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Research Paper

Impact of Maternal Education on the Intensity and Timeliness of Antenatal Care Utilization in Niger

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Abstract

Inadequate access to antenatal care (ANC) is a public health problem promoting maternal and child mortality in many developing countries. In Niger, the utilization of ANC is a requirement for achieving some of the targets of the third Sustainable Development Goal (SDG3). This study analyzed the impact of maternal education on the intensity and timeliness of ANC use. The data were drawn from the 2021 Malaria Indicator Survey (MIS). Data were analyzed using an exponential mean model, and regression adjustment Average Treatment Effect (ATE)/ Average Treatment Effect on the Treated (ATET) estimators. The results showed that 68.66% of the women attended ANC three or four times, whereas 48.58% did not visit health centers up to four times. Only 27.09% of pregnant women attended ANC during the first trimester. The results from Poisson regression showed that ANC visits significantly increased with women's age, education levels, urban residence, listening to radio, wealth index, and use of Fasidar medication. Moreover, the first ANC pregnancy month was associated with the women's age, education level, and wealth index. The ATEs and ATETs were positive for ANC use intensity and negative for use timeliness, respectively. It was recommended that efforts to promote ANC use in Niger should, among others, promote maternal education through media programs.

Keywords: Antenatal Care, Maternal Health, Child's Health, Malaria, Niger

INTRODUCTION

Quality healthcare utilization is one of the fundamental indicators of universal health coverage (UHC) as a prescriptively amplified target in the third Sustainable Development Goal (SDG3) (Chapman, 2016). Relatedly, the objectivity of reducing maternal and child mortality, which are distinctive targets in SDG3, is also anchored on promoting timely access to quality healthcare services in a manner that facilitates substantial promotion of equity and efficiency (United Nations Population Fund, 2009). Therefore, international treaties and global resolutions to promote the fundamental rights of the people to quality healthcare services underscore the need for healthcare service delivery enhancement and removal of every access barrier, be it financial or institutional (Chapman, 2016). Fundamentally, unlike their counterparts in developed countries, many developing economies possess some peculiar limitations that often inhibit progress in some healthcare indicators. Specifically, the requisite manpower and infrastructure for the advancement of healthcare quality and access are often lacking, thereby distorting the service delivery processes along the patient-nurse-doctor interactive chain (Yanful et al., 2023).

Moreover, in alignment with internationally acknowledged good practice, healthcare quality enhancement will promote attainment of desirable treatment outcomes for every patient (World Health Organization, 2018; Kohl, 2018). Therefore, suboptimal service delivery remains the bane of quality healthcare service delivery in many developing countries (World Health Organization, 2018). Some individuals' financial constraints and institutional lapses in adherence to some basic clinical practices have resulted in low utilization of medical services in relation to

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family planning, antenatal, and postnatal care in some developing countries (World Health Organization, 2018). Specifically, in Niger, the past few years have witnessed significant revamp of the healthcare service delivery system. Although the country was ranked last in the 2018 Human Development Index (HDI), there have been significant efforts in all aspects of life to promote human capital development through economic and health policies that are targeted at the enhancement of the UHC (UNICEF, 2019). In addition, there is a need for a comprehensive assessment of the level of progress attained in health care service use in Niger about the demand for antenatal care (ANC).

There is a global public health concern about preventable pregnancy-related complications because every two minutes, a woman reportedly dies (Integrated African Health Observatory, 2023). This can be further amplified by the fact that while 800 women die daily from pregnancy-related complications in 2020, developing countries accounted for about 95% of these deaths (World Health Organization, 2024). In addition, of the 287,000 preventable maternal deaths globally reported in 2020, 202,000 occurred in sub-Saharan Africa (SSA) (World Health Organization, 2024). Although Niger reported a moderately high maternal mortality rate, which slightly decreased from 535 to 520 per 100,000 live births in 2012 and 2018, respectively (UNICEF, 2019), concerns remain regarding the possibility of SSA in meeting some health-related SDGs. There is a consensus among health policymakers that timely interventions by medical personnel could prevent maternal deaths resulting from complications in the form of hemorrhage, hypertension, infection, and other complications, which together account for about 75% of the causes of maternal mortality in Africa (Integrated African Health Observatory, 2023).

Similarly, given the current rate of maternal mortality, an estimated 20.3% reduction in maternal mortality from 2020 had been projected for meeting the set SDG target in 2030 (Integrated African Health Observatory, 2023). Achieving this goal may be difficult because several demographic, economic, cultural, and religious factors influence the utilization of healthcare services by African women (Kota et al., 2023). Specifically, literature has emphasized the role of education in promoting timely healthcare service utilization among women of reproductive age. Women's access to reproductive health has been examined from different perspectives. These include health, family planning, abortion management, sexually transmitted infections, fertility, and reproductive rights (Unacademy, n.d).

However, this study contributes to the existing literature by focusing on women's health, with emphasis on use intensity and timeliness of antenatal care. Although several studies have been conducted on the correlates of antenatal care utilization, little is known about the causal impacts of maternal education on the intensity and timeliness of antenatal care. Our study makes a unique contribution to the literature by using a potential outcome framework to estimate the impact of maternal education on the intensity of use and timeliness of antenatal care. We computed two important indicators of comparison: the average treatment effect (ATE) and the average treatment effect on the treated (ATET).

