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The impact of multidimensional poverty on antenatal care service utilisation in Malawi

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Abstract

Background Poverty remains a key barrier to accessing essential maternal health services, particularly in low- and middle-income countries like Malawi. Despite the recognised importance of antenatal care (ANC) in ensuring healthy pregnancies as well as improving maternal and child health outcomes, ANC services remain underutilised by many women living in poverty. This underutilisation is not solely driven by a lack of financial resources but also by a range of non-monetary factors that constitute multidimensional poverty, such as limited access to education, healthcare services, and infrastructure. While much of the existing literature focuses on monetary poverty, this study explores how multidimensional poverty impacts ANC utilisation. By examining how various deprivations intersect to limit access to ANC, this research contributes to understanding the broader issue of healthcare inequality.

Aim We assess the impact of multidimensional poverty (non-monetary) on antenatal care use in Malawi.

Method Multidimensional poverty was constructed using the Forster-Akire method of the Oxford Poverty and Human Initiative (OPHI). We use data from the 2015–16 Demographic Health Survey (DHS), which includes information on women aged 15–49 who gave birth within five years of the survey. To mitigate selection bias, we use Propensity Score Matching (PSM) techniques for our principal analysis.

Results Our findings reveal that 52% of women adequately utilised ANC services. About 8,428 women were identified as multidimensionally poor, and 4,685 were classified as non-poor. The results of our PMS analysis show a significant negative relationship between ANC utilisation and multidimensional poverty ($B=0.52$; $P<0.008$), indicating that multidimensionally poor women are less likely to use ANC services. Similarly, the timing of ANC visits also showed a negative relationship with multidimensional poverty ($B=0.26$; $P<0.04$), highlighting that multidimensionally poor women are less likely to attend ANC visits within the recommended first trimester.

Conclusion The findings suggest that there is a need for sustainable investments in poverty alleviation programs to address and reduce multidimensional poverty as well as raise awareness of sexual and reproductive health concerns among adolescents and women in Malawi to improve maternal health outcomes.

Keywords Multidimensional poverty, Poverty, Antenatal care, Malawi

Background

Pregnancy and childbirth are periods of heightened vulnerability for mothers and their unborn children. In 2020, 800 women died every day from preventable pregnancy-related causes; a staggering 95% of these maternal fatalities occurred in low and lower-middle-income countries [1]. The importance of early and frequent antenatal care (ANC) visits during pregnancy cannot be overstated. As underscored by Thakkar et al. [2], ANC plays

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a crucial role in identifying and mitigating risk factors in pregnancy and improving maternal and child health outcomes [3, 4].

Malawi's previous guidelines for ANC recommended that women use formal ANC services at least four times during pregnancy [5]. Recent evidence indicates that a higher frequency of antenatal contact with a healthcare provider is associated with a reduced likelihood of stillbirths [6, 7]. Adequate and timely ANC provides opportunities for early detection and management of pregnancy-related risks, and offers essential health tasks such as screening, diagnosis, and disease prevention [8]. More recently, the WHO updated its recommendations to eight visits [9].

Compared to four ANC contacts, eight or more contacts can reduce perinatal deaths by up to 8 per 1000 births [9]. However, a significant challenge persists in sub-Saharan Africa, where many pregnant women, particularly adolescents, initiate antenatal care attendance belatedly [10, 11]. This delay may deprive them of the full spectrum of preventive and curative services offered by such care [12, 13]. ANC situation in Malawi is dire. In 2010, 43% of women had four or more ANC visits, which increased to 47% in 2014 and 48% in 2016. Additionally, only 24% of pregnant women started ANC in the first trimester as of 2016 [14]. The numbers point to a catastrophe in terms of the uptake of ANC. This poor ANC situation may be one factor resulting in poor maternal outcomes in Malawi.

Maternal and neonatal mortality pose formidable challenges to public health in Malawi, where preventable maternal deaths remain alarmingly high [15]. Despite global efforts to reduce maternal mortality rates (MMR) to less than 70 deaths per 100,000 live births by 2030, [16] Malawi faces consistently high maternal mortality rates. As of 2020, the World Bank indicated a rate of 381 deaths per 100,000 live births [17], a slight improvement from 439 deaths per 100,000 live births in 2015 (Fig. 1). The stark disparity in global MMR underscores an urgent need for a comprehensive understanding of the numerous factors influencing maternal health outcomes, with implications not only for the well-being of women but also for human capital development and broader economic productivity.

Existing literature primarily focuses on unidimensional poverty measures, particularly the interaction between ANC and money-metric poverty [18]. Other scholarships explore the relationship between sociodemographic characteristics and ANC use but neglect the direct causal link between multidimensional poverty and ANC. Gomez et al. [19] and Towongo et al. [20], among others, conducted studies that focused on identifying individual, household, and community-level factors that could influence the number of ANC visits attended by women and factors associated with women's adequate utilisation of antenatal care services, respectively. Literature on the effects of monetary poverty on MMR demonstrates a negative relationship [15, 21–24].

Even with that focus, the above studies were not Malawi-specific. In Malawi, interest in ANC determinates has not gone without notice. Alongside this, several dimensions mar women's health in Malawi; among the many, these include lack of health personnel and facilities, education, lack of income, and mass media, to mention a few [25–30]. While some scholarship addresses the intersectionality of various sociodemographic factors [31], no study explores the effect of multidimensional poverty on the use of antenatal care services by Malawian women.

