Poor coverage of quality-adjusted antenatal care services: a population-level assessment by visit and source of antenatal care services in Bihar state of India

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Summary

Background Despite the evidence on the poor quality of antenatal care (ANC) services, significant gap remains in the understanding of quality-adjusted coverage at the population-level for each ANC visit and by the source of ANC services, and in equity in this coverage.

Methods All births between July 2020 and June 2021 were listed from 261,124 households (91.5% participation) representative of the Bihar state. Mothers of all stillbirths and neonatal deaths, and of 25% random sample of livebirths who survived the neonatal period provided data on each ANC visit up to a maximum of first 4 ANC visits, including the source of ANC services and the services received (weight measurement, blood pressure checked, abdomen checked, urine sample taken, and blood sample taken). An ANC visit was deemed of quality if all of these services were received in that visit. We report the coverage of quality-adjusted ANC services (Q-ANC) for ANC visits 1–4 disaggregated by source of ANC services and wealth index (WI). Weighted proportions are reported to take into account the sampling design.

Findings A total of 30,412 births were reported by 29,517 women, and 7270 (82.1%) of the 8853 eligible women participated. Overall, 19,950 unique ANC visits from 6929 women were available for analysis, of which 41.7%, 13.8% and 44.5% were at Village Health and Nutrition Day (VNHD), public facility, and with a private provider, respectively. A total of 4409 (65.3%) of the 1st ANC visits were undertaken at VHND, with the proportion of private provider ANC visits increasing significantly from ANC visit 1 to ANC visit 4 ($p < 0.001$). Q-ANC coverage considering all ANC visits was 20.9% (95% CI 20.7–21.2); and was 0.9% (95% CI 0.8–1.0), 29.9% (95% CI 29.2–30.7) and 36.9% (95% CI 36.5–37.4) for ANC visits in VHND, public facilities, and with private provider, respectively. Q-ANC coverage in the public facility was significantly lower in the 4th ANC visit (25.1%; 95% CI 23.4–26.9) as compared with visits 1 to 3, whereas it was the highest for 1st ANC visit with private provider (50.2%; 95% CI 49.2–51.1) and then dropped for visits 2 to 4. Irrespective of the source of ANC services, Q-ANC coverage increased significantly with increasing WI quartile for ANC visits 1 and 2, with WI quartile 3 women having significantly less coverage for ANC visit 3 compared to the rest, and no significant difference seen in the coverage of ANC 4 visit. Varied pattern of Q-ANC coverage by WI for each ANC visit was seen for public facility and private provider visits.

Interpretation With only 2 of 10 ANC visits deemed of adequate quality, sustainable delivery of quality ANC services are needed for every pregnant woman through-out the pregnancy irrespective of gestation period, number of ANC visit, and source of ANC services.

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Keywords: Antenatal care services; India; Quality; Coverage; Provider; Wealth index; Inequity

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Research in context

Evidence before this study

Despite the evidence on the poor quality of antenatal care (ANC) services predominately from the demographic and health surveys (DHS), significant gap remains in the understanding of quality-adjusted coverage at the population-level for each ANC visit and by the source of ANC services, and in equity in this coverage. We searched PubMed with the terms {"antenatal care services" and "quality" and "India"} and {"antenatal care services" and "equity" and "India"} to identify articles published in English without time period restriction on 6 March 2023. The first set resulted in 21 publications and the second only 1. Most publications on quality of ANC services were based on secondary analysis of the national family health survey data defining quality if the pregnant woman received a combination of ANC service components at any point or at least once during the pregnancy irrespective of the number of ANC visits. Other publications reported quality of ANC services from facility observations or reported the reasons for poor quality of ANC services at the facility-level.

Added value of this study

This is one of the first population-based studies reporting on quality by each ANC visit disaggregated by source of ANC services and wealth index. We found the quality-adjusted coverage of ANC services lagging considerably behind the crude ANC coverage, and disaggregated analysis has highlighted significant inequities in quality coverage between the ANC visits and by source of ANC services. Improving access to ANC services by bringing it closer to the community but without appropriate quality interferes with the overall coverage of ANC services, as the study has documented that the quality of 1st ANC visit matters in ensuring that a pregnant woman completes the desired number of ANC visits. The rich-poor gap in quality-adjusted coverage of ANC services is seen in 1st and 2nd ANC visits, which disappears in the 3rd and 4th ANC visits. The quality of ANC services drops from the 1st to 4th ANC visit in both public facility and with private providers.

Implications of all the available evidence

This study offers a more nuanced understanding of the quality of ANC services than the DHS, by highlighting the urgent need to not only provide but to also sustain quality ANC services for pregnant woman irrespective of the number of ANC visits or the source of ANC services. With widespread poor quality of ANC services in this population, the focus of health system should be on improving the ANC components that have the least coverage in addition to addressing the system-related issues for provision of quality ANC services.

