
DR. XING LIN FENG (Orcid ID : 0000-0003-3588-1859)

Article type : Research Article

Title: Factors affecting the frequency and contents of routine antenatal care in remote rural China in 2009-2016: an observational study

Abbreviated running title: Antenatal care in remote rural China

Xing Lin Feng¹, Ying Wang¹, Zhengchao Chen¹, Ronsmans Carine²

Authors' affiliation:

¹ Department of Health Policy and Management, School of Public Health, Peking University

² London School of Hygiene and Tropical Medicine

Email address:

Xing Lin Feng: fxl@bjmu.edu.cn

Ying Wang: phwangying@126.com

Zhengchao Chen: chenzhengchao@pku.edu.cn

Carine Ronsmans: Carine.Ronsmans@lshtm.ac.uk

Correspondence to:

Xing Lin Feng, Department of Health Policy and Management, School of Public Health, Peking University, Xueyuan Road 38#, Beijing, China, 100191. Correspondence Email: fxl@bjmu.edu.cn

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of Record](#). Please cite this article as [doi: 10.1111/1471-0528.17037](https://doi.org/10.1111/1471-0528.17037)

This article is protected by copyright. All rights reserved

Abstract**Objective:**

We assessed factors associated with frequency and contents of antenatal care (ANC) in remote rural China, including province of residence and individual level factors.

Design:

Survey-based cross-sectional study

Setting:

Remote rural China, Five provinces- Jilin, Shaanxi, Hunan, Guizhou, and Ningxia

Sample:

3,918 women with a live birth in 2009-2016

Methods:

Poisson regression

Main outcome measures:

ANC frequency- 5+ visits starting in the first trimester. ANC contents- co-coverage of six care components, and overuse of ultrasound

Main results:

Three quarters (72.9%) of women had 5+ visits starting in the first trimester, 68.8% received all six care components, and 94.5% had 3+ ultrasounds. Only 30.9% women sought ANC from township hospitals, paying between \$3.8 and 25.8 per-visit. ANC frequency and contents were associated with women's socio-economic characteristics, but provincial effects were much stronger, even after adjusting for individual factors. Women living in Guizhou and Ningxia, the two poorest provinces with high proportions of ethnic minorities, were particularly underserved. Compared to women in Shaanxi, women in Guizhou were 33% (adjusted RR 0.67, 95%CI 0.61-0.74) less likely to receive 5+ ANC starting in the first trimester; women in Ningxia were 17% less likely (adjusted RR 0.83, 95% CI 0.76-0.90) to receive all six care components.

Conclusion:

The province of residence was a stronger predictor of ANC frequency and contents than women's individual characteristics in China, suggesting that strengthening the decentralised system of

financing and organisation of ANC at province level is crucial to achieving success. Future efforts are warranted to engage sub-regional administrations.

Key words: Antenatal care; Quality of Care; Equity; China

Tweetable abstract

The province of residence was a stronger predictor of ANC frequency and contents than individual characteristics of women

1 **Introduction**

2 Routine antenatal care (ANC) represents an important stage along the maternal, new-born and
3 child health (MNCH) care continuum ¹. In 2001, the World Health Organization (WHO)
4 introduced a focused ANC model recommending at least four visits starting within the first
5 trimester, specifying a number of screening and prophylaxis interventions ^{2,3}. Recognising that
6 four visits may be associated with higher risks of perinatal deaths and lower maternal satisfaction
7 than eight visits, the WHO updated its guidelines in 2016 by increasing the minimum number of
8 visits, adding more service components ^{4,5}.

9 Globally, consensus has long been reached that adequate ANC should go beyond a sufficient
10 number of visits ^{6,7}. However, efforts to incorporate the content of ANC into monitoring
11 frameworks have only emerged recently ⁸⁻¹¹. In 2010, Victora et.al ⁸ measured ANC contents by
12 incorporating 11 care components that were recommended by the Brazilian government. More
13 recently, assessments have been based on measurement of the co-coverage of 6-8 care
14 components, including height, weight, blood pressure, urine test, blood analysis, tetanus
15 vaccination, prescription of folic acid, and dietary supplements of vitamins and iron ^{10,11}. These
16 components can be a marker of risk or represent conditions whose management may prevent
17 new-born deaths, stillbirths, and obstetric complications ¹². In 2018, Arsenault et.al ¹³ used data
18 from 91 low- and middle-income countries (LMICs) to assess contents of ANC based on three
19 care components: blood pressure measurement, blood sampling and urine sampling test. These
20 studies revealed substantial ANC quality gaps regardless of the number of visits, and inequalities
21 across urban-rural settings and women's socio-economic status.