LITERATURE REVIEW

The concept of reproductive health emphasizes safety in an individual's decisions on sex and reproductive matters (World Health Organization, n.d.). In 1994, the International Conference on Population and Development (ICPD), which was held in Cairo, defined reproductive health as: 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, in all matters relating to the reproductive system and its functions and processes" (World Health Organization, n.d.). Therefore, whenever procreation comes within this framework, the safety of the lives of women and their children through effective utilization of antenatal care becomes a top priority for public health policies. Moreover, the utilization of antenatal care is clinically meant to promote maternal and child health. This serves as a testament to the rights of

women and children to access adequate healthcare services, as emphasized by several international scientific bodies, including the International Conference on Population and Development in 1994 and the Fourth World Conference on Women in 1995 (The Fourth World Conference on Women, 1995; United Nations Population Fund, 2009).

The concept of health care is perfectly unified by dynamic proactive interactions among professionals in the health care sector, health care service availability by the public and private actors, and patient attendance at the facilities. Therefore, different conceptual frameworks for health care use have identified several factors that influence consumers' healthcare utilization levels. The fundamental issue of relevance is people's access to health care services with clear consideration of service availability, affordability, and reachability (Ryvicker et al., 2018; Sofaer, 2009). In addition, consumers' level of literacy on health issues promotes their ability to properly communicate with service providers for accurate diagnosis of ailment and treatment adherence (Ryvicker et al., 2018; Sofaer, 2009). Therefore, education becomes a critical factor in women's healthcare service utilization decisions. This is fundamentally important in Niger, where women's adult literacy was 29.7% in 2022, compared to 62.1% for Sub-Saharan Africa (SSA) (UNESCO, 2025).

However, the utilization of healthcare services is a complex process with multidimensional covariates (Sofaer, 2009). Therefore, several theoretical constructs have been proposed by scholars to emphasize the relevance of some variables as covariates of patients' health outcomes. Andersen (1995) proposed a theoretical model of health care use that focuses on some environmental factors, the characteristics of the population, and health care behavioral factors as the major determinants of health outcomes. However, the model was modified by Andersen (2008), who focused on individual factors and processes of health care service use as part of the explanatory variables of health outcomes. Kufafka et al. (1999) presented a model that explains patients' health use decision-making processes based on several cognitive theories. The model explored the relevance of perceived threats from observed symptoms and demographic variables in explaining the decision to seek treatment.

In some empirical analyses, different variables were explored as correlates of health care service use. Specifically, with a focus on antenatal care, several demographic variables have been used as explanatory variables with different policy implications. In a study by Saad-Haddad et al. (2016), the determinants of antenatal care use and recommended ANC usage (four or more visits) in seven countries were education and wealth index. In a study in Nigeria, Dahiru and Oche (2015) used logistic regression to analyze the determinants of antenatal care use in the country. The findings showed that use was influenced by the couples' education levels, wealth index, and urban residence. Awusi et al. (2009) found that using the Chi-square approach, the majority of women with secondary education, postsecondary education, and regular income utilized antenatal care, whereas most of those with four children did not use it. In a spatial analysis conducted in India, John et al. (2019) used the ordinary least squares (OLS) regression to analyze the determinants of antenatal care use. The results showed that the percentage of women who had full antenatal visits was influenced by literacy rate, birth order, and health infrastructure availability.

Nghargbu and Olaniyan (2019) found that focusing on antenatal utilization decisions and the frequency of utilization in Nigeria with logistic regression and negative binomial regression, respectively, the results for Nigeria revealed that wealth index, distance to health facilities, and no female provider available were statistically significant. Nketiah-Amponsah et al. (2013) used negative binomial regression and found that in Ghana, the intensity of antenatal care utilization was significantly influenced by birth order, health insurance, education levels, wealth index, region, and sector of residence. Mesfin and Farrow (1996) also found that in Ethiopia, the probability of not using antenatal care significantly increased with unplanned pregnancy, high parity, no formal

education, and being widowed.

Tessema and Minyihun (2021) found that the probability of attending at least four antenatal appointments in selected East African countries was significantly influenced by education levels, birth order, planned pregnancy, and wealth index. Badolo et al. (2022) also found that in Burkina Faso, the probability of using ANC was influenced by poverty status, being employed, and the quality of ANC in the resident areas. Kim and Kim (2019) examined the factors affecting the utilization of three maternal health care services, prenatal, delivery, and postnatal, among women in Chad. It was found that use of all these services was low, and the correlates were the education levels of women, husbands' education levels, husbands' occupation, wealth index, sector, and region of residence. A comparison of the determinants of the utilization of ANC and child vaccination in Niger, Mali, and Chad was conducted by Carlson et al. (2011). The results showed that Mali had the lowest non-utilization rate of 12%, as against 47% for Chad and 36% for Niger. Non-utilization was explained by mother's education, partner's education, and region of residence in the three countries, while wealth index, women's occupation, and ethnic identity were significant predictors in Niger and Mali. Ngaba and Kamga (2021) analyzed the determinants of obstetric care use inequality in Chad using regression-based decomposition. It was found that education, urban residence, and income contributed the most to inequality.

Although several studies had been conducted on the determinants of antenatal care use in Africa, few studies exist on Niger as a country. More importantly, although some studies adopted the use decision and intensity, little is known about the determinants of use timeliness. We explored these gaps by integrating a model of the treatment effect analytical framework to understand the causal impact of maternal education on the utilization and timeliness of antenatal care in Niger.