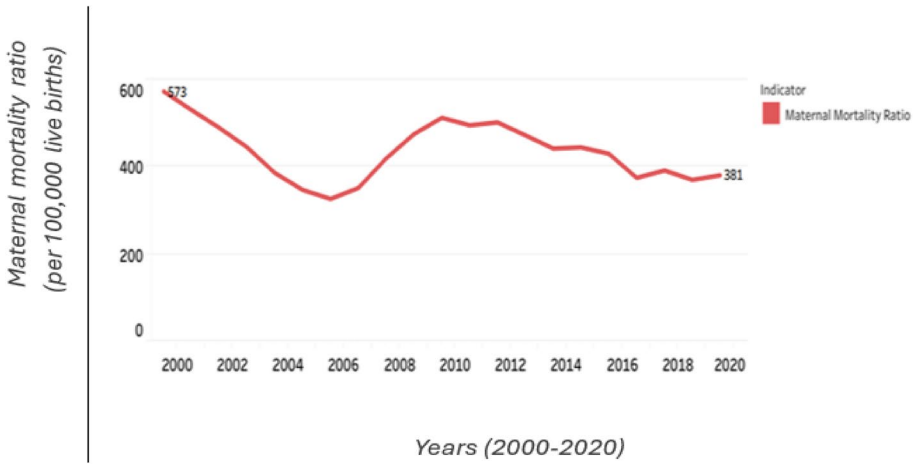

Fig. 1 The maternal mortality ratio of Malawian women over the years from 2000 to 2020 [5]

The use of multidimensional poverty, as opposed to income-based poverty, is considered superior for several reasons. Scholars argue that multidimensional poverty provides a more comprehensive understanding by considering various dimensions of deprivation beyond just income [32, 33]. First, not all needs can be met through the market, as markets are imperfect [34]. Governments and Non-Governmental Organisations (NGOs) often provide essential services like clean water and education. Second, households and individuals have different capabilities (functioning's) to use their income to meet needs and achieve goals, depending on their endowments [35]. Third, people living in poverty describe their situations using a variety of dimensions and not just incomes. Fourth, income or spending is merely a means to an end; what truly defines poverty is the outcome, not just the money itself. Fifth, income-based poverty measures are unreliable in the short-to-medium term, as they do not necessarily reflect an individual's or household's ability to sustain themselves [36]. Furthermore, income-based poverty measures overlook other crucial determinants, such as access to hygiene, protection, and safe drinking water, which form part of multidimensional deprivation [37]. As a result, multidimensional poverty is often considered more effective since it captures intraclass differences, especially in areas where a large proportion of the population may be monetarily poor [33].

Based on the information above, this paper will evaluate the relationship between non-monetary multidimensional poverty (also known as multidimensional poverty) and the utilisation of antenatal care. This exploration analysis aims to provide a better understanding, considering that poverty has been proven to adversely affect individuals' capacity to access and make use of resources, along with influencing the quality of available services.

Conducting this study in Malawi is crucial. While the government has implemented various social protection programs to alleviate poverty, the link between non-monetary poverty and women's health outcomes remains poorly understood. With a staggering 58.8% of the population living in multidimensional poverty [38] and some of the highest maternal mortality rates in the world [39], there is a pressing need for further research and interventions.

Materials and methods

Data and sample

This research utilised secondary data from the 2015–16 Malawi Demographic Health Survey (MDHS), a nationally representative dataset involving 24,562 women aged 15–49 from 26,361 selected households. The 2015–16 MDHS marks the fifth instance of the MDHS since 1992. The individual questionnaires from the MDHS include fertility, mortality, family planning, marriage, reproductive health, child health, nutrition, and HIV/AIDS. The 2015–16 MDHS utilised a two-stage stratified sampling methodology. Districts were divided into urban and rural areas, resulting in 56 sampling strata. In the first stage, 850 Enumeration Areas (EAs) were chosen with a probability proportional to their size within each stratum. Some larger EAs were segmented, with one segment randomly selected for the survey. In the second stage, a systematic selection process was employed to choose 30 households per urban cluster and 33 households per rural cluster from the household listing. Interviews were conducted with 23,504 women aged 15–49 and 7,356 men aged 15–54. The sample allocation incorporated power allocation to ensure consistent precision across districts and urban–rural areas. The methodology considered average numbers of women and men per household, informed by data from the 2010 MDHS. We restrict our analysis to women who had given birth in the five years leading up to the survey. All our analyses used weights as required for the DHS data.

Dependent variable

This study's dependent variable is binary, representing the frequency of ANC visits. A predefined threshold of a minimum number of ANC visits is four. This threshold aligns with the established guidelines of the Focused ANC (FANC) model, also recognised as the basic ANC model. The FANC prescribes four key ANC visits distributed between 8 and 12 weeks of gestation, 24 and 26 weeks, 32 weeks, and 36 and 38 weeks [40]. Therefore, individuals who attended at least four visits were assigned a numerical value of 1, while those who did not reach this threshold were assigned a numerical value of 0. The timing of the first ANC visit was separately assessed on the same covariates as a binary outcome; if a mother started her first ANC visits within the first trimester (early initiation or 12 weeks after the onset of pregnancy) this variable was assigned the numerical value of 1; and a value of 0 as assigned if otherwise. The first trimester threshold is defined by WHO guidelines and used at the time of data collection.

Explanatory variables

1. *Multidimensional poverty index*

The primary independent variable of focus is the Multidimensional Poverty Index (MPI), a comprehensive measure capturing deficiencies in fundamental needs and essential human capabilities within households. The MPI describes a range of poverty patterns that extend beyond simple income-based metrics, providing valuable insights

into different forms of deprivation [41]. The Global MPI has been used to assess severe non-monetary poverty in over 100 developing countries. Introduced in 2010 by the Human Development Report Office (HDRO) and the Oxford Poverty and Human Development Initiative (OPHI), the MPI supports Sustainable Development Goal 1, which aims to eradicate poverty in all its forms globally and evaluates combined shortcomings in indicators related to Sustainable Development Goals 1, 2, 3, 4, 6, 7, and 11 [42]. The MPI includes a detailed profile of deprivation for every household and individual within it, examining ten indicators across health, education, and living standards (see Table 1 for indicators). Each MPI indicator within the dimensions of multidimensional poverty is assigned a deprivation value. The deprivation status for each indicator is determined using a specific threshold, or cut-off point, that defines whether an individual is deprived in that area [41]. As a result, the MPI becomes a measure of deprivation, with poverty being assessed based on the number of indicators in which an individual is lacking.