22 In 2009, the Chinese government introduced the National Essential Public Health Program ¹⁴,
23 which targets 12 areas of public health, including management of chronic conditions, child health
24 care, and antenatal care. The program had an annual budget of 5.5 trillion US Dollars between
25 2009 and 2016, to be delivered to township hospitals which target rural populations ^{15,16}. In
26 practice, China adopted WHO's focused ANC model, recommending a minimum of five visits,
27 one ultrasound scan, and extra blood tests for Rh blood group, blood glucose, liver function,
28 kidney function, hepatitis B, HIV and syphilis ¹⁷. Despite these investments, gaps in ANC

1 coverage persist. Coverage is lower in rural areas ^{18,19}, in particular the South-Western region ¹⁸,
2 and among the poor ²⁰⁻²³, those with low levels of education ^{21,22,24,25}, ethnic minorities ²⁶⁻²⁹ and
3 internal-migrants^{30,31}. Health programs in China are decentralised: priority setting and program
4 planning is made by provincial governments and budgets, including transfers from the central
5 level, are allocated at the provincial level ³²⁻³⁴. However, in the literature most analyses of
6 coverage and quality have focused on individual-level factors such as education or ethnicity, with
7 little attention to variation between administrative unites that drive programme content and
8 coverage.

9 Using survey data from rural remote populations in five provinces in China, we assessed the
10 frequency and contents of ANC, and examined variation across provinces and by women's
11 individual demographic and socio-economic factors with a focus on variations by province. By
12 asking the question whether adequate ANC reaches remote and vulnerable populations, we make
13 recommendation to the Chinese government and draw attention to the global health community on
14 how to make investments more effective.

15

16 **Methods**

17 The study was conducted in five relatively poor provinces in 2015-2016: Jilin, Hunan, Shaanxi,
18 Guizhou, and Ningxia (Figure S1). China's stewardship of MNCH programs has been
19 decentralised at provincial levels, and the provincial department of health manages the information
20 that is reported from each county. Experts from the provincial health authorities were consulted
21 (see acknowledgements for details) to help with the selection of 3-4 remote rural counties with
22 relatively poor MNCH outcomes in each province, resulting in 16 counties across the five
23 provinces. Within each county we stratified all townships into three strata according to the driving
24 time to the county centre, using Baidu Map. We randomly selected 3-4 townships within each
25 stratum, and for each township we selected at least two villages - one farthest and one nearest to
26 the township hospital. For each village we retrieved the names from the surveillance system of all
27 mothers whose most recent birth took place in 2009-2016. Guided by the child's age at the time of
28 interview, we sampled the mothers of 100 children aged 0-6 months, and 20 each for subsequent

1 age groups (6 months-1 year, 1-2 years, 2-3 years, 3-4 years, 4-5 years, and 5-6 years).
2 Adapted from China's National Health Service Survey and the Demographic and Health Survey,
3 we built a structured questionnaire to ask women about their last live birth, including whether they
4 visited any hospitals or health centres during pregnancy, the gestational week at which they had
5 the first visit, and their most frequently consulted hospital or health centre. We asked the total
6 number of visits and whether they had received any of the following six care components at each
7 visit, in accordance with China's national guideline: weight measurement, blood pressure
8 measurement, finger blood sampling test, venous blood sampling test, urine test, and fundal height
9 measurement (by showing her how doctors measure the abdomen). We also asked about the total
10 number of ultrasound scans, and the total out-of-pocket costs for all ANC visits combined. 11
11 master students from the School of Public Health, Peking University did the face-to-face
12 interviews. Patients were not involved in the development of the research.
13 We ascertained three sets of outcomes. First, we assessed the frequency of ANC by measuring the
14 proportion of women who had 1+ visits, 5+ visits and 8+ visits, and that started in the first
15 trimester. Second, among those with 5+ visits that started in the first trimester we assessed
16 contents of ANC by measuring the proportion of women who had received all the six care
17 components at least once. Third, we examined the proportion of women who had received 3+
18 ultrasound scans (among those with 3+ antenatal visits) and the proportion who had received 5+
19 scans (among those with 5+ visits). The WHO does not recommend routine scans at every visit as
20 a means to improve maternal and perinatal outcomes⁵. Since 3+ scans were nearly universal in our
21 study sample, we defined overuse of ultrasound scans as 5+ scans among those with 5+ visits.
22 We grouped households' annual income per capita into tertiles, and classified women's educational
23 achievement as illiterate, completed primary, secondary, college and above. Other covariates
24 included households' distance to the county centre assessed as driving time within Baidu Map,
25 women's ethnicity, parity, age, marriage and health insurance coverage for giving birth. We also
26 described the place of ANC (township hospitals, county level hospitals, and hospitals out of the
27 home county) and the out-of-pocket costs per visit by place of ANC.
28 We examined the distribution of women's demographic and socio-economic characteristics and

1 each outcome across the five provinces, testing for differences using Chi-square tests. We
2 calculated proportions to measure ANC frequency and contents, and overuse of ultrasound scans.
3 We adjusted all monetary values to the year 2016, and graphed out-of-pocket costs per ANC visit
4 by province, using boxplots.
5 We estimated the crude and adjusted relative risks (RRs) of province and individual-level factors
6 on frequency and contents of ANC, and overuse of ultrasound scans, using Poisson regression. We
7 chose Poisson rather than logistic regression because the outcome was common, and we wanted to
8 report RRs instead of odds ratios (ORs). When estimating RRs, we chose the group with the
9 largest observations as the reference group. In the multivariate analysis, we included all covariates
10 as mentioned above. These variables were either priori predictors of health care usage (insurance
11 and age) or were associated with ANC coverage in the univariate analysis (P values<0.05).