RESEARCH METHOD

The Data

The data for this study were drawn from the Malaria Indicator Survey (MIS) conducted in Niger in 2021. The data were collected by the l'Institut National de la Statistique (INS) in Niger under the Demographic and Health Survey (DHS) program from 12 August to 27th October 2021. The United States Agency for International Development (USAID) provided financial assistance. Moreover, technical assistance were also provided by the Government of Niger, United States Presidential Malaria Initiative (PMI), Catholic Relief Services (CRS), and the National Malaria Control Program.

The sampling frame considered the rural-urban and regional populations in Niger and ensured adequate representativeness. Specifically, there were four questionnaires for administration to selected respondents. The household, female, biomarker, and field survey outcome questionnaires were administered. Trained field agents were the enumerators of the face-to-face interviews. The data collected in the women's questionnaire, which was administered to women who were 15-49 years old, were used in this study. Similarly, our sample was formed from those who responded to the number of times they sought antenatal care services.

The data collection enumerators were trained for two weeks before the questionnaire was pretested. The survey data collection team consisted of 50 persons (34 women and 16 men). The training occurred between July 12th and August 7th, 2021. However, the questionnaire was pre-tested by 12 enumerators and 8 health officers. Data collection was not implemented in the Tillabéri and Diffa regions due to insecurity, thereby reducing the number of visited clusters. This situation would only affect the representativeness of the data for the whole country.

A total of 4966 households were selected for the interview: 3694 were from rural areas and 1272 were from urban areas. Of the selected households, 1,198 and 3,567 resided in urban and rural areas, respectively. The participants provided their consent before their involvement in the

study. However, those women who were younger than 18 years participated, and this was subject to the consent of the adult members of the responsible households. Successful interviews were conducted in 1183 and 3546 households. Within the selected households, eligible women who were 15-49 years of age were 1690 and 4263 in urban and rural areas, respectively. However, the number of women who completed the survey was 1619 and 4176 in urban and rural areas, respectively (Institut National de la Statistique and ICF, 2023). This study used the women's reproductive age data file with information on antenatal care use.

Limitations and Ethical Compliance of the Study

The major limitations of this study were the fact that some of the targeted women did not provide consent to participate, and the two regions were omitted due to prevailing insecurity. Therefore, the representativeness of the data for the whole country may have been affected.

Estimated Econometric Model

The exponential mean model was used for data analysis. This model is applicable when the dependent variable is a count outcome. In this study, we estimated two models (k = 1 or 2). The first (k=1) has the dependent variable being antenatal care use intensity, which was measured as the number of antenatal visits during pregnancy. The second model (k=2) captures the timeliness of seeking antenatal care, which was measured as the pregnancy month at which antenatal care was sought. Using STATA 18 software, we tested the goodness-of-fit of the estimated Poisson regression model to ensure that the distributions were truly Poisson. The possibility of overdispersion was examined using the deviance goodness-of-fit and Pearson goodness-of-fit statistics, which showed no statistical significance ($p>0.05$). These results concurrently agreed that there was no overdispersion and that the Poisson regression could be appropriately fitted. Therefore, we have no justification to deviate from the proposed Poisson regression model. The estimated models are as follows:

$$Y_{ik} = exp(\alpha_k + X_i\beta_k) + \varepsilon_{ik}$$

Y_{ik} is the dependent variable, with i referring to the women and k referring to the value of the antenatal care intensity or the timeliness of seeking ANC. The explanatory variables were selected based on Andersen's (2008) healthcare utilization model, and the included variables were age of woman (years), region with Agadez being the reference (Coded as 1 for yes and zero otherwise for each of Diffa, Dosso, Maradi, Tahoua, Tillaberi, Zinder, and Niamey), urban (yes = 1, 0 otherwise), time to water (minutes), household size, number of under-5 children, gender of households' heads (male = 1, 0 otherwise), household head age (years), frequency of reading newspapers (not at all is the reference with each of less than once a week and at least once a week coded as 1 for yes and 0 otherwise), frequency of listening to radio (not at all is the reference with each of less than once a week and at least once a week coded as 1 for yes and 0 otherwise), frequency of watching television (not at all is the reference with each of less than once a week and at least once a week coded as 1 for yes and 0 otherwise), wealth index, child birth order, child is twins (yes = 1, 0 otherwise) and took Fansidar (yes = 1, 0 otherwise). We tested for multicollinearity among the selected independent variables using the variance inflation factor (VIF). The stochastic error terms in equation 1 are denoted as ε_{ik}.

Treatment Effects Model Specification

We explored the impact of education on the intensity and timeliness of ANC use. Education was coded as 0, 1, 2, and 3 for none, primary, secondary, and tertiary, respectively. The treatment indicators that were computed were the potential outcome means (POM), average treatment effect

(ATE), and average treatment effect on the treated (ATET). The POM is computed as $E(Y_0)$ in the population for no education, primary education, secondary education, or tertiary education if all women were to receive treatment. Therefore, POM is the counterfactual for each treatment group. The ATE is the difference between the mean values of the treated and control groups $[E(Y_1) - E(Y_0)]$. The ATET is the difference between the outcomes for the treated group with treatment and what they would have had if they were not treated $[E(Y_1) - E(Y_0)/T=1]$. The regression adjustment estimator was used due to its readily convergent behavior compared with any other estimators, such as inverse probability weighting (IPW) or regression adjustment with IPW, where convergence was problematic.

