, number of doses DPT, BCG, OPV: coverage, number of doses; MV: coverage	2009: 55; 2012: 40	2009: 369; 2012: 439	..	..	Other (no name): 1 (2009) & 0 (2012)

(Table 1 continues on next page)

	Study design (period)	Study setting	Study population	Sample size	Indicators	Ethnic minority: number				
						Han	Hui	Uyghur	Tibetan	Other ethnicities
(Continued from previous page)										
Jiang Z et al, 2014 (C)[43]	Cross-sectional survey (2012)	Nine rural counties in Guangxi, Shaanxi, Guizhou, and Gansu Province	Children younger than 5 years	3743	BCG, OPV, DPT, hepatitis B, MV: scheduled (timely full) coverage	Not stated	..	..	..	Other (no name): not stated
Qi et al, 2015 (C)[44]	Cross-sectional survey (2013)	Linxia Hui Autonomous Prefecture in Gansu Province	Children aged 2–3 years old	4704	BCG, hepatitis B, OPV, DPT, MV: adequate coverage; childhood immunisation coverage	2016	..	..	..	Other (Hui, Dongxiang, or others): 2688
Zhou et al, 2016 (E)[45]	Cross-sectional survey (2010)	20 counties in Guangxi, Guizhou, Tibet, and Shaanxi Province	Children aged 12 months	3297	EPI timely full coverage	1057	..	..	800	Zhuang: 492; Buyei: 210; Miao: 448; Other (Hui, Mongolian, Tujia, or others): 290

MCH=maternal and child health. C=Chinese paper. E=English paper. EPI=Expanded Programme on Immunisation by WHO. Hepatitis B=hepatitis B vaccine. DPT=diphtheria, pertussis, and tetanus vaccine. OPV=oral polio vaccine. BCG=Bacillus Calmette–Guérin vaccine. MV=measles vaccine.

Table 1: **Summary of individual studies of ethnicity and MCH indicators**

The individual and pooled ORs of the association between ethnic affiliation and maternal or child health outcomes and service coverage are shown in the appendix (pp 9-13, 14-25) and figures 2 and 3. The pooled crude odds of maternal mortality were twice as high for ethnic minorities than for Han women (OR 2·16 [95% CI 0·97–4·82]). Similarly, the pooled crude ORs for neonatal mortality (1·45 [0·92–2·30]), infant mortality (1·68 [0·81–3·48]), and child mortality (2·02 [1·23–3·32]) were higher among ethnic minorities than among Han (figure 2; appendix p 14). No study examining the association between ethnic affiliation and mortality outcomes adjusted for confounders.

Ethnic minority women had lower odds of using antenatal care (OR 0·60 [95% CI 0·48–0·75]) or giving birth in health facilities (0·50 [0·39–0·64]) compared with Han women, but there was strong evidence for between-study heterogeneity (I^2 96·7% and 95·8%, respectively; p<0·0001; figure 2; appendix pp 15–16). The pooled adjusted ORs for antenatal care and facility birth were 0·54 (95% CI 0·42–0·71) and 0·76 (0·47–1·24), respectively (figure 3; appendix pp 19–20).

The odds of any immunisation were much lower among ethnic minority children than among Han children (OR 0·34 [95% CI 0·24–0·47]), with high heterogeneity across studies (I^2 98·6%, p<0·0001; figure 2; appendix pp 17–18). After adjustment for confounders, the pooled OR for any immunisation was 0·57 (95% CI 0·44–0·74; figure 3; appendix pp 21–22).

Women of Hui ethnicity had lower odds of antenatal care (OR 0·48 [95% CI 0·33–0·72]) and facility birth (0·34 [0·16–0·72]) compared with Han women, but there was no difference in immunisation coverage (appendix p 23). Women and children of Tibetan and Uyghur ethnicities had lower odds of MCH care coverage (OR 0·27 [95% CI 0·09–0·83] and 0·39 [0·16–0·95], respectively) than the Han population (appendix pp 24–25).

The I^2 statistics varied over a range from 0% to 99%, with most subgroups in the 80–90% range (appendix pp 14–25). The funnel plots were symmetric for each MCH indicator, with the Begg's test (p=0·1143 for mortality, p=0·0913 for antenatal care, p=0·8926 for facility birth, p=0·3481 for hepatitis B immunisation, and p=0·2561 for other immunisations, separately) suggesting no evidence of publication bias for meta-analyses (appendix pp 26–30). The sensitivity analyses and meta-regression showed the summary measures of effects between ethnicity and each MCH indicator were stable (appendix pp 31–35).

The 15 ecological studies matching our inclusion criteria are described in table 3.[45–59] Ten studies reported on maternal health outcomes and eight on child health outcomes (three reported on both). The number of population groups that were compared in the studies varied substantially: from two villages in Yunnan Province to a comparison between all 2296 counties in China.[47,59] The ethnic composition of the geographically defined groups varied substantially, but only two studies explicitly defined a threshold above which groups could be defined as ethnic minority or examined associations between the proportional share of ethnic minorities and MCH indicators.[49,59] Nearly all studies reported lower uptake of MCH care and higher mortality among ethnic minority than among non-ethnic minority populations. Interestingly, the two studies comparing large numbers of population groups found some ethnic minority populations that fared better than the Han majority. For example, Liu and colleagues[54] found that uptake of

	Characteristics of study design	Completeness of data	Definitions of outcomes	Definitions of ethnic groups	Statistical analysis	Adjustment for confounders
Maternal health						
Lu et al, 2000 (C)[15]	Simple random sampling, but methods not stated	Not given	Antenatal care initiation at ≤12 gestational weeks; antenatal visits (≥5), birth in county or higher level hospital	Reported by respondent	Crude %, linear regression but treating the ethnicity as a continuous variable	Paper reports regression analysis adjusted by confounders but data cannot be used because the ethnicity was treated as a continuous variable
Risk	High risk	Unclear risk	Low risk	Low risk	Low risk	High risk
An et al, 2002 (C)[16]	Multistage random sampling, data source clearly stated	Not given	Facility birth not defined	Reported by respondent	Crude %, logistic regression but treating the ethnicity as a continuous variable	Paper reports regression analysis adjusted by confounders but data cannot be used because the ethnicity was treated as a continuous variable
Risk	Low risk	Unclear risk	Unclear risk	Low risk	Low risk	High risk
Yan et al, 2003 (C)[17]	Stratified random cluster sampling, methods not clearly stated, data source not clearly stated	99·99%	Facility birth not defined	Reported by respondent	Crude %, no statistical analysis, adjustment for survey design not clear	None
Risk	High risk	Low risk	Unclear risk	Low risk	High risk	High risk
An et al, 2004 (C)[18]	Multistage random sampling, data source clearly stated	Not given	Antenatal visits (>=3)	Reported by respondent	Crude %, logistic regression and treating the ethnicity as a binary variable (Han and other ethnicities)	Adjusted by education of women, source of income, financial situation of the family, parity, family health habits, education of village doctor, medical licence of village doctor, the maternal care awareness of village doctor, frequency of disinfection in village clinic, the distance between village and township
Risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	Low risk
Li, 2004 (E)[19]	Multistage random sampling, data source clearly stated	5% missing data	Any prenatal examination	Reported nationality of household head	No crude %, logistic regression, appropriate weighting	Adjusted by women's status, literacy, village type, distance to clinic
Risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Fang et al, 2005 (C)[20]	Survey but methods not described	Not given	Prenatal care during last pregnancy	Reported by respondent	Crude %, logistic regression	Adjusted by age, education, income, district
Risk	High risk	Unclear risk	Low risk	Low risk	Low risk	Low risk
Li et al, 2008 (C)[21]	Multistage stratified cluster random sampling, methods clearly stated, data source clearly stated	Not given	Women who delivered in township hospitals or above, and received assistance from professional midwives	Reported by respondent	Crude %, logistic regression but not reporting the diversities among ethnicities, adjustment for survey design not clear	None
Risk	Low risk	Unclear risk	Low risk	Low risk	High risk	High risk
Chang et al, 2009 (C)[22]	Random sampling, but methods not clear	Not given	Facility birth not defined	Reported by respondent	Crude %, logistic regression	Adjusted by mother's education and occupation and child's birth order, year of birth, sex
Risk	High risk	Unclear risk	Unclear risk	Low risk	Low risk	Low risk
Cui et al, 2009 (C)[23]	Multistage random sampling, data source not clear	Not given	1st antenatal visit in 1st trimester (not defined)	Reported by respondent	Crude %, χ^2 test, logistic regression for antenatal visit (≥1) but not reporting the diversities among ethnicities	None
Risk	Unclear risk	Unclear risk	Unclear risk	Low risk	Low risk	High risk
Zhu et al, 2009 (C)[24]	Random sampling, methods not clearly stated, data source not clearly stated	94·6%	Antenatal visits (≥1), facility birth not defined	Reported by respondent	No crude%, binary logistic regression	Adjusted by education, whether attended reproductive health training, occupation, Hukou or not
Risk	High risk	Low risk	Unclear risk	Low risk	Low risk	Low risk
Lei et al, 2010 (C)[25]	Multistage random sampling, methods clearly stated, data source clearly stated	Not given	Antenatal visits (≥5)	Reported by respondent	No crude %, logistic regression	Adjusted by Qinba Project County or not, women's age, education, health awareness, parity, time to township health centre, time to county hospital, annual income, year of birth
Risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	Low risk