For example, if a person is deprived in a certain indicator, it is assigned a value of 1, while non-deprivation is assigned a value of 0. Weights are then assigned to the indicators in the dimensions. The MPI is a composite measure, derived from the sum of all indicators given equal weights [37]. Dividing the sum of all indicators (which are weighted equally) by the total number of indicators ($n=8$) results in an index value between 0 and 1. In this study, MPI is represented as a binary variable where 1 represents "multidimensionally poor" and 0 represents "not multidimensionally poor".

2. *The education level of the mother* is captured by four categories: no education, primary education, secondary education, or higher education.
3. *The age of the mother* is captured by four age ranges: 15–20, 21–29, 30–35, and 36–49. This age-related categorisation provides a nuanced understanding of how maternal age influences healthcare service utilisation.
4. *Geographical variables* describe the mother's residential setting—rural (0) or urban (1)—and region—South (1), North (2), or Central (3) Malawi, offering insights into the potential regional variations in ANC service utilisation.
5. *Employment status* is captured as a binary variable that indicates whether the mother is employed (1) or unemployed (0). This variable provides valuable information on the potential impact of maternal employment on healthcare service utilisation.
6. *Birth parity* is used to categorise the mother's number of children into three groups: 1–3, 4–6, and 7 or more children. This sheds light on how the number of existing children might influence antenatal care service utilisation patterns.

Table 1 Variables used in the construction of the global multidimensional poverty index

Dimension and its weight	Indicator and its weight	Description
Health (1/3)	Nutrition (1/16)	A household is deprived if there is at least one child under 5 who is either underweight, stunted, or wasted
	Child mortality (1/6)	A household is deprived if any children died in the household in the last 5 years
Education (1/3)	Years of schooling (1/6)	A household is deprived if all members aged 15+ have less than 8 years of schooling OR cannot read or write English or Chichewa
	School attendance (1/6)	A household is deprived if at least one child aged 6-14 is not attending school
Living standards (1/3)	Electricity (1/18)	A household is deprived if it does not have access to electricity
	Cooking fuel (1/18)	A household is deprived if rubbish is disposed of on a public heap, burned, disposed of by other means or there is no disposal
	Housing (1/18)	A household is deprived if at least two of the following dwelling structural components are of poor quality: • Walls (grass, mud, compacted earth, unfired mud bricks, wood, iron sheets or other materials) • Roof (grass, plastic sheeting or other materials) • Floor (sand, smoothed mud, wood or other materials)
	Assets (1/18)	Members of the household are considered deprived in assets if the household does not own more than one of: radio, TV, telephone, bike, motorbike, refrigerator, computer or animal cart and does not own a car or truck
	Drinking water (1/18)	Members of the household are considered deprived if the household does not have access to safe drinking water according to MDG guidelines, or safe drinking water is more than a 30-minute walk from home roundtrip
	Sanitation (1/18)	Members of the household are considered deprived if the household's sanitation facility is not improved, according to MDG guidelines, or it is improved but shared with other households

7. *Marital status* is a covariate used to indicate whether the mother is married or non-married. This variable acknowledges the potential influence of marital status on healthcare service utilisation behaviors.
8. *Contraceptive use*: This variable will also be included in the analysis to see if the use of contraceptives also influences the utilisation of antenatal care by pregnant women.

Data analysis

We employ three methods of analysis. First, we calculate frequencies and then undertake bivariate analysis. Secondly, we conduct regression analysis through a logit model. Lastly, we undertake a propensity score matching (PSM) technique. PSM comes in because selection bias may result from a causal relationship between our two variables of interest, multidimensional poverty and ANC use. This comes from the fact that health is endogenous since it is both a consumption and an investment (Folland & Stano), [43]. To ensure unbiased estimates, we used PSM to mitigate selection bias and facilitate a shift toward a causal estimate [44]. A propensity score is the likelihood of receiving a treatment (in this case, being multidimensionally poor) conditional on the baseline covariates.

To estimate the treatment effects using PSM, the first step will be to compute a logit propensity score (probability of attending at least 4 ANC visits based on given covariates) for each observation. These propensity scores will be used to match observations later. Therefore, the following equation will be estimated:

$$Y_i = \alpha + \beta_1 MPI + \beta iXi + \mu \tag{1}$$

In this equation, the binary variable Y_i captures two aspects of antenatal care (ANC) use for each individual '*i*,' where '*i*' represents an individual in the study: the frequency of ANC visits and the timing of the first ANC visit. For frequency, Y_i takes the value of 1 if an individual '*i*' attended at least 4 ANC visits and 0 otherwise. Regarding the timing of visits, Y_i is assigned 1 if the individual '*i*' visits within the 12 weeks of the gestation period and 0 otherwise. The explanatory variable MPI represents the multidimensional poverty index, interpreted by the coefficient β_1. The vector of covariates is represented by X_i, while μ accounts for the error term, capturing unobservable factors that influence ANC use.

Propensity score matching

The estimation of the propensity scores using the logit model will be as follows [44]

$$\mathrm{PS} = \mathrm{P(X_i)} = \mathrm{Pr\,(Yi = 1|X)} \tag{2}$$

Where *PS* is the propensity score; $\mathrm{P(X_i)}$ is the likelihood of an expecting mother attending at least 4 visits and the probability of a mother attending ANC visits within the first trimester, conditioned on X Covariates. As demonstrated by other scholars, the observations for the propensity score obtained above are matched using the neighbour matching algorithm with replacement to stabilise the obtained estimators [45]. The Average Treatment Effect (ATE) of each expecting mother:

$$\mathrm{ATE_i} = \mathrm{Y_i}(1) - \mathrm{Y_i}(0) \tag{3}$$

Provided that the ATE measure the average differences in the outcomes between the treatment and control groups, we observe that *Yi*(1) represents outcome (1 if attended at least 4 visits and 0 otherwise) for the treated sample; *Yi*(0) represents the outcome for the control sample.