13 **Results**

14 Figure S1 maps the location of the five provinces, and the table shows the population size,
15 economic development, household income, adult illiteracy and under 5 mortality for each
16 province. Where possible, we also report ranges across the sampled counties within each province.
17 Amongst the five provinces, Guizhou is the poorest with high adult illiteracy and under 5
18 mortality. In general, the 16 counties are poorer, have higher adult illiteracy and higher under 5
19 mortality than their provincial average. The sampled counties from Jilin, Hunan and Shaanxi are
20 similar in health and socio-economic development but counties from Ningxia and Guizhou tend to
21 have similarly poorer health and socio-economic characteristics.

22 Amongst the 3,918 women investigated, 71.6% completed primary education, 31.7% were ethnic
23 minorities, 22.2% lived more than 60 kilometres (km) away from the county centre, 56.8% had
24 two or more live births and 93.0% had insurance coverage (Table S1). Importantly, these
25 characteristics varied substantially across the five provinces. Women from Guizhou and Ningxia
26 were the poorest (with 40.6% and 55.8% respectively living in the poorest tertile), had the highest
27 rate of illiteracy (11.3% and 10.1% respectively), and had the highest proportion of ethnic
28 minorities (80.8% and 70.8% respectively). Distance to the county centre varied and was

1 particularly long in Guizhou where 49.6% of women lived more than 60km away from the centre,
2 whilst only 8.1% of women from Hunan did so.

3 The frequency and contents of ANC are shown in Table 1. Most women went to ANC at least
4 once but coverage declined substantially for five or eight or more visits. Uptake of 5+ ANC visits
5 that started in the first trimester was higher in Jilin and Shaanxi (87.2% and 83.8% respectively)
6 but lower in Ningxia, Hunan and Guizhou (71.2%, 65.6% and 52.2% respectively). About two
7 thirds of women (68.8%) with any ANC had received the six care components at least once,
8 ranging from 81.6% for venous blood tests to 93.8% for blood pressure measurement. 85.1 and
9 78.8% women from Jilin and Shaanxi, respectively, received all six care components, comparing
10 to only 62.5%, 57.9%, and 57.7% in Hunan, Guizhou, and Ningxia, respectively. Overuse of
11 ultrasound scans was very common in all provinces: 94.5% of women with 3+ visits had received
12 three or more ultrasound scans and 71.2% of women with 5+ visits had received five or more
13 ultrasound scans.

14 Half (50.9%) of all women who sought ANC went to county hospitals, and only 30.9% sought
15 ANC from township hospitals (Figure 1). The proportion of women using township hospitals was
16 the lowest in Jilin and Shaanxi (27.8% and 15.2% respectively) but highest in Ningxia (49.8%).
17 Costs per visit were lowest in township hospitals and highest in hospitals outside the county of
18 residence (Figure S2 and Table S2). Costs per visit in township hospitals ranged from a median of
19 \$25.8 (11.9-52.6) in Hunan to \$3.8 (1.2-8.3) in Ningxia.

20 Table 2 shows the factors that are associated with the uptake of 5+ANC visits starting in the first
21 trimester). Coverage increased from 68% in 2009-2012 to 75% in 2013-2016. The crude analysis
22 reveals substantial variation between provinces, only partly explained by differences in women's
23 socio-economic status in the multivariate analysis. Compared to women in Shaanxi, those living in
24 Guizhou and Hunan were 33% (adjusted RR 0.67, 95%CI 0.61-0.74) and 19% (adjusted RR 0.81,
25 95%CI 0.76-0.86) less likely to receive 5+ ANC visits starting in the first trimester, after taking
26 account of socio-demographic variations. Effects of socio-economic differentials persisted in the
27 adjusted analysis but took smaller sizes than provincial factors. For example, compared to the
28 poorest income tertile, women in the richest tertile were 12% (adjusted RR 1.12, 95%CI

1 1.06-1.18) more likely to have 5+ ANC visits starting in the first trimester; illiterate women were
2 19% (adjusted RR 0.81, 95%CI 0.71-0.92) less likely to do so than those with primary education;
3 and women living more than 60km from the county centre were 8% less likely to have 5+ visits
4 started in the first trimester than those living 20-40km away (adjusted RR 0.92, 95%CI 0.87-0.97).
5 Having health insurance was not associated with receiving sufficient frequency of ANC visits, and
6 the effect of ethnicity disappeared after adjustment (adjusted RR 1.02 95%CI 0.96-1.09).