FINDINGS AND DISCUSSION

Demographic characteristics of the women

The results presented in Table 1 indicate the demographic characteristics of Nigerien women of reproductive age. The average age of the participants was 27.73 years. Most women resided in Maradi (24.81%), followed by the Zinda (22.61%), Tahoua (20.45%), and Tillaberi (14.25%) regions. However, Diffa and Agadez had the least number of respondents at 1.89% and 2.61%, respectively. The distribution of respondents though influenced by insecurity in some regions is in alignment with the population distribution in Niger, with Zinder, Maradi, Tahoua and Tillaberi having the highest number of people based on the 2020 projected population (City Population, 2020). In addition, 21.68% of respondents lived in urban areas. The proportion of urban respondents is slightly higher than the general population distribution, with 17% reported in 2023 (World Bank, 2023). The results also showed that the majority (73.01%) of the women had no education. This is in alignment with the 30% national literacy level reported for the adult female population in Niger (World Bank, 2024). This is supported by the results that revealed that the majority (98.43%) of the women did not read newspapers at all. In terms of the frequency of listening to the radio, 75.14% did not listen to the radio. Education is a facilitator of good health behavior adoption (Bertolazzi et al., 2024). Among women, it is a promoter of several socioeconomic dynamics and the development of cultural and societal integration (Hannum & Buchmann, 2005).

The average time it took to fetch water was 32.52 minutes. Specifically, when water is not on the house premises, the responsibility for water collection rests on women and girl children. This can be viewed as a waste of precious time that could have been used for other productive activities (UNICEF, 2016). The results showed that the average household size was 8.20 members per household, which can be compared with the national average of 7 children per woman reported by The Conversation (2023). Niger remains Africa's fastest-growing country (The Conversation, 2023) and has one of the youngest populations in the world (World Economic Forum, 2016). Our results showed that the average number of under-5 children was 2.25 children per household, while 93.14% of the households' heads were males. The average household head age was 41.95 years, and the average wealth index was -15122.

Table 1. Descriptive statistics of women selected demographic characteristics

Variables	Mean	Std. Err.
Antenatal visit	3.2521	0.0326
Age of the woman	27.7251	0.1589
Region		
Agadez	0.0261	0.0005
Diffa	0.0189	0.0004

Variables	Mean	Std. Err.
Dosso	0.0845	0.0015
Maradi	0.2481	0.0042
Tahoua	0.2045	0.0032
Tillaberi	0.1425	0.0030
Zinder	0.2261	0.0036
Niamey	0.0494	0.0016
Urban	0.2168	0.0026
Rural	0.7832	
Education level		
None	0.7301	0.0089
Primary	0.1613	0.0080
Secondary	0.1014	0.0059
Tertiary	0.0072	0.0015
Time to water arrival	32.5209	0.9041
Household size	8.2000	0.1324
Number of under-5 participants	2.2481	0.0373
Gender	0.9314	0.0056
Household head age	41.9530	0.3340
Newspaper Frequency		
Not at all	0.9843	0.0021
Less than once a week	0.0106	0.0019
At least once a week	0.0051	0.0013
Radio Frequency		
Not at all	0.7514	0.0093
Less than once a week	0.1384	0.0073
At least once a week	0.1102	0.0067
Tv Frequency		
Not at all	0.8630	0.0060
Less than once a week	0.0527	0.0046
At least once a week	0.0843	0.0049

Antenatal visit intensity and timeliness

Figure 1 shows the distribution of the respondents according to the number of antenatal visits and the pregnancy month during which antenatal care was sought. The results revealed that 30.84% of the respondents went for antenatal care three times, while 27.82% went four times. In addition, 8.06% of the respondents did not visit antenatal care, whereas 3.9% and 1.1% visited six and seven times, respectively. Our results showed that the majority of the respondents did not comply with the World Health Organization's (WHO's) recommended eight ANC visits, for which one should be made in the first trimester, two in the second trimester, and five in the third trimester (World Health Organization, 2016). Specifically, less than 1% of the women attended ANC eight or more times. However, when based on the old recommendation of at least four visits, 48.58% of the

women did not have up to 4 ANC visits, with 4.64%, 13.10%, and 30.84% having one, two, and three visits, respectively. Our findings agree with the submission of UNICEF (2016), which indicated that 52% of women in SSA attended ANC four or more times. In another study, 38.8% of the women used ANC four or more times in Malawi (NgÁmbi et al., 2022). Based on the timeliness of seeking treatment, the results showed that only 27.09% of the women complied with the recommendation of the WHO for one ANC visit during the first trimester. Moreover, 62.54% of patients visited for ANC within the second trimester, whereas 10.35% visited for ANC during the third trimester.