Therefore, this study will adopt the average treatment on the treated sample (ATT), with a binary indicator of the dependent variable and a treatment group of "poor" represented as $\mathrm{M_1} = 1$ and the control group of "non-poor" represented as $\mathrm{M_1} = 0$, the equations will be as follows:

$$\mathrm{ATT} = \mathrm{E[ATE_i|M_i} = 1] \tag{4a}$$

$$\mathrm{ATT} = \mathrm{E[Y_i}(1) - \mathrm{Y_i}(0)|\mathrm{M_i} = 1] \tag{4b}$$

This equation calculates the average difference in the utilisation of the ANC between the treated and the control groups.

$$\mathrm{ATT} = \mathrm{E_{p(xi)}\{[Y_i}(1)|\mathrm{M_i} = 1, \mathrm{P(X_i)}] - \mathrm{E[Y_i}(0)|\mathrm{M_i} = 0, \mathrm{P(X_i)}]|\mathrm{M_i} = 1\} \tag{4c}$$

Equation (4c) incorporates the propensity score P(Xi) representing the likelihood of being in the treatment group (multidimensionally poor), given a set of covariates.

Results

Descriptive statistics

The descriptive statistics for the variables assessed in this study are presented in Table 2. The analysis included 13,113 women who had given birth within five years prior to the survey. The results indicate that 34.4% of the sample were multidimensionally poor, with the frequency of ANC visits averaging 52% and 26% of women attending ANC visits at the recommended time. Only 20.6% of women met the frequency and timing recommendations for ANC visits. Regarding residence, 17.3% of the women resided in urban areas. Most of the women were married

Table 2 Descriptive statistics of variables assessed

Variable	Mean
Multidimensional poverty	34.4%
Frequency of ANC visits	52%
Timing of ANC visits	26%
Frequency & timing of ANC visits	20.6%
Residence	17%
Married	82.5%
Employed	65.8%
Use contraceptives	61%
Mothers age	
15-20	13.9%
21-29	46.7%
30-35	23.4%
36-49	16%
Close to the nearest health facility	53.5%
Birth parity	
1-3	61.1%
4-6	30.3%
7+	8.6%
Region	
Northern region	1.9%
Central region	34.6%
Southern region	46.3%
Literacy	
No education	11.7%
Primary	65.2%
Secondary	21.2%
Higher	1.9%

(82.5%), and 65.8% of the women were employed. Contraceptive use was reported by 61% of the sample. Most women were under 35 years old (81%); 13.9% were aged 15–20, 46.7% were aged 21–29, 23.4% were aged 30–35, and 16% were aged 36–49. Regarding birth parity, 61.1% of women had between 1–3 children, 30.3% had 4–6 children, and 8.6% had 7 or more children. Most women live in the Southern region 46.3%, 34.6% in the Central region, and 19% live in the Northern region. Literacy levels varied, with 11.7% having no education, 65.2% having primary education, 21.2% having secondary education, and only 1.9% having higher education.

Apart from the descriptives, it is also vital to understand which dimensions contribute to deprivation. This is indicated in Fig. 2. The 2015–16 data highlights significant areas of deprivation among this population. A significant percentage of respondents (89%) were deprived of electricity, 75% did not have adequate housing, and 48% experienced asset deprivation. These high levels of deprivation indicate widespread economic insecurity and underscore the need for comprehensive policies and interventions to address these fundamental deficits and improve overall living standards.

After reviewing the univariate analysis, we look at the bivariate relationship between the primary variable and other related factors. This step is essential because it shows how the primary variable is linked to each factor independently, without considering the effects of other factors. This helps us examine how different groups compare across several characteristics. Table 3 presents this bivariate analysis, exploring the connection between multidimensional poverty and various covariates.

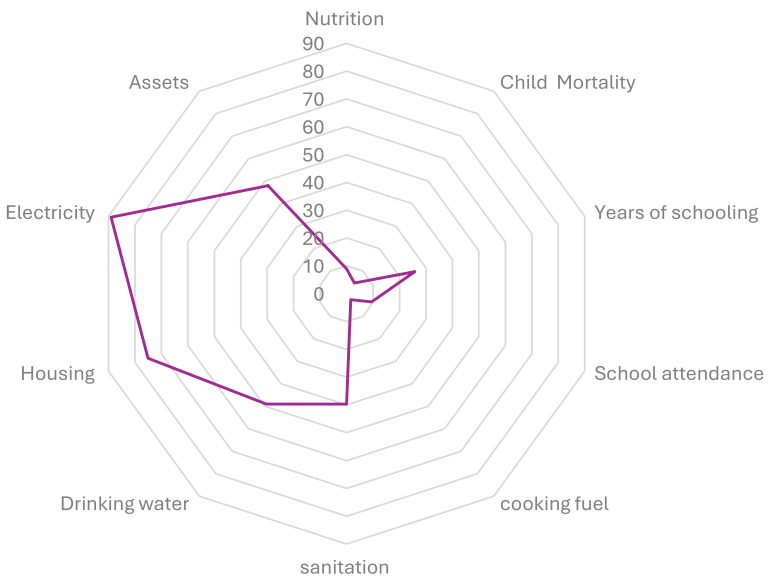

Fig. 2 The distribution of multidimensional poverty deprivations across key dimensions. Source: Computed by Author

Table 3 highlights key sociodemographic differences between multidimensionally poor and non-poor individuals. A larger proportion of the poor reside in rural areas (93.85%) compared to the non-poor (76.83%), while urban areas have a higher percentage of non-poor individuals (23.17%) than the poor (6.15%). Regionally, the Southern region has the highest proportion of multidimensionally poor individuals (51.10%), with the Northern region having the lowest (11.12%). In terms of age, the youngest group (15–20 years) is slightly more represented among the poor (14.20%), though the non-poor are more prevalent in older age groups, particularly those aged 36–49 years (14.37% vs. 13.89%). Education is a significant factor, with a much higher percentage of the poor lacking education (22.14%) compared to the non-poor (6.25%), while more non-poor individuals have

