WOMEN'S EMPOWERMENT AND ITS ASSOCIATION WITH PREGNANT WOMEN'S NUTRITIONAL STATUS AND BIRTH WEIGHT IN WEST SHEWA ZONE, CENTRAL WEST ETHIOPIA: A FOLLOW-UP STUDY

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DISSERTATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PhD) IN PUBLIC HEALTH

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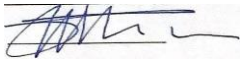
Prof. Mitike Molla (PhD)		28/03/2025
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List of original papers

This dissertation work is based on the following four original papers, which are listed below.

Paper I. Etea T, Yalew A, Sisay M. Pregnant women's empowerment in West Shewa Zone, Ethiopia: its dimensions, levels and determinants (Draft manuscript)

Paper II. Etea T, Yalew A, Sisay M, Shiferaw S. Predicting nutritional status during pregnancy by women's empowerment in West Shewa Zone, Ethiopia. Front. Glob. Womens Health. 2023; 4. doi: 10.3389/fgwh.2023.1147192.

Paper III. Etea T, Yalew A, Sisay M. Mediating effects of women's empowerment on dietary diversity during pregnancy in Central West Ethiopia: A structural equation modeling. Glob. Health Action. 2023; 16:1, 2290303, DOI: 10.1080/16549716.2023.2290303

Paper IV. Etea T, Yalew A, Sisay M. A structural equation modeling analysis of women's empowerment influence on birth weight of infants in West Shewa Zone, Ethiopia. Ethiop. J. Health Dev.2023; 37(4). DOI: https://doi.org/10.20372/ejhd.v37i4.6024

Acronyms/Abbreviations

ANC	Antenatal Care
ANOVA	Analysis of Variance
AOR	Adjusted Odds Ratio
BMI	Body Mass Index
CFA	Confirmatory Factor Analysis
CFI	Bentler Comparative Fit Index
CI	Confidence Interval
Cm	Centimeter
DHS	Demographic and Health Survey
g/dL	Gram per deciliter
EDHS	Ethiopian Demographic and Health Survey
EFA	Exploratory Factor Analysis
FAO	Food and Agricultural Organization
G	Gram
GDI	Gender Development Index
GPI	Gender Parity Index
HCG	Human Chorionic Gonadotropin
LBW	Low Birth Weight
LMP	Last Menstrual Period
MUAC	Mid-upper arm circumference
MDD-W	Minimum Dietary Diversity-Women
RMSEA	Root-Mean-Square Error of Approximation
SD	Standard Deviations
SDGs	Sustainable Development Goals
SEM	Structural Equation Modeling
SRMR	Standardized Root Mean Square Residual
SWPER	Survey-based Women's emPowERment index
TLI	Tucker–Lewis index
UNICEF	United Nations Children’s Fund
WEAI	Women’s Empowerment in Agriculture Index
WHO	World Health Organization
WLS	Weighted Least Squares
WLSMV	Weighted Least Squares Means and Variance Adjusted

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Abstract

Background: Maternal nutrition during pregnancy has a significant impact on the health of the mother as well as newborn's birth weight, health, and chances of survival in infancy and beyond. In Ethiopia, a substantial percentage of pregnant women have poor nutritional status due to inadequate dietary intake. Consequently, low birth weight is prevalent in the country. On the other hand, it is well acknowledged that improvements in maternal nutritional status and birth outcomes can be achieved through women's empowerment. Nevertheless, the relationships between the multiple dimensions of women's empowerment and nutritional status of pregnant women and birth outcomes have not been adequately explored.

Objectives: To determine the level of women's empowerment and its association with nutritional status and dietary diversity of pregnant women, and birth weight among women attending antenatal care at public health facilities in West Shewa Zone, Central West Ethiopia.

Methods: A health facility-based cross-sectional and prospective follow-up studies were conducted from January to December 2021. Multistage sampling was used to enroll 1,453 second- and third-trimester antenatal care-attending pregnant women; and they were followed until delivery. At enrolment, information on socio-demographic, obstetric, and women's empowerment characteristics on economic, familial/interpersonal, socio-cultural, time, and psychological empowerment dimensions was collected using a semi-structured, pretested questionnaire which was administered by interviewers after getting participants' written informed consent. Besides, mid-upper arm circumference (MUAC) and hemoglobin levels were measured at enrolment. Data on dietary diversity were gathered at enrolment and in the next antenatal care follow-up visit using the minimum dietary diversity for women tool. Birth weight was measured within one hour after delivery. Univariable descriptive analysis was conducted to describe each variable. Exploratory and confirmatory factor analyses were conducted on half of the samples to identify and validate dimensions of women's empowerment. Bivariable and multivariable logistic regression analyses were used to identify the factors associated with women's empowerment. Multivariable logistic regression was applied to assess the relationships between pregnant women's empowerment and anemia status and mid-upper arm circumference levels. Structural equation modeling was used to examine the mediating effects of women's empowerment on dietary diversity during pregnancy, as well as to investigate its direct effect of

women's empowerment on birth weight. All statistical tests were considered significant at p-value less than 0.05.

Results: The factor analysis results identified and confirmed that household decision-making power, economic, communication, psychological, assertiveness, and time dimensions to operationalize women's empowerment for Paper I and II. About 54.2% (95% Confidence Interval (CI): 51.7, 56.8) of the pregnant women were empowered overall. The highest and least empowerment was in household decision-making power and communication dimensions, respectively. Older women were more empowered in economic (adjusted odds ratio (AOR)=2.2, 95%CI: 1.2, 4.0) and assertiveness (AOR=1.9, 95%CI: 1.1, 3.1) dimensions than younger women. Women's higher education level was positively associated with household decision-making power (AOR=2.6, 95%CI: 1.4, 4.9), communication (AOR=4.9, 95%CI: 2.8, 8.8), psychological (AOR=2.0, 95%CI: 1.3, 2.9) and time (AOR=4.0, 95%CI: 2.3, 7.2) dimensions. Being rural women, housewives, and having multiple children were negatively associated with the time dimension.

About 32.1% (95% CI: 29.7, 34.5) of the pregnant women were anemic, while 21.1% (95% CI: 19.0, 23.2) of them were undernourished. The odds of being free from anemia among overall empowered pregnant women was 1.91 times higher among less empowered pregnant women (AOR=1.9, 95% CI: 1.5, 2.4). Similarly, empowered pregnant women had higher odds of having MUAC ≥ 23 cm compared to those with less empowered pregnant women (AOR=1.8, 95% CI: 1.3, 2.4). Pregnant women who were empowered in the economic (AOR=1.71, 95% CI: 1.26, 2.22) and assertiveness (AOR=1.90, 95% CI: 1.46, 2.38) dimensions had higher odds of being free from anemia compared to those less empowered in these areas. Empowered pregnant women in household decision-making power (AOR=1.6, 95% CI: 1.2, 2.2) and psychological (AOR=1.4, 95% CI: 1.0, 1.9) dimensions had higher odds of having normal MUAC measures than those less empowered in the respective dimensions.

More than half, 61.8% (95% CI: 59.2, 64.4), of the pregnant women consumed inadequately diversified diets during their pregnancy. Household decision-making power (beta (β)=0.131, $p<0.05$), psychological (β=0.237, $p< 0.001$) and time (β=0.146, $p<0.01$) dimensions were directly and positively associated with dietary diversity during pregnancy. Household decision-making power, psychological and time empowerment were higher among pregnant women who

had higher education level. These dimensions were significant mediators in the relationship between pregnant women's education and dietary diversity. However, the economic dimension was related to neither pregnant women's education nor dietary diversity.

The mean birth weight of the newborns was 3,168.5g (standard deviation=460.6). About 6.3% (95% CI: 5.0, 7.8) of them weighed low at birth. Newborn's birth weight was higher among women who had higher household decision-making power (β=0.091, $p<0.05$). On the contrary, higher economic empowerment among women was associated with delivering infants with lower birth weight (β=-0.444, $p<0.001$).

Conclusions: Around half of the pregnant women were empowered. Poor nutritional status among pregnant women remains a public health concern in the study area. Generally, empowered pregnant women had better nutritional status compared to those with less empowerment. A significant number of pregnant women did not consume sufficiently diversified diets. Empowerment in household decision-making power, psychological, and time dimensions was linked to the consumption of more diverse diets during pregnancy. Notably, better education of the pregnant women was also significantly associated with their higher empowerment in these dimnsions implying women's empowerment as a pathway by which education contributed to adequate dietary diversity during pregnancy. Birth weight was higher among mothers with higher household decision-making power but lower among those who had higher economic empowerment.

Recommendations: Empowering women in economical, household decision-making power, assertiveness, and psychological dimensions can be considered as a strategy in policy and intervention programs to achieve better nutritional status among pregnant women. Interventions that aim at reducing poor dietary diversity during pregnancy should emphasize on women's empowerment in household decision-making power, psychological and time dimensions as well as increasing availability of formal education to women, which is also important for empowering them. Birth weight can be improved by empowering women in household decision-making power. Further examinations on the mechanisms of the influence of women's empowerment dimensions on pregnant women's nutritional status and birth weight are recommended to enhance the effectiveness of empowerment interventions in improving maternal and child health.

Key words: pregnant women, nutritional status, dietary diversity, birth weight, women's empowerment, West Shewa Zone, Ethiopia

1. Introduction

1.1. Background

Rapid growth and development in human life occur from pregnancy to a child's 2nd birthday (1). In line with this, maternal nutrition during pregnancy is widely recognized as a crucial factor for the health of both the mother and the fetus, influencing the fetus's growth and development (2–4). It affects not only the immediate outcomes of pregnancy but also the long-term health of the infant (5,6).

Although it is preventable, poor nutritional status affects millions of pregnant women globally (7). For instance, anthropometric, biochemical, and dietary assessments in developing countries demonstrate that pregnant women are often affected by poor nutritional status (8–10). Mid-upper arm circumference (MUAC) (11) and hemoglobin levels (12) have been used as indicators of the nutritional status of pregnant women. Ethiopian studies have reported as high as 31.8% of pregnant women have poor nutritional status as indicated by their low MUAC (13)**.** Moreover, anemia based on hemoglobin status during pregnancy remains a public health problem in the country (9,14–16). According to Ethiopian Demographic and Health Survey (EDHS) 2016, 29% of pregnant women were anemic (17).

Similarly, dietary diversity has been used to assess the nutrient adequacy of women's diets (18). Consuming a diverse range of foods helps meet the increased nutrient requirements of pregnancy, supporting the needs of the pregnant woman, the fetus, and future lactation (18–20). Pregnant women with inadequate dietary diversity are likely to consume less amounts of nutrients than required, increasing their risk of deficiency and related adverse health outcomes for both themselves and their babies (4,21,22). In developing countries, many pregnant women do not consume adequately diversified diets during pregnancy (23,24). In Ethiopia, the pooled prevalence of inadequate dietary diversity among pregnant women is 59% (23), implying the need to address this public health issue.

Birth weight is an important predictor of morbidity and mortality in childhood and adulthood (25,26). Based on birth weight, newborns are classified into low birth weight (LBW) (<2,500g), normal birth weight (2,500g to 3,999 g) and macrosomia (≥4,000g) (25,27). Both LBW and

macrosomia are linked to higher short- and long-term risks for newborns. In 2020 alone, an estimated 19.8 million newborns weighed low at birth worldwide (25). Recognizing it as a global public health problem, the World Health Organization (WHO) aims to reduce LBW by 30% by 2025 compared to 2012 (28). In Ethiopia also abnormal birth weight is prevalent, with the national survey showing that 13% of births were low in weight (17). On the other hand, as high as 19.1% of macrosomia has been reported (29).

Empowerment is “a process by which the powerless gets greater control over circumstances in terms of both ideology and resources” (30). On the other hand, women’s empowerment is defined as “an expansion in the range of potential choices available to women so that actual outcomes reflect the particular set of choices which the women value” (31). It is underlined that resources, agency, and achievements should be indivisible in measuring women’s empowerment (31). Moreover, economic, socio-cultural, familial/interpersonal, legal, political, and psychological dimensions have been identified as factors that affect women’s empowerment (32). The various dimensions and indicators of women's empowerment emphasize that it is reflected in their decision-making power, ability to access and control resources, sense of self-worth, and their ability to control both their own lives and the lives of their families (31–34).

Understanding the importance of the issues, the United Nations put empowering women, addressing the nutritional needs of pregnant women and ensuring healthy lives, and promoting well-being for all at all ages among its priority agendas of the Sustainable Development Goals (SDGs) (35). Besides being an end goal in itself, women’s empowerment is highly acknowledged as one of the significant factors for achieving better maternal and child health and nutrition outcomes (36–39). However, the associations between women’s empowerment and nutritional status of pregnant women, and the birth weight of their newborns are not well documented in Ethiopia.

1.2. Statement of the problem

According to WHO, anemia is considered to be a public health problem if population studies reveal an anemia prevalence of 5% or higher, as measured by hemoglobin concentration (12). Globally, around 37% of pregnant women are affected by anemia (40). Understanding the depth of the problem, WHO has planned to reduce anemia by 50% by 2025 (41). In 2019, anemia was estimated to contribute to 22% of maternal deaths (42).

The Ethiopian Government's National Nutrition Strategy focuses on improving the nutritional status of pregnant women (43). Despite national efforts to combat undernutrition, a significant proportion of pregnant women in Ethiopia remain malnourished (8–10,15,16). Similarly, the findings in the Oromia Region have also confirmed that anemia, based on hemoglobin measurement during pregnancy, was a moderate (44) and severe (45) public health problem in the Region. Moreover, West Shewa Zone was identified as one of the areas with the highest prevalence of anemia among pregnant women (46). Low maternal hemoglobin levels (<11 g/dL) during pregnancy have been associated with adverse birth and maternal outcomes, including preterm birth, stillbirth, small-for-gestational-age infants, postpartum hemorrhage, and preeclampsia (3). Moreover, pieces of evidence from different regions of Ethiopia indicate undernourishment, which is operationalized by MUAC<23cm, affects a significant number of pregnant women in the country (8,10) including the West Shewa Zone (47,48). MUAC level of a pregnant woman is known to determine the birth weight of newborns (49) and the development of gestational diabetes mellitus (50).

Nutritional deficiencies during pregnancy lead to adverse health outcomes that affect both the mother and her baby, including an increased risk of obstructed labor, death due to postpartum hemorrhage (2), preterm birth (4), and low birth weight (4,22). Unfortunately, as high as 94% inadequate dietary diversity among pregnant women has been reported in Sub-Saharan African countries (51). Likewise, considerable proportions of pregnant women in Ethiopia consume monotonous food and inadequately diversified diets. According to Ethiopian studies, a range of 44.4% to 84.4% of pregnant women consumed inadequately diversified diets during their pregnancy (48,52–57). These studies indicated that cereal or grain food groups comprised the highest proportion of pregnant women's diet, whereas meat, egg, and dairy products

consumption was very low. In the study area, as high as 73.6% of pregnant women were reported to consume less diversified diets than recommended (47).

About 15% of births around the world are low in weight (25). LBW increases the risks of infant mortality (58), poor cognitive development (59) and chronic diseases in adult life (60). On the other hand, macrosomia increases the risks of perinatal asphyxia (61) and neonatal hypoglycemia (62). Macrosomic infant has higher long-term risks of type 2 diabetes (63), overweight (64), and cancer (65) while the mother can experience postpartum hemorrhage (66), persistent perineal defects, and anal dysfunction (67). A range of 8.8% (68) to 23.3% (69) LBW has been reported from Ethiopia's different regions. In the Oromia region, it was 13.1% (17). Moreover, LBW is a significant contributor of infant deaths in Ethiopia (70,71). The prevalence of macrosomia in Ethiopia has increased over time. Recent studies have indicated a prevalence of macrosomia ranges from 7.5% (72) to 19.1% (29) in the country.

Despite efforts to reduce anemia among reproductive-age women and low birth weight at a global level (28,41), maternal malnutrition and abnormal birth weight remain a global public health concern (73). Parallel to this, the Government of Ethiopia's National Nutrition Strategy aims at improving the nutritional status of vulnerable populations such as pregnant women by implementing different activities including anemia prevention and dietary diversification during pregnancy (43). Regardless, maternal undernutrition is a public health concern in Ethiopia (10,15,16). Though women's empowerment is deemed important for maternal and child nutrition improvement, there is still a gap in identifying the important dimensions owing to its context-specific and multidimensional nature (74).

Women's empowerment is characterized by its multidimensionality and abstract nature (31,32,75) and can be influenced at multiple levels including individual, household, community, and national levels (32). As a result, it can be measured differently from one study to the other. Owing to this, different studies may report varying findings on the same investigation based on which dimension and level are measured.

Although different indicators and dimensions were used to measure women's empowerment, the available studies reported mixed findings on the relationships between women's empowerment and their nutritional status and birth outcomes. For instance, a study in Northern Benin found that the leadership dimension was a significant predictor of the nutritional status of reproductive-

age women, while decision-making and economic security did not show a significant association with women's nutritional status (76).

In Ethiopia, women with low decision-making autonomy were more likely to be malnourished compared to those with high decision-making autonomy (77). Some studies have reported a positive and significant relationships between women's empowerment and dietary diversity among reproductive-age women (76,78–81). However, some studies have also found negative (82) or no associations (78). A study conducted in Ethiopia found that women's empowerment, as measured by Women Empowerment in Agricultural Index, was positively associated with better women's dietary diversity (83). Moreover, women's empowerment was linked to increased dietary diversity during pregnancy. For example, higher levels of empowerment were associated with the consumption of more diverse diets among pregnant women. Pregnant women with greater household decision-making power and economic empowerment were more likely to have a more varied diet compared to those with lower levels of empowerment (84). Overall, women's empowerment in the various dimensions is believed to promote the health and nutritional status of women before and during pregnancy, thereby increasing the chance of delivering normal-weight babies (76,82,85–88).

The focus on women's empowerment at this particular period lies not only in the concern for the mother's health but also at the heart of the newborn's lifelong well-being, which is highly dependent on the mother's well-being during pregnancy. Even if good nutritional status and adequate dietary diversity during pregnancy are positively associated with better pregnancy and birth outcomes, the contribution of poor dietary diversity and maternal undernutrition during pregnancy to adverse outcomes is a reality in Ethiopia (4,89). Nonetheless, to the best of our knowledge, little is known in Ethiopia about the role the various dimensions of women's empowerment play in the nutritional status of pregnant women and the weight of the newborn they deliver. Therefore, we aimed to examine the associations of the multiple dimensions of pregnant women's empowerment levels with their nutritional status during pregnancy and the weight of their newborns.

1.3. Rationale of the study

Despite the recognized importance of women's empowerment in maternal and child health and nutrition improvement, its impact is insufficiently examined in developing countries including Ethiopia (90). The fact that considerable proportions of pregnant women's poor nutritional status and abnormal birth weight reports from different studies in Ethiopia are implications for the prevention of poor nutritional status and pregnancy outcomes to be recognized as an important public health priority in the country.

Most studies in Ethiopia have addressed the determinants of nutritional status of pregnant women (9,10,53,55) and birth weight (68,69) from socio-demographic and dietary perspectives. However, the influence of the multiple dimensions of women's empowerment on nutritional status and dietary diversity among pregnant women and its consequence on infants' birth weight have not been empirically examined and their correlations are not well established. Therefore, this study aimed to fill this gap and generate evidence to strengthen interventions intended to improve maternal and child health in the study area.

Although women's empowerment is recognized as a significant factor in maternal and child nutrition and health improvement, its influence may vary across countries with different cultures. In addition, it is the dimensions of empowerment that give useful information when analyzing associations and setting targets for possible intervention programs used to improve health outcomes (91). Thus, this study helped to identify the setting-specific and multiple dimensions of women's empowerment that are more significant to nutritional status and newborns' birth weight status since they were poorly understood in the study area and it was not clear to what extent maternal empowerment contributes to the study's outcomes.

Therefore, the findings of this study could be used as input both for empowering women and the development of enriched interventions for improving maternal nutritional status and birth outcomes in the study area as well as at the national level for policymakers setting strategies targeting pregnant women and newborns.

2. Literature review

2.1. Nutritional status of pregnant women

2.1.1. Nutritional status by MUAC among pregnant women

Anthropometric measurements, Body Mass Index (BMI), and MUAC, have been used to identify nutritional status during pregnancy. Some studies have applied adult women's BMI cut-off value for identifying malnutrition in pregnant women with the assumption it applies for pregnant women (92). MUAC has been widely used owing to its relatively strong association with LBW, narrow range of cut-off value, ease of measuring, and insensitivity to changes during pregnancy contrary to BMI. A cut-off value of <23cm is recommended (49).