Introduction

Antenatal care (ANC) visits comprise high-impact interventions with the potential to prevent and reduce maternal and perinatal morbidity, and perinatal deaths.[1–3] The World Health Organisation (WHO) recommends every pregnant woman to have a minimum of four ANC visits, with the first ANC visit in the first trimester of pregnancy to ensure optimum care during pregnancy, and recently recommended eight or more ANC visits for women for positive pregnancy experiences.[1] Until recently, quality of ANC services was equated to coverage of 4 or more ANC visits, and did not focus on what services were provided to pregnant women in these ANC contacts.[4–11] Much of the available literature on ANC quality in low- and middle-income countries is captured from the demographic and health surveys (DHS), which is based on the pregnant woman receiving a combination of ANC service components at any point or at least once during the pregnancy irrespective of the number of ANC visits.[12–22] A recent scoping review has identified several input and process factors that influence the provision and utilization of optimum quality ANC services, including availability of trained workforce, commodities, guidelines, context-specific programs, that are essential to create enabling facility environment for quality ANC services.[23] Currently, there is a significant gap in the understanding of quality-adjusted coverage at the population-level for each ANC visit and by the source of ANC services that can provide specific guidance to improve quality of ANC services, and to address the equity gaps in access to quality ANC services.[12,21,24–26]

As per the National Family Health Survey round 5 (NFHS-5), which is equivalent of DHS in India, the coverage of 4 or more ANC visits was reported at 58.5% for India, with it ranging at the state-level from 20.7% in Nagaland to 93% in Goa for livebirths between 2014 and 2021.[27] In addition to the poor coverage of 4+ ANC visits, concerns have been raised about the quality of ANC services in India.[14,17,19,25,28,29] The Government of India has initiated a program to increase the coverage and quality ANC services,[30] wherein pregnant woman are examined and appropriately investigated by a physician across the public health facilities.[30] In this background, we report on the quality-adjusted coverage of ANC services in a population-based assessment from the Indian state of Bihar, which was reported to have 4 +ANC coverage at 25.2% as per NFHS-5.[31] We have recently reported significantly inadequate quality of ANC services provided at the public health facilities from exit survey in this state with less than one-third of the pregnant women having received quality ANC services.[32] In this paper, we present quality-adjusted coverage of ANC services (Q-ANC) for each ANC visit disaggregated by the source of ANC services and explore inequities by wealth index in this coverage for a state-

representative sample of births documented in the Every Newborn Health Assessment & Neonatal Care Evaluation 2020 (ENHANCE 2020) survey.

Methods

Overview

ENHANCE 2020 was approved by the Institutional Ethics Committee of the Public Health Foundation of India. All participants provided written informed consent, and for those who could not read or write, the participant information sheet and consent form were explained by the trained interviewer, and a thumb impression was obtained.

Survey design

A reduction of 23.3% in neonatal mortality rate (NMR) in Bihar was reported over a 5-year period between 2011 (32.2%) and 2016 (24.7%).[33] ENHANCE 2020 was designed to document change in NMR between 2016 and 2020. Assuming a subsequent declining trend in NMR similar to 2011–2016, the reduction in NMR for the 4-year period from 2016 to 2020 would be 18%. We estimated a sample of 30,000 livebirths for ENHANCE 2020, assuming a 10% refusal rate and 85% power to detect a reduction of 18% in NMR from 2016 to 2020 at the 95% confidence level.

All births that occurred from July 2020 and June 2021 among usual resident women aged 15–49 years were considered eligible for this study.[34] We used a multi-stage sampling design to obtain a representative sample of these births from all the 38 districts of Bihar. Each district of Bihar is divided into 5–27 blocks giving a total of 534 blocks in the state; we considered 50% of these blocks for the survey. Using the Census 2011,[35] we stratified the 534 blocks as those having only rural population and (70.2%) and those with both rural and urban populations (29.8%); and randomly sampled 267 blocks for the survey which included 187 (70%) blocks with only rural population and 80 (30%) blocks with both rural and urban populations to reflect the urban-rural population distribution in the state. Within these 267 blocks, the secondary sampling units (SSUs) were villages in rural areas and urban frame survey blocks in urban areas as defined by the Census 2011. The SSUs with <175 households were combined with an adjacent SSU, and the large rural SSUs were split into equal sized segments of 175–200 households using natural boundaries. A total of 1340 SSUs (941 rural and 399 urban) were sampled in proportion to the number of SSUs in each block, using systematic random sampling.

Data collection

Each selected SSU was mapped and all the households (a household was defined as people eating from the same kitchen) enumerated. During the enumeration, trained interviewers documented the birth outcomes between July 2020 and June 2021 among usual resident women aged 15–49 years in each household. Date of birth, sex of the baby born, and whether it was a live-birth or stillbirth was documented for each birth. We also documented births between July 2020 and June 2021 for women who had died during or after giving birth to ensure a robust estimation of total births in this population.

Following enumeration, all women with stillbirth and neonatal death, and 25% of women with neither of these adverse birth outcomes selected using systematic random sampling in each cluster were considered eligible for a detailed interview. For the analysis presented, the interview of these women documented sociodemographic information and the number of ANC visits sought during pregnancy with the focal child. We undertook detailed documentation for all ANC visits up to a maximum of first four ANC visits for each woman which included the source of ANC services, gestation month at each visit, and the services received (weight measurement, blood pressure checked, abdomen checked, urine sample taken, and blood sample taken) for each visit. We collected information on whether the women had received Iron Folic Acid (IFA) tablets/syrup and Calcium tablets anytime during the pregnancy with the focal child.

Data collection was completed between August 2021 and April 2022. The questionnaire was developed in English and then translated into Hindi (local language), after which these were back-translated into English to ensure the accurate and relevant meaning and intent of the questions. Pilot testing of the questionnaire was carried out and modifications made as necessary. Interviews were captured using the Computer-assisted Personal Interview software in hand-held tablets. A total of 10% of the enumeration data were checked from 50% of the sampled clusters, which translated into 670 clusters. Similarly, a total of 20% of interviews were checked in 50% of the 1340 sampled clusters.