Table 3 Bivariate analysis of the multidimensional poverty index and covariates

Variable	Not multidimensionally poor N (%)	Multidimensionally poor N (%)	Total N(%)	Significance
Residence				***
Rural	6,612 (76.9)	4,230 (93.9)	10,842 (82.7)	
Urban	1,994 (23.4)	277 (6.2)	2,271 (12.3)	
Region				
North	1,997 (23.2)	501 (11.12)	2,498 (19.1)	
Central	2,835 (33)	1,703 (38)	4,538 (34.6)	
South	3,774 (44)	2,303 (51.1)	6,077(46.3)	
Mother age				***
15–20	1,181 (13.7)	640 (14.2)	1,821 (14)	
21–29	4,187 (49)	1,935 (42.93)	6,122 (47)	
30–35	2,001 (23.3)	1,065 (23.6)	3,066 (23.4)	
36–49	1,237 (14.4)	867 (19.2)	2,104 (16)	
Literacy				***
No education	538 (6.3)	998 (22.1)	1,536 (11.7)	
Primary	5,344 (62.1)	3,204 (71.1)	8,548 (65.2)	
Secondary	2,488 (29)	298 (6.6)	2,786 (21,3)	
Higher	236 (2.7)	7 (0.16)	243 (1.9)	
Employment				**
Not working	3,064 (35.6)	1,425 (31.6)	4,489 (34.3)	
Working	5,542 (64.4)	3,082 (68.4)	8,624 (65.8)	
Contraceptive use				***
Not using	3,143 (36.5)	1,974 (43.8)	5,117 (39)	
Using	5,463 (63.5)	2,533 (56.2)	7,996 (61)	
Marital status				
Non-married	1,315 (15.3)	982 (21.8)	2,297 (17.5)	
Married	7,291 (84.7)	3,525 (78.2)	10,816 (82.5)	
Birth Parity				**
1–3	5,674 (66)	2,336 (51.8)	8,010 (61.1)	
4–6	2,381 (27.7)	1,596 (35.4)	3,977 (30.3)	
7 +	550 (6.4)	577 (12.8)	1,127 (8.6)	
Distance				*
Not a problem	4,396 (51.1)	1,700 (37.7)	6,096 (46.5)	
Big problem	4,210 (48.9)	2,807 (62.3)	7,017 (53.5)	
Frequency of ANC				***
Less than 4	3,955 (46)	2,329 (51.7)	6,284 (47.9)	
More than 4	4,651 (52)	2,178 (54)	6,829 (48.3)	
Timing of ANC				***
Recommended time	6,282 (73)	3,411 (75.7)	9,693 (74)	
Otherwise	2,324 (27)	1,096 (24.3)	3,420 (26)	

*** $p < .01$, ** $p < .05$, * $p < .1$

secondary or higher education. Employment disparities also exist, with a larger share of the poor currently working (68.38% vs. 64.40%). Additionally, contraceptive use is lower among the poor (56.20% vs. 63.48%), and the poor are more likely to have 4–6 children (35.41% vs. 27.67%). Issues such as distance to healthcare and fewer antenatal care visits (less than four) are also more pronounced among the poor (62.28% and 51.68%, respectively) compared to the non-poor (48.92% and 45.96%).

Logit regression results for the impact of multidimensional poverty on ANC

The results from the logit model in Table 4 highlight several important factors that influence the use of ANC services. The analysis shows that multidimensionally poor women are less likely to attend ANC visits ($\beta = -0.106$, $p < 0.01$). Women living in urban areas are more likely to use ANC services than those in rural areas ($\beta = 0.18$, $p < 0.01$). Additionally, education plays a key role, with higher levels of education linked to greater ANC usage ($\beta = 0.171$, $p < 0.01$). Older mothers also tend to make more ANC visits ($\beta = 0.165$, $p < 0.01$), and women who use contraceptives are more likely to seek ANC services ($\beta = 0.147$, $p < 0.01$). Furthermore, employment is another positive factor, as employed women are more likely to attend ANC visits ($\beta = 0.096$, $p < 0.05$). However, distance to health facilities has a negative impact, with women living far are less likely to make ANC visits ($\beta = -0.071$, $p < 0.1$). Similarly, women with more children (higher birth parity) are less likely to utilise ANC services ($\beta = -0.093$, $p < 0.05$).

Region and marital status did not have significant effects at typical levels. The logistic regression analysis for the timing of ANC visits showed similar results to those of the frequency of ANC visits, with only minor differences in the strength of the effects Table 5.

With a clear association between MPI and the timing of ANC, we observe that distance ($\beta = -0.085$, $p = 0.04$) plays a crucial role in determining how promptly individuals attend these visits. As the distance to the nearest health facility increases, the likelihood of attending ANC visits within the recommended timeframe decreases. This holds true regardless of one's region or residence; both factors were insignificant with $P-$ values of 0.22 and 0.25 respectively, at a 95% confidence interval. Furthermore, literacy and contraceptive use have significant positive impacts on ANC visit attendance, with coefficients of 13% and 26% respectively.

We also find that as a mother's age increases, the likelihood of attending ANC visits in a timely manner also increases. However, as the number of children increases, the mother's attendance of ANC visits within the first trimester becomes less likely. By interacting the two variables for both frequency and timing to separately assess the relationship between birth parity and mother's age, it is observed that as a mother's age increases along with the number of children she has, there is a higher likelihood of adequately accessing and utilising ANC services. This likelihood improves even further if the mother has attained an education beyond primary school level, is engaged in economic activity, and uses contraceptives.