(Table 2 continues on next page)

	Characteristics of study design	Completeness of data	Definitions of outcomes	Definitions of ethnic groups	Statistical analysis	Adjustment for confounders
(Continued from previous page)						
Long et al, 2010 (E)[26]	Multistage random sampling, data source clearly stated	Replacement sample if no-one home	1st trimester defined as ≤12 weeks gestation, birth in township or higher level hospital	Reported by respondent	No crude %, logistic regression with the data in 2007	Adjusted by age, education, history of fetal loss, distance to health facility, parity, income, insurance participation
Risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Feng, 2011 (C)[27]	Routine reporting system not described	Not given	Maternal mortality not defined	Reported by respondent	Crude %, no statistical analysis	None
Risk	High risk	Unclear risk	Unclear risk	Low risk	High risk	High risk
Liu et al, 2011 (E)[28]	Multistage random sampling, data source clearly stated	Not given	Antenatal visits (≥5), birth in township or higher level hospital	Reported by respondent	No crude %, logistic regression	Adjusted by age, family number, mother and father education, household size, parity, wealth index, altitude of county, province
Risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	Low risk
Ren, 2011 (E)[29]	Stratified multistage random sampling, data source not stated	No-one refused to take part	First trimester defined as ≤16 weeks gestation	Reported by respondent	No crude %, logistic regression, adjustment for survey not clear	Adjusted by age of mother, age of child, sex of child, education, household assets, number and sex of children in household
Risk	Unclear risk	Low risk	Low risk	Low risk	High risk	Low risk
Rong et al, 2011(C)[30]	Random sampling, but methods not clearly stated, data source not stated	Not given	Facility birth not defined	Reported by respondent	Crude%, χ^2 test	None
Risk	High risk	Unclear risk	Unclear risk	Low risk	Low risk	High risk
Chen et al, 2013 (C)[31]	Multistage, probability-proportional-to-size random sampling, data source clearly stated	Not given	First antenatal visit within the first 3 months of last menstrual period	Reported by respondent	Crude %, logistic regression but not reporting the diversities among ethnicities	None
Risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	High risk
Jiang et al, 2014 (C)[32]	Multistage, probability proportional to size, data source clearly stated	100%	Caesarean section	Reported by respondent	Crude %, logistic regression and treating the ethnicity as a binary variable (Han and other ethnicities)	Adjusted by average income per month, education, whether received antenatal care
Risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Du et al, 2015 (E)[33]	National routine reporting, but methods not stated	Not given	Maternal deaths not defined, birth in township or higher lever hospital	County-based: non-minority if ethnic minorities <37·8% of population, minority county if ethnic minorities >37·8% of population	Crude %, multivariate linear regression but not reporting the diversities among ethnicities	None
Risk	High risk	Unclear risk	Unclear risk	High risk	Low risk	High risk
Child health						
Long, 1996 (C)[34]	Non-proportional, stratified, random cluster sampling, methods clearly stated, data source not clear	100%	Child mortality not defined	Reported by respondent	Crude %, χ^2 test, adjustment for survey design not clear	None
Risk	Unclear risk	Low risk	Unclear risk	Low risk	High risk	High risk
Li, 2004 (E)[19]	Multistage random sampling, data source clearly stated; sample of children unclear	5% missing data	Childhood immunisation coverage not defined (from mother's report)	Reported nationality of household head	No crude %, logistic regression, appropriate weighting	Adjusted by women's status, literacy, village type, distance to clinic
Risk	High risk	Low risk	High risk	Low risk	Low risk	Low risk
Wei et al, 2005 (C)[35]	Stratified sampling, methods clearly stated, data source clearly stated	Not given	Hepatitis B coverage not defined (from blood test)	Reported by respondent	Crude %, χ^2 test, adjustment for survey design not clear	None
Risk	Low risk	Unclear risk	High risk	Low risk	High risk	High risk

(Table 2 continues on next page)

	Characteristics of study design	Completeness of data	Definitions of outcomes	Definitions of ethnic groups	Statistical analysis	Adjustment for confounders
(Continued from previous page)						
Zhou et al, 2007 (C)[36]	Probability proportionate to size (PPS) sampling, data source clearly stated	Not given	3 doses of hepatitis B vaccine within first 12 months; first dose of hepatitis B vaccine within 24 h of delivery (from mother's report)	Reported by respondent	Crude %, χ^2 test	None
Risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	High risk
Yang, 2008 (C)[37]	Routine data, data source clearly stated	Not given	Child mortality not defined	Reported by respondent	Crude %, no statistical analysis	None
Risk	Low risk	Unclear risk	Unclear risk	Low risk	High risk	High risk
Gao et al, 2009 (C)[38]	Routine reporting system not described	Not given	Child mortality not defined	Reported by respondent	Crude %, χ^2 test	None
Risk	High risk	Unclear risk	Unclear risk	Low risk	Low risk	High risk
Liang et al, 2009 (E)[39]	Multistage random sampling, data source clearly stated	94% response rate	3 doses of hepatitis B vaccine within 12 months, first dose of hepatitis B within 1 day after birth (from mother's report, household immunisation certificate, facility immunisation card, and blood test)	Reported by respondent	Weighted %, logistic regression with the data of children born before 2001	Adjusted by age, sex, urban or rural, region, place of birth
Risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Zhou et al, 2009 (E)[40]	Two stage, stratified cluster sampling, data source clearly stated	Not given	First dose of hepatitis B within 1 day after birth, hepatitis B coverage not defined (from mother's report, household immunisation certificate and facility immunisation card)	Reported by respondent	Crude %, logistic regression only for timely birth dose coverage, adjustment for survey design not clear	Adjusted by place of residence, sex, parental education, place of delivery, immunisation card, knowledge of immunisation, migrant status
Risk	Low risk	Unclear risk	High risk	Low risk	High risk	Low risk
Wang et al, 2012 (C)[41]	Simple random sampling, but methods not clearly stated	Not given	Childhood immunisation coverage not defined, inconsistency between the text and the table title (from mother's report)	Reported by respondent	Crude %, logistic regression	Adjusted by parents' occupation, family's monthly earnings, no. of children in the family, Xinjiang Hukou or not
Risk	High risk	Unclear risk	High risk	Low risk	Low risk	Low risk
Ding et al, 2014 (C)[42]	Multistage random sampling, data source clearly stated	Not given	Childhood immunisation coverage not defined (from mother's report)	Reported by respondent	Crude %, χ^2 test	None
Risk	Low risk	Unclear risk	High risk	Low risk	Low risk	High risk
Jiang Z et al, 2014 (C)[43]	Multistage stratified cluster random sampling, data source not clear	80%	Scheduled immunisation coverage based on "international child basic EPI framework" (from mother's report and household immunisation certificate)	Reported by respondent	No crude %, logistic regression, adjustment for survey not clear	Adjusted by mother's age, whether in poverty or not, education of mother, mother married or not
Risk	Unclear risk	Low risk	Low risk	Low risk	High risk	Low risk
Qi et al, 2015 (C)[44]	Lot Quality Assurance Sampling, methods clearly stated, data source clearly stated	Not given	Adequate immunisation coverage defined as having received the full number of doses on time; childhood immunisation coverage defined as having received the full number of doses of eight vaccines on time (from immunisation scars, household immunisation certificate and facility immunisation card)	Reported by respondent	Crude %, χ^2 test, logistic regression with an integrated indicator of eight vaccines	Adjusted by age, living place, mother's education, place to receive vaccines, time spent on the road to receive vaccines
Risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	High risk
Zhou et al, 2016 (E)[45]	Two-stage cluster sampling, data source clearly stated	Not given	EPI timely full coverage defined as having received full doses of DTP, OPV, MV, and BCG by age 12 months (from household immunisation certificate and facility immunisation card)	Reported by respondent	No crude %, logistic regression, no adjustment for survey design	Adjusted by place of birth, residence, and immunisation, parents' migration status, Expanded Program on Immunisation-related knowledge, province
Risk	Low risk	Unclear risk	Low risk	Low risk	High risk	Low risk