Analysis presented in this paper

Since the sample was a multi-stage stratified cluster sample, sampling weights were calculated based on the sampling probabilities separately for each sampling stage for each study cluster. We calculated the selection probabilities for a cluster from the sample and the birth outcomes, and obtained the overall probability as the product of both of these probabilities; sampling weight was estimated by taking the reciprocal of this overall probability. The design weight was then adjusted for household non-response and individual non-response to obtain the final sampling weight. The quality related analysis is presented by ANC visits and by women. For the analysis by ANC visits, individual ANC visits with a maximum of first 4 ANC visits per woman that were captured in detail were utilised. The source of ANC services was categorised as the Village Health Nutrition

Day (VHND),[36] public facility (all levels), and private provider (denoting all types of private service providers). We report on the distribution of ANC visits by the source of ANC services for ANC visits 1 to 4. The service coverage for–weight measurement, blood pressure measurement, abdomen check-up, and urine and blood sample collection—is presented for individual ANC visits 1 to 4 disaggregated by the source of ANC services. All of these components are considered essential components of every ANC visit as per the Indian ANC guidelines.[37] Therefore, a particular ANC visit was deemed of quality if a woman reported having received all of the above components of ANC services in that particular visit. We report the Q-ANC coverage for each ANC visit from visits 1 to 4 disaggregated by source of ANC services, by birth outcome (livebirth who survived neonatal period, neonatal death, and stillbirth), and pregnancy trimester. Furthermore, 7 of the 12 months during July 2020 and June 2021, August to November 2020 and April to June 2021, were COVID-19 peak periods in India.[34,38] Therefore, we also estimated Q-ANC for ANC visits undertaken during COVID-19 peak and non-peak periods.

We also estimated the overall Q-ANC coverage by not considering the abdomen check-up for the 1st ANC visit as the abdomen check-up as per the Indian ANC guidelines is recommended from 2nd pregnancy trimester onwards to monitor pregnancy progression, foetal well-being and its position.[37] We did not include tetanus toxoid in this assessment as it's administration in pregnant women is dependent on certain factors, including time since the last pregnancy and that it is not a component that needs to delivered at every ANC visit.[39] The tetanus toxoid coverage for the last pregnancy in Bihar was reported at 89.5% in the most recent statewide assessment.[31] Similarly, we report on the proportion of women who had received IFA tablets/syrup and Calcium tablets during the pregnancy with the focal child, but did not include it in quality assessment as it is not a component that needs to delivered at every ANC visit, and not all pregnant women are provided with this supplement.

For the analysis presented by women, the coverage of 1, 2, 3 and 4 ANC visits by source of ANC services is reported with and without quality-adjustment for all women and also disaggregated by wealth index quartile. Quality of ANC services by woman was defined as a woman having received quality ANC services at every ANC visit irrespective of the number of ANC visits by the woman. We calculated the wealth index for each woman in our study using the standard methods used in the NFHS to calculate the wealth index as detailed by the DHS program for India,[27,40] and present the Q-ANC coverage for each ANC visit from visits 1 to 4 disaggregated by wealth index quartile to highlight the gap in this coverage, if any. This is reported for all ANC visits irrespective of source of ANC services, for ANC visits in public facilities, and for those with a private provider. We have reported 95% confidence interval for all estimates as relevant, and design-based F test of significance is reported.[41] STATA V.13.1 version was used for all analysis.

Role of the funding source

The funder had no role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

Results

A total of 30,412 birth outcomes between July 2020 and June 2021 were reported by 29,517 women during the enumeration from 261,124 households (91.5% participation) covering a population of 1,260,984. Of the 30,412 birth outcomes, 582 (1.91%) were stillbirths and 831 (2.73%) were neonatal deaths.

A total of 7270 (82.1%) of the 8853 eligible women participated for detailed interview, including 1218 (16.8%) women with adverse birth outcome. Sociodemographic variables for women by birth outcome are reported in Appendix pp 3. At least one ANC visit was reported by 6929 women (95.9%), and the coverage of 3 or more ANC visits was 61.7% (95% CI 61.2–62.1) and that of 4 or more ANC visits was 37.3% (95% CI 36.9–37.8) in this population. A total of 4488 women reported first ANC visit in the first trimester of pregnancy (64.9%), 6154 (89.4%) women reported being given IFA tablets, and 4061 (61.9%) were given calcium tablets. The mean number of ANC visits was 3.10 (95% CI 3.09–3.12), and ranged from 0 to 30 ANC visits. The mean number of ANC visits was significantly lower in women residing in rural areas, those with education of class 5 or less, those belonging to the lowest wealth index quartile, and those with at least one other child as compared with their counterparts in Appendix pp 4. The mean number of ANC visits was not different over the study period (p = 0.248).

Characteristics of ANC visits

A total of 19,950 unique ANC visits from 6929 women who reported at least one ANC visit were available for detailed analysis (Appendix pp 5). Majority of the ANC visits reported in the first pregnancy trimester were in the 1st ANC visit (84.7%), but variation was seen in the number of ANC visit by the pregnancy trimester (Appendix pp 6). Of all the ANC visits, 41.7%, 13.8% and 44.5% were reported to be in VHND, public facility, and with a private provider, respectively. Among the 2986 public facility ANC visits, majority of the visits were in a primary health centre (2193; 72.6%) followed by district hospital or medical college hospital (733; 24.3%), and 60 (3.0%) were in a sub health centre. A total of 4372 (63.1%) of the 1st ANC visits were

undertaken at VHND, and the proportion of private provider ANC visits increased significantly from ANC visit 1 to ANC visit 4 ($p < 0.001$; Appendix pp 7).