Table 4 Logit model estimation of the determinants of antenatal care service use

ANCV	Coef.	St. Err.	*p*-value	[95% Conf	Interval]	Sig
MPI	−0.106	0.04	0.008	−0.184	−0.028	***
Residence	0.18	0.051	0.000	0.08	0.281	***
Region	−0.016	0.024	0.487	−0.063	0.03	
Literacy	0.171	0.032	0.00	0.107	0.235	***
Mothers age	0.165	0.028	0.00	0.11	0.219	***
Contraceptives	0.147	0.037	0.00	0.075	0.219	***
Married	−0.022	0.047	0.637	−0.115	0.07	
Employed	0.096	0.038	0.011	0.023	0.17	**
Distance	−0.071	0.037	0.056	−0.143	0.002	*
Birth parity	−0.093	0.041	0.023	−0.172	−0.013	**
Constant	−0.353	0.095	0.000	−0.539	−0.166	***
Mean dependent var	0.521		SD dependent var		0.500	
Pseudo r-squared	0.010		Number of obs		13,113	
Chi-square	179.217		Prob > chi2		0.000	
Akaike crit. (AIC)	17,999.111		Bayesian crit. (BIC)		18,081.406	

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: Calculated by author

Table 5 Logit model estimation of the determinants of the timing of ANC visits

TANCV	Coef.	St. Err.	*p*-value	[95% Conf	Interval]	Sig
MPI	−0.050	0.04	0.04	−0.1409	−0.038	***
Residence	−0.064	0.056	0.254	0.176	0.046	
Region	−0.032	0.026	0.22	−0.020	0.08	
Literacy	0.128	0.036	0.00	0.0562	0.2005	***
Mothers age	0.131	0.028	0.00	0.070	0.19	***
Contraceptives	0.261	0.037	0.00	0.175	0.343	***
Married	−0.048	0.047	0.37	−0.115	0.07	
Employed	0.0176	0.043	0.681	−0.066	0.102	
Distance	−0.08	0.0417	−0.041	−0.167	−0.003	***
Birth parity	−0.171	0.041	0.00	−0.273	−0.079	***
Constant	−1.471	0.099	0.00	−1.665	−1.2769	***
Mean dependent var	0.26		SD dependent var		0.500	
Pseudo r-squared	0.0065		Number of obs		13,113	
Chi-square	93.1		Prob > chi2		0.000	
Akaike crit. (AIC)	9333.011		Bayesian crit. (BIC)		7477.10	

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: Calculated by author

Matching results

Matching diagnostics

Before we undertake the matching, several tests must be performed to ensure that our matching passes the requirements. This involves checking the overlap conditions, common support, and variable balance. This will be done for each dependent variable of interest.

To estimate the treatment effects, the propensity score approach assumes that there are no significant differences between treated and untreated individuals after matching [46]. Any indication of differences necessitates balancing the treatment and control groups. In this context, covariates are considered balanced when the standardised differences in the matched data are close to zero, and the variance ratios approach one. Table 6 presents a comprehensive summary of the covariate balance, highlighting both the standardised differences and variance ratios between treated and control groups before and after matching [47, 48]. This further corroborates the effectiveness of the matching procedure in minimising differences between treated and control observations.

Figure 3 presents a plot for the distribution of propensity scores generated through the PSM estimator. The top panel shows the initial distribution before matching the sample, while the bottom panel shows the distribution after matching. In both panels, the solid line represents the propensity scores distribution of the treated sample (the multidimensionally poor population), while the dotted line represents the untreated (the non-poor). The initial panel demonstrates sufficient overlap between the two groups, with a significant portion of the distribution including women from both groups regardless of their treatment status. The lower panel validates that matching has adjusted the distribution of propensity scores to align closely. Consequently, the covariates associated with being treated or not are now represented as if the primary distinction between the treated and control groups is the treatment itself.

Table 6 Covariate balance overview: pre- and post-matching comparison

	Standardized Differences		Variance Ratio	
	Raw	Matched	Raw	Matched
Residence	−0.496	−0.007	0.324	0.988
Married	−0.168	0.000	1.317	1.000
Employed	0.084	0.001	0.943	0.999
Use contraceptives	−0.149	0.021	1.062	0.990
Mothers age	0.104	0.003	1.151	0.967
Distance	0.271	−0.004	0.940	1.001
Birth parity	0.312	−0.009	1.337	1.007
Region	0.262	0.023	0.736	0.957
Literacy	−0.759	0.001	0.708	1.021

Overlap condition for the frequency and timing of ANC visit

Figure 4 cements the overlap evidence shown in Fig. 3 by showing the proportions of the treated and untreated on and off common support. The results are satisfactory: most of the sampled women's propensity scores are within the common support region. This provides evidence that the PSM estimator produces reliable estimates.