MCH=maternal and child health. C=Chinese paper. E=English paper. EPI=Expanded Programme on Immunisation by WHO. Hepatitis B=hepatitis B vaccine. DPT=diphtheria, pertussis, and tetanus vaccine. OPV=oral polio vaccine. BCG=Bacillus Calmette–Guérin vaccine. MV=measles vaccine.

Table 2: **Quality criteria for individual studies of ethnicity and MCH indicators**

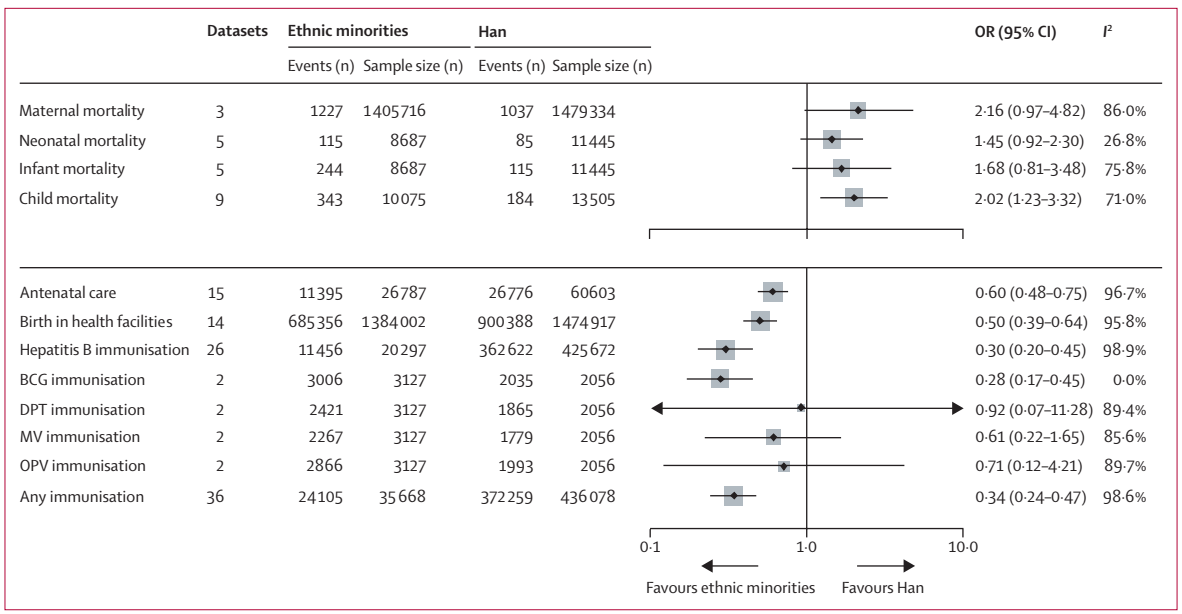

Figure 2: **Pooled crude ORs between ethnicity and maternal and child health indicators**
OR=odds ratio. BCG=Bacillus Calmette–Guérin vaccine. DPT=diphtheria, pertussis, and tetanus vaccine. MV=measles vaccine. OPV=oral polio vaccine.

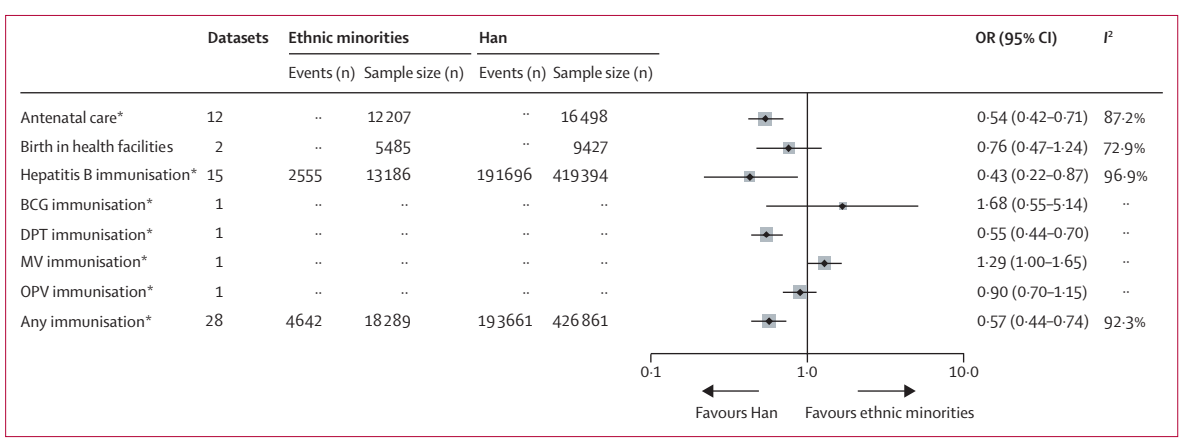

Figure 3: **Pooled adjusted ORs between ethnicity and maternal and child health indicators**
OR=odds ratio. BCG=Bacillus Calmette–Guérin vaccine. DPT=diphtheria, pertussis, and tetanus vaccine. MV=measles vaccine. OPV=oral polio vaccine. *Not all the datasets report the crude data.

facility-based delivery, antenatal care, and postnatal care was higher among Hui and Naxi women than among the Han, while Wang and colleagues[59] reported lower under-5 mortality rates among Koreans and Manchus compared with the Han.

Discussion

Our systematic review provides strong evidence of poorer health outcomes and MCH care access among ethnic minorities than among Han populations in western China. Results were remarkably consistent across MCH indicators. The pooled odds of child mortality were twice as high for ethnic minorities as for Han populations. Ethnic minority women were less likely than Han women to use antenatal care, to give birth in a health facility, or to immunise their child. After taking account of the potential confounding effects of wealth or education, ethnic minority women were less likely to use antenatal care or to immunise their children compared with Han women.