Service coverage by ANC visit

The coverage of ANC service components by the number of ANC visit disaggregated by the source of ANC services is shown in Table 1. The ANC visits in VNHD irrespective of the number of ANC visit predominately provided weight check-up followed by blood pressure measurement, with hardly any other service provision. In public facility ANC visits, the coverage of weight check-up and blood pressure measurement was >70% irrespective of the number of ANC visit, however, the coverage of urine sample collection dropped ($p < 0.001$) and that of abdomen check-up increased ($p < 0.001$) from ANC visit 1 to 4. Some variation in this pattern was seen by the type of public facility as shown on Appendix pp 8. On the other hand, though the coverage of blood pressure measurement, urine and blood sample collection was higher in the 1st ANC visit with a private provider as compared with a public facility, all of these coverages dropped significantly from ANC visit 1 to ANC visit 4 in the private provider ANC visits ($p < 0.001$).

Quality-adjusted coverage by ANC visit

The overall Q-ANC coverage considering all the 19,950 ANC visits irrespective of the source of ANC services was 20.9% (95% CI 20.7–21.2), and it was the least for the ANC visits in VHND (0.9%; 95% CI 0.8–1.0). This coverage was 29.1% (95% CI 28.4–29.9) considering all ANC visits in public facilities and 36.9% (95% CI 36.5–37.4) for ANC visits with a private provider. The Q-ANC coverage in the public facility was not statistically different between ANC visits 1 to 3, and was significantly lower for ANC visit 4 (Table 1). On the other hand, this coverage with a private provider was the highest in the 1st ANC visit (50.2%; 95% CI 49.1–51.2) and then dropped for the 2nd, 3rd and 4th ANC visits (Table 1).

Considering the type of public health facility, the Q-ANC coverage was the least for sub health centre ANC visits and was the highest for district/medical college hospital ANC visits (Appendix pp 8).

On estimating the Q-ANC coverage based on the pregnancy trimester in which the visits were undertaken, this coverage was significantly higher for the ANC visits in the 3rd pregnancy trimester (24.6%; 95% CI 24.1–25.1) as compared with those in the 1st (20.3%; 95% CI 19.8–20.8) and 2nd (18.9%; 95% CI 18.5–19.2) pregnancy trimesters. The Q-ANC coverage for live-births that did not result in neonatal death (21.3; 95% CI 21.0–21.6) was significantly higher than that for those that resulted in neonatal death (18.0; 95% CI 17.4–18.7) but was not different for stillbirth (20.0; 95% CI 19.1–20.9) as shown in Appendix pp 9. On not

	VHND ANC visits (N = 8124)[a]					Public facility ANC visits (N = 2986)[a]					Private facility ANC visits (N = 8818)[a]				
	1st N = 4372	2nd N = 2331	3rd N = 1104	4th N = 317	F-test of significance	1st N = 661	2nd N = 1008	3rd N = 820	4th N = 497	F-test of significance	1st N = 1891	2nd N = 2776	3rd N = 2421	4th N = 1730	F-test of significance
Weight checked	2600 (58.0)	1289 (54.0)	637 (57.4)	194 (64.1)	p < 0.001	494 (72.2)	751 (73.9)	611 (74.7)	391 (76.6)	p < 0.001	1339 (74.0)	1867 (69.2)	1654 (70.4)	1213 (71.1)	p < 0.001
Blood pressure measured	1821 (40.4)	888 (36.7)	452 (41.4)	138 (47.4)	p < 0.001	525 (75.4)	809 (79.6)	658 (81.5)	422 (85.6)	p < 0.001	1610 (87.7)	2194 (80.4)	1885 (79.4)	1365 (78.6)	p < 0.001
Urine sample provided	203 (4.1)	45 (1.8)	17 (2.0)	3 (0.5)	p < 0.001	392 (58.8)	542 (54.2)	401 (52.3)	213 (43.8)	p < 0.001	1389 (76.5)	1509 (55.5)	1001 (42.0)	658 (38.3)	p < 0.001
Blood sample provided	324 (6.7)	115 (4.5)	38 (2.5)	16 (2.6)	p < 0.001	429 (64.4)	753 (71.9)	596 (72.2)	362 (72.5)	p < 0.001	1451 (79.4)	1849 (66.6)	1464 (60.6)	960 (53.8)	p < 0.001
Abdomen checked	286 (5.6)	150 (5.4)	64 (5.5)	19 (3.7)	p < 0.001	358 (50.9)	584 (57.3)	525 (65.5)	313 (63.7)	p < 0.001	1476 (78.5)	2198 (79.4)	1942 (79.7)	1390 (82.7)	p < 0.001
Weighted Q-ANC coverage (95% CI)	1.3 (1.1–1.4)	0.5 (0.4–0.6)	0.4 (0.3–0.5)	0.03 (0.02–0.1)	p < 0.001	29.4 (27.8–31.1)	29.6 (28.4–30.8)	30.8 (29.4–32.3)	24.8 (23.2–26.6)	p < 0.001	50.2 (49.2–51.1)	38.7 (37.9–39.5)	30.6 (29.8–31.4)	29.5 (28.5–30.5)	p < 0.001

VHND denotes Village Health and Nutrition Day and CI confidence interval. The numbers are unweighted. [a]Data on source of ANC services missing for 5, 6, 7 and 4 cases for 1st, 2nd, 3rd and 4th ANC visit, respectively.