Worldwide studies reveal that undernourishment (low MUAC) affects pregnant women in different corners of the world. For instance, around 38% of pregnant women had low MUAC (<23cm) in Eastern India (93). A finding from Cambodia also reported more than 20% of pregnant women had MUAC < 23cm (94). In Khartoum, Sudan, 12.5% of the pregnant women were malnourished (MUAC<23 cm (95). According to a study in Kenya, 9.9% of pregnant women in urban low-income settlements in Nairobi had MUAC < 23 cm (96).

Some studies conducted in Ethiopia applied a cut-off value of MUAC<21cm to determine the nutritional status of pregnant women. For instance, studies from Gambella (97), Central Rift Valley (13), and Wondo Genet district (98) reported that 28.6%, 31.8%, and 9.2% of pregnant women were undernourished (MUAC<21cm), respectively. On the other hand, studies that used MUAC<23cm to determine undernourishment among pregnant women in Konso district (99)(G, Bench-Sheko and Kaffa Zones (100), and six districts of Sidama region (101) indicated that 43.1%, 42.4%, and 38% of the pregnant women had <23cm MUAC measurement, respectively.

Similarly, studies in different districts and zones of Oromia region pointed out that low MUAC is prevalent. For instance, about 41%, 44.9%, and 44.9% of pregnant women in Tiro Afeta, Woliso and Goma districts (102), Gumay district (103), and Liban district (104) had MUAC<23 cm during their pregnancy, respectively. In West Shewa Zone, study area, 23.9% and 17.7% of the pregnant women in Ambo (47) and Gindeberet districts (48) were undernourished (MUAC< 23cm), respectively.

2.1.2. Magnitude of anemia among pregnant women

Studies in different parts of the world determined anemia status during pregnancy using WHO's cut-off value for hemoglobin level in blood i.e. hemoglobin < 11g/dl (12) and have reported varying results. Reduction of anemia prevalence among reproductive-age women is one of the indicators of SDGs (indicator 2.2.3) (105) besides the commitment to halve it by 2025 (41). The global prevalence of anemia among pregnant reproductive-age women is 37% (40). The prevalence of anemia among pregnant women has decreased slightly over the years in low- and middle-income countries. Around 40.1% of the pregnant women in these countries are anemic (106). In addition to being the most affected continent, a severe form of anemia among pregnant women is also most prevalent in Africa (40). The pooled prevalence of anemia among pregnant women was estimated to be 41.8% (107) in East Africa, indicating it is a major public health problem in the region.

According to a systematic review and meta-analysis, the estimated overall prevalence of anemia among pregnant women in Ethiopia was 26.4%. In the subgroup analysis, the pooled prevalence was higher in community-based studies than in facility-based studies. Furthermore, the lowest and highest pooled prevalence of anemia among pregnant women were in the Addis Ababa region, 10.1%, and Somali region, 56.8%, respectively. It was 26.5% in Oromia region (108). Further analysis of the 2016 EDHS data showed that mild (17.1%) and moderate anemia (17.3%) were more common than severe anemia (3.1%) (109). Even though the percentages vary, the individual study findings in different regions of Ethiopia also confirm anemia during pregnancy is a public health problem. Recent studies from regions of Amhara (110), Tigray (111), Sidama (15), and Eastern Ethiopia (9) have reported 20.9%, 16.3%, 24.1%, and 33.1% anemia among pregnant women, respectively. Similar to the findings in other regions of Ethiopia, studies in the Oromia region have also indicated that as high as 46.1% of pregnant women could be affected by anemia (45).

These evidences from different corners of the country indicate that the government of Ethiopia's National Nutrition Program II (NNP II) target to reduce the prevalence of anemia among pregnant women to 14% by 2020 (43) still requires more work even beyond its era. Moreover, they imply the need for more activities to be on track to meet the UN's global target of ending all forms of malnutrition by 2030 (35).

2.2. Magnitude of dietary diversity among pregnant women

The different studies reviewed here have used individual dietary diversity scores using the 24-hour dietary recall method, women's dietary diversity score (WDDS) and minimum dietary diversity for women (MDD-W), as well as the food frequency questionnaire approach to assess dietary diversity during pregnancy. Most recent studies have widely applied MDD-W which categorizes food groups into 10: 1) Grains, white roots and tubers, and plantains; 2) Pulses (beans, peas, and lentils); 3) Nuts and seeds; 4) Dairy; 5) Meat, poultry and fish; 6) Eggs; 7) Dark green leafy vegetables; 8) Other vitamin A-rich fruits and vegetables; 9) Other vegetables; 10) Other fruits.

Studies conducted around the world revealed varying findings on dietary diversity during pregnancy. For instance, a study that used MDD-W to assess dietary diversity in four low-middle-income countries discovered that 20%, 25%, 50%, and 70% of the pregnant women in Pakistan, the Democratic Republic of the Congo, Guatemala and India had adequate dietary diversity, respectively (112). According to a study in the Banlung district of Nepal, around 45% of pregnant women consumed $\leq$ 5 of the 10 food groups (84).

Studies in Sub-Saharan African countries indicate that African pregnant women predominantly rely on plant-based food groups rather than animal foods. At the same time, the consumption of fruits is low during pregnancy (23,113). Some studies have also found that there was no change in the amount and type of foods consumed during pregnancy irrespective of the increased nutritional need during pregnancy (114,115). A study in Southern Benin revealed that dietary diversity was the same before and during pregnancy, and it was low in all three trimesters (114). A health facility-based study in Puntland, Somalia, reported that around 48.2% of the pregnant women had an inadequately diversified diet (24).

Evidence from studies around the different corners of Ethiopia reveals that inadequate dietary diversity among pregnant women is prevalent. Moreover, the most common diets of pregnant women are dominated by plant-source foods lacking adequate energy, protein, and other micronutrient contents. Low consumption of animal-source foods such as dairy, eggs, fish, poultry, and meat has been reported (23,47,48,52–57). Studies in Addis Ababa (54), Gurage Zone (55), Raya Azebo Zone (116), East Gojjam Zone (117), Kaffa Zone (53), and Afar region (52) reported 51.6%, 84.4%, 38.8%, 53.2%, 49%, and 73% of inadequate dietary diversity during

pregnancy, respectively. Similarly, studies in the Oromia region have also indicated that a significant proportion of women eat less diversified diets during their pregnancy. Around 44.4%, 73.6%, and 56.4% of pregnant women in the Gindeberet district (48), Ambo district (47) and Nekemte town (118) had inadequate dietary diversity (<5 food groups out of 10), respectively. The majority of these studies in Ethiopia indicated that grains, white roots and tubers, and plantains were the most consumed food groups whereas meat, poultry, and fish were the least consumed food groups.

2.3. Magnitude of birth weight

Around 19.8 million (15%) newborns were estimated to be born with LBW globally in 2020, which pointed out the need for more activities to achieve the 2025 global target of a 30% reduction of LBW. The highest LBW incidence was estimated for South Asia, 24.4%, while Eastern Asia was predicted to have the least LBW babies, 5.5%. The incidence of LBW infants in Sub-Saharan Africa was 13.9% meanwhile it was 14% for Eastern Africa (25). Similar to LBW, the prevalence of macrosomia (high birth weight) varies from country to country. Studies from better-income countries such as Germany (119), the United States of America (120) and China (121) indicated that 12%, 7.8%, and 7.4% of births were macrosomic, respectively. Studies from developing countries such as Nigeria (122) and Ghana (123) reported 4.7% and 6.5% cases of macrosomia, respectively.

A hospital-based study in Adwa, Northern Ethiopia reported that 10% of term live births in the region were underweight (124). In the Tigray region, out of the total 10.5% low birth weight from randomly selected hospitals, 57.8% of them were from term births whereas macrosomia incidence was 6.7% (125). Around 19.1% of deliveries in private clinics in Mekelle City were recorded as macrosomic (29). Similarly, a study at the University of Gondar Comprehensive Specialized Hospital indicated that 7.5% of births were macrosomic (72). A prevalence of 24% LBW was recorded among deliveries in public hospitals in North Wollo (126). In a cross-sectional study conducted at public health institutions of Hawassa City, Southern Ethiopia, among 580 newborns, 11.9% of the newborns were macrosomic (127). A magnitude of 13.1% LBW was reported in public hospitals based cross-sectional study among 377 newborns in Addis Ababa (128). A relatively higher magnitude of LBW (23.3%) was recorded among deliveries in public hospitals found in the Harari region (69). A cross-sectional study conducted in Jimma

Medical Center, Southwest Ethiopia indicated that the prevalence of LBW among singleton births was 7.8% meanwhile macrosomia was 6.6% (129). According to a prospective cohort study conducted in the Arsi zone, the prevalence of LBW was 9.1% (4). Deliveries in hospitals found in Bale Zone, Oromia region show that 12.2% of the newborns weighed less than 2.5kg (130).

2.4. Women's empowerment- conceptualization, measurement, and tools

2.4.1. Conceptualizing/understanding women's empowerment

The concept of empowerment is commonly tied to "choices" (31,131). For instance, the World Bank defines empowerment as "the process of increasing the assets and capabilities of individuals or groups to make purposive choices and to transform those choices into desired actions and outcomes" (131). Similarly, it was referred to as "the expansion in people's ability to make strategic life choices in a context where this ability was previously denied to them" (31). Resources, perceptions, relationships, ideology, and power have been regarded as components of empowerment (31,32,132).

Even though there is no single, consented women's empowerment definition, most of the definitions center around access and control over resources and circumstances for better achievement in quality of life by women (30,133). However, Kabeer's definition of women's empowerment as "an expansion in the range of potential choices available to women so that actual outcomes reflect the particular set of choices which the women value" (31) is the most widely applied since it is specific enough to give a clear picture of empowerment. According to Kabeer's framework of empowerment, the choice is a combination of three interrelated dimensions: resources, agency, and achievements. Resources are preconditions under which choices are made; the agency is the heart of the process through which choices are made, and achievements are outcomes of choices. The framework underlines material, human, and social resources are vital in empowerment. Agency, the ability to define one's goals and act upon them, encompasses not just decision-making and choice but also resistance, bargaining, negotiation, and reflection. Agency comprises the ability to articulate strategic choices, as well as to control resources and decisions that affect crucial life outcomes. Resources shape the route and outcomes (including well-being outcomes) of the empowerment process by supplying the 'building blocks' and defining the initial conditions that either encourage or inhibit women's

agency. Kabeer concluded that the three dimensions should be indivisible in measuring women's empowerment. She argued it is not possible to establish the meaning of an indicator, whatever dimension of empowerment it is intended to measure, without reference to the other dimension of empowerment.

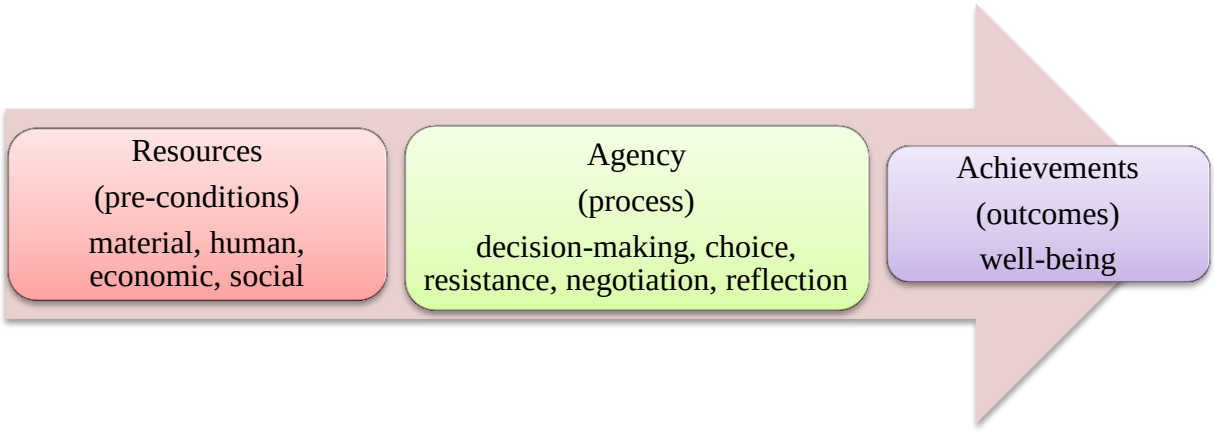


Figure 1. Nalia Kabeer's conceptual framework of women's empowerment (1999).

Multidimensionality has been reflected in the available women's empowerment frameworks. For instance, the framework United Nations Children's Fund (UNICEF) uses encompasses welfare, access to resources, awareness-raising, participation, and control (134). According to Malhotra and colleagues, there are various dimensions along which women can be empowered: economic, socio-cultural, familial/interpersonal, legal, political, and psychological. These dimensions are very broad in scope, and within each dimension, there is a range of sub-domains within which women may be empowered. The economic dimension includes empowerment sub-domains such as women's control over income, access to and control of family resources, women's access to employment, ownership of assets and land, access to credit, involvement, and access to markets among others (32). Women's economic empowerment is defined as having access to and control over the means to make a living on a sustainable and long-term basis and receiving the material benefits of this access (135).

Women's freedom of movement, lack of discrimination against daughters, access to modern transportation, participation in extra-familial groups and social networks; women's literacy and access to a broad range of educational options, positive media images of women, their roles and contributions are some of the domains used to represent a socio-cultural dimension of empowerment. A range of empowerment sub-domains from participation in domestic decision-

making, control over sexual relations to freedom from domestic violence and systems providing easy access to reproductive health services are included under familial/interpersonal dimension of empowerment. The legal dimension can be interpreted in terms of knowledge of legal rights; domestic support for exercising rights, and laws supporting women's access to resources and options including other domains. Domestic support for political engagement, exercising the right to vote, women's involvement or mobilization in the local political system/campaigns; representation in local bodies of government, and women's representation in regional and national bodies of government are some of the subdomains used to operationalize political dimension of empowerment. Self-esteem, self-efficacy, psychological well-being, collective awareness of injustice, and women's sense of inclusion and entitlement have been considered as some of the domains to reflect the psychological empowerment dimension (32).

These dimensions can be categorized under resources, agency, and achievements components according to Kabeer. The economic and socio-cultural dimensions can come under the umbrella of resource; the psychological dimension under agency, and the outcomes of well-being from any of these dimensions under achievements (31). Moreover, all the dimensions can be operationalized at the individual/household, community, regional, national, and even global levels, although some dimensions are measured better on certain levels. For example, the psychological dimension is best measured at the individual level. Economic empowerment could also be measured at the individual or household level. Socio-cultural empowerment, on the other hand, may best be measured at the community level (32).

2.4.2. Measuring women's empowerment

Empowerment is intangible, i.e. it can only be approximated using proxies or indicators, and multidimensional. This poses major challenges to measuring women's empowerment (31,32). However, it can be assessed based on different indicators. Selecting the appropriate dimension to include in a study is challenging. The trend shows often selection of dimensions based on previous research or what is available in the survey data, while qualitative studies have been used by some to select culturally appropriate dimensions (136,137). Moreover, principal component analysis has been used to select dimensions most relevant to a study (138). Exploratory and confirmatory factor analyses have been used to identify the proper indicators and dimensions (76,78). It is suggested that a single indicator is not sufficient to measure a specific dimension of

empowerment (139). Moreover, focus group discussion can be used to validate the results of a quantitative study, or as a complementary measure to address questions on empowerment that a fully quantitative study is unable to accommodate and interpret the meaning of the results (32).

2.4.3. Women's empowerment measuring tools

Individuals and international organizations have developed tools that help to measure women's empowerment quantitatively. Women's Empowerment in Agriculture Index (WEAI) (33), Survey-based Women's emPowERment index (SWPER) (140), Demographic and Health Survey (DHS) (34) are among them.

WEAI is one of the most commonly used theoretical frameworks to quantitatively measure women's empowerment in agriculture. Developed by Alkire and colleagues in 2013, WEAI is a survey-based index that generates individual-level data collected through interviews with men and women within the same households. It measures the roles and extent of women's engagement in the agriculture sector. The WEAI is constructed using two weighted sub-indexes: (i) The Five Domain Empowerment Index (5DE); and (ii) The Gender Parity Index (GPI). The 5DE index looks at five domains of empowerment: production, resources, income, leadership, and time, and the GPI measures the empowerment of women compared to their male counterparts in the household. In the WEAI index, a woman is considered to be empowered if she has adequate achievements in at least four out of five domains or when in some combination of the weighted indicators that reflects 80% of total adequacy. Households are classified as having gender parity if either the woman is empowered (her empowerment score is 80% or higher) or her score is greater than or equal to the empowerment score of the male decision-maker in her household. The WEAI can be adapted to measure the empowerment of women in rural areas more generally, whether they are farmers, agricultural or non-agricultural wage workers, or engaged in non-farm businesses (33).

One of the advantages of WEAI is its multidimensionality which involves both sexes. It is criticized because of the cut-off points labeled for categorizing women's empowerment status since determining what constitutes an adequate level of empowerment may involve subjective, unverified judgments. According to Richardson, participant feedback or expert opinions might mitigate unverified judgments of certain cut-points; however, this feedback is likely highly contextual and may only be relevant to the experiences of individuals in certain geographic

locations or demographic groups (141). Although women's empowerment can be measured at different levels, WEAI centers at the individual level (33).

The SWPER index is developed to measure women's empowerment in Africa based on the women's empowerment part of DHS data from 34 African countries. It has 15 item questions within three dimensions of empowerment: attitude to violence, social independence, and decision-making for measuring women's empowerment. It allows within-country and between-country comparisons, as well as time trend analysis for African countries, which no other survey-based index provides (140). However, there are some reservations about its use. It is criticized that some SWPER items measure health outcomes themselves, instead of the preconditions for empowerment. Moreover, the index omits important components of empowerment, including choice and agency around political and economic participation or leadership. SWPER is validated only for married and reproductive-age women (142).

It has been recommended that the index would benefit from additional questions in each of the 3 dimensions (140). The precision of the SWPER index may be limited by the use of principal component analysis and concerns about external validity. The index does not provide factor loadings for each domain by country, making it challenging to acertain the order of women's empowerment domains across different countries. External validation was performed by correlating SWPER with the Gender Development Index (GDI), but these two measures of empowerment are distinct. The GDI evaluates gender equality by calculating the female-to-male ratio of the Human Development Index, which includes indicators such as health, knowledge, and living standards. In contrast, SWPER relies solely on data from women to measure various empowerment indicators, such as attitudes toward violence, social independence, and decision-making (143).

DHS asks married women 9 questions under three dimensions of women's empowerment: economic, socio-familial, and legal empowerment since 1999 (34). The questions under economic empowerment include relative income to husband/partner, control over men's income, control over women's income, decision making on large household purchases; under socio-familial empowerment decision making regarding family visits, women's health, and attitude towards domestic violence under five scenarios; and women's judicial and legislative entitlements over land and house under legal empowerment. Similar to the other tools, DHS has also limitations. It doesn't assess women's cultural perception of empowerment (143). The tool

is meant to be used only for partnered women in their reproductive age. This may exclude many vulnerable groups of women. For instance, disabled women and sex workers, who are among the most marginalized and disempowered, might be less likely to be married, and, thus, they are not included in the index. Many adolescents are also excluded since they are highly likely to be unmarried. It is also limited in its scope to address all aspects of women's empowerment. The indicator's scope is also limited by the fact that data from DHS do not cover all aspects of empowerment (140).

There are instances where the whole portion, some of the portions, and a combination of some of the portions from each women's empowerment measuring tool are selected to measure women's empowerment. For instance, the whole portion of WEAI and DHS as well as a combination of the different measuring tools were used to operationalize women's empowerment through different studies (76,83,144,145).

2.5. Women's empowerment and their nutritional status

There is a lack of studies that focus on the relationship between pregnant women's empowerment and their nutritional status. Most of the studies are on non-pregnant women. These studies have found mixed results between women's empowerment and their nutritional status. The composite and different dimensions of women's empowerment are reported to have different effects on their nutritional status. For instance, empowerment in household decision-making was associated with better maternal nutritional status (76,77,86) while null associations were also reported (145). An African study in the Kalal´e district of northern Benin found a positive association between women's composite empowerment and their nutritional status. In this study, the leadership domain was significantly associated with nutritional status meanwhile decision-making, mobility, economic security, male involvement in housework, and nonfamily group domains were not significantly associated with nutritional status (76). In Ethiopia, women with low decision-making autonomy were more likely to be undernourished than those with high decision-making autonomy (77). Another Ethiopian study that measured women's empowerment using WEAI revealed that control over income and the number of work hours were positively related to women's nutritional status (83).