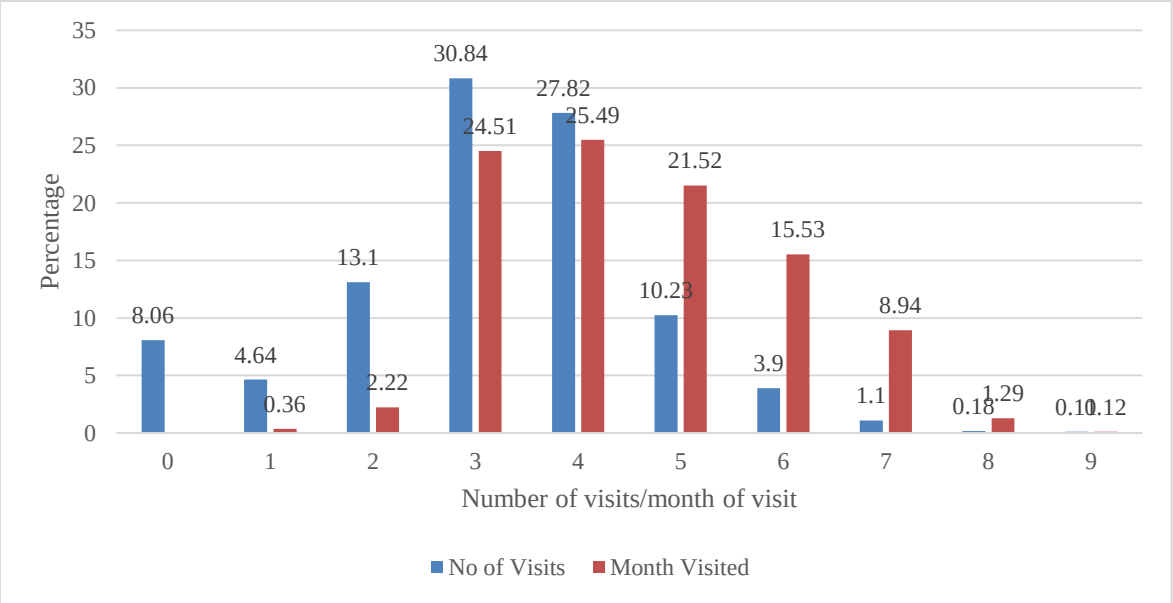

Figure 1. Distribution of the number of antenatal visits by month of pregnancy.

Education creates awareness of the benefits of health care services (Zimmerman et al., 2015). Figure 2 shows the distribution of respondents' number of antenatal visits according to education status. This result reveals that 10.2% of those without any form of formal education did not attend ANC. Moreover, of those who had a total of less than four ANC visits, 50.94% had no formal education, 48.77% had primary education, and 37.39% had secondary education. However, 18.52%, 22.22%, and 15.52% of respondents with higher education went for a total of five, six, and seven ANC visits, respectively.

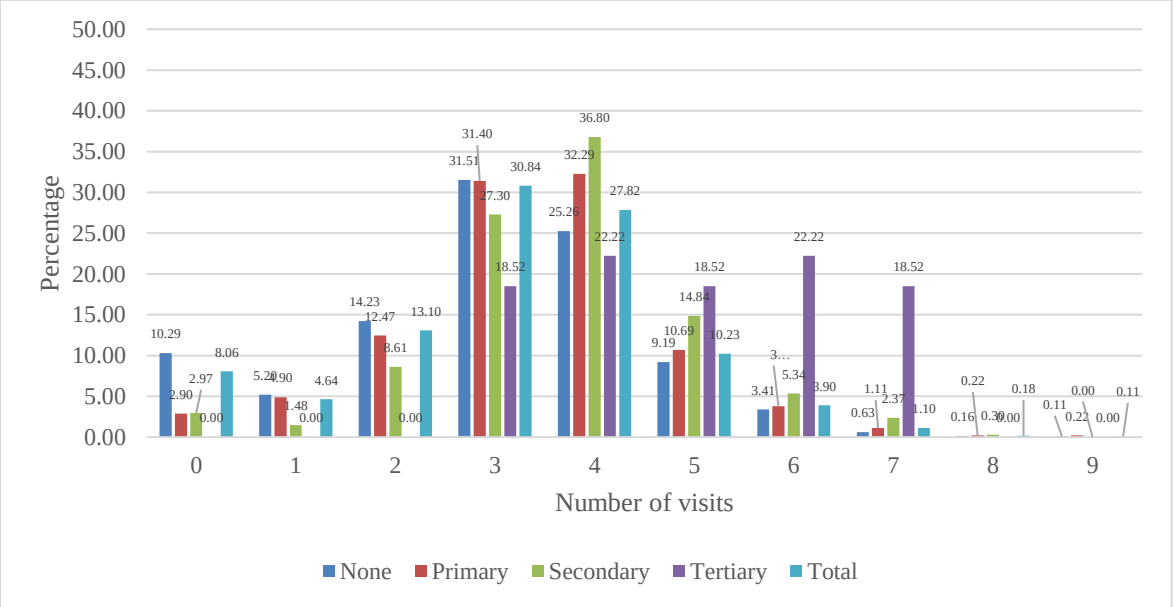

Figure 2. Distribution of the number of ANC visits according to education level.