Table 1: **Services received in the antenatal care (ANC) visits 1 to 4 and weighted coverage of quality-adjusted ANC services (Q-ANC) by the source of ANC services.**

considering abdomen check-up as a component in the 1st ANC visit, the overall Q-ANC coverage was 20.5% (95% CI 20.1–20.9); this coverage for the 1st ANC visit without the abdomen check-up was significantly higher ($p < 0.0001$) than that with the abdomen check-up in both the public facility (43.2% 95% CI 41.4–44.9) and with a private provider (59.5%; 95% CI 58.5–60.4) ANC visits.

The Q-ANC coverage by the wealth index quartile for ANC visits 1 to 4 is shown in Fig. 1. Irrespective of the source of ANC services (Fig. 1A), the Q-ANC coverage increased significantly with increasing wealth index quartile for ANC visits 1 and 2 ($p < 0.0001$); quartile 3 women had significantly less coverage for ANC visit 3 compared to the rest ($p < 0.0001$), and no significant difference was seen in the coverage of ANC 4 visits. When considering only the ANC visits with a private provider (Fig. 1B), Q-ANC coverage increased significantly with increasing wealth index quartile for ANC visit 1 ($p < 0.0001$); quartile 4 women had significantly higher coverage for ANC visit 2 ($p < 0.0001$), and quartile 3 women for ANC visit 3 as compared with the rest ($p < 0.0001$). However, for the public facility ANC visits (Fig. 1C), quartile 1 women had significantly lower Q-ANC coverage for ANC visit 1 ($p < 0.0001$), but had coverage similar to quartile 4 women for ANC visit 4.

Irrespective of the source of ANC services, the Q-ANC coverage for ANC visits during the Covid-19 peak period (20.7%; 95% CI 20.3–21.1) was not significantly different from those during the Covid-19 non-peak period (21.1%; 95% CI 20.8–21.4). By source of ANC services (Appendix pp 10), the Q-ANC coverage for ANC visits during the Covid-19 peak period was significantly lower (33.9; 95% CI 33.2–34.6) from those during the Covid-19 non-peak period (39.0; 95% CI 38.4–39.6) for the private provider ANC visits; these were not different for VHND and public facility ANC visits.

Coverage of quality-adjusted ANC services by women

Majority (64.6%) of the women with only 1 ANC visit had visited VHND for ANC services, and the proportion of 1st ANC visit in a VHND reduced drastically for women who reported 3 (25.7%) or 4 (13.6%) ANC visits (Appendix pp 11). The likelihood of a woman reporting 3 or 4 ANC visits was significantly higher with decreasing number of VHND ANC visits ($p < 0.001$). The proportion of women belonging to quartiles 1–3 used VHND significantly more than quartile 4 women for ANC visit 1 ($p < 0.001$), however, the utilisation of private provider increased with increasing number of ANC visits irrespective of wealth index quartile (Appendix pp 12).

Irrespective of the number of ANC visits, the Q-ANC coverage was higher by 19.5% and 64.6% for women in quartile 3 (20.7%; 95% CI 19.9–21.5) and quartile 4 (28.5%; 27.6–29.5) as compared with those in quartile 1 (17.3%; 95% CI 16.5–18.2), respectively. This coverage for women in quartile 2 was 19.7% (95% CI 18.8–20.6).

Table 2 shows the coverage by women for each ANC visit with and without quality adjustment, overall and disaggregated by wealth index quartile. Irrespective of the wealth index, the Q-ANC coverage was 8.8, 5.3, 3.6 and 4 times lower than the coverage without quality adjustment for 1, 2, 3 and 4 ANC visits, respectively. Irrespective of wealth index, the Q-ANC coverage was only 9.2% (92% CI 8.9–9.5) for 4 ANC visits (Table 2). On considering the women by wealth index quartile, the percent drop between the coverage with and without quality adjustment ranged from 67.5% to 94.3%, and the Q-ANC coverage was the highest for 4th ANC visit for women in the wealth quartile 4 (15.6; 95% CI 14.8–16.5). The pattern was similar within wealth quartiles 2 to 4 with ANC visit 1 having the least and ANC visit 4 having the highest Q-ANC coverage; ANC visit 3 had the highest Q-ANC coverage for women in quartile 1.

The Q-ANC coverage for women living in the rural areas (19.5%; 95% CI 19.1–19.9) was lower than for women living in the urban areas (28.1%; 95% CI 26.9–29.3). The Q-ANC coverage in women with a livebirth was 21.4 (95% CI 20.9–21.8), with livebirth without neonatal death was 21.8 (95% CI 21.4–22.3), in those with neonatal death was 17.3 (95% CI 16.3–18.5), and in those with stillbirth was 24.0 (95% CI 22.3–25.8).

Discussion

To our knowledge, this is among the first population-based assessments from India reporting on the magnitude of inequities in Q-ANC coverage in detail. We found the Q-ANC coverage lagging considerably behind the ANC coverage without quality adjustment, and the disaggregated analysis has highlighted significant inequities in quality coverage between the ANC visits and by the source of ANC services. Importantly, with the widespread poor Q-ANC coverage in this population, sustainable delivery of quality services for pregnant woman through-out the pregnancy irrespective of the gestation period, the number of ANC visit, and the source of ANC services is urgently needed.