7 Table 3 shows the factors that are associated with women's uptake of all the six components of
8 ANC at least once. There was enormous variation between provinces, even after adjustment for
9 socio-economic factors. For example, women in Jilin were 10% more likely to receive all the six
10 components than women in Shaanxi (adjusted RR 1.10, 95%CI 1.05-1.16)) and women in Ningxia
11 were 17% less likely (adjusted RR 0.83, 95% CI 0.76-0.90) to do so. Interestingly, contents ANC
12 was similar in Guizhou and Shaanxi after adjustment (adjusted RR 0.97, 95%CI 0.87-1.07). More
13 importantly, women's individual-level socio-economic characteristics were not or only weakly
14 associated with ANC contents in the crude analyses, and none were associated after adjusting for
15 provincial factors.

16 Overuse of ultrasound scans was high regardless of the place of ANC (Table S3). Again, there was
17 substantial variation by province which could not be explained by individual-level factors (Table
18 4). Ningxia had the highest overuse of ultrasound scans in the adjust analysis (adjusted RR=1.34
19 95%CI 1.24-1.44, compared to Shaanxi). Income and education were not associated with overuse
20 of ultrasound.

22 **Discussion**

23 **Main findings**

24 Using survey data from China's hard to reach rural populations in five provinces between 2009
25 and 2016, we found relatively high coverage of routine ANC in both frequency and contents,
26 coexisting with universal overuse of ultrasound scans. Women's individual socio-economic
27 characteristics and geographic access were associated with ANC frequency and contents, but
28 provincial variation was greater, even after adjusting for individual characteristics.

1

2 **Strengths and limitations**

3 This study included a large sample of women in remote rural counties, but some caution is
4 required in the interpretation of results. First, we purposely chose 16 rural remote counties from
5 five less developed provinces, and we cannot say with certainty that the women sampled represent
6 all poor counties in China. Second, we asked women to recall the components of care they
7 received during ANC and the costs associated, which may be subject to bias. Women may not
8 remember the specific tests they received or might over-report certain procedures, though whether
9 this has led to under- or over-estimation of the contents of ANC is uncertain. Third, a mere listing
10 of components of ANC misses important dimensions of the quality of ANC, such as whether the
11 findings from the screening have led to further examinations and/or treatment, or what the quality
12 of the inter-personal relationships is.

13

14 **Interpretation**

15 Very few studies have explored variations in frequency or contents of ANC across geographical
16 areas within countries that have relevance for programme planning ^{10,11,13}, and we are not aware of
17 any previous studies from China. Studies conducted in Mexico and India ranked administrative
18 regions within each country by ANC performance, but they did not adjust for variation in
19 individual-level factors between the regions ^{10,11}. In 2018, Arsenault et al ¹³ found that there was
20 substantial variation between countries in the three quality contents of ANC in 91 LMICs, but
21 neither individual level factors were adjusted nor variations within countries' administrative
22 regions were explored.

23 Our estimate that 73% of women could access 5+ ANC starting in the first trimester is higher than
24 that reported elsewhere in rural China ^{18,19,25,28,35,36} and in other LMICs ^{7,10,11}. Similarly, the
25 finding that 75% of women with sufficient ANC received all the six care components, which is a
26 first report from China to date, is better than that observed in other LMICs ^{7,10,11}. While these
27 studies ascertained ANC amongst women with 4+ visits started in first trimester, we examined 5+
28 visits in accordance with Chinese government recommendations. However, using 4+ visits as the

1 threshold, ANC contents does not vary (74%, data not shown). These findings are encouraging,
2 suggesting that China's recent efforts have been effective in extending coverage to the remote
3 rural vulnerable populations.

4 Previous studies from China and elsewhere have shown substantial variation in number and timing
5 of ANC visits across urban-rural settings ^{18,19,24} and by women's socio-economic status ^{23,25,30,31}.

6 Studies across the world have also shown substantial variations between women in ANC contents
7 ^{7,10,11,13}, but studies from China have been scant. Using survey data from 42 western rural counties
8 in 2011, Gao et al ²⁵ reported that amongst women with 1+ ANC, 80% had blood pressure
9 measurements, 74% were weighed, and only 51% received routine blood tests, with coverage
10 being lowest amongst the least educated. Our estimates of coverage for each component are much
11 higher, and we found no education-related inequalities, suggesting that China's recent efforts in
12 scaling up quality ANC, particularly amongst the most disadvantaged, may have been successful.