Studies among East African reproductive-age women showed that their household decision-making power was a significant predictor of their hemoglobin level (146). A study in Ethiopia

reported that women's decision-making didn't influence their anemia status rather greater magnitude of anemia was linked to their low access to resources and health information (147). Psychological empowerment is characterized by a sense of perceived control, competence, and goal internalization (148). Hence, it promotes the chance of engaging in healthy behaviors including healthy food choices and healthy dietary practices, thereby contributing to better nutritional status. Women's increased self-confidence was found to positively influence their and their children's nutrition outcomes (76,149,150). High women's workload was linked with poor nutritional status of women (82,86). Women may work more to increase the quantity and quality of food available to their households, but longer work hours may also increase their energy expenditure, resulting in poor nutrition outcomes (82). It was also noted that intra-household communication may help achieve improved maternal nutrition outcomes (78). Empowered communication improves women's economic and decision-making power (151,152).

2.6. Women's empowerment and their dietary diversity

Most of the available studies that assessed the relationship between women's empowerment and their dietary diversity are on non-pregnant women. They didn't address the dietary diversity of pregnant women. It has been highlighted that women's participation in household decision-making and their ability to purchase food positively impact the availability of diverse and nutrient-rich diets in the household and, consequently, adequate dietary diversity intake among women (144,153). Having access to and control over economic resources by women has been linked with the consumption of more diverse diets (83,86). Time empowerment of women was significantly associated with better dietary diversity (83,86).

According to a study in urban Bangladesh, women's decision-making agency was positively associated with their dietary diversity (154). In Jharkhand State, India, women's decision-making autonomy was strongly associated with women's diets. Women who made one or more household decisions alone were more likely to regularly consume pulses and meat/fish/eggs than those whose husbands made one or more decisions alone. On the other hand, women who made one or more decisions jointly were less likely to regularly consume pulses, dairy products, and meat/fish/eggs compared to those whose husbands made one or more decisions alone (153).

Findings from Ghanaian DHS pointed out that women's decision-making autonomy influences women's dietary diversity. The odds of achieving higher dietary diversity were higher among

women who had a say in deciding household purchases compared to women who did not have a say (144). Another study in Benin also found a significant and positive association between the women's composite empowerment and their dietary diversity score (76). In Ethiopia, higher dietary diversity was reported among women with higher empowerment status (83). Women's empowerment was also linked to dietary diversity during pregnancy. For instance, a higher level of household decision-making power and economic empowerment were found to be predictors in the consumption of more diverse diets among pregnant women (84).

2.7. Women's empowerment and infants birth weight

The available studies that examined the relationship between women's empowerment and birth weight have found that at least some women's empowerment variables had significant inverse associations with low infant birth weight. For example, a study in rural Bangladesh indicated that pregnant women with the lowest decision-making autonomy were more likely to have a LBW child compared to empowered women in the same dimension (88). The percentage of LBW infants was lower among mothers who were autonomous in taking care of their own health (18% versus 21% who were not), making large purchases (17% versus 22%), visiting relatives (18% versus 22%) and going to the market (18% versus 22%) according to Indian study. Besides, economic independence or involvement of the women was associated with less likelihood of infant LBW (155). It was also reported that greater social support predicts better fetal growth (156). Another Indian study also revealed that lower maternal autonomy measured by final say on own healthcare, large household purchases, purchases for daily needs, and visits to family or relatives was identified as a significant predictor for LBW (138). On the other hand, long working hours and heavy workloads have been associated with lower birth weight (87,157).

2.8. Conceptual framework

The conceptual framework for this study (Figure 2) was developed based on literature reviews. Resources, agency, and achievement framework was adapted to operationalize women's empowerment (31). The framework can be explained in terms of economic, familial/interpersonal, socio-cultural, time, and psychological empowerment dimensions (32,33). The economic, socio-cultural, and time dimensions come under the umbrella of resource whereas psychological and familial/interpersonal dimensions address agency. Achievement is the outcome of well-being from any of these dimensions (31,32). These dimensions, including the socio-demographic characteristics of pregnant women, affect women's nutritional status, dietary diversity, and birth weight. The expectation was that a higher score on each dimension or aggregate dimension would lead to better decision-making power, more control over economic life, better social network, better self-esteem and confidence, and less workload which in turn can result in better nutritional status, dietary diversity, and normal birth weight. When a pregnant woman is more empowered, she has better access to food, and this has a positive effect on her dietary diversity. Similarly, if she is empowered, she has better awareness of what is best for the health of the mother and newborn during pregnancy, so she strives to maintain the right nutritional status, utilize healthcare services, and deliver a normal birth weight baby.

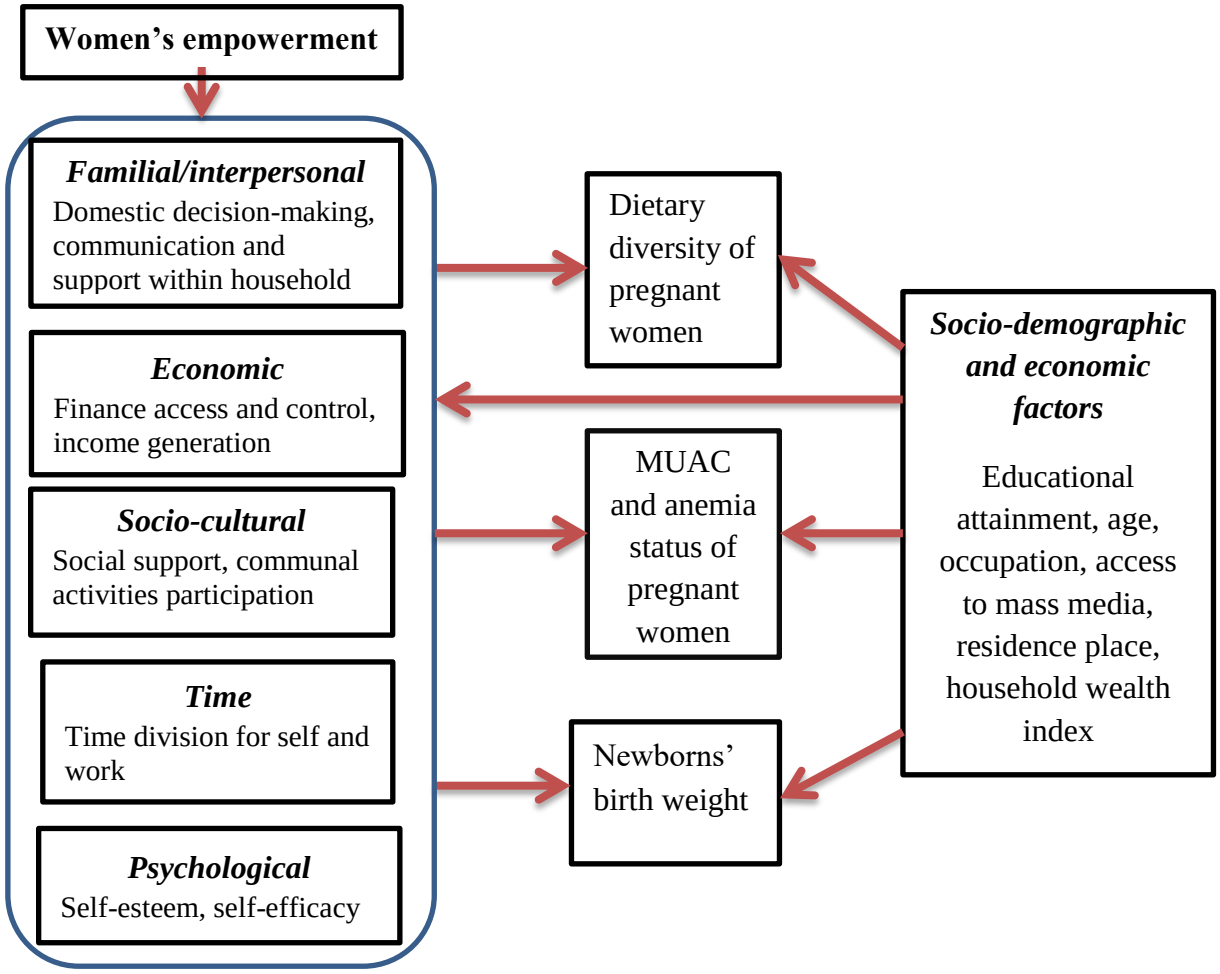


Figure 2. Conceptual framework on links between women's empowerment and pregnant women's nutritional status, dietary diversity and newborns' birth weight based on literature review (31–33).

3. Research questions, objectives and hypotheses

3.1. Research questions

1. What is the level of empowerment among pregnant women in West Shewa Zone, Ethiopia?
2. Is women's empowerment associated with nutritional status during pregnancy in West Shewa Zone, Ethiopia?
3. What is the association between women's empowerment and the dietary diversity of pregnant women in West Shewa Zone, Ethiopia?
4. Does women's empowerment status affect newborns' birth weight in West Shewa Zone, Ethiopia?
5. What dimensions of women's empowerment matter most for nutritional and birth weight statuses in the study area?

3.2. Research objectives

3.2.1. General objective

To determine the level of women's empowerment and its association with nutritional status, dietary diversity, and their newborn's birth weight among pregnant women attending antenatal care at public health facilities in West Shewa Zone, Central West Ethiopia.

3.2.2. Specific objectives

1. To determine the level of women's empowerment and factors associated with it among pregnant women attending antenatal care at public health facilities in West Shewa Zone (Paper I)
2. To assess the association of women's empowerment with the nutritional status of pregnant women attending antenatal care at public health facilities in West Shewa Zone (Paper II)
3. To examine the mediating effects of women's empowerment on dietary diversity of pregnant women attending antenatal care at public health facilities in West Shewa Zone (Paper III)
4. To explore the correlation between pregnant women's empowerment status and birth weight in West Shewa Zone (Paper IV)

3.3. Research hypotheses

1. Empowerment during pregnancy is associated with better nutritional status among pregnant women in West Shewa Zone, Ethiopia.
2. Higher empowerment of pregnant women is associated with higher dietary diversity during pregnancy in West Shewa Zone, Ethiopia.
3. Empowered pregnant women would have a better chance of delivering normal weight babies than their less empowered counterparts in West Shewa Zone, Ethiopia.

4. Methods and Materials

4.1. Study area

The study was conducted in West Shewa Zone, Oromia regional state, Ethiopia. The capital is Ambo town, which is located 112 km to the West of Addis Ababa, the capital city of Ethiopia. The Zone had a total area of 14,788.78 km^2. According to the 2017 population projection estimate, the Zone had a population of 2,701,287, of which males were 1,344,477 and females were 1,356,810. Of these, aroud 12% of them are urban inhabitants. The largest ethnic group in the Zone was Oromo, making Afan Oromo the widely spoken language. The majority of the inhabitants were followers of Protestantism and Orthodox Christianity; followed by traditional belief and Islam. The number of reproductive-age women was estimated to be around 647,025. According to the 2019 report, the estimated number of pregnant women in the Zone was 91,982. Farming was the main livelihood of rural residents. In urban kebeles, the residents were employed either in government or private sectors. There were also merchants. Teff was the main staple food. West Shewa Zone had 22 districts and 583 kebeles. There were 5 hospitals, 89 health centers, and 528 health posts in the Zone (158,159).

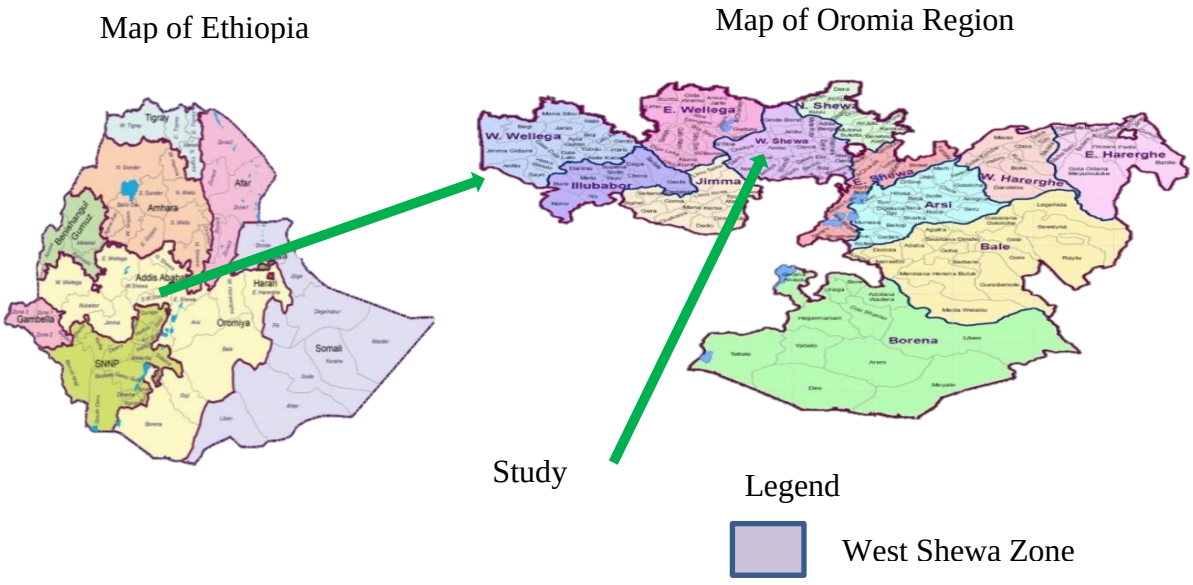


Figure 3. Map of West Shewa Zone, Central West Ethiopia.

4.2. Study design and period

Health facility-based cross-sectional and prospective follow-up study designs were employed in this study. For specific objectives 1 to 3, a cross-sectional study design was used whereas a prospective follow-up study was used for specific objective 4. A cross-sectional study design was conducted to assess the level of empowerment among pregnant women (Paper I), the relation between women's empowerment and nutritional status during pregnancy (Paper II), and the mediating effects of women's empowerment on dietary diversity during their pregnancy (Paper III). A prospective follow-up study was conducted to identify the association of pregnant women's empowerment with the birth weight of the babies they delivered (Paper IV). The whole study was conducted from January and December 2021.

4.3. Population

4.3.1. Source population

All pregnant women between 18 and 49 years of age attending antenatal care (ANC) follow-up in public health facilities found in the West Shewa Zone were the source population for Papers I to IV.

4.3.2. Study population

For Papers I to III, the study populations were randomly selected pregnant women in their second and third trimesters attending antenatal care units in randomly selected public health facilities found in the West Shewa Zone. For Paper IV, all the pregnant women who were selected and enrolled in the study were followed until delivery. Their newborns' birth weight was the outcome of interest. Therefore, mother-newborn pairs were the study population for Paper IV.

4.4. Inclusion and exclusion criteria

4.4.1. Inclusion criteria

Pregnant women in their second- and third- trimester (gestational age between 26 and 34 weeks), whose pregnancy was confirmed by laboratory urine test at the public health facilities, were recruited while coming to the ANC unit of the health facilities. According to EDHS 2016 (17),

the majority of pregnant women had their first or second antenatal care visit in their second and third trimester. Informal assessment in 6 public health centers in the study area also showed that most ANC visits occurred during this time. In addition, there was a second round of measurement, which was taken in a month after enrolment. This fell on the second or third ANC visit. According to EDHS 2016 (17), around 31.8% of the women had $\geq$ 4 ANC visits, which was even lower in rural areas. Similarly, informal discussions with some health professionals working in the ANC unit in the study area also highlighted that there was a tendency to have one or two ANC visits and come for delivery; and also most ANC visits occurred during the second and third trimesters. Hemoglobin concentrations typically decrease during the second trimester and begin to rise in the third trimester (12). To minimize the inclusion of pregnant women with low hemoglobin levels due to their stage in pregnancy and to achieve the required sample size within a reasonable time, the study focused on women between 26 and 34 weeks of gestation. The gestational age of the fetus was determined based on the woman's reported date of her last normal menstrual period. Besides, fundal palpation by midwives and nurses was used to determine the gestational age. For those pregnant women who had ultrasound checkups elsewhere, the ultrasound results were also used as input for determining the gestational age of the fetus.

4.4.2. Exclusion criteria

Pregnant women who were without a partner/husband, unable to provide valid information because of mental problems, and had been living in the study area for less than 6 months before the survey were excluded. For specific objective III, pregnant women with missing second round dietary diversity measurement were excluded from the final analysis. Moreover, twin births, preterm cases, and women who delivered at home were not included in the final analysis of specific objective IV.

4.5. Sample size determination

The sample size for each specific objective was calculated. Sample sizes for specific objectives 1-4 were calculated using Epi-Info StatCalc version 7.2.2.6 software which is available at https://www.cdc.gov/epiinfo/support/downloads.html. Finally, the largest sample size of all was taken to increase the power and precision level of the study.

The sample size for specific objective 1 (Paper I)

Single population proportion formula was used to determine the sample size required for determining the level of pregnant women's empowerment.

$$\boldsymbol{n = \frac{(Z_{\alpha/2})^2 p(1-p)}{d^2}}$$

Where:

n= Desired sample size

p = Estimated proportion

$Z_{\alpha/2}$ = Corresponding Z score for a confidence level of (1 - α) %

d = Desired precision (margin of error)

Pregnant women's decision-making power on their own health care was one of the variables assessed under women's empowerment in this study. Thus, a proportion of pregnant women who made decisions about their own health care, 29.1%, was used to calculate the sample size for this objective (88). Assuming a 95% confidence level (two-sided α = 0.05) and 3% margin error, a sample size of 880 was required for this objective. Multistage sampling was used; therefore, a design effect of 1.5 was considered. Finally, adding a 10% non-response rate, the final total sample size required for this objective was 1,453 pregnant women.

The minimum sample size required to address the factors associated with women's empowerment was calculated using the double population proportion formula, which is presented below.

$$n=\frac{\left\{Z^{\alpha}/_{2}\sqrt{\frac{P(1-P)}{r}}+Z_{\beta}\sqrt{P_1(1-P_1)+\frac{P_2(1-P_2)(1-r)}{r}}\right\}^2}{(P_2-P_1)^2(1-r)}$$

Where:

n=Desired sample size

$Z_{\alpha/2}$ = Corresponding Z score for a significance level of (1 - α) %

Z_{β} = Corresponding Z score for power (1-β)

r = Ratio of unexposed to exposed

P = Pooled proportion= $(P_1 + rP_2)/(1+r)$

P_1 = Proportion of outcome among the population with the exposure of interest

P_2 = Proportion of outcome among the population without the exposure of interest

The available studies which assessed the factors associated with women's empowerment are conducted on non-pregnant women. These studies have reported that age is among the determinants of women's empowerment (160–162). For instance, older women are more economically empowered than younger women (161). Pregnant women's economic empowerment was among the factors examined in this study. Therefore, during sample size calculation, we considered the following assumptions: 50% economic empowerment among older pregnant women (P_1=0.50), anticipated 10% lower proportion of economic empowerment among younger pregnant women (P_2=0.40), 95% confidence level, 80% power and a one-to-one ratio between those economically empowered older and younger pregnant women. The calculated sample size was 816. Owing to the multistage sampling nature of our study, a design effect of 1.5 was used. After adding a 10% non-response rate, a total of 1,345 pregnant women were required for this objective.

The sample size for specific objective 2 (Paper II)

The sample size for paper II was determined using the double population proportion formula. There were no similar studies that assessed the association of pregnant women's empowerment with their nutritional status. As a result, in calculating the sample size, the following parameters and assumptions were taken into consideration. Women's empowerment was taken as exposure i.e. those who were empowered as exposed and those who were less empowered as a non-exposed group, and the proportion of nutritional status among pregnant women in the study used for calculation was considered from the non-exposed (less empowered) population. Sample size was calculated with the following inputs: a proportion of MUAC<23cm 21.8% (P_1=0.218) among pregnant women (8), 95% confidence interval (two-sided= $Z_{\alpha/2}$=1.96), power of 80%, anticipated 10% lower prevalence of MUAC<23cm among exposed group (P_2=0.118) and a ratio of unexposed to exposed 1:1 (r=1), which gave a total sample size of 476 pregnant women. Considering a design effect of 1.5 because of multistage sampling use and adding a 10% non-response rate, the final total sample size required for paper II was 785 pregnant women.