The Q-ANC coverage was the least for ANC visits at the VHNDs. Four out of 10 ANC visits overall and 7 out of 10 among the 1st ANC visits were in VHNDs in this population, with the Q-ANC coverage being extremely low in these visits. VHNDs are designed to provide first-contact integrated primary health care and has the mandate to provide focussed ANC care, referral for women with signs of complications during pregnancy and those needing emergency care, and the requirement to have all the necessary supplies to provide all ANC service component.[36] We found the VHND visits to predominately provide only weight and blood pressure check-up for pregnant women. Significant gaps in the

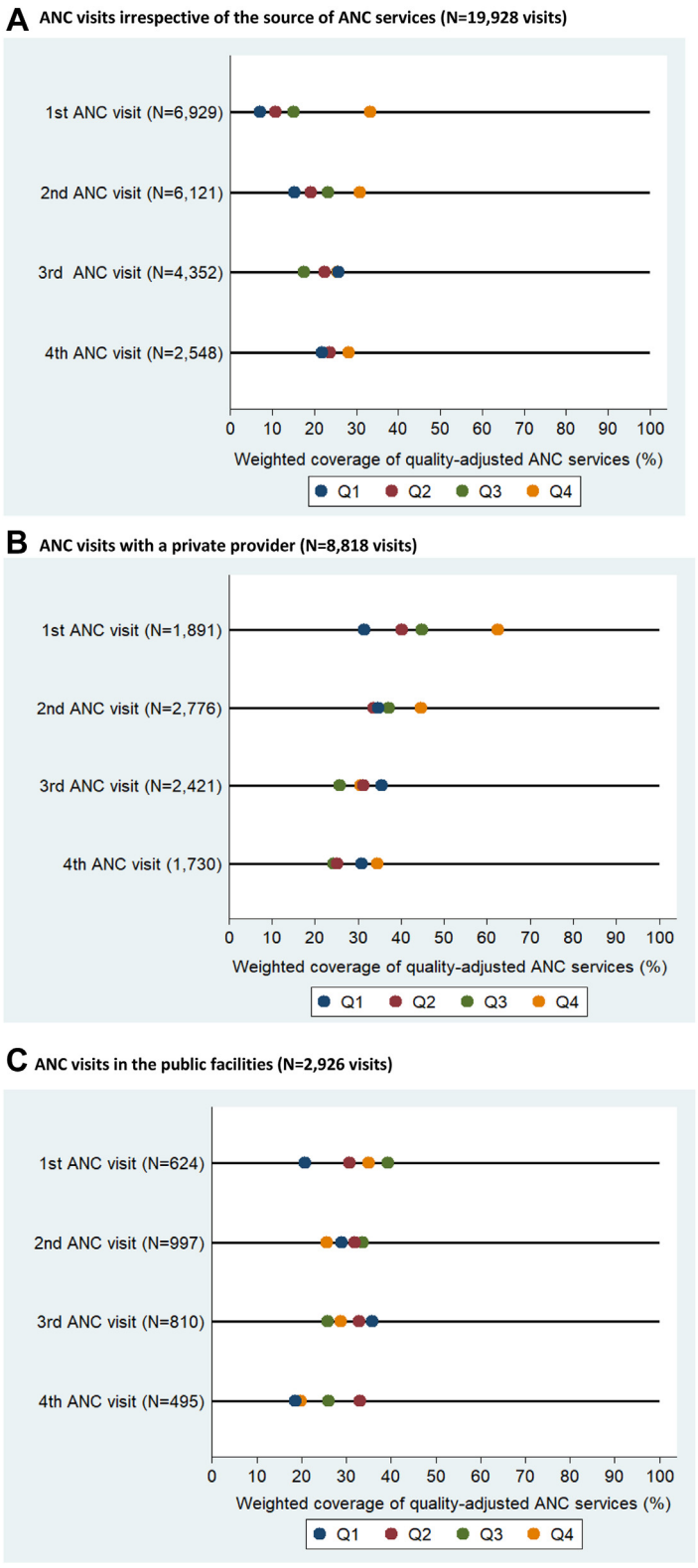

Fig. 1: Weighted coverage of quality-adjusted antenatal care (ANC) services by the number of visit disaggregated by the wealth index quartile for women (Q1–Q4). Q1 is the poorest and Q4 is the richest wealth quartile. Data on source of ANC services was missing for 22 visits.