13 Several reasons explain why performance of ANC may vary by province in China. First, health
14 financing is largely decentralised and provincial governments set priorities for investment in
15 public hospitals, including infrastructure and human resources ³²⁻³⁴. China's provincial
16 governments also operate the social health insurance schemes. They determine the premiums,
17 benefit packages, and the rates for each service ¹⁵. Per capita government health expenditure
18 varied by more than 3-folds across provinces ³³. This helps explain why Guizhou and Ningxia
19 lagged behind, as they may have lower levels of public investment. Second, provincial
20 governments have high discretionary power in choosing priorities for investment, and determining
21 health program implementation- including setting clinical standards on equipment and human
22 resources and on service content and procedures ³². In Jilin, strict standards are in place to certify
23 health facilities and most township hospitals failed to reach the standard for quality ANC services
24 at the time of our study ³⁷. Consequently, few township hospitals provided ANC, with their tasks
25 shifting to service coordination and referrals. In Shaanxi, a pilot program was prompted during the
26 study period to deliver integrated ANC³⁸. This helps explain why Jilin and Shaanxi performed
27 better than Hunan, with similar level of economic development. Third, some of the poor counties
28 may have benefited from targeted health programmes that established quality service procedures

1 and trained obstetricians and midwives in county hospitals ³⁹. This may have contributed to
2 Guizhou's relatively high coverage of the six care components for women with sufficient visits.
3 Explaining provincial variation is complex, but future analyses are warranted to better inform
4 policy.

5 China National Essential Public Health Program, with ANC in township hospitals as one core
6 components, earmarked central transfers from \$2.2 to \$7.4 per capita between 2009 and 2016 to
7 the least developed provinces and prompted explicit performance evaluations to engage provincial
8 authorities ¹⁷. This may have contributed to the improving performance, but the Program only
9 represents 5% of the total provincial government health expenditure ³³, and out-of-pocket costs of
10 ANC remain high, as we reported. In addition, only a third of women sought ANC from township
11 hospitals, with most women opting for county or higher level hospitals where costs are higher.
12 Women may perceive the services offered at county or higher level hospitals to be of higher
13 quality, though there is very little evidence on the actual quality of ANC in various types of health
14 facilities in China.

15 Ultrasound scans in pregnancy are not restricted in China, except for the purpose of sex
16 determination ⁴⁰. This seems to be unique in the world ⁴¹ and goes against the WHO
17 recommendation of no routine ultrasound at every visit⁵. This survey was based on a
18 representative sample of the population. We found that 94.5% of women received three or more
19 ultrasounds and 71.2% received five or more, consistent with previous reports ^{25,42}. It is unlikely
20 that the high number of ultrasounds reflects high risk, suggesting a substantial overuse. Some have
21 argued that this is due to the overreliance of Chinese hospitals on expensive procedures that
22 generate profit ⁴², whilst others have suggested that women may perceive ultrasound as a marker
23 of good quality ²² or that ultrasound may serve as a psychological means to ensure safety and
24 prevent anxiety ^{43,44}. We found that overuse of ultrasound was not associated with women's
25 education and income, suggesting that ultrasound was affordable in remote rural China.
26 Anecdotally, some women in our sample said that ultrasound scans were the only reason for
27 seeking ANC, and they bypassed free ANC in township hospitals because ultrasound was often
28 not available there. There is no evidence that antenatal ultrasound scans do any harm to health, but

1 the repeat use of unnecessary procedures will waste valuable resources that would have been
2 better used in evidence-based actions.

3

4 **Conclusion**

5 The Chinese government has made substantial efforts to universalise routine ANC by revitalizing
6 township hospitals ¹⁵. The relatively high performance of ANC in remote rural settings suggests
7 that reforms have borne fruit. However, the government's huge investment was inefficient, as few
8 women actually utilised the services provided by township hospitals. The variation in ANC
9 performance across provinces indicates the independent and important role of the provincial
10 government. The Central Government may consider building mechanisms that further engage
11 provincial governments. In addition to financial investment, the capacity and service readiness of
12 township hospitals should be further strengthened, to be better coordinated and supported by
13 county hospitals.

14

15 China's experience may also contribute important lessons for other low- and middle-income
16 countries. Whilst efforts have been made to focus on vulnerable populations and make country
17 governments accountable, the global health community has paid little attention to engaging
18 sub-national administrations who manage and implement health programs. Future efforts are
19 warranted to a deep understanding of how regional health decision-making may make a change to
20 better improve health coverage and equity.

21

22 **Disclosure of interests**

23 None

24

25 **Funding**

26 Newton Advanced Fellowship jointly supported by the Academy of Medical Sciences and China
27 National Natural Science Foundation (71761130083); China National Natural Science Foundation
28 Excellent Young Scientist Program (71422009). The funders played no role in conducting the

1 study or writing of the paper.