Figure 3 further shows the distribution of the number of ANC visits by region and sector in Niger. The results reveal that across the regions, 30.56% and 12.12% of the respondents from Diffa and Agadez did not use ANC. Moreover, 37.25% of those from the Maradi region had three ANC visits, whereas 36.14% of those from Dosso visited four times. Five ANC visits were conducted by 17.49% of the women from the Tahoua region. In addition, based on the economic sector, 8.29% and 8.04% of the respondents from the rural and urban sectors, respectively, did not report any ANC. Also, in urban areas, 27.97% and 30.90% of the respondents reported four and three ANC visits, respectively. Moreover, in rural areas, 25.91% and 30.05% had four and three ANC visits, respectively. Table 2 further reveals the sources of ANC visits. This shows that 65.45% of the women attended ANC at integrated health centers, while 27.42% used a health unit/box.

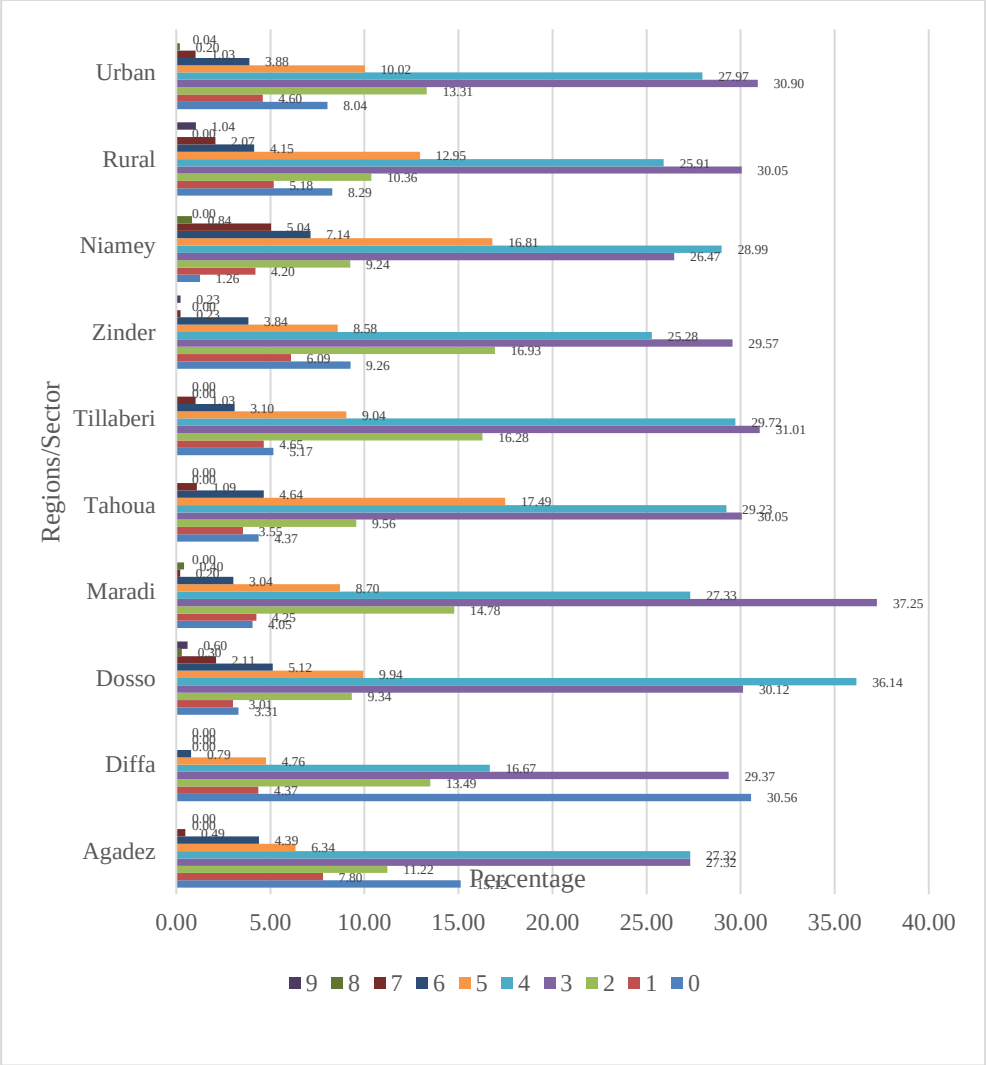

Figure 3. Distribution of number of ANC visits by region and economic sector

Table 2. Sources of antenatal care among women in Niger.

Sources of antenatal care	Mean	Std. Err.
Respondent's home	.0028022	.0010579
Other home	.0016013	.0008002
Government/national hospital	.0040032	.0012636
Reference maternity	.0228183	.0029883
Regional hospital center/health center mother-child	.0100080	.001992
District hospital	.0232186	.0030137
Integrated health center	.6545236	.0095162
National social security fund	.0056045	.001494
Health unit/box	.2742194	.0089278
Other public sector	.001201	.0006931
Private hospital/clinic	.0228183	.0029883
Private doctor	.0004003	.0004003
Private ANBEF clinic/center	.001201	.0006931
NGO hospital/clinic	.0008006	.000566
Other NGO medical sectors	.001201	.0006931

Sources of antenatal care	Mean	Std. Err.
Other	.0004003	.0004003

Determinants of ANC Visit Intensity and Timeliness

Table 3 shows the Poisson regression results for ANC use with intensity and timeliness as dependent variables. The two models and estimated parameters showed good fit and strong statistical significance (Prob>F = 0.0000). The distributions were confirmed to be Poisson, with the deviance goodness-of-fit postestimation tests in STATA 18 software did not show statistical significance (p>0.05). Therefore, there was no basis for trying other related count-dependent variable models.