Wealth index quartile	Number of ANC visits	Number of women with this number of ANC visits irrespective of quality	Weighted coverage of ANC visits irrespective of quality (95% CI)	Number of women with this number of quality-adjusted ANC visits	Weighted coverage of quality-adjusted ANC visits (95% CI)	Percent reduction in the weighted coverage with and without quality adjustment (95% CI)
All women (N = 7269)	1 visit	808	9.7 (9.4–10.0)	86	1.1 (1.0–1.2)	−88.7 (−96.1 to −81.2)
	2 visits	1769	24.6 (24.1–25.0)	296	4.6 (4.4–4.8)	−81.3 (−85.8 to −76.8)
	3 visits	1804	24.3 (23.9–24.7)	467	6.7 (6.4–6.9)	−72.4 (−77.1 to −67.7)
	4 visits	2548	37.3 (36.8–37.9)	603	9.2 (8.9–9.5)	−75.3 (−78.8 to −71.9)
Q1 women (N = 1892)	1 visit	308	14.0 (13.4–14.7)	23	0.8 (0.7–0.9)	−94.3 (−105.8 to −82.8)
	2 visits	592	32.8 (31.8–33.9)	69	4.0 (3.6–4.4)	−87.8 (−94.8 to −80.8)
	3 visits	419	24.8 (23.8–25.8)	104	7.8 (7.2–8.4)	−68.5 (−77.8 to −59.3)
	4 visits	423	21.5 (20.8–22.3)	107	4.7 (4.4–5.1)	−78.1 (−87.8 to −68.5)
Q2 women (N = 1865)	1 visit	228	10.2 (9.6–10.8)	24	1.2 (1.0–1.3)	−88.2 (−102.5 to −73.9)
	2 visits	453	24.6 (23.9–25.3)	66	4.4 (3.9–4.9)	−82.1 (−90.9 to −73.3)
	3 visits	500	26.5 (25.7–27.3)	126	6.2 (5.8–6.6)	−76.6 (−85.2 to −68.0)
	4 visits	589	33.4 (32.5–34.4)	135	7.9 (7.4–8.5)	−76.3 (−83.7 to −69.0)
Q3 women (N = 1807)	1 visit	168	8.7 (8.2–9.3)	21	1.3 (1.1–1.5)	−85.1 (−101.2 to −69.0)
	2 visits	440	25.2 (24.4–26.0)	81	5.5 (5.0–6.1)	−78.2 (−87.1 to −69.2)
	3 visits	453	23.3 (22.5–24.1)	105	5.2 (4.8–5.5)	−77.7 (−87.1 to −68.2)
	4 visits	675	39.8 (38.9–40.7)	150	8.7 (8.2–9.3)	−78.1 (−84.7 to −71.6)
Q4 women (N = 1700)	1 visit	104	5.7 (5.3–6.1)	18	1.1 (0.9–1.3)	−80.7 (−101.9 to −59.5)
	2 visits	281	15.2 (14.5–15.9)	80	4.4 (4.0–4.9)	−71.1 (−84.0 to −58.1)
	3 visits	432	22.8 (22.0–23.6)	132	7.4 (6.9–8.0)	−67.5 (−77.9 to −57.2)
	4 visits	858	55.2 (54.1–56.3)	210	15.6 (14.8–16.5)	−71.7 (−77.0 to −66.4)

CI denotes confidence interval. The numbers are unweighted.

Table 2: **Weighted coverage of antenatal care (ANC) visits, with and without quality-adjustment for all women and by wealth index quartile.**

VHNDs for other health services have also been reported.[42–46] As many pregnant women utilise VHND for their first ANC visit, addressing the quality of ANC services at VNHDs would not only improve the mandate of VHND to identify complications and provide referral for pregnant women but also ensure that free good quality ANC services at VHNDs contribute towards improving equity in quality through the universal health coverage. The SDG target 3.8 aims at achieving universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality, and affordable essential medicines and vaccines for all.[47] Therefore, equity analysis is vitally important to enable identifying who gets the worst quality of care to help guide policy decisions toward equitable distribution of health gains in the SDG era and beyond. On one hand, significant gaps in quality of ANC services by socio-economic status (SES) have been reported, and on the other equitable levels of poor quality are also documented.[14,26] Previous studies on inequities in ANC contacts have highlighted that those in the lowest SES experience both a limited coverage as well as poor quality of services.[12,18,24–26] This is also true in our population as women belonging to the lowest wealth index quartile reported the least number of ANC visits, had the highest utilisation of VHND for ANC visit 1, and received the least coverage of quality-adjusted ANC services. The pattern of Q-ANC coverage by the number of ANC visit offers an interesting insight that the relative advantage of a higher Q-ANC coverage for women in the highest wealth index quartile disappeared in the 3rd and 4th ANC visits. This pattern predominately resulted from the private provider ANC visits and higher proportion of 1st ANC visits in the VHNDs, and we found a reversal of this pattern for the public facility quality-adjusted ANC visits, with rich-poor gap in the opposite direction and in the 3rd and 4th ANC visits.

The use of private providers was much higher than the public facilities for ANC services in this population. One needs to consider if this pattern were a result of the poor quality of ANC services in VHND as majority of the 1st ANC visits in this population were in VHNDs, thereby, reducing the confidence in the public health system among women for these services.[48,49] However, of note is also that in the same population, we recently reported no evidence of decrease in the coverage of maternal services during Covid-19 peak period but documented a significant shift towards the private sector health facilities over this period, which could be due to

the reluctance in using public sector facilities as many of these facilities were treating Covid-19 patients.[34,50] This shift, possibly, countered the access-related issues for maternal services in this population, a phenomenon also documented elsewhere.[51] We did find a lower Q-ANC for ANC visits with private provider during the Covid-19 peak period as compared with the non-peak period but no difference was seen between these two periods for public facility ANC visits. The Q-ANC coverage remained significantly lower in the public facility ANC visits irrespective of the number of ANC visit as compared with the private provider ANC visits.[12,52,53] The drop in Q-ANC coverage in both public facility and with private providers from 1st to 4th ANC visit is intriguing, and needs further unpacking. More nuanced qualitative studies, particularly prospective in nature, could help understand why some ANC service components are not provided to women even in the later stages of pregnancy that could result in poor identification of high-risk pregnancies, thereby, interfering with prevention of maternal and newborn mortality and morbidity.[1,2]