2

3 **Ethical approval**

4 This study was approved by the ethical review board of Peking University (IRB No.

5 00001052-10085)

6

7 **Contribution to authorship**

8 XLF and CR conceived the paper. XLF designed the research, analysed the data and made the first
9 draft. Ying Wang and ZhengChao Chen contributed substantially to the questionnaire design, the
10 survey organisation, interviewer training, and data inputting and cleaning process. CR commented
11 and finalised the paper.

12

13 **Acknowledgements**

14 We also sincerely thank the following master students from School of Public Health, Peking

15 University to participate in the survey and data inputting process. They are: Yonghuan He, Yuting

16 Song, Kehui Huang, Wenjun Tang, Ying Li, Chenyang Li, Ru Zheng, Yuanpeng Liu and Ran

17 Liao.

18 We would also give our thanks to the following local MNCH experts from the 5 five provinces

19 who help us coordinate the survey: Yan Li from Jilin, Qiyun Du from Hunan, Hongjiang Mu from

20 Guizhou, Chunmei Wen from Shaanxi, and Haiyan Lv from Ningxia. In particular, we would

21 thank Dr. Bo Song, Li Song, and Jie Qiu from the Ministry of Health, China to help us coordinate

22 the abovementioned experts at provincial level.

23

24 **Supporting information**

25 Additional supporting information may be found online in the Supporting Information section at

26 the end of the article.

27 **Figure S1** Location of the 5 provinces, and selected socio-demographic indicators by each

28 province and the counties that were investigated

1 **Table S1** Demographic and socio-economic characteristics of women giving birth in remote rural
2 China from 5 provinces, 2009-2016

3 **Figure S2** Per visit medical costs associated with ANC in remote rural China, 2009-2016

4 **Table S2** Per visit medical costs associated with ANC in remote rural China, by province,
5 2009-2016

6 **Table S3** Effect of place of antenatal care on the uptake of all 6 antenatal care components and 5+
7 ultrasound scans, amongst women who had 5+ antenatal visits in remote rural China, most recent
8 live births, 2009-2016

Table 1 Frequency and contents of antenatal care in remote rural China, by timing of initiation and number of visits, most recent live births, 2009-2016

Province	Overall	Jilin	Hunan	Shaanxi	Guizhou	Ningxia
ANC visits and timely coverage						
% of women receiving any ANC (1+ visit)	98.6%	99.8%	99.6%	99.6%	93.3%	99.9%
% of women receiving 5+ visits	77.0%	91.0%	69.8%	87.6%	56.3%	76.0%
% of women receiving 5+ visits started in the first trimester	72.9%	87.2%	65.6%	83.8%	52.2%	71.2%
% of women receiving 8+ visits	33.5%	63.1%	25.5%	44.1%	20.0%	15.3%
% of women receiving 8+ visits started in the first trimester	32.4%	61.9%	24.1%	43.2%	19.0%	14.4%
% receiving all 6 care components at least once, among						
Women with a recent birth	67.9%	85.1%	62.3%	78.5%	54.0%	57.6%
Women with any ANC (1+ visit)	68.8%	85.1%	62.5%	78.8%	57.9%	57.7%
Women with 1+ visit started in the first trimester	71.1%	85.8%	64.9%	80.4%	61.9%	59.4%
Women with 5+ visits	75.2%	87.1%	69.7%	82.1%	70.0%	61.9%
Women with 5+ visits started in the first trimester	75.9%	86.9%	71.1%	82.5%	71.1%	62.6%
Women with 8+ visits started in the first trimester	83.3%	89.2%	76.9%	85.5%	77.2%	71.3%

		%				
Components of care among women with any ANC						
% receiving weight measurement	92.1%	97.0	94.3%	95.9%	83.2%	88.3%
		%				
% receiving blood pressure measurement	93.8%	98.3	96.1%	97.0%	85.6%	90.5%
		%				
% receiving blood routine test	89.4%	95.7	92.7%	94.7%	78.6%	83.5%
		%				
% receiving venous blood test	81.6%	90.6	73.8%	88.2%	74.1%	78.8%
		%				
% receiving urine test	90.0%	95.0	91.2%	94.9%	80.6%	86.0%
		%				
% receiving fundal height measurement	87.7%	96.5	88.3%	92.0%	84.0%	78.0%
		%				
Overuse of ultrasound scans						
% receiving 3+ ultrasound scans for women with 3+ visits	94.5%	97.8	91.6%	95.0%	90.7%	96.1%
		%				
% receiving 5+ ultrasound scans for women with 5+ visits	71.2%	76.6	62.3%	65.9%	57.6%	88.2%
		%				
Sample size						
Women with a recent birth	3,918	658	718	1,022	670	850
Women with any ANC	3,864	657	715	1,018	625	849
Women with 1+ visit started in the first trimester	3,508	618	641	950	528	771
Women with 5+ visits	3,018	599	501	895	377	646
Women with 5+ visits started in the first trimester	2,856	574	471	856	350	605
Women with 8+ visits started in the first trimester	1,271	407	173	442	127	122

Notes:

We ascertained 5+ visits and initiation of antenatal care within the first trimester according to

China's national standards, and ascertained 8+ visits according to the WHO' recommendations. We included 6 antenatal care components according to China's national standards. The WHO recommended 1 ultrasound scan before 24 gestation week, and against use of routine ultrasound after 24 weeks. Giving the obvious overuse of ultrasound scans, we defined over use of ultrasound as 3+ scans for those with 3+ antenatal visits, and 5+ scans for those with 5+ antenatal visits.