Compared with previous studies,[1] it is a strength that we draw from both English and Chinese sources, and that we include group as well as individual comparisons. Anderson and colleagues have argued that one should draw data from government health statistical agencies,[1] but government data in China rely on geographic proxy measures (eg, autonomous provinces, prefectures, or counties) rather than on information from distinct ethnic groups. Geographic proxy measures have policy value in that benefits can be targeted at administratively defined groups with clear channels of responsibility.[60]

	Comparison groups and setting (period)	Data sources	Indicators (definition)	Definition of ethnic groups	Statistical analysis	Results
Maternal health						
He et al, 2000 (C)[46]	One ethnic minority county (Huangcaoba) in Gejiu city of Yunnan Province (1999) versus 20 poor/rich counties and rural/urban counties in 16 Provinces (1996)	Cross-sectional survey in one village (1999), methods not stated; national data from a cross-sectional survey in 16 Provinces (1993–96)	≥1 antenatal visit; facility birth (not defined)	One county in autonomous prefecture (55% Yi, 33% Miao, 3% Dai, 9% Han); ethnic composition of the comparison groups not stated	None	(1) ≥1 antenatal visit: Huangcaoba: 18·20%; national (1996): poor counties 28·50%, rural average 68·30%, rich counties 75·10%, urban average 95·60%; (2) facility birth: Huangcaoba: 10·10%; national (1996): poor counties 6·50%, rural average 21·70%, rich counties 38·20%, urban average 87·30%
Risk	Low risk	Unclear risk	Unclear risk	Low risk	High risk	..
Luo et al, 2002(C)[47]	Two counties in Yunnan Province with different ethnic composition (1995–2000): Xundian and Jindong	Cross-sectional survey (2001), methods clearly stated	Facility birth (not defined)	Xundian: Hui and Yi Autonomous County Jindong: Yi Autonomous County	None	(1) 1995–99: Xundian 47·4%, Jingdong 40·1%; (2) 2000: Xundian 58·2%, Jingdong 45·6%.
Risk	Low risk	Low risk	Unclear risk	High risk	High risk	..
Li et al, 2008 (E)[48]	11 autonomous minority versus five non-minority prefectures in Yunnan Province	2000 census and National Maternal and Child Health Surveillance System	% women who had antenatal examination	% minorities is 14·5% in non-minority prefectures and 58·4% in minority prefectures	Unadjusted rate ratios	Non-minority versus minority prefectures (1996: 73·2% *vs* 51·3%, rate ratio 0·7; 2000: 89·1% *vs* 75·1%, rate ratio 0·8)
Risk	High risk	Low risk	Low risk	Low risk	High risk	..
Du et al, 2009 (E)[49]	24 counties in Xinjiang Province with different ethnic composition (1997)	Confidential enquiry and verbal autopsy of maternal deaths, using multiple data sources	Maternal mortality (ICD-9)	% of minority populations in each county	(1) Pearson correlation between maternal mortality ratio and % minority groups; (2) Stepwise linear regression of maternal mortality ratio and % minority groups, adjusting for average number of village doctors and % of villages without doctors	(1) Correlation coefficient 0·124; (2) Regression coefficient 8·3 (95% CI 2·7–13·9), p=0·006
Risk	Low risk	Low risk	Low risk	Low risk	Low risk	..
Wu et al, 2010 (C)[50]	31 ethnic minority counties in Sichuan Province versus Sichuan Province (2001–09)	Maternal and child health information system, methods not stated	Facility birth (not defined); maternal mortality (not defined)	"31 ethnic minority counties, all of whose hospital delivery rate was less than 50% in 2008", definition not clear	None	(1) Facility birth: Province 67·3% (2001)–89·8% (2009); ethnic counties 35·1% (2001)–51·8% (2009) (2) Maternal mortality: Province 41·7 deaths per 100 000 livebirths (2009); ethnic counties 98·6 deaths per 100 000 livebirths (2009)
Risk		Unclear risk	Unclear risk	High risk	High risk	..
Rong et al, 2011 (C)[51]	Comparison between six counties with different ethnic composition: Luxi county in Yunnan; Congjiang and Leishan county in Guizhou; Hualong county in Qinghai; Gongbujiangda county in Tibet (period not clear)	Cross-sectional survey, method clearly stated (year not stated)	Facility birth (not defined)	"Main" ethnic minorities in each county: Leishan: Miao Congjiang: Dong Nongchuan: Jingpo Luxi: Dai Huailong: Hui and Tibetan; Gongbujiangda: Tibetan	None	Leishan, 49·3%; Congjiang, 41·9%; Longchuan, 46·8%; Luxi, 71·4%; Hualong, 66·7%; Gongbujiangda, 45·8%
Risk	Low risk	Low risk	Unclear risk	High risk	High risk	..
Wellhoner et al, 2011 (E)[52]	One ethnic minority community in catchment area of Surmang clinic, Yushu county, Qinghai Province (1999–2004) versus western China (2000–05) and Qinghai Province (2003)	Cross-sectional survey in one community (clearly described) and national data from MCH reporting system and health services survey	Facility-based delivery (not defined)	"All were Tibetan, from the Kham region"; ethnic composition of Qinghai or western China not stated	None	Ethnic minority community, 0·2%; western China, 66·6%; Qinghai Province, 34·4%
Risk	Low risk	Low risk	Unclear risk	Unclear risk	High risk	..

(Table 3 continues on next page)

	Comparison groups and setting (period)	Data sources	Indicators (definition)	Definition of ethnic groups	Statistical analysis	Results
(Continued from previous page)						
Tan et al, 2012 (C)[53]	Two counties (Yushu, Rangqian) in Yushu Tibetan region, Qinghai Province *vs* Qinghai Province (2008), Qinghai Rural Area (2008), Type IV Rural Area (the least developed area, 2006) and China (2008)	Cross-sectional survey in the two counties (2009) and multiple data sources for national and provincial comparison, methods not stated	≥1 antenatal visit; facility birth (at any level)	Two counties in autonomous prefectures; "The survey only used Tibetan language"	None	(1) ≥1 antenatal visit:China 94·4%, Qinghai 80·4%, ethnic minority counties 49·1%; (2) facility birth: China 88·6%, Qinghai 86·1% and 84·6% for Qinghai rural areas, Type IV rural areas (2006) 32%, ethnic minority counties 9·5%
Risk	Low risk	Unclear risk	Low risk	Unclear risk	High risk	..
Liu et al, 2016 (E)[54]	993 villages with different ethnic composition in 14 counties in Sichuan, Gansu and Yunnan Province where MCH care is accessible (2011)	Cross-sectional survey of women's representatives and village leaders in each village	Hospital-based delivery (not clearly defined); ≥1 and ≥5 antenatal visits	Major ethnic group of a village is Han, Yi, Tibetan, Miao, Hui, Naxi, or other ethnicity	Crude %, multivariate analysis adjusting for distance, income, availability and quality of services, education and topography	(1) Hospital-based delivery: Han 86%; non-Han 70%; Yi 58%; Tibetan 54%; Miao 82%; Hui 95%; Naxi 94%; other 90% (p<0·05 for Yi, Tibetan, Hui, and Naxi); (2) any prenatal care: Han 94%; non-Han 80%; Yi 68%; Tibetan 80%; Miao 83%; Hui 96%; Naxi 97%; other 98% (p<0.05 for Yi and other); (3) 5+ prenatal care: Han 69%; non-Han 55%; Yi 40%; Tibetan 33%; Miao 59%; Hui 88%; Naxi: 93%; other 81% (p<0.05 for Yi, Tibetan, Hui, and other)
Risk	Low risk	Low risk	Unclear risk	Low risk	Low risk	..
Song et al, 2016 (E)[55]	Two ethnic minority counties with low hospital delivery rates in two ethnic minority autonomous prefectures in Sichuan Province (Butuo and Daofu county; 2011)	"Quantitative" methods but data source not stated	Hospital delivery (not clearly defined)	Butuo is 100% Yi and Daofu 100% Tibetan	None	Butuo county, 22·1%; Daofu county, 47·1%
Risk	Low risk	High risk	Unclear risk	Low risk	High risk	..
Child health						
Zhang et al, 1994 (E)[56]	Seven regions with different ethnic composition in Tibet Autonomous Region (1990)	1990 census	Infant mortality rate, not defined	% Tibetan nationality in each region	None	Infant mortality ranges from 82 per 1000 in Lhasa to 197 per 1000 in Nanqu region
Risk	Low risk	Low risk	Unclear risk	Low risk	High risk	..
Luo et al, 2002(C)[47]	Two counties in Yunnan Province with different ethnic composition (1995–2000): Xundian and Jindong	Cross-sectional survey (2001), methods clearly stated	Timely first dose of hepatitis B vaccine within 48 h after delivery; hepatitis B vaccine coverage in neonates (not defined); 3-dose immunisation rate of hepatitis B vaccine	Xundian: Hui and Yi Autonomous County, Jindong: Yi Autonomous County	None	(1) Timely first dose of hepatitis B vaccine: 1995–99: Xundian 2·8%, Jingdong 0·5%; 2000: Xundian 38·6%, Jingdong 25·0%. (2) Hepatitis B vaccine coverage in neonates: 1995–99: Xundian 4·4%, Jingdong 3·1%; 2000: Xundian 50·6%, Jingdong 41·9%. (3) 3-Dose immunisation rate of hepatitis B vaccine: 1995–99: Xundian 36·1%, Jingdong 24·6%; 2000: Xundian 76·3%, Jingdong 82·7%
Risk	Low risk	Low risk	Low risk	High risk	High risk	..
Li et al 2008 (E)[48]	11 autonomous minority *vs* five non-minority prefectures in Yunnan Province	2000 census and National Maternal and Child Health Surveillance System	Infant mortality (per 1000 livebirths), child mortality (per 1000 children aged 1–4 years)	% minorities is 14·5% in non-minority prefectures and 58·4% in minority prefectures	Unadjusted rate ratios	(1) Infant mortality in non-minority *vs* minority prefectures (1996: 42·4 per 1000 *vs* 54·0 per 1000, rate ratio 1·3; 2000: 31·6 per 1000 *vs* 38·6 per 1000, rate ratio 1:2); (2) child mortality in non-minority versus minority prefectures (1996: 53·9 per 1000 *vs* 67·7 per 1000, rate ratio 1:3; 2000: 40·7 per 1000 *vs* 46·5 per 1000, rate ratio 1:1)