Sample size based on the anemia status of pregnant women was also calculated with the following inputs: a proportion of anemia 29% (P_1=0.29) among pregnant women (163), anticipated 10% lower proportion of anemia among an exposed group (P_2=0.19), 95% confidence level ($Z_{\alpha/2}$ =1.96), 80% power of the study ($Z_{1-\beta}$ =0.84), and 1:1 ratio of unexposed to

exposed groups. Considering the 1.5 design effect owing to the multistage sampling application and 10% non-response rate, the final sample size required was 947 pregnant women.

However, to increase the power of the study, all pregnant women enrolled in the study were considered during the analysis.

The sample size for specific objective 3(Paper III)

Double population proportion formula was used to calculate the sample size for paper III. There were no similar studies that assessed the effect of pregnant women's empowerment on their dietary diversity. As a result, the following parameters and assumptions were taken into consideration. Women's empowerment was taken as exposure i.e. those who were empowered as exposed and those who were less empowered as a non-exposed group, and the proportion of dietary diversity among pregnant women used for calculation was considered from unexposed (less empowered) population. Thus, a proportion of inadequate dietary diversity of 74.6% (P_1=0.746) among pregnant women (57), 95% confidence interval (two-sided), power of 80%, anticipated 10% lower proportion of inadequate dietary diversity among exposed (empowered) group (P_2=0.646), and a ratio of unexposed to exposed 1:1 (r=1) were used as input for sample size calculation, which resulted in a sample size of 666 pregnant women. Considering a design effect of 1.5 because of multistage sampling use and a 10% nonresponse rate, the final total sample size required for paper III was 1,099 pregnant women. However, to increase the power of the study, all pregnant women enrolled in the study and with complete date were included during the final analysis.

The sample size for specific objective 4(Paper IV)

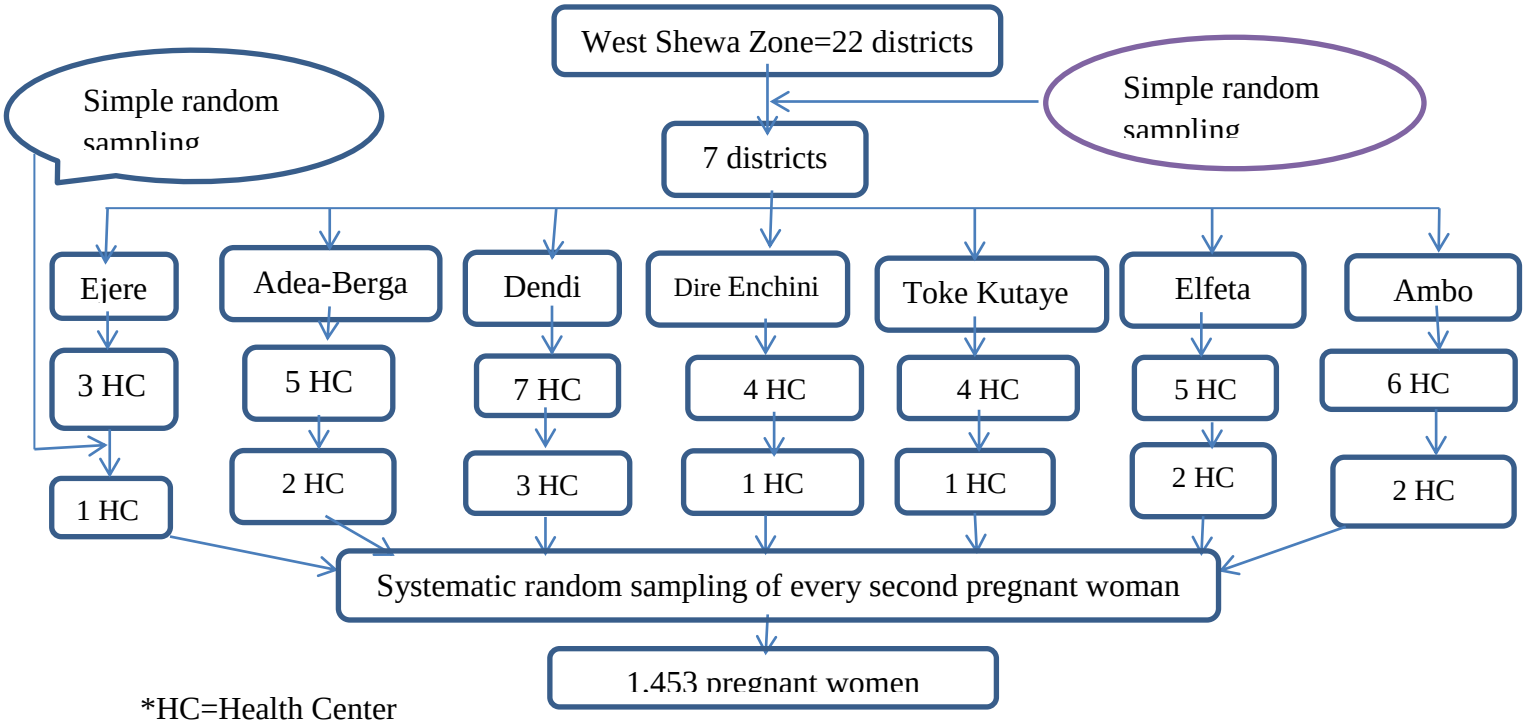
Thirty-two percent of LBW among unexposed (women with the lowest decision-making power) (88), a ratio of unexposed to exposed 1:1, 95% confidence level, 80% statistical power, and odds ratio of 0.6 (88) were used, resulting in a sample size of 622. Taking into account a 10% non-response and missed follow-up rate, as well as a design effect of 1.5 due to the multistage sampling method, the total required sample size was 1,026 pregnant women newborns pairs. However, to increase the power of the study, all pregnant women enrolled in the study and completed the follow-up successfully were included in the final analysis.

Finally, 1,453 pregnant women were enrolled as part of the larger study.

4.6. Sampling procedure

A multistage sampling procedure was used to identify study participants and enroll them in the study for all four specific objectives. First, seven out of the 22 districts in the West Shewa Zone (30% as a rule of thumb) were randomly selected using a lottery method. Then, a total of 12 public health centers were proportionally selected using a lottery method based on the number of public health centers in each selected district. The sampling frame was created using ANC client registries' list of second- and third-trimester pregnant women who had received ANC service at the selected public health facilities.

A total of 2,209 second- and third-trimester pregnant women attended ANC follow-up services in the health facilities over the past 3 months. The total sample size was then allocated proportionally to the selected health facilities based on the number of these pregnant women who visited the facilities for ANC services in the past three months using $\frac{n}{N} x$Ni formula. Finally, a systematic random sampling was used to select every second willing pregnant woman until the required sample size (n =1,453) was met. The sampling interval (k^{th}) was calculated by dividing the general population by the total sample size (Figure 4 and Table 1).



*HC=Health Center

Figure 4. Schematic representation of sampling procedure, West Shewa Zone, Central West Ethiopia, 2021.

Data were collected after the women had received ANC services. Public health facilities that did not provide hemoglobin tests were excluded from the study.

Table 1. Determination of number of study participants based on proportional allocation to size, West Shewa Zone, Central West Ethiopia, 2021.

S.no	District	Randomly selected health centers	No. of 6-, 7- and 8-month pregnant women presented at the ANC unit in the last 3 months(N_i)	Allocated sample size ($\frac{n}{N} x$Ni) *
1	Ejere	Ejere health center	157	(0.658*157)=103
2	Adda-Berga	Muger health center	261	(0.658*261)=171
3	Adda-Berga	Inchini health center	159	(0.658*159)=105
4	Dendi	Ginchi health center	316	(0.658*316)=208
5	Dendi	Asgori health center	107	(0.658*107)=70
6	Dendi	Faji Gelila health center	76	(0.658*76)=50
7	Dire Inchini	Dire Inchini health center	219	(0.658*219)=144
8	Toke Kutaye	Guder health center	225	(0.658*225)=148
9	Elfeta	Beke health center	168	(0.658*168)=111
10	Elfeta	Gute health center	119	(0.658*119)=78
11	Ambo	Ambo health center	281	(0.658*281)=185
12	Ambo	Awaro health center	121	(0.658*121)=80
	Total		N=2,209	n=1,453

* n/N=1,453/2,209=0.658

4.7. Study variables

4.7.1. Outcome (dependent) variables

- Women's empowerment level (Paper I), nutritional status of pregnant women (MUAC and hemoglobin level of pregnant women) (Paper II), dietary diversity during pregnancy (Paper III), and newborns' birth weight (Paper IV) were the dependent variables.

4.8.2. Independent variables

- Socioeconomic and demographic factors
    - Pregnant women's age, residence place, occupational status of pregnant women and their partners, educational status of pregnant women and their partners, access to mass media, household wealth index

- Women's empowerment
    - Household decision-making power, economic, psychological, communication, assertiveness, and time dimensions
- Obstetric-related factors
    - Birth order, parity (number of children), gestational age, birth interval, sex of newborn

4.8. Data collection

A semi-structured questionnaire was developed and adapted after reviewing different related literature including EDHS (17) and was administered face-to-face by interviewers to collect data on pregnant women's socioeconomic and demographic factors, obstetric characteristics, empowerment as well as dietary diversity. The questionnaire was initially prepared in English and translated into the local language Afan Oromo. Two language experts from Afan Oromo department in Ambo University, who spoke both Afan Oromo and English, translated the English version to Afan Oromo, and back to English to check the translation's consistency.

Data collectors were females who were fluent in Afan Oromo, had completed grade 12, and were trained on the tools and procedures of data collection by the principal investigator. Qualified and trained midwives and/or nurses working at the antenatal care service provision unit at the selected health facilities were used to identify and link those pregnant women who fulfilled the inclusion criteria to the data collectors. In addition, they were responsible for collecting data on the MUAC of pregnant women. Skilled and trained birth attendants at the selected health facilities were also the ones who collected data on the weight of newborns immediately after birth. Training was given to the midwives/nurses and birth attendants on the measuring tools and procedures. Four public health professionals with first degree from the study area were used as supervisors after orientation about the objective of the study and training on the techniques of data collection by the principal investigator. The supervisors were responsible for supervising the data collectors, following the progress of data collection, checking the completeness of the questionnaires, and correcting any mistake or problem that happened. The overall data collection process was coordinated by the principal investigator. The whole data collection process was undertaken from January to December 2021.

4.8.1. Women's empowerment measurement

Women's empowerment questions were developed so that they address the multidimensionality of empowerment. Indicators used to measure women's empowerment for this study were based on previous works (31–34). They implied that women's empowerment can occur at both the individual and household levels. Also, the pillars of women's empowerment, agency and resources, are reflected in the familial/interpersonal, economic, socio-cultural, time, and psychological dimensions. Twenty-nine items were included in the survey to capture women's empowerment. Agency was measured using questions related to attitude, decision-making, and self-security powers, while resource was measured through income- and time-related indicators. To highlight on questions' content, the familial/interpersonal dimension asked questions on decision-making power, communication and support within the household; questions on access and control of assets, contribution to household income, and right to use source of income were used to measure economic dimension; socio-cultural dimension questions centered on attitudes towards food taboos, social support and participation in communal activities; questions relating to time spent on workload, housework duties and for leisure measured time dimension; questions relating to self-confidence and efficacy were used to assess psychological dimension (Annex V-Part III).

4.8.2. MUAC measurement

Standardized equipment and procedures were used to measure MUAC and hemoglobin levels. MUAC of the left arm was measured using a non-stretchable adult MUAC tape, ensuring the arm was free of clothing. The women were instructed to sit and bend their left arm at 90°. The measuring tape was placed at the tip of the shoulder (acromion) and the tip of the elbow (olecranon process). The midpoint between these two points was marked, and the circumference was measured to the nearest 0.1 cm. This measurement was repeated three times, and the mean of the three readings was taken. Pregnant women with a MUAC measurement below 23cm were classified as malnourished (wasted) (49).

4.8.3. Hemoglobin level measurement

Hemoglobin concentration was measured by taking a finger-prick blood sample from each pregnant woman using a HemoCue Hb 201 (HemoCue AB, Angelholm, Sweden) device. The

site was first cleaned with a disinfectant, and a prick was made on the tip of the middle finger. The first drop of blood was wiped away, and the second drop was used to fill the microcuvette, which was then inserted into the cuvette holder of the HemoCue Hb analyzer to measure the hemoglobin concentration (164). Pregnant women are classified as anemic if their hemoglobin level is below 11 g/dL in the first and third trimesters, and below 10.5 g/dL in the second trimester. Anemia severity during pregnancy is categorized into three levels: mild anemia (10–10.9 g/dL), moderate anemia (7.0–9.9 g/dL), and severe anemia (<7.0 g/dL). According to the WHO recommendations, hemoglobin values are adjusted for every 500 m for altitudes exceeding 1,000 m above sea level (12). The altitude of the study area ranges from 1,735 to 2,917 m above sea level (165). As a result, 0.5–1.3 g/dL was subtracted from each individual hemoglobin measurement. Blood samples were taken by experienced medical laboratory technologists at the selected health centers, who performed the hemoglobin tests following the standard operating procedures (164).

4.8.4. Dietary diversity assessment

Face-to-face interviews with pregnant women were held using the adopted Food and Agricultural Organization (FAO) Minimum Dietary Diversity-Women (MDD-W) tool (20) to collect data on dietary diversity during pregnancy. The MDD-W tool was used to minimize recall bias. Pregnant women were asked to recall and list all the foods they had consumed in the past 24 hours, including snacks. To confirm that the consumption was ≥15g, the women were asked if they had eaten at least a spoonful of each food item throughout the day. The foods consumed were then categorized into 10 major food groups: 1) Grains, white roots and tubers, and plantains; 2) Pulses (beans, peas and lentils); 3) Nuts and seeds; 4) Dairy; 5) Meat, poultry, and fish; 6) Eggs; 7) Dark green leafy vegetables; 8) Other vitamin A-rich fruits and vegetables; 9) Other vegetables; 10) Other fruits.

A score of 1 was given for a particular food category consumed in the past 24 hours and 0 if not consumed, giving the minimum and maximum possible scores of 0 and 10, respectively. A score ≥5 was categorized as adequate and <5 as inadequate dietary diversity (20). Special occasions such as holidays or fasting days can inflate or deflate dietary diversity scores. To minimize their effect, MDD-W was measured twice in nonconsecutive days, i.e. at enrolment and the next ANC

follow-up visit. Then, the average of the two round measurements was used for analysis purposes. Complete data were collected on 1,383 pregnant women.

4.8.5. Birth weight measurement

Full-term newborns (those born between 37 and 42 weeks of gestation) were weighed without clothing within one hour of delivery using beam scales, with measurements recorded to the nearest 10.0 g. Skilled birth attendants who assisted with the delivery at the health facilities conducted the birth weight measurements.

4.9. Follow-up

There were two follow-up visits after enrolment. At enrolment, basic and general information on socioeconomic and demographic, obstetric history, empowerment status, gestational age, MUAC level, hemoglobin level, and dietary diversity were gathered. The second round of dietary diversity was measured during the next ANC follow-up visit. The pregnant women were followed until delivery. Finally, the birth weight of their newborns was measured immediately after delivery.

4.9.1. Tracing mechanisms

Tracing mechanisms were applied to reduce loss to follow-up in the study. At enrolment, pregnant women were asked to give their address (residence place and mobile number if they had) and if they had been registered in the family folder by health extension workers. When a pregnant woman didn't show up for the second follow-up data collection appointment, two tracing mechanisms were used. First, she was contacted by calling her if she had a mobile phone. If she didn't have a mobile phone, health extension workers were used to contact her based on her residence location and family folder registry information. When a pregnant woman changed her ANC follow-up and delivery place to another public health facility in the study area, data collection was continued in the public health facility she transferred to. However, when she transferred to private health facilities and moved out of the study area, she was considered a loss to follow-up.

4.10. Data quality assurance

Semi-structured questionnaires were developed after reviewing various literature and EDHS standard questionnaires. They were administered face-to-face to minimize respondents misunderstanding. Questionnaires translated into one of the locally spoken languages Afan Oromo was used to reduce confusion. All data collectors and supervisors were trained including practical sessions (role-play practice) on participants' enrollment, questionnaire filling, anthropometric measurements, and follow-up just before starting the actual data collection.

To ensure the validity and reliability of the questionnaire, a pretest was conducted on 30 pregnant women found in one of the districts in the study area but which was not included in the study. Amendments were made to confusing words, sentences, and questions based on the pretest's findings. Simultaneously, the success of data collectors' and supervisors' training was also checked. Completeness and quality of collected data were checked regularly by supervisors and principal investigator and amendments were made when drawbacks were found. Calibrated equipment and standard procedures were followed for measuring MUAC, hemoglobin level, and birth weight. Besides, these data were collected by qualified health professionals. To minimize interpersonal and intrapersonal errors among the data collectors, MUAC was measured thrice and the mean was used for analysis.

4.11. Data management and analysis

Data were coded, entered, and cleaned using EpiData 3.1. They were performed by the principal investigator to reduce data management errors. Samples from the entered data were crosschecked against the hard copy questionnaire to identify and correct errors committed during data entry. The data were exported to STATA version 16.0 (StataCorp) and RStudio version 4.2.3 for analysis. Missing values and outliers were checked using frequency tabulation and visualization, and corrections were taken accordingly before further analysis. Errors discovered were fixed after examining the hardcopy questionnaire. The presence of outliers was checked by using a box plot and sorting minimum and maximum values. The skewness and kurtosis test and scatterplot were used to check the normality and linearity of continuous variables, respectively. Descriptive analysis was conducted to examine the study participants' background characteristics. According to their appropriateness frequency, percentages, measures of central tendency, and measures of dispersion were used to analyze the data first hand. Counts and percentages were used to express

categorical variables whereas means (standard deviation) were used for continuous variables. All the variables of women's empowerment were recoded to make them suitable for analysis and interpretation.

Principal component analysis for household wealth index

Data on household assets were collected based on DHS questions. The responses to questions used to calculate the wealth index were recoded into binary variables (0 and 1). Questions with "yes" or "no" answers, as well as those with more than two options, were converted into bivariate variables. Sources of drinking, cooking, and washing water, toilet facilities, and roof and floor materials were classified as improved or unimproved, while cooking fuel was categorized as solid or clean according to the DHS classification (166). Principal component analysis was then applied to calculate the household wealth index. Households were divided into three equal categories: high, medium, and low quartiles based on their wealth index scores.

For Paper I: The entire analysis was conducted using STATA version 16.0 (Stata Corporation, College Station, TX). The items/indicators used to measure women's empowerment in this study had not been analyzed together before. Therefore, exploratory factor analysis (EFA) was performed to identify the structure of individual items and determine the dimensions suitable for measuring women's empowerment (167). This was followed by cross-validation using confirmatory factor analysis (CFA). A correlation test was first performed on the 29 items that measured empowerment to assess their suitability for factor analysis. The data were divided into two groups using a random uniform distribution: one sample for EFA and the other for CFA. The factor test results showed that the chi-square ($\chi 2$) for the Bartlett test of sphericity was significant at p-value < 0.001, and the Kaiser–Meyer–Olkin test result was 0.782, indicating that the correlation strength between the variables was adequate for factor analysis. Next, polychoric correlation was calculated, as it is recommended for categorical variables (168). EFA was conducted using the polychoric correlation matrix as input instead of the raw variables. Oblique rotation was applied to rotate the indicators. No indicator had a factor loading between 0.4 and 0.49, although an indicator with a loading of 0.4 onto a factor is generally considered acceptable for constructing a dimension (169). Therefore, individual indicators with rotated factor loadings greater than 0.5 (170) were used to construct the different dimensions of women's empowerment. Indicators with significant negative pattern coefficients, single loaders to a factor

and those that cross-loaded onto two or more factors with a pattern coefficient greater than 0.320 (171) were removed. Moreover, indicators that lowered the reliability coefficient (ordinal alpha < 0.7) for a factor were removed one by one. A factor with poor reliability was eliminated at the end. As one indicator was removed, analysis was done on the remaining indicators. Ultimately, six factors were reteained based on eigenvalues >1 and the interpretability of factors (170,172). The number of indicators was reduced to 22, and ordinal alpha coefficients for the six factors ranged from 0.74 to 0.84.