The parameters for the age of women showed statistical significance in the two models (p<0.05). The parameter for use intensity implies that an increase in the age of women will increase the expected number of antenatal visits, with all other variables held constant. Similarly, a one-unit increase in women's age will lead to a reduction in the time to seek ANC. These findings agree with previous studies that found antenatal care use to be positively associated with the age of women (Ali et al., 2018; Simkhada et al., 2008). There are different pathways through which maternal age can influence ANC visits. Specifically, the likelihood of falling into a high-risk pregnancy group increases with age due to previous cesarean sections or complications (Frick, 2021; Abosse et al., 2010; Lampinen et al., 2009). However, the finding of Belayneh et al. (2014) showed that younger women had a higher likelihood of initiating ANC visits in the first trimester.

The results also revealed that when compared with women from Agadez, women who resided in Dosso, Maradi, Tahoua, and Niamey showed a significantly higher expected number of antenatal visits (p<0.05). The financial and administrative operations of health care service delivery in Niger largely rest on the government with 75-80% stake (Munshi, 2023). However, the distributional pattern of healthcare facilities also influences their use. Niamey, Maradi, and Tahoua have a good distribution of health care services. The fundamental problem of health care service use in Niger borders on accessibility because in some instances, patients may have to trek 14 kilometers or 6 hours to seek treatment (Elliot et al., 2005).

In addition, the parameter for women who resided in urban areas also showed statistical significance (p<0.01) with positive signs. This finding implies that women who resided in urban areas had a higher expected number of antenatal visits. This trend is expected due to the high concentration of health care facilities in most urban areas. In the context of Niger, accessibility to health care services is facilitated among urban residents who have existing transportation systems are functioning (Munshi, 2023). Our result agrees with those of Melaku et al. (2014), Dahiru and Oche (2015), Yaya et al. (2017), Haruna-Ogun (2018), and Verney et al. (2018).

The results further revealed educational differences among the estimated parameters. The estimated parameters for education showed that compared with women without education, Nigerien women with primary education had a significantly higher number of expected antenatal visits (p<0.05). Moreover, women with secondary and tertiary education had a higher expected number of antenatal visits (p<0.01) compared to those with no education. Similarly, the parameters of education in the timeliness of seeking ANC treatment model showed statistical significance (p<0.05) with negative signs. These results indicate that, compared with those without formal education, the time to first ANC treatment was significantly shorter across each education group.

These results are in alignment with those reported in Table 4, which shows that the ATE and ATET have positive signs for the ANC intensity of utilization and negative signs for the ANC timeliness of use. Specifically, the ATE revealed that compared with those who had not formal education, the average intensities of ANC utilization for women with primary, secondary, and tertiary education were higher by 0.2879, 0.2965, and 1.0494, respectively. Similarly, the ATE for

timeliness of ANC utilization revealed that compared with women without formal education, those with formal education had a decrease in the pregnancy month for seeking ANC by 0.2561 and 0.2885 for primary and secondary education, respectively. The ATET revealed that compared with never being treated, primary, secondary, and tertiary education increased the average ANC use intensities by 0.2610, 0.3148, and 1.1146, respectively. Similarly, compared with if they never received treatment, primary and secondary education reduced the month of pregnancy before seeking ANC treatment by 0.2776 and 0.2943, respectively. These results agree with expectations because education is a facilitator of health-promoting behavior. Therefore, the findings are in line with those of Awusi et al. (2009), Nketiah-Amponsah et al. (2013), Saad-Haddad et al. (2016), Dahiru and Oche (2015), and Tessema and Minyihun (2021).

The results further revealed the role of media programs in promoting the utilization of ANC services. Specifically, the results in Table 3 revealed that compared with women who did not listen to the radio at all, women who listened to the radio less than once a week had a higher expected number of antenatal visits ($p<0.01$). It was also revealed that women who listened to the radio at least once a week had a higher expected number of antenatal visits than those who did not listen to the radio at all ($p<0.05$). Radio programs can be a source of health-promoting information that can facilitate the utilization of ANC services. Similarly, the intensity of ANC use or timely treatment seeking can be facilitated by passing information through radio programs. Our results are in alignment with those of Aliyu and Dahiru (2017).

The estimated parameters for the wealth index were statistically significant ($p<0.01$) and positive in the ANC use intensity model. This result implies that an increase in the wealth index will increase the expected number of antenatal visits. Similarly, in the ANC timeliness use model, the parameter has a negative sign ($p<0.01$). This finding implies that an increase in the wealth index reduced the number of months of pregnancy before seeking antenatal care. These results project the role of wealth and emphasize the fact that women from wealthy households had higher ANC use intensity and reported for ANC earlier than those from poor households. These findings emphasize the healthy behavior promotional impacts of households' wealth or income and are in line with those of Nketiah-Amponsah et al. (2013), Saad-Haddad et al. (2016), Dahiru and Oche (2015), Nghargbu and Olaniyan (2019), and Tessema and Minyihun (2021). The results also showed that women who took Fansidar had a higher expected number of antenatal visits ($p<0.01$). Note that malaria in pregnancy is associated with stillbirth (Moore et al., 2017; McClure et al., 2022; Saito et al., 2020).