(Table 3 continues on next page)

	Comparison groups and setting (period)	Data sources	Indicators (definition)	Definition of ethnic groups	Statistical analysis	Results
(Continued from previous page)						
Risk	High risk	Low risk	Low risk	Low risk	High risk	..
Schuster, 2009 (E)[57]	96 counties or townships in Xinjiang Uyghur Autonomous Region	2000 census, 2005 Statistical Yearbooks and 2005 Yearly Macroeconomic Statistics, methods not stated	Infant mortality rate (not defined)	Comparison between Uyghur and Han, but not clear how ethnicity of county/township is ascertained	Linear mixed effect model, adjusting for urban:rural, tertiary education and unemployment	Counties or townships with Uyghur nationality have higher infant mortality rates (p=0·0000)
Risk	Low risk	Unclear risk	Unclear risk	Unclear risk	Low risk	..
Wu et al, 2010(C)[50]	31 ethnic minority counties in Sichuan Province; Sichuan Province (2009)	Maternal and child health information system, methods not stated	Infant mortality rate (not defined)	"31 ethnic minority counties, all of whose hospital delivery rate was less than 50% in 2008", definition not clear	None	Province 12·08%, ethnic counties 15·50%
Risk	High risk	Unclear risk	Unclear risk	High risk	High risk	..
Wen et al, 2011 (C)[58]	Counties with different ethnic composition in western China: Leishan and Congjiang counties in Guizhou, Longchuan and Luxi counties in Yunnan, Hualong county in Qinghai, Gongbujiangda county in Tibet versus Province (2008)	"Ethnic minority region MCH health information strengthening programme", routine provincial data. Methods not stated	Under-5 mortality (not defined)	Autonomous counties: Congjiang (Dong 48·6%, Miao 43·9%, Zhuang 4·7%, Yao 1·9%, Han 0·9%); Leishan (Miao 90·8%, Han 7·7%, Sui 1·5%); Longchuan (Jingpo 35·3%, Han 35·3%, Dai 20·6%, Hui 2·9%, Deang 2·9%, Achang 2·9%); Luxi (Han 42·9%, Dai 35·7%, Jingpo 14·2%, Deang 7·1%); Hualong (Hui 47·9%, Tibetan 23·9%, Han 16·9%, Salar 11·3%) Gongbujiangda (Tibetan 100·0%)	None	Congjiang 99·6%, Leishan 49·9% (compared with 27·1% for the Province); Longchuan 26·1%, Luxi 19·2% (compared with 19·2% for the Province); Hualong 22·8% (compared with 23·5% for the Province), Gongbujiangda 64·2% (compared with 35·6% for the Province)
Risk	Low risk	Unclear risk	Unclear risk	Low risk	High risk	..
Wang et al, 2016 (E)[59]	2296 counties with different ethnic composition in China (287 minority and 2009 non-minority; 1996 and 2012)	Multiple data sources between 1990 and 2013, with rigorous consistency checks and adjustments for completeness	Under-5 mortality (deaths in children under 5 years per 1000 livebirths)	At least 50% of county population belongs to one specific ethnic group	Population weighted average in each county in 1996 and 2012	(1) 1996: median across ethnic minority counties 88·1 per 1000 (range 26·4-163·9) *vs* 42·4 per 1000 across non-minority counties. Yi, Tajik, Kyrgyz, Tibetan, and Buyei counties have highest mortality. (2) 2012: median across ethnic minority counties 24·2 per 1000 (range 9·6–54·3) *vs* 12·8 per 1000 across non-minority counties. Monba, Tajik, Kyrgyz, Yi and Dongxiang have highest mortality
Risk	Low risk	Low risk	Low risk	Low risk	Low risk	..
Zhou et al, 2016 (E)[45]	Comparison between Provinces with different ethnic composition using cross-sectional survey (2010)	Cross-sectional household surveys with two-stage cluster sampling before (2004) and after (2010) an intervention in each county (clearly described). Household immunisation certificates, facility immunisation card and immunisation scars were checked	Timely full immunisation ("as defined by WHO")	"The majority of children in Guanxi, Guizhou and Tibet belonged to one of China's ethnic minorities; virtually all in Shaanxi Province were Han ethnicity"	No crude %, logistic regression, no adjustment for survey design but adjustment for place of birth, residence and immunisation, parents' migration status, and EPI-related knowledge	Adjusted OR comparing counties in Shaanxi Province with counties in Guangxi Province (adjusted OR 0·34 [95% CI 0·17–0·68]), Guizhou Province (adjusted OR 0·45 [95% CI 0·23–0·86]), and Tibet (adjusted OR 0·17 [95% CI 0·01–2·89])
Risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	..

MCH=maternal and child health. C=Chinese paper. E=English paper. EPI=Expanded Programme on Immunisation by WHO. Hepatitis B=hepatitis B vaccine. DPT=diphtheria, pertussis, and tetanus vaccine. OPV=oral polio vaccine. BCG=Bacillus Calmette–Guérin vaccine. MV=measles vaccine.

Table 3: **Summary and quality of ecological studies of ethnicity and MCH indicators**

However, the share of ethnic minorities in Autonomous Regions such as Xinjiang (59·5%), Guangxi (37·2%), Ningxia (35·2%), and Inner Mongolia (20·5%) are not dissimilar to those in Qinghai (47·0%), Guizhou (35·7%), and Yunnan (33·4%), Provinces not designated as Autonomous Regions.[4] If one wants to make inferences about the health status or access to care for specific ethnic groups, and understand the underlying causes of

variation, then proxy measures are a poor substitute for individual comparisons.