CFA was performed on the remaining half of the data sample, which had been randomly split, to validate the fitness of the factors identified from the EFA. The model fit was evaluated using the following acceptable cutoff values: root-mean-square error of approximation (RMSEA) < 0.08, Bentler comparative fit index (CFI) ≥ 0.90, Tucker–Lewis index (TLI) ≥ 0.90, and standardized root mean square residual (SRMR) < 0.08 (173,174). To improve the model's fit, four indicators with R-squared values less than 0.2 were removed, as they contributed to very high error levels (173). In cases where correlation was found between the error terms of individual indicators measuring the same factor, the indicator with the lower factor loading was removed. As a result, one indicator was eliminated. After these adjustments, the final RMSEA, CFI, TLI, and SRMR values were 0.063, 0.928, 0.901, and 0.05, respectively, indicating an acceptable model fit. The CFA confirmed the six factors and 17 indicators were retained with pattern coefficients ranging from 0.54 to 0.94. The total variance explained by the dimensions was 83.5%. Ordinal alpha values for the 6 factors ranged from 0.75 and 0.93, indicating that the model had good reliability (175).

The six factors/dimensions, that operationalized women’s empowerment, were identified as household decision-making power, economic, communication, psychological, assertiveness, and time. Details of the indicators that measured the six dimensions are presented in Table 4. The household decision-making power dimension refers to the involvement of women in decisions regarding household matters. Four items remained to measure this dimension. These items asked if the women participated in decisions regarding what food to buy and consume, food prepared every day, daily needs household purchases, and their own healthcare. A score of 1 was given if the woman participated in the decision-making either alone or jointly with her husband/partner, and a score of 0 was assigned if the decision was made by her partner or someone else. Four items remained to assess the economic dimension. A score of 1 was assigned if the woman

engaged in activities that generated cash income, had cash savings of her own, and had direct access to household money in her hand to use. Otherwise, a score of 0 was assigned to a "no" response. The women were given a score of 1 if they made decisions alone or jointly whereas 0 score was given if others made decisions regarding their earnings.

The Psychological dimension addressed issues related to the women's self-esteem and self-confidence. Three items were related to it. The women were asked if they felt confident in solving problems by themselves; and being important and respected household members. Response of "always" was assigned 1, while "not at all" and "sometimes" were assigned 0 for the indicators that examined this dimension. The communication dimension deals with discussions on feelings and household matters between partners. The items found to measure this dimension were the frequency of discussion between partners about worries or feelings and household money spending. Scores of 2, 1, and 0 were given for the indicators' responses of "always", "sometimes", and "never", respectively. The assertiveness dimension assessed the certainty level of women in defending their rights. The items that were related to this dimension asked the women how sure they were in going to a health facility and using family planning even if their husband/partner objects. The women who answered "completely sure" were given a score of 2, whereas "somewhat sure" got a score of 1. Those who were "neither sure nor unsure," "somewhat unsure" and "not at all sure" were given a score of 0. Out of the five questions asked regarding time, two of them remained to explain the time dimension. Values of 0, 1, and 2 were assigned if the women's response to the average time spent on housework daily and the actual time spent on housework the previous day were greater than 10 hours, between 5 and 10 hours, and less than 5 hours, respectively.

Measurement invariance of the six dimensions confirmed by CFA was assessed using multi-group CFA across age, residence place, and education level of the respondents. The configural, metric, and scalar invariance were all examined across the groups. Age of the study participants was grouped into 1=$\leq$19, 2=20-29 years, and 3= $\geq$30 years. Residence place was categorized into 1=urban, and 2=rural. Education level was categorized into 1=Illiterate, 2=Grade 1 to 8, and 3=grade 9 and above. Configural, metric, and scalar invariance models can be compared using chi-square (χ2), CFI, TLI, and RMSEA. χ2 is likely to be significant as sample size increases due to its sensitivity to sample size. Therefore, measurement invariance was assessed based on ΔRMSEA, ΔCFI, and ΔTLI. The equivalent model is considered to be acceptable when

ΔRMSEA $\leq$.015, ΔCFI ≤ 0.010 and ΔTLI ≤ 0.010(176). The results of the measurement invariance are presented in Table 2. As the results showed measurement equivalence was met across the different groups. The results suggested that women's empowerment measuring tool was approved to be valid (construct validity) separately for the different age, living area, and education level groups of the pregnant women.

Table 2. Measurement invariance findings of multi-group confirmatory factor analysis for residence place, age, and education level groups.

Model	Invariance	Model compared	RMSEA	Δ RMSEA	CFI	Δ CFI	TLI	Δ TLI
Residence place								
M1	Configural		0.059		0.917		0.902	
M2	Metric	M1	0.058	0.001	0.918	-0.001	0.904	-0.002
M3	Scalar	M2	0.058	0.001	0.916	0.002	0.904	0.000
Age								
M1	Configural		0.057		0.915		0.903	
M2	Metric	M1	0.055	0.002	0.915	0.000	0.905	-0.002
M3	Scalar	M2	0.054	0.001	0.914	0.001	0.906	-0.001
Education level								
M1	Configural		0.059		0.920		0.903	
M2	Metric	M1	0.056	0.003	0.919	0.001	0.906	-0.003
M3	Scalar	M2	0.054	0.002	0.916	0.003	0.907	-0.001

The six dimensions were used to calculate the composite measure of women's empowerment. Higher values on the indicator questions for each dimension indicated greater empowerment, while lower values reflected lower empowerment. A cutoff point was established for each dimension and the composite dimension to categorize women as either empowered or less empowered, based on the proportion of women with total scores above or at/ below the mean. Equal weight was assigned to each dimension and indicator when calculating women's empowerment status.

Binary logistic regression was conducted to assess the association between socioeconomic, demographic as well as obstetric related variables and composite women's empowerment and individual women's empowerment dimensions. The independent variables included pregnant women's education level, age, occupation, household assets, access to mass media, and number of children. The husband/partner's educational and occupation status were also among the control variables. Age and number of children were continuous variables; the rest were

categorical. The pregnant women's and partners' educational levels were categorized into illiterate, primary, secondary and diploma, and first degree and above. The occupational status of the women and partners was grouped into government employee, private employee and farmer; housewife was an additional option for the women. The pregnant women were also asked if they had access to mass media or not. Households were categorized into high, medium and low quartiles based on their household wealth index score.

Predictor variables significant at p-value <0.25 (177) were included in multivariable logistic regression analysis. Two models were used. In the first model, the composite women's empowerment score was used to assess its association with the predictor variables. The association of the individual dimensions with the predictor variables was investigated in the second model. Pseudo-R^2 was used to assess model fit. p-value< 0.05 and 95% confidence intervals were used to declare a significant association of results.

For Paper II: STATA version 16.0 (Stata Corporation, College Station, TX) was used for paper II analysis. The analytical method and procedures applied in Paper I to identify the items and dimensions that operationalized women's empowerment were repeated for Paper II as well. Therefore, the same dimensions and items as Paper I were used to operationalize women's empowerment for Paper II. Analysis for Paper II was based on all the study participants enrolled for Paper I.

In the bivariable analysis, the socioeconomic and demographic characteristics of the women and households, along with obstetric-related variables significantly associated with the women's nutritional status, were identified and included in the final models as control variables. Age, gestational age, parity, and pregnancy gap were treated as continuous variables, while the others were categorical. The educational levels of both the pregnant women and their partners were categorized as illiterate, primary, secondary, diploma, first degree, second degree, and above. The occupational status of the women and their partners was grouped into categories including government employee, private employee, farmer, merchant, daily laborer, and student, with housewife as an additional category for women. Place of residence was dichotomized into urban or rural areas. Pregnant women were also asked about their access to mass media, specifically whether they had access to electronic media, written materials, or nothing. The household wealth index was divided into high, medium, and low tertiles.

Multivariable logistic regression analyses were conducted to find the associations of individual and composite women's empowerment dimensions with anemia and MUAC status during pregnancy. Control variables significant at p-value < 0.25 were included in multivariable logistic regression analysis. Two models were used. In the first model, the composite women's empowerment score was used to assess its association with outcome variables. The associations of the individual dimensions of women's empowerment with pregnant women's nutritional status were investigated in the second model. The variance inflation factor of the independent variables in the models was below 10. The likelihood-ratio chi-square and Pseudo-R^2 tests were used to assess model fit. p-value <0.05 and 95% confidence intervals were used to declare a significant association of results.

For Paper III: Descriptive analysis was performed using STATA version 16.0 (Stata Corporation, College Station, Texas). EFA and CFA were conducted to identify the underlying dimensions of women's empowerment and confirm their generalizability. SEM was then used to examine the pathways from pregnant women's education levels to their dietary diversity through multiple dimensions of women's empowerment. Both factor analyses and SEM were conducted using RStudio version 4.2.3.

For this study, women's empowerment was operationalized using the household decision-making power, economic, psychological, and time dimensions. Initially, 22 items were included to capture these dimensions. Six questions assessed the household decision-making power of the women. The women were asked whether they participated in decisions about what food to buy and consume, what food to prepare daily, daily needs household purchases, own healthcare, number of children to have, and household money use. A score of 1 was assigned if the woman participated in the decision-making either alone or jointly with her husband/partner, while a score of 0 was assigned if decision was made by her partner or someone else.

The economic dimension was measured using six items that examined whether the woman engaged in activities with cash income, had cash savings of her own, owned assets that could generate income, had direct access to household money in her hand to use, participated in decisions about how to use her earning, and had access to money that she could spend freely. Responses were coded as 1 for "Yes" and 0 for "No". A score of 1 was given if the woman made

decisions alone or jointly, while a score of 0 was assigned if others made decisions about her earnings.

To measure the psychological dimension, five questions related to self-esteem and self-confidence were asked. The women were asked if they felt confident solving problems on their own and if they felt respected and important in their households. A score of 2 was given for responses indicating "always", while "sometimes" and "not at all" were scored as 1 and 0, respectively. For questions assessing confidence in going to a health facility or using family planning despite objections from a partner/husband, scores of 4, 3, 2, 1, and 0 were given based on responses ranging from "completely sure" to "not at all sure."

The time dimension was assessed using five items. Values of 0, 1 and 2 were assigned if the indicators' response to the average time spent on housework daily and the actual time spent on housework the previous day were greater than 10 h, between 6 and 10 h and less than 6 h, respectively. Women were also asked if they had time to participate in community activities, with "Yes" scoring 1 and "No" scoring 0. Women's satisfaction with the availability of time for leisure activities was coded as 1 for "satisfied" and 0 for "unsatisfied". Higher values of the items' responses indicated a higher level of empowerment. Items related to decision-making and psychological dimensions were used to measure agency, while economic and time-related items were used to measure resources.

Factor analyses were conducted on the 22 items used to measure women's empowerment as these items had not been analyzed together previously. The dataset was divided into two groups using a random uniform distribution. EFA was conducted on one data group, and CFA was conducted on the second data group. A correlation test was carried out on the items to assess their suitability for factor analysis. The Kaiser–Meyer–Olkin test result was 0.77, and the chi-square for the Bartlett test of sphericity was significant ($p < 0.001$). EFA was then performed to identify the underlying structure and dimensions of women's empowerment (167). A weighted least squares estimator was used for EFA, which is appropriate for categorical variables (168,178). Four factors with eigenvalues >1.0 were produced by EFA and interpreted after oblique (oblimin) rotation. Individual items with a rotated factor loading ≥0.4 were used to construct the different factors (174). Cross loader item (item loading on two or more factors with pattern coefficient >0.320) (171) and item that contributed for a lower reliability coefficient

(ordinal alpha <0.7) for a factor were removed step by step. Finally, the four factors were retained based on eigenvalues >1 and interpretability of factors (170,172). The number of items was reduced to 13.

CFA was done on the four factors identified by the EFA using the second randomly split half-data to confirm their fitness. Weighted least squares means and variance adjusted (WLSMV) estimator was used, which is the preferred approach for categorical variables analysis (178). SEM is powerful in analyzing the relations between measured and latent variables (178). The four women's empowerment dimensions were used as latent variables. SEM was used for this paper, which consisted of measurement and structural parts (178). The latent constructs comprised the SEM measurement model, whereas the structural model included the measured variables. SEM is also useful to examine the direct, indirect, and total effects of variables.

In Paper III, SEM was used to examine the mechanisms that linked pregnant women's education, empowerment, and dietary diversity. Women's higher education status has been identified as one of the significant determinants in the consumption of adequately diversified diets among pregnant women in Ethiopia (23,55,57). At the same time, existing literature underlines education as pivotal for women's empowerment (179–181). SEM was used to examine the direct relationships of pregnant women's education and multiple dimensions of women's empowerment with dietary diversity during pregnancy. It further assessed the mediating effects of women's empowerment dimensions in the pathway between pregnant women's education and their dietary diversity in the study area. The dimensions of women's empowerment were modeled as mediator variables in SEM. Pregnant women's characteristics, along with household and obstetric variables, were included as control variables due to their potential influence on either or both dietary diversity and women's empowerment. The variables considered included the respondent's age, parity, and the occupational status of both the respondent and her partner, as well as the educational level of the respondent's partner. These variables were treated as continuous during analysis. The place of residence was dichotomized as either urban or rural. Respondents were asked whether they had access to mass media (either electronic media or written material) or not, with responses coded as 1 for "Yes" and 0 for "No". Households were classified into three categories—high, medium, and low—based on their wealth index score.

The endogenous variables in the model were dietary diversity and empowerment of pregnant women. Exogenous variables included the women's education, socio-demographic, and obstetric characteristics. Control variables that were significant at a p-value < 0.2 in the bivariable analysis were included as confounders in the final SEM model. The estimation for SEM was conducted using the WLSMV, which accounts for categorical variables in the analysis (178). Standardized results were reported. Dietary diversity was used as a continuous variable in SEM analysis. For descriptive analysis purposes, it was categorized into adequate and inadequate. If the pregnant woman's average score was ≥5 food groups, it was categorized as adequate and <5 food groups as inadequate dietary diversity (20). CFI ≥0.9, TLI ≥ 0.9, RMSEA≤ 0.08, and SRMR≤ 0.1 values were used to determine model fitness for both factor analysis and SEM (174).

For Paper IV: STATA version 16.0 (Stata Corporation, College Station, Texas) was used for descriptive analysis. Among the 1,453 pregnant women enrolled in the study, complete data on birth weight was obtained from 1,165 participants. Therefore, analysis was done based on 1,165 though the calculated minimum sample size required for this objective was 1,026. To analyze the disparities in socioeconomic and demographic characteristics as well as women's empowerment dimensions between participants with and without birth weight measurements, independent t-tests were used for continuous variables, and Pearson's chi-square tests were applied for categorical variables. The mean birth weight values were compared using t-tests and one-way analyses of variance (ANOVA). For descriptive analysis, birth weight was categorized into low, normal, and macrosomia (25,27).

The same items and dimensions that operationalized women's empowerment for paper III were used to operationalize women's empowerment for Paper IV. CFA was performed to validate the latent constructs used to measure women's empowerment using RStudio version 4.2.3. WLSMV estimator was used owing to the categorical nature of the variables (178). SEM was applied to examine whether women's empowerment predicts birth weight using RStudio version 4.2.3. SEM is powerful in analyzing the relations between measured and latent variables (178). The four women's empowerment dimensions were used as latent variables. The latent constructs comprised the SEM measurement model, whereas the structural model included the measured variables.

The endogenous variables in the SEM were birth weight and dimensions of women's empowerment, while the exogenous variables included the control variables. The control variables were chosen based on their potential confounding effects on either or both birth weight and women's empowerment. These control variables included socio-demographic characteristics of the pregnant women, household and obstetric factors, nutritional status, dietary diversity during pregnancy, and the sex of the newborn. The age of the respondents, parity (number of children born), and gestational age (measured in weeks) were treated as continuous variables.

Gestational age (the number of gestation weeks) was assessed based on the last normal menstrual period and a physical examination. The educational level of both the respondents and their partners was categorized as: no formal education, primary education, secondary education, or diploma and above. The occupational status categories of respondents were government employees, private employees, farmers and housewives. Similarly, the occupational status of respondents' partners was categorized as government employees, private employees and farmers. Binary control variables included place of residence (urban or rural), access to mass media (yes or no), birth order (first or second and above), and sex of the newborn (female or male). Households were categorized into high, medium, and low wealth tertiles based on individual household wealth index scores. Socioeconomic and demographic factors related to both the women and their households are fundamental to women's empowerment (182).

The control variables that were significant at p-value < 0.25 in the bivariable analysis were included in the SEM model as potential confounders. Birth weight was examined as a continuous variable in the SEM analysis. The analysis was performed using the WLSMV estimator. Standardized path coefficients for the direct effects of the variables were reported. The model fit for the CFA and SEM models was determined based on the following indices: CFI ≥0.9, TLI ≥ 0.9, RMSEA ≤ 0.08, and SRMR ≤ 0.1 (174).

4.12. Operational definitions

Anemia in pregnancy: hemoglobin level below 11 g/dL in the first and third trimesters and 10.5 g/dL in the second trimester of pregnancy (12)

- **Mild anemia**: hemoglobin concentration between 10.0–10.9 g/dL (12)
- **Moderate anemia**: hemoglobin concentration of 7.0–9.9 g/dL (12)
- **Severe anemia**: hemoglobin level less than 7.0 g/dL (12)

Birth weight: weight of a newborn immediately after birth (25)

- Low birth weight: birth weight at delivery < 2,500 g (25)
- Normal birth weight: birth weight at delivery between 2500 g to 3,999 g (25)
- Macrosomia: birth weight at delivery ≥4000 g (27)

Dietary diversity: is a qualitative measure of food consumption that assesses the number of different foods or groups of food consumed over the previous 24 hours (20).

- Adequate dietary diversity: consumption of ≥5 food categories out of 10 food groups in the past 24 hours (20).
- Inadequate dietary diversity: consumption of <5 food categories out of 10 food groups in the past 24 hours (20)

Educational attainment: grade level the woman has reached.

Empowerment: the level of power women exhibit interms of interpersonal, economic, socio-cultural, time, and psychological circumstances.

Last menstrual period (LMP): the first date of the last menstrual period.

Minimum Dietary Diversity for Women (MDD-W): is a food group diversity indicator that has been shown to reflect one key dimension of diet quality: micronutrient adequacy (20).

Nutritional status: the status of pregnant women indicated by their MUAC and hemoglobin levels.

Partner: a male member of either a married couple or unmarried couple living together.

Pregnant woman: a woman whose pregnancy was confirmed by a human chorionic gonadotropin (HCG) urine test.

Public health facility: government-owned health centers in West Shewa Zone that provide ANC service.

Undernourished pregnant women: pregnant women with MUAC measurements below 23cm (49).

Women's empowerment: reflection of interpersonal, economic, socio-cultural, time, and psychological empowerment of women on their own and family's wellbeing.

Women's empowerment score: Higher and lower values of the indicators under each dimension were used to denote higher and lower empowerment, respectively. The pregnant women were categorized into empowered and less empowered based on the proportion of pregnant women with total scores above the mean versus those with scores at or below the mean, respectively.

4.13. Ethical considerations

The study was approved by The Institutional Review Boards of the College of Health Sciences of Addis Ababa University (Protocol number: 107/19/SPH). The study was conducted after getting permission from the West Shewa Zone Health Bureau, respective district health bureaus, and public health centers. Participation in the study was based on willingness and informed written consent. The objective and methods of the study, confidentiality, and the possibility of refusing participation at any time during the data collection were explained orally to the pregnant mothers and informed written consent was sought accordingly. Confidentiality was ensured by using codes instead of the names of the study participants during data collection. The data were used only for the study's purpose and were not passed to a third party. Undernourished pregnant women during data collection were counseled about nutrition and to seek supplementary food treatment. Anemic pregnant women were counseled and made get treatment.

4.14. Summary of dissertation work by objectives and methods

Table 3 summarizes the objectives and methods used in this dissertation.

Table 3. Summary of the objectives and methods for Paper I to IV.