The weight and blood pressure measurements showed consistently high coverage across the public facilities and private providers though neither was reported at 100% irrespective of the number of ANC visit. Notably, the coverage of urine sample for examination was relatively lower than that for blood sample in both, perhaps reflecting commitment towards detection of anaemia.[36,37,54] We have recently highlighted the poor laboratory readiness in public facilities impacting the quality of ANC services in this state,[32] and this study further indicates the need to improve the laboratory services at large to improve ANC services. The unprecedented attention that the laboratory services have received during Covid-19 pandemic needs to be expanded to the routine pregnancy laboratory tests as well[55,56] by addressing the laboratory infrastructure and related processes, and paying attention to the laboratory technicians as human resources for health.[57–59] Abnormal foetal movements can be used to predict adverse neonatal outcomes.[60–62] Abdomen check-up was reported significantly higher with the private providers as compared with the public facility ANC visits irrespective of the number of ANC visit. This poor coverage of abdomen check-up is a concern as breech position is a significant risk factor for early neonatal deaths and stillbirths in this population,[33,63,64] but breech position of the baby is not known to most women before delivery as abdomen check-up is either not done or they are not informed.[33,63]

We have recently reported varied implementation of ANC service guidelines, in particular with laboratory diagnostics and doctor consultation, and task shifting from doctors to auxiliary nurse midwife in public facilities as possible reasons for poor quality of ANC services in the state.[32] The private sector health facilities in Bihar are not a homogenous group and range from tertiary care hospitals to nursing homes with varied levels of infrastructure, capacity and skills.[65] With the extensive use of private providers for ANC services in this population, universal access to quality ANC services is not possible without the engagement with the private sector to address the provision of these services.[66,67] Given the magnitude of poor quality ANC services and in the context of the challenges identified previously, significant inputs are required to help bridge the gap between quality-adjusted and non-adjusted coverage of ANC services that is consistent with the aim of government's program and the SDGs.[30,47] It's important to note that though the India Newborn Action Plan recommends monitoring of percentage of pregnant women who received full ANC, it does not provide any definition for full ANC.[68] The routine health information system in India does not capture quality of ANC care, and also does not capture ANC visits by unique woman to understand the coverage of ANC services.[69] With such poor coverage of quality ANC services, it is imperative to explicitly track and monitor the quality of ANC through standard indicators both at the health system and community levels.[10,70–74] Data available in the NFHS allows for quality of ANC services to be measured as weight, blood pressure, urine sample and blood sample collection, and abdomen check-up at least once during the ANC period.[27] Using this definition for Bihar state, the quality of ANC services was estimated in NFHS-5 at 66.6% for most recent livebirths in the last 5 years, and at 67.8% for livebirths in year 2019,[31] which is 3 times higher than the quality of ANC services per woman in our study accounting for quality at every ANC visit for livebirths in 2020–21. Another method to assess quality of ANC services uses a combination of coverage and content of ANC services; the content component of this indicator also considers only each content component received at least once during the antenatal care period and not at every ANC visit as done by NFHS.[6] We have shown in this study that data capture per ANC visit is possible in population-level surveys and because the quality of ANC services is significantly different when considering every ANC visit, such detailed documentation could be considered in the DHS to generate more wide-scale information on quality of ANC services to facilitate provision of quality services at every visit for every pregnant woman.[75]

The strengths of this study are inclusion of all pregnancies irrespective of the outcome as stillbirth or livebirth, capture of quality of services for each ANC visit, and by the source of ANC services. This, we believe, has offered more nuanced understanding of the quality of ANC services than the DHS which is currently the predominant source for information on quality of ANC services at the population-level in many low- and middle-income countries.[12,14–16,19,21] The inequity in Q-ANC coverage further disaggregated by wealth index has

highlighted that poor coverage of these services is widespread, and that by number of ANC visit has highlighted the need to improve sustainability of delivery of quality services for pregnant woman throughout the pregnancy irrespective of the gestation period, the number of visit, and the source of ANC services.

There are some limitations to be considered as well. First, we have relied on self-reported data, which are subject to recall bias. We believe this bias to be of less concern as women self-report accurately indicators related to concrete and observable actions performed on them (eg, blood pressure check, anaemia screening and urine test) as opposed to information or advice they were offered.[76,77] Furthermore, the Q-ANC coverage for public facility ANC visits in this study corroborates well with another study based on exit survey of pregnant women in public facilities of the state (30.4%),[32] indicating low recall bias in our study. Second, the quality measures used are not comprehensive but are concrete and observable actions performed on women. These were captured as dichotomous indicators, where survey respondents answered yes or no, that does not necessarily measure quality comprehensively as it neither captures the appropriateness not timeliness of assessments and diagnostic tests offered during the ANC services. However, it is not possible to measure such nuances in a population-level survey. Considering these limitations, we may have over-estimated quality-adjusted coverage of ANC services. Lastly, we did not document whether the private provider for ANC services was informal or formal, which may need to be considered in planning private sector engagement to improve quality of ANC services.

In conclusion, poor quality of ANC services is widespread in this population. The insights on inequity by wealth index by ANC visit and by woman offers a nuanced understanding that can facilitate addressing the rich-poor gap in access to quality services. Efforts to sustain the quality of services at each ANC visit irrespective of the source of ANC services through appropriate and effective tracking and monitoring of ANC services both at the health system and community levels are urgently needed to ensure that every pregnant woman receives quality services at every ANC visit.

Contributors

RD, GAK, and LD conceptualised the study. RD drafted the manuscript. GAK and MM performed the data analysis. MA and SSSD performed data management and quality check. All authors contributed to the study tools, interpretation and agreed with the final version of the paper. GAK and MM verified the data underlying this study. RD, GAK and MM had full access to all the data in the study, and all the authors had the final responsibility for the decision to submit for publication.

Data sharing statement

The de-identified individual participant data and a data dictionary can be made available on request by writing to the first author. A data sharing agreement will need to be executed.

Declaration of interests

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lansea.2023.100332.

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