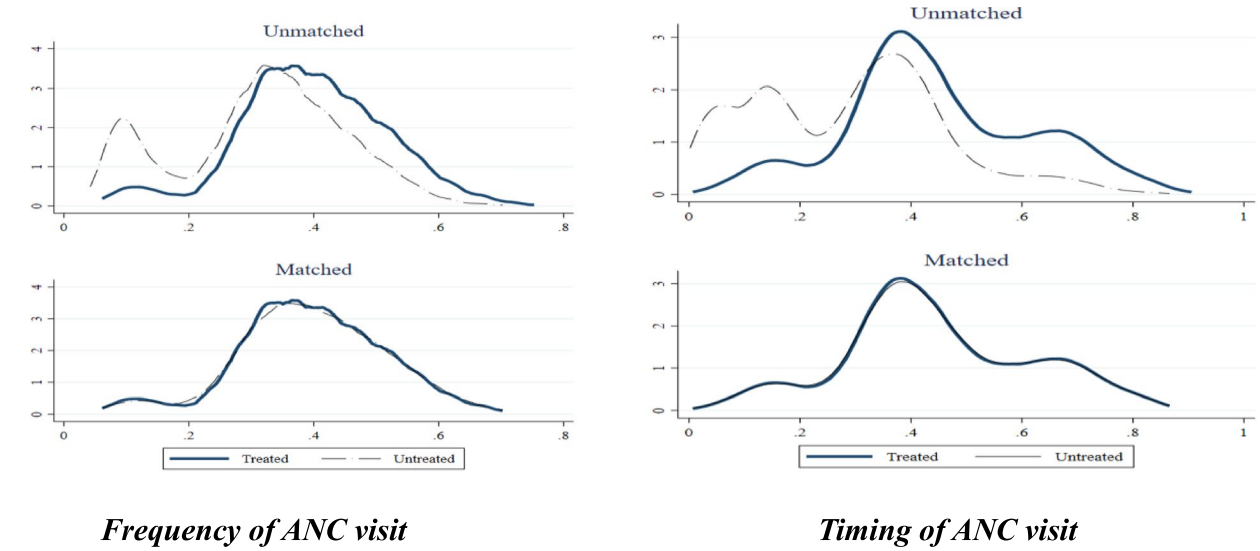

Fig. 3 The distribution of propensity score before and after matching, author

Common support condition for the frequency and timing of ANC visit

Significant results were found after estimating the propensity scores of the model. Tables 7 and 8 shows the estimation results for the frequency of ANC visits. The Average Treatment Effect on the Treated (ATET) coefficient is −0.037, indicating that being in the treated group (multidimensionally poor) is associated with a decrease of 3.7% in the probability of attending more than four ANC visits. With a significant p-value of 0.001 at a 95% confidence level, the mean dependent variable of 0.521 suggests that, on average, 52.1% of the sampled population attend more than four ANC visits. Regarding the timing of ANC visits, with a statistical significance of 0.021, the ATET coefficient stands at -0.023. This indicates that poverty is linked to a reduced likelihood of a woman attending her first ANC visit within the first trimester. Furthermore, only 26% of women make timely ANC visits.

Discussion

The primary aim of this study was to evaluate the impact of multidimensional poverty on ANC service utilisation among Malawian women, with a keen focus on individual, household, and community-level variables that could explain variations in service use. Our salient findings are indicated below.

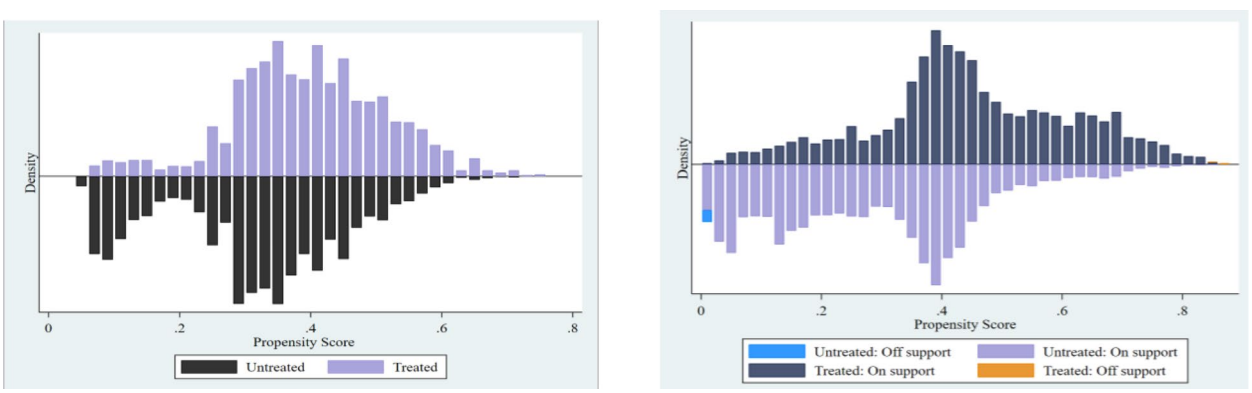

Fig. 4 The distribution of observations on common support, (Visualized by author)

Table 7 Treatment-effects estimation for the frequency of ANC visits

ANCV	Coef.	St. Err.	*p*-value	[95% Conf	Interval]	Sig
ATET	-.037	.011	.001	-.059	-.014	***
Mean dependent var	0.521		SD dependent var		0.500	

*** $p<.01$, ** $p<.05$, * $p<.1$

Source: Tabulated by author

Table 8 Treatment-effects estimation for the timing of ANC visits

TANCV	Coef.	St. Err.	*p*-value	[95% Conf	Interval]	Sig
ATET	-.023	.01	.021	-.043	-.003	**
Mean dependent var	0.261		SD dependent var		0.439	

*** $p<.01$, ** $p<.05$, * $p<.1$

Source: Tabulated by author

The findings underline the need to address socioeconomic disparities between the poor and non-poor, as evidenced by the inverse relationship observed between multidimensional poverty and ANC service use. Notably, 34% of the sampled population were identified as multidimensionally poor, with higher rates among those in rural areas. The demographic profile revealed that 83% of participants were women under 35 years old. While 52% attended more than four ANC sessions, only 26% did so within the first trimester, far below WHO recommendations as adequate ANC utilisation. Furthermore, just 20% of women, predominantly from urban areas, met the number and timing criteria for ANC visits. Regional disparities were also apparent, with minimal ANC service uptake among women in the southern region. Regional disparities in in ANC uptake have also been observed in previous studies in Malawi [49]. With education greatly explaining the various regional dimensions [50] as people from the south appear to have less schooling [14, 28].

Based on our findings, higher education levels for both spouses and mothers are revealed to significantly enhance ANC utilisation, emphasising education's role in improving health outcomes. Educated women, especially those who have gone beyond secondary education understand the value of ANC visits and navigate healthcare systems effectively. This finding aligns with studies from Bangladesh, Nigeria, Ghana, and Ethiopia [4, 10, 11, 51–53]. Education improves various health-seeking behaviors, enables informed choices, and bridges language and cultural barriers. Additionally, education empowers women to challenge traditional gender norms and make autonomous decisions about their sexual and reproductive health [54]. Empowered women can easily make a voice regarding their health outcomes, as it has also been recently noted in Mozambique [55, 56].