Table 2 Factors that are associated with the uptake of 5+ antenatal visits starting in the first trimester in remote rural China, most recent live births, 2009-2016

	N	%	Crude RR	95%CI	Adjusted RR	95%CI
Year of birth						
2009-2012	918	68%	0.91	0.86,0.95	0.88	0.84,0.93
2013-2016	3000	75%	1.00		1.00	
Province						
Jilin	658	87%	1.04	1.00,1.08	1.07	1.02,1.12
Hunan	718	66%	0.78	0.74,0.83	0.81	0.76,0.86
Shaanxi	1022	84%	1.00		1.00	
Guizhou	670	52%	0.62	0.58,0.67	0.67	0.61,0.74
Ningxia	850	71%	0.85	0.81,0.89	0.93	0.87,0.99
Income tertile						
Q1 (Poorest)	1311	64%	1.00		1.00	
Q2 (Middle)	1300	76%	1.18	1.12,1.24	1.10	1.05,1.16
Q3 (Richest)	1303	79%	1.23	1.17,1.29	1.12	1.06,1.18
Mother's education						
Illiterate	220	50%	0.70	0.61,0.80	0.81	0.71,0.92
Primary	2806	72%	1.00		1.00	
Secondary	621	81%	1.12	1.07,1.17	1.07	1.02,1.12
College and above	256	87%	1.21	1.14,1.27	1.06	1.00,1.13
Mother's ethnicity						
Minority	1240	63%	0.82	0.78,0.86	1.02	0.96,1.09
Han majority	2676	77%	1.00		1.00	

Distance to county

<=10km	361	84%	1.17	1.10,1.23	1.09	1.03,1.15
10-20km	820	80%	1.10	1.05,1.15	1.05	1.01,1.10
20-40km	1337	72%	1.00		1.00	
40-60km	529	73%	1.02	0.95,1.08	1.04	0.98,1.10
>60km	871	63%	0.87	0.82,0.92	0.92	0.87,0.97

Mother's age

<20	282	66%	0.88	0.81,0.96	0.98	0.89,1.07
20-	2484	75%	1.00		1.00	
30-	1136	71%	0.95	0.91,1.00	1.00	0.96,1.05

Parity

1	1680	78%	1.00		1.00	
2	1819	72%	0.92	0.89,0.96	0.95	0.91,0.99
3 and above	408	57%	0.73	0.66,0.79	0.81	0.73,0.89

Mother's insurance coverage

No	263	71%	0.97	0.89,1.05	0.95	0.88,1.02
Yes	3642	73%	1.00		1.00	

Legally married when giving birth

No	332	61%	0.82	0.75,0.89	0.89	0.81,0.98
Yes	3584	74%	1.00		1.00	

Notes:

1. 3918 women, defined as those in need of ANC were included in this analysis.
2. Poisson regression with robust standard errors were used to estimate relative risks (RRs).

Table 3 Factors that are associated with the uptake of all 6 antenatal care components at least once, amongst women who received 5+ antenatal visits starting in the first trimester in remote rural China, most recent live births, 2009-2016

	N	%	Crude RR	95%CI	Adjusted RR	95%CI
Year of birth						
2009-2012	621	73%	0.95	0.90,1.00	0.93	0.88,0.98
2013-2016	2235	77%	1.00		1.00	
Province						
Jilin	574	87%	1.05	1.01,1.10	1.10	1.05,1.16
Hunan	471	71%	0.86	0.81,0.92	0.89	0.83,0.95
Shaanxi	856	82%	1.00		1.00	
Guizhou	350	71%	0.86	0.80,0.93	0.97	0.87,1.07
Ningxia	605	63%	0.76	0.71,0.81	0.83	0.76,0.90
Income tertile						
Q1 (Poorest)	841	72%	1.00		1.00	
Q2 (Middle)	984	78%	1.08	1.02,1.14	1.00	0.95,1.06
Q3 (Richest)	1030	77%	1.07	1.01,1.13	0.96	0.91,1.01