Table 3. Results of exponential mean modeling of the determinants of antenatal care use

	ANC Intensity		**ANC Timeliness**	
Variables	**Coef.**	**t stat**	**Coef.**	**t stat**
Age of the woman	0.0038	2.48	-0.0031	-2.77
Region Agadez is the reference.				
Diffa	-0.1599	-1.67	-0.0589	-1.74
Dosso	0.2267	3.43	-0.0413	-1.44
Maradi	0.1379	2.11	-0.0036	-0.13
Tahoua	0.2070	3.24	-0.0629	-2.25
Tillaberi	0.0926	1.10	-0.0225	-0.77
Zinder	0.0608	0.89	0.0191	0.70

	ANC Intensity		ANC Timeliness	
Variables	**Coef.**	**t stat**	**Coef.**	**t stat**
Niamey	0.1564	2.52	-0.0430	-1.32
Urban	0.1408	4.02	0.0401	1.26
Education: no education is the reference				
Primary	0.0598	2.35	-0.0477	-2.37
Secondary	0.1007	3.11	-0.0515	-2.15
Tertiary	0.2039	3.40	-0.1402	-2.75
Time to water arrival	-0.0002	-0.95	0.0000	-0.22
Household size	0.0019	0.60	-0.0014	-0.49
Number of under-5 participants	-0.0068	-0.55	0.0057	0.62
Gender	-0.0568	-1.46	0.0001	0.00
Household head age	0.0005	0.54	-0.0005	-0.71
Frequency of newspaper reading (not at all is the reference)				
Less than once a week	0.0372	0.66	0.0117	0.19
At least once a week	-0.1591	-1.93	-0.0217	-0.40
Frequency of listening to radio (not at all is the reference)				
Less than once a week	0.0717	2.87	-0.0353	-1.93
At least once a week	0.0869	2.46	-0.0215	-0.89
Frequency of watching to TV (not at all is the reference)				
Less than once a week	0.0056	0.15	-0.0059	-0.19
At least once a week	0.0653	1.69	0.0354	1.12
Wealth index	0.0000	3.37	0.0000	-4.11
Child birth order	0.0124	0.73	0.0016	0.13
The child is twins.	0.0444	0.65	-0.0298	-0.62
Took Fansidar	0.0727	3.52	-0.0033	-0.37
Constant	0.5983	5.70	1.5856	22.18
Number of observations	2717		2472	
F (27, 164)	7.2200		11.3200	
Prob > F, where	0.0000		0.0000	

Table 4. Distribution of ATE and ATET across educational levels in Niger

	ATE			ATET			POM			
	Primary	**Secondary**	**Tertiary**	**Primary**	**Secondary**	**Tertiary**	**None**	**Primary**	**Secondary**	**Tertiary**
ANC Intensity										
Parameter	0.2879	0.2965	1.0494	.2610	.3148	1.1146	3.1029	3.3908	3.3993	4.1523
z-statistic	3.83	2.81	0.87	3.30	3.15	0.92	81.51	51.56	34.37	3.43
ANC Timeliness										
Parameter	-0.2561	-0.2885	7.8512	-0.2776	-0.2943	8.5518	4.6706	4.4144	4.3821	12.5218
z-statistic	-3.34	-2.68		-3.64	-2.86		125.32	65.33	43.17	

CONCLUSION

The efficiency of antenatal care remains one of the vital indicators of UHC, with a significant impact on some targets in the SDGs. Although global progress has been made in addressing maternal and child mortality, some statistics have shown that more needs to be done if specific targets in the SDGs are to be met. The underlying challenge of promoting maternal and child health now rests on equitable and timely access to ANC. This study contributes to the ongoing debates and provides a policy implementation platform for addressing the intensity of ANC utilization and timeliness for the utmost advancement of maternal and child health. Our methodology deviated from previous analytical approaches by integrating the potential outcome framework of the causal treatment analysis within the exponential mean regression model to determine the ATE and ATET of education on the intensity and timeliness of ANC utilization.

Our results highlight some critical policy initiatives for promoting ANC use in Niger. More importantly, our findings provide some basis for evaluating the impacts of Niger's Plan de Développement Sanitaire et Social (PDSS), which started in 2017. Specifically, within the ambit of ongoing health policy formulation, initiatives to promote ANC utilization should address inadequate usage, given that the majority of the women did not comply with the eight visits that had been recommended by the WHO. These findings emphasize the need for school-based campaigns on ANC use at different educational levels in Niger. In addition, there is a need for persistent use of media outlets to create awareness regarding the recommended number of ANC visits and the benefits of such visits for averting maternal and child mortality. Such an initiative should target women in some regions with low ANC utilization, no formal education, and in rural areas. It is important to ensure the implementation of such campaigns in different languages that can be best understood by women. Moreover, although ANC services are offered free- of charge in Niger's public health care facilities, several poverty-related issues still mitigate accessibility. This implies that, beyond the freeness of ANC treatments, the institutional framework for promoting health care access and equity should be reconsidered, with the ultimate barriers facing the poor fully understood. Finally, there is a need to promote malaria prevention among pregnant women, which must be promoted due to the pressing health care pressures it poses. Such an initiative should propose a model of equity in the distributional pattern of mosquito-treated nets. Finally, this study has some limitations based on the basic problems associated with the cross-sectional

research methods. Therefore, there is a need for experimental or longitudinal studies that can effectively track causality between education and ANC.

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