Little analytical work has been done on the underlying reasons for health gaps between Han and ethnic minority populations in China.[3,9] Much of the international literature on the causes of health differentials between ethnic minority and non-ethnic minority populations draws from indigenous populations in high-income countries, including Aboriginal Canadians or Australians, and it is uncertain whether these explanatory models apply to China.[61,62] In China, ethnic minority status is associated with economic and educational disadvantages, rural residence, mountainous topography, and poor infrastructure, but living conditions vary substantially across and even within specific ethnic groups, and a unique analytical framework encompassing all ethnic minorities would not be appropriate. For example, two of the largest ethnic groups, the Manchus and the Hui, are among the most urbanised and their income levels are not dissimilar to that of the Han majority.[6] However, the Hui are highly dispersed across the country, and there are distinct, heterogeneous subgroups with their own geographical ties and cultural practices. The Yi ethnic group, on the other hand, are mostly subsistence farmers living in remote mountainous areas of southern Sichuan, with low levels of education and little access to formal health care.[63] The substantial heterogeneity in child mortality between ethnic minorities shown by Wang and colleagues[59] shows the diversity among ethnic minority groups. In 2012 six minority groups (Yi, Tibetan, Dongxiang, Kyrgyz, Monba, and Tajik) lived in counties with child mortality rates greater than 40 per 1000 livebirths, while three groups lived in counties with child mortality rates very similar to the Han (12·0, 14·1, and 14·6 per 1000 among Manchu, Zhuang, and Yao, respectively, *vs* 12·8 per 1000 among Han). Wider environmental factors such as mountainous terrain and poor infrastructure might be as important as individual or household characteristics in explaining the poverty gap between Han and minority populations, so the same might be true for health gaps.[6,59] Yet, the studies in our review that had taken account of confounders such as income and education still reported poor access to MCH care, pointing to ethnic differentials that persist beyond the economic and educational disadvantages of certain ethnic groups.

Although this study identified more papers than earlier reviews on this topic,[3,9] few aimed to explain the health disparities between the Han majority and ethnic minorities. Indeed, ethnic affiliation was often a secondary determinant—a factor to adjust for in the analysis—rather than a focus of the study per se. Many studies aggregated non-Han ethnic groups into a single or "other" ethnic minority category, thereby masking possible variation between individual ethnic groups.[64] Qualitative research has explored some of the reasons why ethnic minority populations might have low access to care, but the number of studies is small. Research among Yi and Tibetan women, for example, has suggested that women might choose to give birth at home because of the high cost of care, the poor quality of township hospitals, and the cultural inappropriateness of birthing practices that cause women discomfort and embarrassment.[63,65,66] Low levels of education and health-care knowledge could also contribute to low uptake of MCH care among ethnic minorities like Yi, Miao, Tibetan, Dong, Uygur, and Yugur.[67–72] Local beliefs, behaviours, and fears that translate into women's suspicion of delivering in clinics or hospitals might play a part, but there is no uniformity of beliefs and behaviours across population groups and findings from small ethnographic studies are difficult to generalise.[65] Although there is evidence from western China that geographic accessibility in ethnic minority areas is poorer,[73] there is dispute over how important a barrier to care it is. Some argue that it is critical,[66,74] while others suggest that its significance has been overstated.[63,65]

Our search was comprehensive and systematic, but our design might have some limitations. First, we focused our analysis on ethnic minorities in western China because poverty is concentrated in this region and three-quarters of all ethnic minorities live there. Ethnic minorities such as the Manchus tend to live in the more industrialised north and northeast, and their degree of urbanisation and lifestyle approximates that of the Han. Because we compare ethnic minority and Han populations in a region which is less developed and has worse health outcomes than eastern or central China,[11] our estimates of effect underestimate the difference between ethnic minority and Han populations at a national level.

Second, we only included studies comparing individual ethnic groups for which odds ratios with 95% CIs were available. This means that studies relying on census data but not providing sample sizes were excluded. We are aware of five such studies, all of which confirmed the higher infant and child mortality of ethnic minority populations compared with Han populations.[48,75–78] Third, we excluded studies making ecological comparisons at the province or regional level, even though some provinces are designated Autonomous Regions. As outlined above, autonomous provinces or regions are too diverse in ethnic composition to make meaningful comparisons. Fourth, we used odds ratios for our estimates of effect because almost all studies used logistic regression. With outcomes as common as the MCH indicators reported here, odds ratios are a poor approximation for risk ratios, and care has to be taken in the interpretation of the magnitude of effect. Fifth, there was great heterogeneity between the studies, though the pooled odds ratios for the various indicators were remarkably consistent. The sensitivity analyses and meta-regression showed that publication year and sample size were not significantly associated with the

pooled odds ratio, and that no single study affected the aggregated associations between ethnicity and MCH indicators. Sixth, most data were collected between 2000 and 2009, and we were unable to examine changes over time in the strength of association between ethnicity and MCH outcomes between 1990 and 2016. Four studies reported data points over two or more periods,[33,38,39,42] but only one found a change over time in ethnic disparities for hepatitis B immunisation coverage.[39] Lastly, misreporting of ethnicity is not a problem in China because a person's ethnicity is determined at birth, depending on the parents' ethnic group. When both parents belong to the same ethnic group the child will have its parents' ethnicity; when the parent's ethnicity differs the parents can choose between the mother's or the father's ethnicity.

There is a lack of peer-reviewed research that seeks to explain ethnic minority health differentials in China. Yet China, unlike other countries,[1] has a wealth of primary data that could further our understanding of why ethnic minority populations are lagging behind. Many large-scale surveys, including the China National Health Service Surveys, China Health and Nutrition Surveys (CHNS), and China Family Panel Survey (CFPS), collect data for MCH indicators, ethnicity, and other sociodemographic characteristics of individuals and households.[11] Analyses could go beyond the mere descriptions of inequalities by region or by urban and rural areas, and aim to explore how sociodemographic characteristics, including ethnicity, interact to cause variation in access to care. Similarly, the 10-yearly censuses collect data for individual ethnicity, health outcomes, and sociodemographic factors, allowing a detailed exploration of variations between ethnic groups over time.

In China, the delivery of health services to remote areas where many ethnic minorities live is difficult because of severe shortage in health professionals, poor infrastructure, low population density, and complex migration patterns. Over the past 20 years, the Chinese Government has introduced several strategies that aim specifically at reaching ethnic minorities as well as strategies that aim to reach remote and poor populations in general. The latter includes medical insurance to rural residents through the New Cooperative Medical Scheme, the supply of free public health services to primary care facilities in rural areas and human resource policies to train, deploy, and retain health-care professionals in rural areas—including the training of ethnic minority health-care professionals.[79] The Targeted Poverty Alleviation Project has been launched since 2016 to increase the accessibility to local health care among families officially registered as Poverty-stricken Households with a zero deposit or payment strategy.[80] Furthermore, the government has encouraged the entry of traditional medicine practiced by various ethnic groups into the medical market and some provinces have recently opened new departments specifically to promote health development for ethnic minorities.[81,82] Whether these policies will be successful in improving health outcomes among ethnic minorities remains to be seen. As MCH outcomes continue to improve nationally, ethnic minorities will take a greater share of the overall burden of adverse MCH outcomes, and further strategic investments to address the specific challenges faced by people living in remote areas will become necessary.

Contributors

YH was involved in extracting data, doing data synthesis, interpreting results, and writing the article. DS assisted with protocol design and development, extracted data, interpreted results, and drafted and revised the Article. LP and FT were involved in data extraction and Article writing. JP was involved in the concept, design, interpretation, and writing of the Article. CR designed the research protocol, assisted with data extraction and data synthesis, interpreted the results and wrote the Article. All authors approved the final submitted version.

Declaration of interests

We declare no competing interests.

Acknowledgments

This study was funded by the China Medical Board.