Paper	Objective	Study design	Study population	Sample size	Data collection	Analysis
I	To determine the level of pregnant women's empowerment and factors associated with it	Cross-sectional	2nd- and 3rd-trimester pregnant women	1,453 and 1,345	- Face-to-face interview using a semi-structured questionnaire	- Descriptive analyses - EFA - CFA - Bivariable and multivariable logistic regression analysis
II	To assess the association between women's empowerment and nutritional status of pregnant women	Cross-sectional	2nd- and 3rd-trimester pregnant women	785 and 947	- Interviewer administered semi-structured questionnaire - MUAC measurement with non-stretchable measuring tape - Hemoglobin concentration measurement by taking a finger-prick blood sample	- Descriptive analyses - EFA - CFA - Bivariable and multivariable logistic regression analysis
III	To examine the mediating effects of women's empowerment on dietary diversity during pregnancy	Cross-sectional	2nd- and 3rd-trimester pregnant women	1,099	- Face-to-face interview using semi-structured questionnaire - MDD-W tool for dietary diversity measurement	- Descriptive analyses - EFA - CFA - SEM analysis
IV	To identify the effects of pregnant women's empowerment on birth weight	Prospective follow-up	Mother-newborn pairs	1,026	- Face-to-face interview using semi-structured questionnaire - Data extraction checklist for birth weight	- Descriptive analyses - Independent t-test - Pearson's chi square test - ANOVA - CFA - SEM analysis

5. Results

5.1. Women's empowerment level and associated factors

5.1.1. Socio-demographic characteristics of study participants

Out of 1,453 pregnant women who participated in this study, most 1,143 (78.7%) of them had received formal education. The mean age of the pregnant women was 28.1 years (SD=5.3) with a range of 18 to 44 years. About 1,308 (90%) had access to at least one form of mass media. The mean number of children the pregnant women had was 2.4 (SD=1.5), with a minimum of 1 and a maximum of 8. Descriptive results are presented in Table 4.

Table 4. Socio-demographic and obstetric characteristics of study participants in West Shewa Zone, Central West Ethiopia, 2021 (n=1,453).

Characteristics		Frequency	%
Socio-demographic characteristics			
Age in years	≤19	83	5.7
	20-29	797	54.9
	≥30	573	39.4
Residence place	Rural	564	38.8
	Urban	889	61.2
Respondent's education level	No formal education	310	21.3
	Primaryeducation	503	34.6
	Secondary	272	18.7
	Diploma	218	15.0
	First-degree and above	150	10.3
Respondent's occupation	Government employee	300	20.7
	Private employee	395	27.1
	Farmer	306	21.1
	Housewife	452	31.1
Household wealth index	Low	489	33.7
	Middle	495	34.1
	High	469	32.3
Obstetric characteristics			
First pregnancy	Yes	606	41.7
	No	847	58.3
Gestational age	2nd trimester	108	7.4
	3rd trimester	1,345	92.6
Number of living children	≤2	516	60.9
	3-4	243	28.7
	≥5	88	10.4
Birth interval between the current and previous pregnancy in years	<3	396	46.8
	≥3	451	53.3

5.1.2. Women's empowerment status

Among the 1,453 pregnant women, 788 (54.2%) (95% CI: 51.7, 56.8) were classified as empowered. The highest levels of empowerment were observed in the household decision-making power dimension, while the lowest levels were found in the communication dimension. Most pregnant women reported having empowerment in decisions regarding food preparation for the household. However, of 1,453 pregnant women, only 498 (34.3%) had their own cash savings. Less than half had frequent communication with their partners. Similarly, fewer than 31% of the women reported being assertive enough to pursue their goals despite obstacles. Around half of the women reported a strong sense of self-worth and -confidence. Regarding time spent on housework, 756 (54.3%) of the pregnant women spent more than 6 hours daily, and 33 (3%) reported spending over 10 hours a day on household chores. Table 5 presents the detailed empowerment levels of the pregnant women, with percentages reflecting the highest scores for each indicator after recoding.

Table 5. Level of pregnant women's empowerment in West Shewa Zone, Central West Ethiopia, 2021 (n=1.453).

Dimensions	Items	n(%)	Mean(SD)
Household decision-making power	Decision on what food to buy and consume	1,248(85.9)	
	Decision on food prepared everyday	1,323(91.1)	
	Decision on own healthcare	1,318(90.7)	
	Decision on daily needs household purchases	1,271(87.5)	
	Mean score of decision-making power (out of 0-4 total points)		3.6 (1.1)
	% women > mean	1,149(79.1)	
Economic	Engagement with cash income activities	978(67.3)	
	Cash savings of own	498(34.3)	
	Decision on own earning use	1,049(72.2)	
	Direct access to household money for use	1,099(75.6)	
	Mean score of economic dimension (out of 0-4 total points)		2.5 (1.3)
	% women > mean	866(59.6)	
Communication	Discussion between partners about worries or feelings	359(24.7)	
	Discussion between partners on household money spending	485(33.4)	
	Mean score of communication (out of 0-4 total points)		2.4(1.0)
	% women > mean	564(38.8)	
Psychological	Self-confidence in problem-solving	574(39.5)	
	Feeling as important household member	958(65.9)	

	Feeling household members respect your opinion	729(49.9)	
	Mean score of psychology (out of 0-3 total points)		1.6(1.2)
	% women > mean	772(53.1)	
Assertiveness	Sure in going to health facility in the presence of partner's objection	372(25.6)	
	Sure in using family planning even if partner objects	444(30.6)	
	Mean score of assertiveness (out of 0-4 total points)		1.7(1.5)
	% women > mean	741(51.0)	
Time	Daily time expenditure on housework	664(45.7)	
	Time spent on housework the previous day	790(54.4)	
	Mean score of time (out of 0-4 total points)		2.9(1.0)
	% women > mean	854(58.8)	
Total women's empowerment mean score (out of 2-23 total points)			14.7(4.1)
% women > mean		788(54.2)	

5.1.3. Factors associated with pregnant women's empowerment

The multivariable logistic regression analysis revealed that residence place, age, educational status of the pregnant women, occupational status of the pregnant women, and partners were significantly associated with composite women's empowerment (Table 6). Rural pregnant women were less empowered than urban pregnant women (AOR= 0.6, 95%CI: 0.4, 0.9). On the other hand, pregnant women in the age group between 20 and 29 years and ≥ 30 years were 2.5 and 2.2 times more empowered than pregnant women ≤19 years (AOR=2.5, 95%CI: 1.5, 4.2) and (AOR=2.2, 95%CI: 1.3, 4.0), respectively. As the education level of pregnant women increased, their empowerment level also increased. Generally, empowerment was higher among pregnant women who were educated compared to those who had no formal education. Farmer and housewife pregnant women were 81.7% (AOR=0.2, 95%CI: 0.1, 0.3) and 74.9% (AOR=0.3, 95%CI: 0.2, 0.4) less empowered than those pregnant women who were working in government and private sectors, respectively.

Table 6. Socio-demographic factors associated with composite women's empowerment in West Shewa Zone, Central West Ethiopia, 2021. (n=1,453)

Characteristics	Empowerment status		COR (95% CI)	AOR (95% CI)	p-value
	Empowered n(%)	Less empowered n(%)			
Age					
≤19	23(27.7)	60(72.3)	Ref.		
20-29	455(57.1)	342(42.9)	3.5(2.1, 5.7)*	2.5(1.5, 4.2)	0.001
≥30	310(54.1)	263(45.9)	3.1(1.9, 5.1)*	2.2(1.3, 4.0)	0.007
Residence place					
Urban	561(63.1)	328(36.9)	Ref.		
Rural	229(40.3)	335(59.7)	0.4(0.3, 0.5)	0.6(0.4,0.9)	0.021
Household wealth index					
Low	204(41.7)	285(58.3)	Ref.		
Middle	272(54.9)	223(45.1)	1.7(1.3, 2.2)*	0.7(0.5, 1.0)	0.077
High	312(66.5)	157(33.5)	2.8(2.1, 3.6)*	0.7(0.5, 1.2)	0.187
Pregnant women's education level					
No formal education	105(33.9)	205(66.1)	Ref.		
Primary + Secondary	379(48.9)	396(51.1)	1.9(1.4, 2.5)*	1.5(1.0, 2.2)	0.036
Diploma and above	304(82.5)	64(17.5)	9.3(6.5, 13.3)*	4.9(2.8, 8.3)	<0.001
Husband/partner's education level					
No formal education	56(32.0)	119(68.0)	Ref.		
Primary + Secondary	373(50.7)	365(49.3)	2.2(1.5, 3.1)*	1.5(0.9, 2.3)	0.108
Diploma and above	359(66.4)	181(33.6)	4.2(2.9, 6.1)*	1.2(0.7, 2.1)	0.556
Pregnant women's occupational status					
Private and government employee	546(75.7)	179(24.3)	Ref.		
Farmer	104(34.0)	202(66.0)	0.5(0.2, 0.7)*	0.2(0.1, 0.3)	<0.001
Housewife	166(36.8)	286(63.2)	0.7(0.4, 0.8)*	0.3(0.2, 0.3)	<0.001
Husband/partner's occupational status					
Private and government employee	617(61.3)	423(38.7)	Ref.		
Farmer	168(41.4)	237(58.6)	2.7(2.1, 3.5)***	2.4(1.6, 3.6)	<0.001
Access to mass media					
Yes	726(55.5)	582(44.5)	1.7(1.2, 2.4)**	0.8(0.5, 1.2)	0.243
No	61(42.3)	84(57.7)	Ref.		

*p<0.001, **p<0.01, ***p<0.05

Note: Pseudo-R^2 = 0.16, p < 0.001

Table 7 summarizes the multivariable logistic analysis results between socio-demographic variables and individual women's empowerment dimensions. Empowerment in household decision-making power was higher among pregnant women who had higher education levels, who were farmers, with high household wealth index, and whose current pregnancy was their first. Older pregnant women were found to be more empowered in the economic dimension than younger pregnant women while farmer and housewife pregnant women were economically less empowered as compared to those working in government and private sectors. Economic empowerment was 1.7 times higher among pregnant women with a high household wealth index than those with a low household wealth index (AOR=1.7, 95%CI: 1.0, 2.8).

Rural women were less empowered in the communication dimension than urban women. The household wealth index and education level of the pregnant women were positively associated with their communication empowerment. On the other hand, housewife pregnant women were less empowered in the communication dimension than working pregnant women. Pregnant women who were on the high household wealth index and had higher education levels were psychologically more empowered than those on the low household wealth index and had no formal education, respectively. Farmer and housewife pregnant women were less empowered in the psychological dimension than government and privately employed pregnant women.

Older pregnant women were more assertive than younger pregnant women. Pregnant women with higher education level partners were more empowered in the assertiveness dimension than those with no formal education partners. Farmer pregnant women were less empowered in the assertiveness dimension than working pregnant women (AOR= 0.6, 95%CI: 0.4, 0.9). Rural pregnant women were 58.1% less empowered in time dimension as compared to urban pregnant women (AOR=0.4, 95%CI: 0.3, 0.6). As the education level of pregnant women increased, their empowerment in the time dimension also increased. Time empowerment was lower among farmers (AOR= 0.2, 95%CI: 0.2, 0.4) and housewives (AOR= 0.3, 95%CI: 0.2, 0.4) pregnant women, respectively. Women who had given birth before were 56.5% less empowered in the time dimension than women whose current pregnancy was their first (AOR= 0.4, 95%CI: 0.3, 0.6).

Table 7. Associations of individual women's empowerment dimension with socio-demographic characteristics in West Shewa Zone, Central West Ethiopia, 2021. n=1,453

Characteristics	Decision making AOR (SE)	Economic AOR (SE)	Communication AOR (SE)	Psychological AOR (SE)	Assertiveness AOR (SE)	Time AOR (SE)
Age of respondents (years)						
≤19	Ref	Ref		Ref	Ref	
20-29	1.2(0.3)	2.7(0.8)**		1.5(0.4)	1.9(0.5)**	
≥30	1.1(0.3)	2.2(0.7)**		1.5(0.4)	1.9(0.5)***	
Residence place						
Urban	Ref	Ref	Ref	Ref	Ref	Ref
Rural	0.7(0.1)	1.2(0.3)	0.6(0.1)**	0.9(0.2)	1.5(0.3)***	0.4(0.1)*
Household wealth index						
Low	Ref	Ref	Ref	Ref	Ref	Ref
Middle	1.1(0.2)	1.3(0.3)	1.7(0.3)**	1.0(0.2)	0.6(0.1)**	0.9(0.2)
High	1.7(0.5)***	1.7(0.5)***	1.6(0.4)	1.7(0.4)***	0.4(0.1)*	0.9(0.2)
Respondent's education level						
No formal education	Ref	Ref	Ref	Ref	Ref	Ref
Primary + Secondary	1.0(0.2)	0.8(0.2)	2.4(0.6)*	1.4(0.2)***	0.9(0.2)	1.7(0.3)***
Diploma and above	2.6(0.8)**	1.7(0.5)	4.9(1.4)*	2.0(0.4)**	1.4(0.4)	4.0(1.2)*
Husband/partner's education level						
No formal education	Ref	Ref	Ref		Ref	Ref
Primary + Secondary	1.0(0.3)	1.2(0.3)	0.8(0.2)		1.7(0.4)***	1.1(0.3)
Diploma and above	0.9(0.3)	0.8(0.2)	1.3(0.4)		2.3(0.6)**	0.9(0.3)
Respondents' occupational status						
Government and private employee	Ref	Ref	Ref	Ref	Ref	Ref

Farmer	1.8(0.4)**	0.1(0.02)*	0.9(0.2)	0.5(0.1)**	0.6(0.1)**	0.2(0.1)*
Housewife	0.8(0.1)	0.1(0.01)*	0.6(0.1)*	0.7(0.1)***	0.9(0.1)	0.3(0.1)*
Husband/partner's occupational status						
Government and private employee		Ref	Ref	Ref	Ref	Ref
Farmer		2.2(0.5)**	3.0(0.7)*	3.1(0.6)*	0.8(0.2)	0.8(0.2)
Access to mass media						
Yes		1.2(0.3)	1.4(0.3)		0.5(0.1)*	0.6(0.1)**
No		Ref	Ref		Ref	Ref
Pseudo-R^2	0.06	0.26	0.11	0.04	0.04	0.23

*p<0.001, **p<0.01, ***p<0.05

5.2. Women's empowerment and nutritional status during pregnancy

5.2.1. Nutritional status of pregnant women

Out of the 1,453 pregnant women, 269 (18.5%) (95% CI: 16.6, 20.6) were found to be anemic (hemoglobin < 11 g/dL) before altitude adjustment. After adjusting for altitude, the prevalence of anemia increased to 466 (32.1%) (95% CI: 29.7, 34.5). Among the 466 anemic pregnant women, 10 (2.2%) had severe anemia, 250 (53.6%) had moderate anemia, and 206 (44.2%) had mild anemia. Regarding gestational age, 34 (7.3%) were in the second-trimester, and 432 (92.7%) were in the third-trimester. The mean hemoglobin level was 12.4 g/dL (SD=1.7). Additionally, of the 1,453 pregnant women, 306 (21.1%) (95% CI: 19.0, 23.2) were classified as malnourished (MUAC <23 cm). The mean MUAC value was 25.0 cm (SD=2.2).

5.2.2. Associations between women's empowerment and pregnant women's nutritional status

Pregnant women's composite empowerment score was significantly and positively associated with the anemia status and MUAC level. The odds of being free from anemia among empowered pregnant women was 1.9 times higher than among less empowered pregnant women (AOR=1.9, 95% CI: 1.5, 2.4). Similarly, empowered pregnant women had higher odds of having MUAC ≥ 23 cm compared to those with less empowered pregnant women (AOR=1.8, 95% CI: 1.3, 2.4).

On the other hand, only economic and assertiveness dimensions were significantly associated with pregnant women's anemia status. Economically empowered pregnant women had 1.7 higher odds of being free from anemia than those less empowered in the same dimension (AOR=1.7, 95% CI: 1.3, 2.2). The odds of being free from anemia among pregnant women who were empowered in the assertiveness dimension was 1.9 times higher than those women who were less empowered in the same empowerment dimension (AOR = 1.9, 95% CI: 1.5, 2.4).

Similarly, only two dimensions were positively and significantly associated with the MUAC level of the pregnant women. Pregnant women empowered in household decision-making power had higher odds of having MUAC ≥ 23 cm (AOR=1.6, 95% CI: 1.2, 2.2) than those less empowered in this dimension. Having MUAC ≥ 23 cm was 1.4 times higher among psychologically empowered pregnant women compared to those psychologically less

empowered pregnant women (AOR=1.4, 95% CI: 1.0, 1.9). The association results are presented in Table 8.

Table 8. Associations of women's empowerment with pregnant women's nutritional status in West Shewa Zone, Ethiopia, 2021. (n=1,453)

Model	Anemia status* Anemic	Anemia free	AOR (95% CI for AOR)	p-value	MUAC** MUAC <23 cm	MUAC ≥ 23 cm	AOR (95% CI for AOR)	p-value
Model I								
Composite women's empowerment								
Less empowered	275 (18.9)	390 (26.8)	Ref		183 (12.6)	482(33.2)	Ref	
Empowered	191 (13.2)	597 (41.1)	1.9 (1.5, 2.4)	0.000	123 (8.5)	665(45.8)	1.8 (1.3, 2.4)	0.000
Model statistics								
LR (Chi-square)	89.2				110.4			
Pseudo-R^2	0.049				0.074			
p-value	0.000				0.000			
Model II								
Household decision-making power								
Less empowered	120 (8.3)	184 (12.7)	Ref		95(6.5)	209 (14.4)	Ref	
Empowered	346 (23.8)	803 (55.3)	1.2(0.9, 1.6)	0.164	211(14.5)	938(64.6)	1.6(1.2, 2.2)	0.003
Economic								
Less empowered	246 (16.9)	341(23.5)	Ref		159(10.9)	428(29.5)	Ref	
Empowered	220(15.1)	646(44.5)	1.7(1.3, 2.2)	0.000	147(10.1)	719(49.5)	1.4(0.9, 1.7)	0.172
Communication								
Less empowered	314 (21.6)	575(39.6)	Ref		200(13.8)	689(47.4)	Ref	
Empowered	152 (10.5)	412(28.4)	1.1(0.9, 1.5)	0.340	106(7.3)	458(31.5)	1.1(0.8, 1.4)	0.764
Psychological								
Less empowered	246 (16.9)	435(29.9)	Ref		169(11.6)	512(35.2)	Ref	
Empowered	220 (15.1)	552(38.0)	1.2(0.9, 1.5)	0.186	137(9.4)	635(43.7)	1.4(1.0, 1.9)	0.027
Assertiveness								
Less empowered	281 (19.3)	431(29.7)	Ref		165(11.4)	547(37.7)	Ref	
Empowered	185 (12.7)	556(38.3)	1.9(1.5, 2.4)	0.000	141(9.7)	600(41.3)	1.2(0.8, 1.4)	0.702
Time								
Less empowered	236 (16.2)	363(25.0)	Ref		151(10.4)	448(30.8)	Ref	
Empowered	230 (15.8)	624(43.0)	1.2(0.9, 1.5)	0.273	155(10.7)	699(48.1)	1.3(1.0, 1.8)	0.070
Model statistics								
LR (Chi-square)	124.1				120.7			

Pseudo-R^2	0.068	0.081
p-value	0.000	0.000

*Adjusted for age, residence place, household wealth index, pregnant women's and their partners' educational level and occupational status, access to mass media, birth order

**Adjusted for age, residence place, household wealth index, pregnant women's educational level, occupational status of the pregnant women and their partners, birth order

5.3. Women's empowerment and dietary diversity

Of the 1,453 pregnant women enrolled in the study, 70 of them didn't have a second-round dietary diversity measurement. Hence, the analysis was based on the 1,383 pregnant women who had complete data. This sample size was enough to address this objective because it was more than the calculated minimum sample required for this objective, which was 1,099.

5.3.1. Factor analyses results of women's empowerment

Factor analysis results identified and confirmed four dimensions to operationalize women's empowerment for this objective. Four factors/dimensions were retained based on the EFA result. Four items loaded to household decision-making power and economic dimensions; three items loaded to psychological dimension; and two items loaded to time dimensions (Table 9). Reliability (ordinal alpha) test results for household decision-making power, economic, psychological, and time dimensions were 0.76, 0.84, 0.74, and 0.81, respectively. Fit indices for the final EFA model were RMSEA=0.035; TLI=0.977; and SRMR=0.02. The correlations among the four factors were significant (p-value < 0.05) and less than 0.42. Fit was acceptable for the final CFA model as well: RMSEA=0.042; CFI=0.996; TLI=0.994; and SRMR=0.069.