							1
Mother's education							
Illiterate	110	61%	0.82	0.70,0.95	0.90	0.77,1.0	6
Primary	2015	75%	1.00		1.00		
Secondary	500	80%	1.08	1.02,1.13	1.06	0.95,1.1	2
College and above	222	84%	1.13	1.06,1.20	1.08	0.96,1.1	5
Mother's ethnicity							
Minority	785	66%	0.83	0.78,0.87	0.92	0.85,1.0	7
Han majority	2071	80%	1.00		1.00		
Distance to county							
<=10km	304	81%	1.10	1.03,1.17	1.05	0.92,1.2	3
10-20km	652	79%	1.07	1.02,1.14	1.06	0.95,1.2	0
20-40km	966	74%	1.00		1.00		
40-60km	388	76%	1.03	0.96,1.10	1.03	0.89,1.1	7
>60km	546	74%	1.01	0.95,1.07	0.99	0.86,1.1	

							1
Mother's age							
<20	186	68%	0.88	0.80,0.98	1.00	0.89,1.1	2
20-	1853	77%		1.00		1.00	
30-	808	76%	0.99	0.95,1.04	0.99	0.94,1.0	4
Parity							
1	1309	80%		1.00		1.00	
2	1310	74%	0.93	0.89,0.97	0.95	0.91,1.0	0
3 and above	231	65%	0.82	0.74,0.90	0.95	0.85,1.0	5
Mother's insurance coverage							
No	186	70%	0.92	0.84,1.02	0.92	0.84,1.0	1
Yes	2664	76%		1.00		1.00	
Legally married when giving birth							
No	201	66%	0.86	0.78,0.96	0.90	0.81,1.0	0
Yes	2655	77%		1.00		1.00	

Notes:

-
1. 2856 women with 5+ antenatal visits starting in the first trimester were included in this analysis.
 2. Poisson regression with robust standard errors were used to estimate relative risks (RRs).

Table 4 Factors that are associated with the uptake of 5+ ultrasound scans, amongst women who had 5+ antenatal visits in remote rural China, most recent live births, 2009-2016

	N	%	Crude RR	95%CI	Adjusted RR	95%CI
Year of birth						
2009-2012	647	64%	0.85	0.80,0.90	0.85	0.80,0.91
2013-2016	2371	73%	1.00		1.00	
Province						
Jilin	599	77%	1.16	1.09,1.24	1.16	1.08,1.24
Hunan	501	62%	0.94	0.87,1.03	0.94	0.86,1.02
Shaanxi	895	66%	1.00		1.00	
Guizhou	377	58%	0.87	0.79,0.96	0.81	0.73,0.91
Ningxia	646	88%	1.34	1.27,1.41	1.34	1.24,1.44
Income tertile						
Q1 (Poorest)	902	72%	1.00		1.00	
Q2 (Middle)	1030	69%	0.96	0.91,1.02	0.99	0.96,1.07

Q3 (Richest)	1084	72%	1.00	0.95,1.06	1.00	0.96,1.08
Mother's education						
Illiterate	121	77%	1.08	0.97,1.19	1.04	0.94,1.16
Primary	2131	71%	1.00		1.00	
Secondary	528	68%	0.96	0.90,1.02	0.98	0.92,1.05
College and above	229	72%	1.01	0.93,1.10	1.02	0.93,1.11
Mother's ethnicity						
Minority	830	77%	1.11	1.06,1.16	1.02	0.95,1.09
Han majority	2188	69%	1.00		1.00	
Distance to county						
<=10km	315	73%	1.04	0.96,1.12	1.01	0.94,1.09
10-20km	687	68%	0.97	0.90,1.03	0.94	0.88,1.00
20-40km	1023	70%	1.00		1.00	
40-60km	413	76%	1.08	1.01,1.15	1.10	1.03,1.17

>60km	580	73%	1.05	0.98,1. 11	1.08	1.01,1. 15
Mother's age						
<20	195	77%	1.06	0.98,1. 15	1.02	0.94,1. 12
20-	1953	73%	1.00		1.00	
30-	860	66%	0.91	0.86,0. 96	0.93	0.87,0. 98
Parity						
1	1363	73%	1.00		1.00	
2	1385	68%	0.93	0.89,0. 98	0.95	0.90,1. 00
3 and above	264	78%	1.06	0.99,1. 14	1.01	0.92,1. 10
Mother's insurance coverage						
No	199	76%	1.07	0.99,1. 16	1.01	0.93,1. 10
Yes	2813	71%	1.00		1.00	
Legally married when giving birth						
No	217	68%	0.96	0.87,1. 05	0.95	0.86,1. 05

Yes	2801	71%	1.00	1.00
-----	------	-----	------	------

Notes:

1. 3018 women with 5+ antenatal visits were included in this analysis.
2. Poisson regression with robust standard errors were used to estimate relative risks (RRs).

Figure 1 Place of antenatal care for women with 1+ ANC in remote rural China, 2009-2016