References

1 Anderson I, Robson B, Connolly M, et al. Indigenous and tribal peoples' health (The Lancet–Lowitja Institute Global Collaboration): a population study. *Lancet* 2016; **388:** 131–57.
2 Stephens C, Nettleton C, Porter J, Willis R, Clark S. Indigenous peoples' health—why are they behind everyone, everywhere? *Lancet* 2005; **366:** 10–13.
3 Hall GH, Patrinos HA. Chapter 5: China a case study in rapid poverty reduction. In: Indigenous peoples, poverty, and development. New York: Cambridge University Press, 2012.
4 Population Census Office under the State Council and Department of Population and Employment Statistics, National Bureau of Statistics. Tabulations on the 2010 Population Census of the People's Republic of China. Beijing: China Statistics Press, 2012.
5 National Bureau of Statistics. China Statistical Yearbook 2016. Beijing: China Statistics Press, 2016.
6 Hannum E, Meiyan WA. Geography and educational inequality in China. *China Econ Rev* 2006; **17:** 253–65.
7 Wang SG. Poverty Targeting in the People's Republic of China. Tokyo: Asian Development Bank Institute Discussion Paper No. 4, 2004.
8 Hesketh T, Lu L, Xing ZW. The effect of China's one-child family policy after 25 years. *N Engl J Med* 2005; **353:** 1171–76.
9 Yuan B, Qian X, Thomsen S. Disadvantaged populations in maternal health in China: who and why? *Glob Health Action* 2013; **6:** 19542.
10 Stephens C, Porter J, Nettleton C, Willis R. Disappearing, displaced, and undervalued: a call to action for Indigenous health worldwide. *Lancet* 2006; **367:** 2019–28.
11 Gao Y, Zhou H, Singh N, et al. China's Countdown to 2015: Progress and challenges in maternal health in Western China. *Lancet Glob Health* 2017; **5:** e523–36.
12 Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0. The Cochrane Collaboration, 2011: Chapter 8: Assessing risk of bias in included studies.
13 Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics* 1994; **50:** 1088–101.
14 Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* 2009; **151:** 264–69.
15 Lu P, Zheng QQ, Tian Y, Li YQ, Yan CF. The investigative study on health care and service of pregnancy and parturient in 5–province western area. *Matern Child Health Caref China* 2000; **15:** 648–50 (in Chinese).
16 An L, Gao YQ, Zhang JC. Study on the influent factors of hospital delivery in west poor rural areas of China. *Chin Primary Health Care* 2002; **16:** 29–33.
17 Yan WH, Wang ZC, Zhang J. Knowledge of maternal and child health and health behaviours among 4405 women in Xinjiang Uygur Autonomous Region. *Chin J Health Educ* (*Zhonghua Hu Li Za Zhi*) 2003; **19:** 415–17.

18 An L, Gao YQ, Zhang JC. Study on the influent factors of antenatal examination in west poor rural areas of China. *Chin J Reprod Health* 2004; **15:** 146–49.

19 Li J. Gender inequality, family planning, and maternal and child care in a rural Chinese county. *Soc Sci Med* 2004; **59:** 695–708.

20 Fang LW, Lou Chaohua, Gao ES. Study on prenatal care services of married child bearing women in China. *Matern Child Health Care China* 2005; **20:** 1424–26.

21 Li J, Chen LL, Chen SZ, Cen MY, Zhao NQ, Qian X. Study on the status of institutional delivery and its determinants in rural Guangxi autonomous region. *Chin J Epidemiol* 2008; **29:** 224–29.

22 Chang XL, Wang Y, Xu FL. Investigation on facility birth rate of farmers and herdsmen of Tekesi County in Xinjiang Yili Kazak Autonomous Prefecture. *Matern Child Health Care China* 2009; **24:** 676–77.

23 Cui Y, Yang L, Lv MT. Analysis on the status of antenatal checkup program in certain areas of China, 2005. *Chinese Journal of Epidemiology* 2009; **30:** 887–90.

24 Zhu J, Lu WQ, Zhou Q, Ren JN. Study on current status and influencing factors of reproductive health among married minority women. *Chin J Fam Plan* 2009; **17:** 609–13.

25 Lei P, Duan CG, Wu ZC, et al. Evaluation of Qinba Health Program: its impact on antenatal care utilization. *Chin Health Resources* 2010; **13:** 64–66.

26 Long Q, Zhang T, Xu L, Tang S, Hemminki E. Utilisation of maternal health care in Western Rural China under a new rural health insurance system (New Co-operative Medical System). *Trop Med Int Health* 2010; **15:** 1210–17.

27 Feng XM. Study on maternal deaths causes and its intervention measures in Haibei Tibetan Autonomous Prefecture in Qinghai Province during 1996–2007. *Qinghai Med J* 2011; **41:** 73–74.

28 Liu X, Zhou X, Yan H, Wang D. Use of maternal healthcare services in 10 provinces of rural Western China. *Int J Gynaecol Obstet* 2011; **114**: 260–64.

29 Ren Z. Utilisation of antenatal care in four counties in Ningxia, China. *Midwifery* 2011; **27:** e260–66.

30 Rong YN, Sun J. Analysis on the impact factors of hospital delivery in rural ethnic minorities areas. *Med Soc* 2011; **24:** 36–39.

31 Chen YZ, Xu H, Tang XJ, et al. Current state of prenatal examination and associated influences factors in some western minority-inhabited areas. *J Huazhong Univ Sci Technol (Health Sciences)* 2013; **42:** 346–50.

32 Jiang XX, Miao Q, Tang XJ, et al. Analysis on maternal delivery modes and the influencing factors in minority nationality areas in Western China. *Matern Child Health Care China* 2014; **19:** 3047–49.

33 Du Q, Lian W, Naess O, Bjertness E, Kumar BN, Shi SH. The trends in maternal mortality between 1996 and 2009 in Guizhou, China: ethnic differences and associated factors. *J Huazhong Univ Sci Technol Med Sci* 2015; **35:** 140–46.

34 Long XL. The under 5 children mortality and its influential factors in Longsheng County of Guangxi Province, 1992. *Guilin Med J* 1996; **12:** 4–6.

35 Wei F, Zhou J, Pan H, Su YL, Zhou XQ. Investigation of hepatitis B virus infection among children in Qiandongnan Prefecture of Guizhou Province. *Pract Prev Med* 2005; **12:** 867–68.

36 Zhou J, Tang GP, Li ZY, Deng J, Wu GG, Tian XG. Investigation on children immunization coverage rate of hepatitis B vaccine and influential factors. *Mod Prevent Med* 2007; **34:** 1444–47.

37 Yang CY. Analysis on under 5 children mortality in Yuanjiang County during 2003~2007. *China Modern Doctor* 2008; **46:** 66–67.

38 Gao YH, Zheng Y, Yi YG, Hu YJ. Analysis on under 5 children deaths among five major ethnic groups in Mengla County. *Chin J Child Health Care* 2009; **17:** 229–30.

39 Liang X, Bi S, Yang W, et al. Evaluation of the impact of hepatitis B vaccination among children born during 1992-2005 in China. *J Infect Dis* 2009; **200:** 39–47.

40 Zhou Y, Wang H, Zheng J, Zhu X, Xia W, Hipgrave DB. Coverage of and influences on timely administration of hepatitis B vaccine birth dose in remote rural areas of the People's Republic of China. *Am J Trop Med Hyg* 2009; **81:** 69–874.

41 Wang PS, Wang J, Hao JG, Luo X. Analysis on immunization status and influential factors of migrant children in Urumqi. *J Med Pest Control* 2012; **28:** 788–90.

42 Ding WQ, Zhou JH, Zhao B, Zhao HP. Analysis for comparing the health care among children under 5 years old in rural of Tongxin Country between 2009 and 2012. *J Ningxia Med Univ* 2014; **36:** 993–95, 98.

43 Jiang Z, Ju LR, Wang ZF, et al. Current status on child essential immunization coverage in rural Western and Central China. *Chin J Child Health Care* 2014; **22:** 343–46.

44 Qi HY, Fan JL, Zhang XL, et al. Survey and analysis of vaccine inoculation rate of National Immunization Programs in Linxia Prefecture of Gansu Province. *Bull Dis Control Prevent* 2015; **30:** 13–17.