Table 9. Factor analyses results of women's empowerment items in West Shewa Zone, Ethiopia, 2021 (n=1,383)

Dimensions	Items	Factor loadings (EFA)	Factor loadings (CFA)
Household decision-making power	Decision on what food to buy and consume (d1)	0.732	0.918
	Decision on food prepared every day (d2)	0.784	0.991
	Decision on own healthcare (d3)	0.663	0.927
	Decision on daily needs household purchases (d4)	0.763	0.943
Economic	Engagement with cash income activities (ec1)	0.891	0.867
	Cash savings of own (ec2)	0.574	0.797
	Decision on own earning use (ec3)	0.692	0.933
	Direct access to household money for use (ec4)	0.591	0.778
Psychological	Self-confidence in problem-solving (p1)	0.514	0.733
	Feeling as important household member (p2)	0.790	0.933
	Feeling household members respect your opinion (p3)	0.822	0.876
Time	Daily time expenditure on housework (t1)	0.810	0.992
	Time spent on housework the previous day (t2)	0.884	0.847

5.3.2. Pregnant women's dietary diversity

The mean for the 10 food groups consumed by the pregnant women in the previous 24 h was 4.5 (SD=0.7) with a range of 2.5 to 6.5 food groups. Of 1,383 pregnant women, about 855 (61.8%) (95% CI: 59.2, 64.4) of them consumed inadequately diversified diets whereas 528 (38.2%) (95% CI: 35.5, 40.7) of them consumed adequately diversified diets (Table 10).

Table 10. Dietary diversity of pregnant women in West Shewa Zone, Ethiopia, 2021. (n=1,383)

Variables	Frequency (n)	Percentage (%)	
Dietary diversity			
Inadequate	855	61.8	
Adequate	528	38.2	
Consumed food groups	First round n (%)	Second round n (%)	Both rounds n (%)
Grains, white roots and tubers, and plantains	1,383 (100)	1,382 (99.9)	1,382 (99.9)
Pulses	1,182 (85.5)	1,110 (80.3)	953 (68.9)
Nuts and seeds	2 (0.1)	22 (1.6)	0 (0.00)
Dairy	586 (42.4)	578 (41.8)	243 (17.6)
Meat, poultry and fish	296 (21.4)	317 (22.9)	80 (5.8)
Eggs	275 (19.9)	312 (22.6)	67 (4.9)
Dark green leafy vegetables	452 (32.7)	463 (33.5)	175 (12.7)
Other vitamin A-rich fruits and vegetables	356 (25.7)	471 (34.1)	113 (8.2)
Other vegetables	1,374 (99.4)	1,300 (94.0)	1,291 (93.4)
Other fruits	273 (19.7)	432 (31.2)	120 (8.7)

5.3.3. Women's empowerment and dietary diversity of pregnant women

Figure 5 illustrates the adjusted SEM result. The model fit indices were as follows: RMSEA = 0.039, CFI = 0.989, TLI = 0.983, and SRMR = 0.072, all of which indicate an acceptable fit. The pregnant women's education level had no direct association with their economic empowerment dimension ($\beta = 0.032$, $p > 0.05$) and dietary diversity during pregnancy ($\beta = 0.003$, $p > 0.05$). However, education was positively and directly associated with three dimensions of empowerment: household decision-making power ($\beta = 0.196$, $p < 0.05$), psychological empowerment ($\beta = 0.314$, $p < 0.001$), and time empowerment ($\beta = 0.109$, $p < 0.05$). Furthermore, these three empowerment dimensions were positively and directly associated with dietary diversity of the pregnant women: household decision-making power ($\beta = 0.131$, $p < 0.05$), psychological empowerment ($\beta = 0.237$, $p < 0.001$), and time empowerment ($\beta = 0.146$, p

< 0.01). However, economic empowerment (β = -0.108, p > 0.05) showed no significant association with dietary diversity during pregnancy.

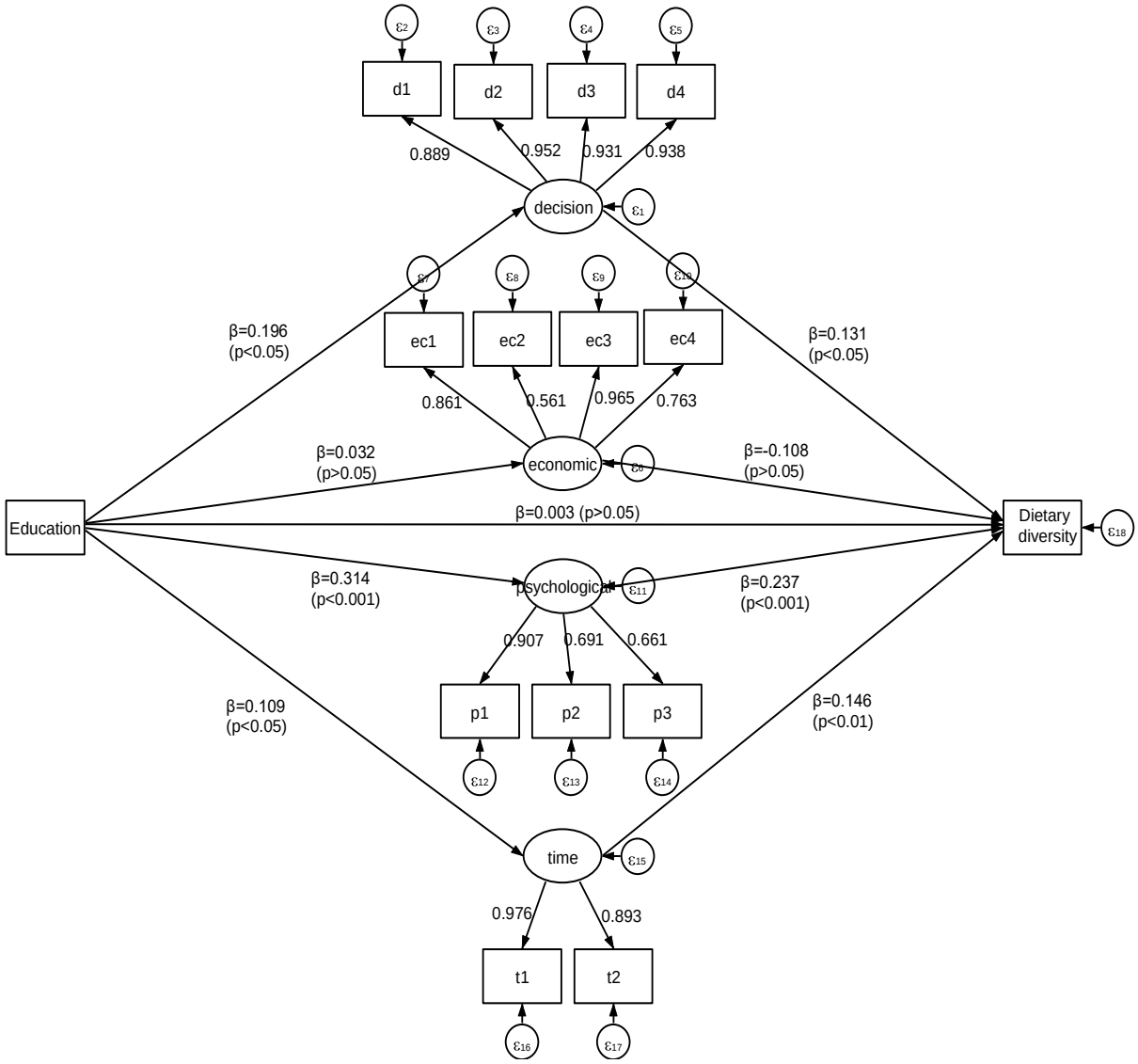


Figure 5. SEM results of the mediating effects of women's empowerment in the relation between pregnant women's education and dietary diversity during pregnancy, West Shewa Zone, Central West Ethiopia, 2021.

The total indirect effect of pregnant women's education on dietary diversity during pregnancy was found to be positive and statistically significant. The dimensions of household decision-making power, psychological empowerment, and time empowerment served as significant mediators in the relationship between pregnant women's education and dietary diversity during pregnancy. Furthermore, the total effect of pregnant women's education on their dietary diversity during pregnancy was also significant, as shown in Table 11.

Table 11. Direct and indirect effects of pregnant women's education on dietary diversity during pregnancy in West Shewa Zone, Ethiopia, 2021. (n=1,383)

Effect	Empowerment dimension	Coefficient	*p*-value
Total effect		0.115	0.016
Direct effect		0.003	0.956
Total indirect effect		0.113	<0.001
Indirect effect through	Household decision-making power	0.026	0.121
	Economic	-0.003	0.592
	Psychological	0.074	<0.001
	Time	0.016	0.045

5.4. Women's empowerment and birth weight

5.4.1. Descriptive results

Analysis for this objective was based on 1,165 participants with complete data on covariates, women's empowerment, and birth weight. There were no significant differences in background characteristics and main exposure of the study, which was women's empowerment status, between the women enrolled in the large follow-up study and those women excluded from the analysis except for age. Women with missing data on birth weight were slightly older (Annex 15).

The mean age of the 1,165 mothers was 28 years (SD=5.4), ranging from 18 to 44 years. The current delivery was the first for 512(44%) of them. For the rest 653(56%) of the mothers, the mean birth interval between the current and previous pregnancy was 2.9 years (SD=1.6) with a range of 1 to 13 years. Of 1,165 mothers, 914(78.5%) of them were empowered in the household decision-making power dimension while 600(51.5%) of them were empowered in the psychological dimension. The majority, 992(85.2%), were decision-makers on food bought and consumed by the household. However, only 400(34.3%) of them had cash savings of their own, and 462(39.7%) of them were self-confident in solving problems on their own. About 521(44.7%) of them spent more than six hours on housework daily. Adequate and inadequate dietary diversity during pregnancy were 457(39.2%) and 708(60.8%), respectively. The mean maternal MUAC was 25 cm (SD=2.2). The mean hemoglobin level during pregnancy was 11.6 g/dL (SD=1.7). Descriptive statistics of the 1,165 mothers who participated in this study are summarized in Table 12.

Table 12. Descriptive characteristics of study participants in West Shewa Zone, Ethiopia, 2021 (n=1,165).

Variables	Frequency	Percentage/ Mean (SD)
Demographic characteristics		
Women's education level		
Illiterate	228	19.6
Primary	409	35.1
Secondary and above	528	45.3
Residence		
Rural	726	62.3
Urban	439	37.7
Women's occupation		
Government employee	249	21.4
Private employee	550	47.2
Housewife	366	31.4
Household wealth index		
Low	406	34.9
Middle	372	31.9
High	387	33.2
Women's empowerment dimensions		
Household decision-making power (mean, out of 0-4 total points)		3.5(1.1)
Economic (mean, out of 0-4 total points)		2.5(1.4)
Psychological (mean, out of 0-6 total points)		4.3(1.5)
Time (mean, out of 0-4 total points)		3.0(1.0)

5.4.2. CFA result of women's empowerment

CFA confirmed that the four dimensions used to operationalize women's empowerment were appropriate. The model fit indices for the CFA model (RMSEA=0.052, CFI=0.992, TLI=0.989, and SRMR=0.072) were within the recommended values, suggesting a good fit of the model to the data. Ordinal alpha results were higher than 0.7 for all the dimensions, suggesting the model had good reliability (175) (Table 13). The correlations among the four dimensions were significant ($p<0.001$) and less than 0.556.

Table 13.Standardized factor loadings and reliability results of confirmatory factor analysis.

Dimensions	Items	Standard loadings	Ordinal alpha
Household decision-making power	Decision on what food to buy and consume (d1)	0.849	0.959
	Decision on food prepared every day (d2)	0.943	
	Decision on own healthcare (d3)	0.913	
	Decision on daily needs household purchases (d4)	0.953	
Economic	Engagement with cash income activities (ec1)	0.819	0.901
	Cash savings of own (ec2)	0.662	
	Decision on own earning use (ec3)	0.979	
	Direct access to household money for use (ec4)	0.838	
Psychological	Self-confidence in problem-solving (p1)	0.982	0.868
	Feeling as important household member (p2)	0.534	
	Feeling household members respect your opinion (p3)	0.626	
Time	Daily time expenditure on housework (t1)	1.000	0.929
	Time spent on housework the previous day (t2)	0.867	

5.4.3. Birth weight

The mean birth weight among 1,165 singleton newborns was 3,168.5g (SD=460.6) (95% CI: 3,142.0, 3,195.0) with a minimum of 2,030 g and a maximum of 4,700g. About 73 (6.3%) (95% CI: 5.0, 7.8) of the newborns had LBW whereas 81 (6.9%) (95% CI: 5.6, 8.6) of them were macrosomic. The distribution of LBW and macrosomia cases by empowerment status of the mothers is presented in Table 14.

Table 14. Distribution of low birth weight and macrosomia by empowerment status of mothers in West Shewa Zone, Ethiopia, 2021 (n=1,165).

Empowerment dimensions	LBW n(%)	Macrosomia n(%)
Household decision-making power		
Less empowered	23(31.5)	15(18.5)
Empowered	50(68.5)	66(81.5)
Economic		
Less empowered	35(48.0)	29(35.8)
Empowered	38(52.0)	52(64.2)
Psychological		
Less empowered	46(63.0)	38(46.9)
Empowered	27(37.0)	43(53.1)
Time		
Less empowered	31(42.5)	31(38.3)
Empowered	42(57.5)	50(61.7)

The mean birth weight was significantly higher among newborns from psychologically empowered women (Table 15).

Table 15. Mean birth weight of newborns by empowerment status of their mothers in West Shewa Zone, Ethiopia, 2021 (n=1,165).

Empowerment dimensions	n(%)	Mean BW (g)	95% CI	p-value[a]
Household decision-making power				
Less empowered	251(21.6)	3119.2	3061.8, 3176.6	0.056
Empowered	914(78.4)	3182.0	3152.2, 3211.8	
Economic				
Less empowered	468(40.2)	3157.1	3114.2, 3200.0	0.490
Empowered	697(59.8)	3176.1	3142.4, 3209.8	
Psychological				
Less empowered	565(48.5)	3126.1	3087.2, 3164.9	0.002
Empowered	600(51.5)	3208.5	3172.5, 3244.4	
Time				
Less empowered	464(39.8)	3152.9	3110.7, 3195.1	0.348
Empowered	701(60.2)	3178.8	3144.7, 3212.8	

Notes: [a]p-value was obtained from the t-test

5.4.4. SEM results on women's empowerment and birth weight

The fit indices results of the SEM indicated a good fit of the hypothesized model: RMSEA=0.042, CFI=0.966, TLI=0.989, and SRMR=0.08. The adjusted SEM results are presented in Figure 6. Household decision-making power and economic dimensions predicted the birth weight of newborns. The household decision-making power of the mothers (β=0.091, p=0.040) was directly and positively related to the birth weight of newborns, while the economic empowerment of the mothers (β=-0.444, p<0.000) was negatively correlated to the birth weight of newborns. The psychological (β=0.063, p=0.140) and time (β=0.052, p=0.189) empowerment dimensions were not associated with birth weight.

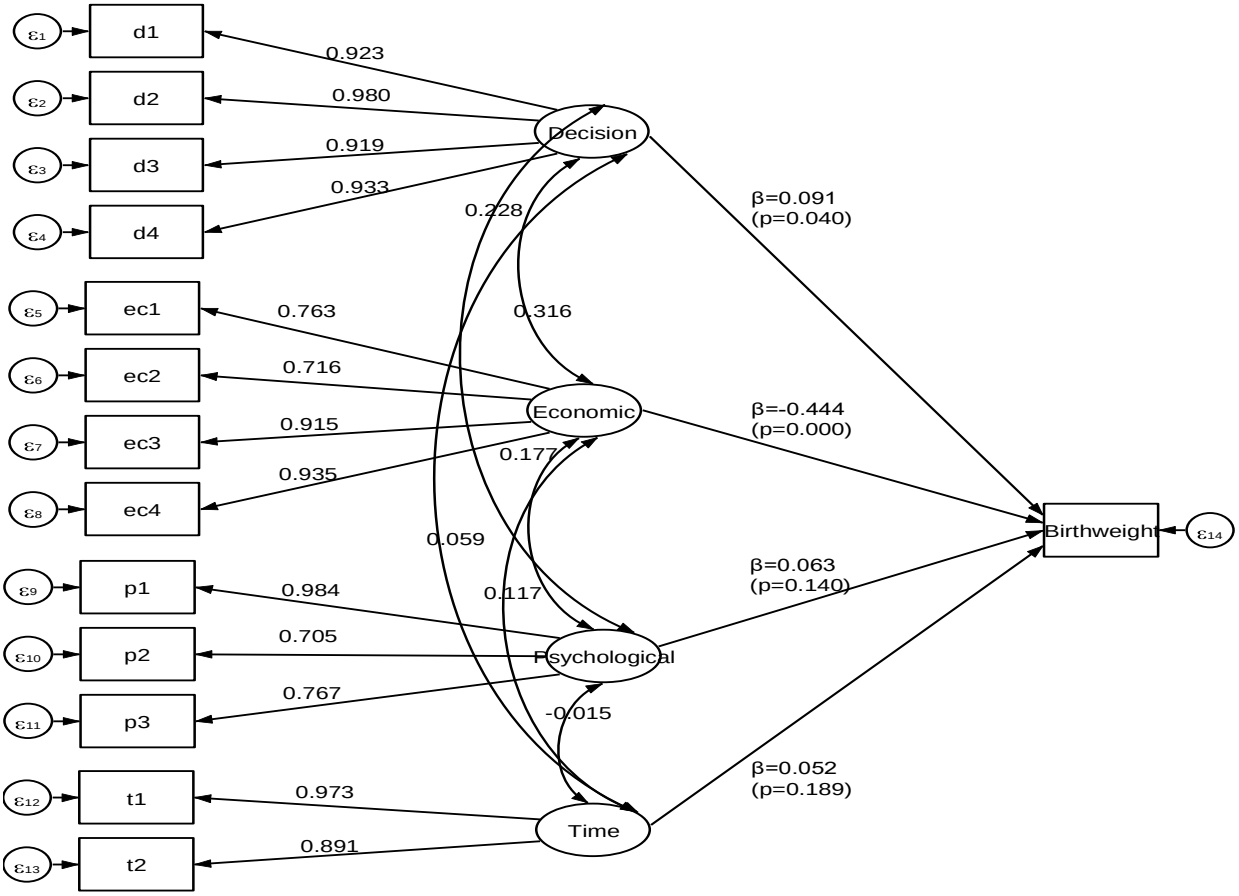


Figure 6. SEM results of the effects of women's empowerment dimensions on birth weight in West Shewa Zone, Ethiopia, 2021.

5.5. Summary of the main findings of the dissertation

Key findings of Papers I to IV are summarized in Table 16.

Table 16. Summary of the key findings by objectives of Paper I to IV, West Shewa Zone, Ethiopia, 2021.

Objective	**Main finding**
To determine the level of pregnant women's empowerment and factors associated with it (Paper I)	**Composite empowerment status:** 54.2% (95% CI: 51.7, 56.8) of the pregnant women were empowered **Factors associated with composite empowerment:** pregnant women who were older and had formal education were more empowered whereas those who lived in rural areas, farmers and housewives were less empowered than their counter parts **Individual dimensions:** among the 6 dimensions, the highest and least empowerment was in household decision-making power and communication dimensions, respectively **Factors associated with individual dimension of empowerment:** older pregnant women were more empowered in economic

	(AOR=2.2, 95%CI: 1.2, 4.0) and assertiveness (AOR=1.9, 95%CI: 1.1, 3.1) dimensions than younger women. Pregnant women's higher education level was positively associated with household-decision making (AOR=2.6, 95%CI: 1.4, 4.9), communication (AOR=4.9, 95%CI: 2.8, 8.8), psychological (AOR=2.0, 95%CI: 1.3, 2.9) and time (AOR=4.0, 95%CI: 2.3, 7.2) dimensions. Being rural women, housewives and having multiple children were negatively associated with time empowerment
To assess the association between women's empowerment and nutritional status of pregnant women (Paper II)	**Proportion of anemia among pregnant women:** 32.1% (95% CI: 29.7, 34.5) **Proportion of pregnant women with MUAC <23cm:** 21.1% (95% CI: 19.0, 23.2) **Associations:** composite pregnant women's empowerment was positively associated with both anemia status and MUAC level. The odds of being free from anemia were higher among pregnant women empowered in economic (AOR=1.7, 95%CI: 1.3, 2.2) and assertiveness (AOR=1.9, 95% CI: 1.5, 2.4) dimensions than those less empowered in these dimensions. Empowered pregnant women in household decision-making power (AOR=1.6, 95% CI: 1.2, 2.2) and psychological (AOR=1.4, 95% CI: 1.0, 1.9) dimensions had higher odds of having MUAC ≥ 23cm measures than those less empowered in the respective dimensions.
To examine the mediating effects of women's empowerment on dietary diversity during pregnancy (Paper III)	**Adequate dietary diversity of pregnant women:** 528 (38.2%) (95% CI: 35.5, 40.7) **Inadequate dietary diversity of pregnant women:** 855 (61.8%) (95% CI: 59.2, 64.4) **Women's empowerment effect on dietary diversity**: dietary diversity was higher among pregnant women who had higher household decision-making power (β=0.131, $p < 0.05$), psychological ($\beta = 0.237$, $p < 0.001$) and time ($\beta = 0.146$, $p < 0.01$) empowerment. Moreover, they were significant mediators in the relationship between pregnant women's education and dietary diversity. However, the economic dimension was related to neither pregnant women's education nor dietary diversity.
To identify the effects of pregnant women's empowerment on birth weight (Paper IV)	**LBW magnitude:** 6.3% (95% CI: 5.0, 7.8) **Macrosomia magnitude:** 6.9% (95% CI: 5.6, 8.6) **Women's empowerment effect on birth weight:** a positive association was found between pregnant women's household decision-making power and the birth weight of the infants they delivered (β=0.091, p=0.040), whereas higher economic empowerment of the women was related to delivering lower birth weight infants (β=-0.444, p<0.001). Pregnant women's psychological and time empowerments were not significantly associated with newborn birth weight.