Furthermore, we observe a positive impact of employment on ANC use [57], as employment provides women with autonomy in managing their sexual and reproductive health, regardless of their marital status or age [58, 59]. Women who are educated, employed and engaged in economic activities are more likely to understand the benefits of maternal health care and attend ANC visits on time [15, 60] They also tend to have larger social networks, giving them further access to education, financial resources, and health care information.

The positive impact of urban residence on the frequency of ANC utilisation aligns with existing literature, which highlights differences in access to healthcare facilities between rural and urban areas [61]. However, other studies suggest that urban poverty, particularly in disadvantaged neighbourhoods of large cities, can lead to poor maternal health outcomes [62]. In Malawi, location plays a significant role, as some areas lack healthcare facilities due to their remoteness [63]. Additionally, many healthcare professionals are reluctant to work in these isolated regions [64], further widening health disparities, including access to ANC services. However, the findings indicate that the delay in the timing of the first ANC visit is not linked to either residence or region. Shedding more light towards the demand side being of importance in determining whether a person timely utilises ANC services.

The limited use of ANC services among young mothers highlights the knowledge gap and the need for increased awareness of the importance of maternal health care. Awareness campaigns should target younger mothers, as well as those with multiple births who may not seek ANC services. Both young and older mothers are vulnerable to pregnancy complications and could benefit from additional educational resources. Studies by Hyzam et al. [65],

Ohaja et al. [66], and Sumankuuro et al. [67] emphasise how media campaigns addressing social norms and community beliefs can help overcome barriers to health-seeking behaviours among pregnant women.

The findings of this study reveal a concerning underutilisation of ANC services, despite the availability of largely free healthcare in Malawi [63, 68]. Multidimensionally poor women are less likely to use ANC services both frequently and early in their pregnancies. Social determinants of health, including literacy, contraceptive use, maternal age, employment, exposure to mass media, and urban residence, are associated with higher ANC utilisation. The covariates affect both the supply and demand aspects of maternal healthcare services. The demonstrated impact of multidimensional poverty on maternal health supports the need for interventions that extend beyond mere physical access to services, particularly in rural areas. Programs aimed at poverty alleviation, income generation, and empowerment through education, entrepreneurship, and financial inclusion can significantly improve ANC use and maternal health outcomes.

Pointing out that multidimensional poverty impacts ANC utilisation is consistent with literature suggesting that poverty limits access to health care services [11, 20, 62, 69]. These barriers could include financial constraints, lack of information, and sociocultural factors that prioritise immediate survival needs over long-term health investments. These findings echo other research that has identified poverty as an inhibitor of health consumption [43].

Having said the above, it is essential to understand the drivers of the results we observe. It is important to highlight that just before the MDHS (2015–16) data collection, Malawi experienced several extreme weather events, which likely worsened the wealth status of many households, disproportionately affecting women [70, 71]. Women were identified as highly vulnerable during this period, prompting government interventions such as cash transfers. This vulnerability reflects a broader trend in Malawi, where poverty and inequality have increasingly been viewed through a gendered lens over the past decade [68]. Similarly, Machira [72] observed that between 2016 and 2019, the rate at which women were able to escape poverty remained very low. These factors likely exacerbated the disparities in ANC utilisation found in our study, particularly among multidimensionally poor women.

Conclusion

In this paper, we evaluated the causal impact of multidimensional poverty on ANC service utilisation. Our key finding is that non-monetary poverty significantly reduces both the timing and frequency of ANC visits. Key findings show that older women who are employed, educated and use contraceptives are more likely to utilise ANC services as recommended. Furthermore, long distances to health facilities also reduce the likelihood of service use. Interestingly, our findings indicate that as mothers age, their likelihood of attending ANC visits in a timely manner increases. Conversely, higher birth parity reduces the likelihood of timely ANC visits during the first trimester. However, when examining the interaction of maternal age and birth parity, we observe that older mothers with more children are more likely to adequately access and utilise ANC services.

Despite the findings, there are several limitations associated with the paper. The primary limitation of this study is the lack of recent data on ANC utilisation. The study relies on 2015–16 MDHS data due to the absence of more recent data capturing the frequency and timing of ANC visits among Malawian women. Data collected in the last few years could provide a more robust and relevant reflection of the current situation. Additionally, unobservable confounding factors that affect the use of ANC services were not captured in the propensity score matching estimation technique. Future studies should consider using time series data to capture the variation and evolution of ANC use over time and address unobservable covariates that are time-variant or time-invariant. The use of cross-section data does not capture transient changes in poverty statuses over time. This is important because the poverty transition has a gender dimension [72]. Furthermore, this study could provide a more comprehensive understanding of the barriers to ANC use by including an assessment of the quality of maternal health care services. Lastly, future studies could benefit from assessing poverty using the Malawi-specific MPI, as incorporating local poverty dimensions might yield different results.

Despite the limitations, our paper has important implications for policy. Understanding the impact of multidimensional poverty on the utilisation of maternal health services is essential for designing effective and sustainable policies, programs and demanding side interventions. Our findings support policy interventions that reduce monetary and non-monetary poverty, promote sexual and reproductive health education, and expand ANC and other healthcare services in underserved areas. Promoting family planning and contraceptive use also plays a crucial role in improving health literacy and ANC uptake. Women can receive information about the importance of ANC and maternal health services during family planning sessions. Additionally, healthcare infrastructure must be adapted to better meet the needs of multidimensionally poor women. Providing targeted training and incentives for health personnel can boost health-seeking

behaviours and enhance service delivery for marginalised women. Outreach programs and mobile clinics are essential for reaching rural areas where health personnel can provide ANC services and sexual and reproductive health education. Direct interaction with healthcare workers may encourage women to attend ANC visits later in pregnancy, while raising community awareness about the importance of maternal health practices.

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Authors' contributions
AGC: Conceptualisation, analysis, and writing; GCC; Writing, re-analysis and supervision.

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Data availability
All data used are publicly available on the DHS website: https://dhsprogram.com/methodology/survey/survey-display-592.cfm.

Declarations

Ethics approval and consent to participate
We used secondary data that does not require taking consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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