45 Zhou Y, Xing Y, Liang X, Yue C, Zhu X, Hipgrave D. Household survey analysis of the impact of comprehensive strategies to improve the expanded programme on immunisation at the county level in Western China, 2006–2010. *BMJ Open* 2016; **6:** e008663.

46 He ZY, Shi XJ, Yang Z, He LM. A survey about bearing health's needs of married women in rural. *Chin J Behav Med Brain Sci* 2000; **9:** 323–25.

47 Luo M, Ding ZR, Wu Y. Investigation of immunization coverage rate of hepatitis B vaccine and HBsAg positive rate of children in poor mountain area of Yunnan Province. *Chin J Vaccines Immunization* 2002; **8:** 77–79.

48 Li J, Luo C, de Klerk N. Trends in infant/child mortality and life expectancy in Indigenous populations in Yunnan Province, China. *Austr N Z J Public Health* 2008; **32:** 216–23.

49 Du Q, Nass O, Bergsjo P, Kumar BN. Determinants for high maternal mortality in multiethnic populations in Western China. *Health Care Women Int* 2009; **30:** 957–70.

50 Wu FY, Cao J, Xiong Q, Liu JT. Investigation on the rate of hospital delivery and strategy research in minority concentrated region in Sichuan. *Matern Child Health Care China* 2010; **25:** 5359–60.

51 Rong YN, Sun J. Analysis on the impact factors of hospital delivery in rural ethnic minorities areas. *Med Soc* 2011; **24:** 36–39.

52 Wellhoner M, Lee AC, Deutsch K, et al. Maternal and child health in Yushu, Qinghai Province, China. *Int J Equity Health* 2011; **10:** 42.

53 Tan LF, Huang CL, Yang RR, Zheng XY. Study on the accessibility of maternal health services for Tibetan women in agricultural and pastoral areas in Yushu Autonomous Prefecture. *Mat Child Health Care China* 2012; **27:** 325–28.

54 Liu C, Zhang L, Shi Y, Zhou H, Medina A, Rozelle S. Maternal health services in China's western rural areas: uptake and correlates. *China Agricult Econ Rev* 2016; **8:** 250–76.

55 Song P, Kang C, Theodoratou E, Rowa-Dewar N, Liu X, An L. Barriers to hospital deliveries among ethnic minority women with religious beliefs in China: A descriptive study using interviews and survey data. *Int J Environ Res Public Health* 2016; **13:** 815.

56 Zhang T, Zhang M. The present population of the Tibetan nationality in China. *Soc Sci China* 1994; **15:** 46–65.

57 Schuster BL. Gaps in the Silk Road: An analysis of population health disparities in the Xinjiang Uyghur Autonomous Region of China. *China Quart* 2009; **198:** 433–41.

58 Wen CM, Yao L, Mou W, Dai L, Zhu J, Wang YP. Cross-sectional study of the death status of the children under 5 years old in minority areas in 2008. *Mat Child Health Care China* 2011; **26:** 1125–27.

59 Wang Y, Li X, Zhou M, et al. Under-5 mortality in 2851 Chinese counties, 1996–2012: a subnational assessment of achieving MDG 4 goals in China. *Lancet* 2016; **387:** 273–23.

60 Hosseinpoor AR, Bergen N. Area-based units of analysis for strengthening health inequality monitoring. *Bull World Health Organ* 2016; **94:** 856.

61 Anderson I, Crengle S, Kamaka ML, Chen TH, Palafox N, Jackson-Pulver L. Indigenous health in Australia, New Zealand, and the Pacific. *Lancet* 2006; **367:** 1775–85.

62 Pulver LJ, Haswell MR, Ring I, et al. Indigenous Health—Australia, Canada, Aotearoa New Zealand and the United States—laying claim to a future that embraces health for us all. World Health Report (2010) Background Paper, No 33. Geneva: World Health Organisation, 2010. http://who.int/healthsystems/topics/financing/healthreport/IHNo33.pdf. (accessed March 16, 2017).

63 Harris A, Zhou Y, Liao H, Barclay L, Zeng W, Gao Y. Challenges to maternal health care utilization among ethnic minority women in a resource-poor region of Sichuan Province, China. *Health Policy Plan* 2010; **25:** 311–18.

64 Pan SW, Li DL, Carpiano RM, Spittal PM, Ruan YH. Ethnicity and HIV epidemiology research in China. *Lancet* 2016; **388:** 1052–53.

65 Adams V, Miller S, Chertow J, Craig S, Samen A, Varner M. Having a "Safe Delivery": Conflicting views from Tibet. *Health Care Women Int* 2005; **26:** 821–51.

66 Gyaltsen K, Gyal L, Gipson JD, Kyi T, Pebley AR. Reducing high maternal mortality rates in Western China: a novel approach. *Reprod Health Matters* 2014; **22:** 164–73.

67 Zhou WL, Zhu HM, Zhang J, Lai WY, Wang HB. The impact factors on hospital delivery care utilization among the childbearing women in Pengshui County. *Chin Primary Health Care* 2005; **19:** 64–66.

68 Wen CM, Sun J, Yao L. Investigation of maternal care utilization rate for women in minority areas. *Chin J Hosp Admin* 2011; **27:** 708–11.

69 Wang Y, Zhang JC. Qualitative research of rural maternal and child health related behaviour in Liangshan Yi Autonomous Prefecture in Sichuan Province. *Sichuan Med J* 2012; **33:** 1522–24.

70 Zhang YH, Ding LJ, Feng XX, Kou XH. The awareness of reproductive healthcare among Yugur childbearing women. *Mat Child Health Care China* 2012; **27:** 1685–87.

71 Nie XH. The current status and solution strategy of maternal healthcare in Xinjiang ethnic minority area. *China J Pharmaceut Econ* 2013; **4:** 418–19.

72 Yang AH, Zhou YB, Eemu AG, et al. Qualitative study on affecting factors of prevention of mother-to-child HIV transmission in Liangshan Yi area. *China Primary Health Care* 2013; **27:** 63–65.

73 Wang X, Pan J. Assessing the disparity in spatial access to hospital care in ethnic minority region in Sichuan Province, China. *BMC Health Serv Res* 2016; **16:** 399.

74 Gipson JD, Hicks AL, Pebley AR. Tibetan women's perspectives and satisfaction with delivery care in a rural birth center. *Int J Gynecol Obstet* 2015; **129:** 244–47.

75 Yusuf S. China's macroeconomic performance and management during transition. *J Econ Perspect* 1994; **8:** 71–92.

76 Xian P. The quality of life among ethnic minorities in Gansu Province. *Gansu Soc Sci* 2004; **3:** 128–30.

77 Guo ZH, Luo JZ, Du KL, Shi WH, Liu JT. The trends of life expectancy and infant mortality among different ethnic groups in Yunnan Province during 1990-2000. *Soft Science of Health* 2005; **19:** 342–44.

78 Chen XF, Zhang JY, Zhang Q. An analysis of the trend of infant mortality rate of Chinese minorities. *Mod Prevent Med* 2006; **33:** 2231–32.

79 Yip WC, Hsiao WC, Chen W, Hu S, Ma J, Maynard A. Early appraisal of China's huge and complex health-care reforms. *Lancet* 2012; **379:** 833–42.

80 National Health and Family Planning Commission-Finance Division. The implementation guidelines on China Health and Poverty Reduction Project, 2016 NO. 26. http://www.nhfpc.gov.cn/caiwusi/s7785/201606/d16de85e75644074843142dbc207f65d.shtml. (accessed March 16, 2017).

81 Health and Family Planning Commission of Yunnan Province. Introduction on the department of ethnic minority traditional medicine, 2016. http://www.pbh.yn.gov.cn/wjwWebsite/web/doc/UU146934541086434471 (accessed March 16, 2017).

82 Health and Family Planning Commission of Sichuan Province. Introduction on the department of ethnic minority traditional medicine, 2016. http://www.scwst.gov.cn/jg/jgsz/cspd/mwc/ (accessed March 16, 2017).