6. Discussion

This study used the resource–agency–achievement framework to examine the level of women's empowerment and its association with pregnant women's nutritional status, dietary diversity, and the birth weight of their newborn. Overall, 54.2% (95% CI: 51.7, 56.8) of the pregnant women were empowered. The highest and least empowerment was in household decision-making power and communication dimensions, respectively. Moreover, nutritional status was better among empowered pregnant women compared to those less empowered pregnant women. Household decision-making power, economic, psychological, and assertiveness dimensions were significant determinants of pregnant women's nutritional status.

Likewise, consumption of more diverse diets was higher among pregnant women who were better empowered in household decision-making power, psychological, and time dimensions. These dimensions also significantly mediated the relationship between pregnant women's education and their dietary diversity. However, their economic empowerment wasn't directly associated with their dietary diversity. It was also an insignificant mediator. Pregnant women's empowerment in household decision-making power was positively associated with the birth weight of the infants they delivered. On the contrary, the economic empowerment of pregnant women was negatively associated with newborn birth weight. Neither their psychological nor time empowerment was associated with the weight of the newborns the women delivered.

6.1. Magnitude of women's empowerment

The fact that different items and dimensions are used for measuring women's empowerment makes it difficult to make comparisons across studies. However, among studies that considered multidimensionality, approachable empowerment result was found in the study conducted in Benin (76). About 55.8% of the women were empowered whereas 54.2% of the women were empowered in the current study. Both Benin and Ethiopia are developing countries that acknowledge and share the necessity of addressing women's empowerment which has highly been influenced by existing socio-cultural circumstances. This result is an indication of the need for further work in empowering women. Likewise, Ethiopia has accepted and been working for the achievement of SDGs, which highlights the promotion of women's empowerment (35). On the other hand, only 6% of women with partners were empowered in Ethiopia according to EDHS 2016 (17), which was significantly low compared to the current study. Besides the

differences in items used for measuring women's empowerment, the EDHS result represented national figures, and the time of study could have contributed to the differences.

6.2. Women's empowerment association with pregnant women's nutritional status

6.2.1. Nutritional status of pregnant women

The current study revealed that 32.1% of pregnant women were anemic. Similar results were reported by studies conducted in different regions of Ethiopia. For instance, 33.1% of pregnant women in Eastern Ethiopia (9) and 32.8% of pregnant women in Arba Minch (183) were found to be anemic after altitude adjustment. However, lower prevalence has been reported by studies in Western Ethiopia (17.8%) (184) and Southeast Ethiopia (27.9%) (185). Not considering altitude adjustment could be among the reasons for differences. Anemia is a moderate public health problem in the study area according to the WHO classification of the public health significance of anemia (12). Maternal anemia during pregnancy has been associated with increased maternal (186,187) and neonatal (187) mortalities. Moreover, this study's finding indicates that Ethiopia needs to continue working on pregnancy anemia prevention and treatment activities to achieve the SDG target of halving anemia among reproductive-age women by 2030. In this study, 21.1% of the pregnant women were malnourished (MUAC < 23 cm). Other studies in Ethiopia have also reported a significant proportion of pregnant women as malnourished (8,10,47,48). This implies the necessity to develop effective interventions and nutritional status improvements among pregnant women.

6.2.2. Women's empowerment association with nutritional status during pregnancy

According to this study's findings, empowered pregnant women had lower odds of being anemic or malnourished than less empowered pregnant women. As women's empowerment levels increase, they have greater knowledge of nutrition and health and greater decision-making power, income control, and time to exercise that knowledge in their self-care (81). Supporting findings have been reported. For instance, women's hemoglobin level was positively associated with their instrumental agency (influence in household decision-making) among East African women (146).

In this study, pregnant women who had higher empowerment in household decision-making were less malnourished than those with lower levels of empowerment in the same dimension.

Empowerment in household decision-making allows women to take control over decisions regarding the purchasing, preparation, and consumption of food for the household, which can positively influence their nutritional status. However, it was unexpected to find no association between household decision-making power and anemia status. This could be due to the multifactorial causes of anemia, which can be influenced by factors such as micronutrient deficiencies, parasitic and chronic infections, geographical location, and dietary habits. Additionally, in Ethiopia, women are often responsible for managing most household tasks, including food-related matters, as evidenced in this study. Therefore, the better decision-making power of the women can lead to better nutritional status at the household level in their family and may not translate directly into improvements in their own nutritional status.

The finding of this study also implies that pregnant women's decision-making power may also be influenced by other dimensions of women's empowerment, such as economic empowerment. Having higher household decision-making power may not lead to improved nutritional status among pregnant women if there is no economic empowerment. Women's economic empowerment may enable women to afford quality food; it can strengthen their household decision-making power, which contributes to improving their well-being (151). Interventions targeting these women would benefit by promoting empowerment in multiple dimensions and encouraging them to transfer their decision-making power to self-care as well. Yet, a similar result was found in the analysis of the 2016 Ethiopian DHS data, which indicated that women's decision-making did not influence their anemia status (147). On the contrary, a study in five East African countries found that women's household decision-making was positively associated with their blood hemoglobin level (146). Differences in indicators used for decision-making measurements, study settings, and study participants might have contributed to varying results. In the current study, only pregnant women were included instead of non-pregnant women in the referred studies (146,147).

Economically empowered pregnant women had fewer odds of being anemic in this study. Control over income was linked with the better nutritional status of women (86). For instance, the greater magnitude of anemia has been linked to the low decision-making capacity of women to access resources and health information (147). Participating in income-generating activities can improve access and control over resources. This enhances their decision-making power and control over their and family's life. Income improves self-confidence and -esteem (188).

Women's participation in household decision-making and their ability to purchase food positively impact the availability of diverse and nutrient-rich diets in the household and, consequently, adequate dietary diversity intake among women (144,153), reducing the likelihood of being anemic. On the other hand, the MUAC status of the pregnant women was not related to their economic empowerment status. Nutritional status during pregnancy depends not only on adequate dietary intake but also on socio-cultural factors, energy expenditure, and nutrition knowledge (93,115). For instance, women work longer hours when both paid and unpaid work are considered (189). Women in Ethiopia are involved in unpaid and tiresome household work, making them the most disadvantaged members of society (190). This circumstance may increase the probability of energy expenditure, resulting in low MUAC. Women may also face time poverty for self-care due to heavy workloads. Unemployed and farmer women in Ethiopia were particularly identified as the most malnourished (77).

The significant and positive association of psychological empowerment with MUAC status in this study shows the important role pregnant women's self-confidence and self-esteem have on nutrition outcomes during pregnancy. Other related studies also found that women's self-confidence was related to their and their children's nutritional status (76,149,150). Psychological empowerment is characterized by a sense of perceived control, competence, and goal internalization (148). Therefore, it enhances the likelihood of adopting healthy behaviors, such as healthy food choices and sticking to healthier dietary habits, ultimately leading to improved nutritional status. Increased self-confidence has been reported as a factor that positively influences nutrition outcomes. However, the lack of a significant association between the psychological dimension and anemia status among pregnant women in this study suggests that further research is needed. This finding may indicate the influence of other underlying factors that obscure the connection between psychological empowerment and anemia status during pregnancy.

This study showed that assertive pregnant women had less odds of being anemic than less assertive pregnant women. Assertive women are likely to stand up for their rights, say what they want or believe in, and object to unreasonable requests (191). This may be reflected in their ability to access resources and utilize health services, which can ultimately affect their nutritional status. It is well-documented that assertive women tend to be more confident and self-assured, traits that are often associated with psychological empowerment. Therefore, it was anticipated

that the assertiveness dimension would be linked to the MUAC levels of pregnant women, similar to the psychological empowerment dimension. However, empowerment in the assertiveness dimension was not found to be associated with MUAC status. The differing results for specific empowerment dimensions and their relationship to the outcome variables suggest that each dimension uniquely influences nutrition outcomes. While assertiveness is important for other dimensions of women's empowerment to be effective (192), it alone may not ensure better nutritional status, as demonstrated in this study. Self-confidence can enhance a woman's ability to utilize available resources and circumstances, but assertiveness by itself may not lead to the desired outcome unless supported by other empowering conditions. Even if pregnant women are assertive, they may not be empowered in other areas of life, which could explain the lack of association observed in this study.

In this study, the communication and time dimensions were not found to be associated with the nutritional outcomes of pregnant women. However, existing literature suggests that high workloads for women are often linked to poor nutritional status (82,86). Women may work longer hours to improve the quantity and quality of food available to their households, but longer work hours may also increase their energy expenditure, resulting in poor nutrition outcomes (82). It was also noted that intra-household communication may help achieve improved maternal nutrition outcomes (78). Effective communication allows women to express their needs and share their thoughts, which in turn can enhance their decision-making power across various domains, including economic and political spheres (151,152).

The unexpected results in this study may imply that the better nutritional status of pregnant women is not necessarily related to empowerment in all dimensions of women’s empowerment. In line with the above explanations, the interconnectedness of the empowerment dimensions may be one of the reasons for the insignificant association results. Empowerment in a specific dimension may not necessarily guarantee better nutritional status among pregnant women; rather, it is the cumulative empowerment of the different dimensions. This is reflected in this study in which significant relations between composite empowerment and nutrition outcomes of pregnant women was observed. Moreover, it has been underlined that the nutritional status of pregnant women depends on multiple factors such as dietary habits, access to health services, infectious diseases, and knowledge (193) besides the independent and control variables considered in this

study. Excluding these factors may have affected our study results. In general, several indicators were dropped during factor analysis. This may have affected our results.

6.3. Relationship between women's empowerment and pregnant women's dietary diversity

6.3.1. Dietary diversity among pregnant women

About 61.8% of the pregnant women did not consume adequately diversified diets in this study. Other studies in Ethiopia also indicated that more than half of women consumed inadequately diversified diets during their pregnancy (53–57). It has been pointed out that low dietary diversity may result in micronutrient deficiency among reproductive-age women (18,21), which is implicated in negative outcomes for both the mother and fetus (194,195).

6.3.2. Association of women's empowerment with dietary diversity during pregnancy

In the present study, there was a significant association between pregnant women's education and their household decision-making power. Better education may lead to better household decision-making power (196). Supporting evidence was found in this study as well. Pregnant women's decision-making power was also significantly related to their dietary diversity during pregnancy. It is expected that as women's participation in decisions about food purchase and preparation for the household increases, the availability of diverse diets in the household to increase as well; which in turn leads to adequate dietary diversity among the household members including the pregnant women. The majority of the pregnant women were responsible for food management at the household level in this study. This may be reflected in the dietary diversity of the pregnant women. On the other hand, different factors including nutrition information, and socio-cultural factors influence dietary diversity during pregnancy according to Ethiopian studies (23,115,197). Hence, it is important to understand the mechanisms of how these factors influence the decision-making power of pregnant women regarding the consumption of diverse diets during pregnancy in such culture culture-influenced society. Consistent with this study's findings, a study in Ghana pointed out women's decision-making power as a significant contributor to the consumption of diverse diets. Women who made decisions regarding household purchases were more likely to eat a diverse diet (144). Yet, a Bangladesh study found a null association between women's decision-making power and dietary diversity (78).

Differences in setting and study participants may contribute to varying results. Only pregnant women were included in this study, whereas the referred study was on non-pregnant women.

Pregnant women's educational status was not associated with their economic empowerment. Furthermore, the direct and indirect null effect of women's economic empowerment on their dietary diversity was unexpected. It has been highlighted that education enables women to generate their own income by increasing their employment opportunities (181). In turn, having access to and control over economic resources by women has been linked with the consumption of diverse diets (81,86). The contradicting findings in this study may suggest that (1) pregnant women can be involved in income-generating activities and have control over resources irrespective of their educational status in the study area; (2) economic empowerment may require the pregnant women to work outside for income generation. The traditional role also dictates them to cover household chores. Consequently, pregnant women may face time poverty for self-care due to heavy workloads. Even if their economic empowerment enables them to afford diverse diets, it may not be transferred to practice. Investigation into the values given for economic empowerment and dietary diversity by pregnant women may help to better understand the association between them. On the contrary, the finding may suggest that economic empowerment may not be enough which enable one to afford diverse diets rather than have the minimum diverse diets per day. The findings may also imply adequate dietary diversity during pregnancy may not necessarily be related to empowerment in every woman's empowerment dimension. Besides, the interdependences of the empowerment dimensions may have contributed to the insignificant results. Economic empowerment merely may not be a guarantee for adequate dietary diversity among pregnant women. It may require them simultaneously to be empowered in their decision-making power or time or psychological dimensions. For pregnant women's economic empowerment to result in adequate diversity during their pregnancy, they may need to be involved in decisions regarding food purchase and preparation; have self-worth, and have the time for self-care.

The significant direct and indirect influence of psychological empowerment on pregnant women's dietary diversity in this study highlights the crucial role self-confidence and esteem have on the consumption of adequately diversified diets during pregnancy. This finding is in line with the existing evidence that reported significant relations between women's self-confidence and nutritional status (76,150). Education enables women to enhance their self-esteem, and

confidence and practice their rights (181,198). Supporting results were also found in this study. Such conditions may promote their ability to take advantage of circumstances and available resources. Therefore, psychologically empowered pregnant women are believed to have the determination to engage in healthy dietary practices including consumption of adequately diversified diets.

This study found that as the education level of pregnant women increased, the time they spent on housework decreased. Educated women are more likely to be empowered economically (181) because education is believed to increase employment opportunities, thereby decreasing the time women spend on unpaid housework. Working housework for long hours can be tiring. This may in turn reduce the time for self-care. It has been pointed out that reducing the time spent on unpaid work enhances women's empowerment (199). This study has revealed around 54% of pregnant women spent between 6 and 16 hours daily on housework. Those pregnant women who spent less time on housework were more likely to eat an adequately diversified diet. The plausible explanation for this may be that pregnant women may be spending more time on income-generating activities that enable them to afford diverse foods. More importantly, time use has been noted to influence women's agency (200). As evidenced in this study as well, educated women are believed to have better decision-making power and self-confidence. Hence, the synergistic interaction of time empowerment with the other empowerment dimensions may have contributed to adequate dietary diversity among the pregnant women empowered in the time dimension. Consistent with this study's finding, reduced working hours among non-pregnant women were significantly associated with their dietary diversity in Nepalese and Ethiopia studies (83,86).

The significant indirect and total effects of pregnant women's education on their dietary diversity in this study are evidence of the different mechanisms education affects dietary diversity. Pregnant women's education had an indirect significant and positive effect on dietary diversity during pregnancy through pregnant women's empowerment dimensions. This is an implication that greater dietary diversity among pregnant women may be assured by promoting education which enables empowerment in multiple dimensions. Pregnant women's education led to adequate dietary diversity among them by empowering their household decision-making ability, psychological and time aspects. As highlighted above, better women's education may lead to empowerment in decision-making, time, and psychological dimensions which may indirectly

lead to adequate dietary diversity. A related study in rural Bangladesh indicated that women's empowerment mediated the significant indirect effect of women's education on their dietary diversity though different empowerment dimensions and non-pregnant women were used (78). Overall, the significant total effect finding in this study emphasizes the crucial role education plays in improving dietary diversity among pregnant women in the study area.

6.4. Women's empowerment and infant birth weight

6.4.1. Infant birth weight status

The results of this study demonstrated that the prevalence of LBW and macrosomia was comparable, suggesting the need for interventions not only for LBW but also for macrosomia.

6.4.2. Women's empowerment association with infant birth weight

A significant and positive effect of the mothers' household decision-making power on birth weight was observed in this study. This is consistent with other studies that reported higher decision-making power of women, resulting in higher birth weight (88,155). The decision-making power of women can affect their health service utilization (201,202) and nutritional status (77,146). This may influence fetal growth, which has implications for birth weight. In this study, women who had the freedom to make decisions regarding their healthcare, food purchases, and preparation had higher birth weight babies than those who did not have these privileges. Better health service utilization among women may improve their health knowledge. They are more likely to have adequate antenatal care visits (203), which helps them access micronutrients, including iron and folic acid supplements, regulate their nutritional status, and check their health and overall pregnancy status. These factors contribute significantly to averting poor birth outcomes, including poor birth weight. Women with better household decision-making power are more likely to consume adequately diverse diets (144), which reduces micronutrient deficiency (20). Dietary diversity during pregnancy can determine the nutritional status of the mother (18,20). This, in turn, is known to affect birth weight (4,22).

Studies have reported that women's economic empowerment is positively associated with better maternal nutrition (86), higher maternal health service utilization (204), and lower parity (205). Besides, women's economic empowerment is known to enhance the household decision-making power of women (151). This evidence suggests that economic empowerment contributes to

better birth weight. However, the negative association between mothers' economic empowerment and birth weight was an unexpected finding in this study. This may be owing to the mediating effect of other variables on the relationship between economic empowerment and birth weight. It is a fact that women have to work to be able to generate income. In addition, the gender role in Ethiopia forces women to accomplish unpaid and tiresome household work (190). These burdens may result in time deprivation to care for themselves. In addition, a heavy workload may increase energy expenditure. Long working hours and heavy workloads have been associated with poor nutritional status (82) and lower birth weight (87,157). Time use is also reported to impact the agency of women (200). Women who had to work outside for long hours for income-generating purposes might not be actively involved in decisions regarding household food purchase and preparation. On the other hand, even if women are involved in income-generating activities, their economic empowerment is sufficient only to allow them to lead subsistence lives. It may not be sufficient to allow them to afford good quality and quantity of food for themselves and their households. This may result in poor nutritional status in women.

Psychologically empowered women are determined to use available resources and services, including maternal health services. They have the strength to cope with stressful situations (206), which contributes to better birth outcomes (207,208). Some studies have shown that the psychological empowerment of women is positively associated with their nutritional status (76). This has been positively associated with birth weight (4). As pointed out above, time empowerment was linked with better maternal nutritional status (82) and household decision-making power (200). Hence, time empowerment was expected to result in better birth weight. However, neither psychological nor time empowerment was associated with birth weight in this study. These findings imply interconnectedness among the empowerment dimensions. Empowerment in the psychological dimension alone may not significantly affect birth weight unless there is economic empowerment, which enables women to afford good quality and quantity of food and access maternal health services. Similarly, women's time empowerment may require simultaneous empowerment in other dimensions to result in an expected outcome. Even if a woman is empowered in the time dimension, it does not necessarily imply that she is empowered in the household decision-making, economic, or psychological dimensions. Further investigations are needed to determine whether women who are empowered in the time

dimension are financially reliant on their partners and whether this has contributed to less empowerment in household decision-making and psychological dimensions among women.

Birth weight was categorized into LBW or not, as well as macrosomic or not. Separate analyses were conducted to examine the effect of the multiple dimensions of women's empowerment on these categorical variables. None of the dimensions were significantly associated with LBW or macrosomia. This may be because there were relatively few LBW and macrosomic infants, which reduced the statistical power to detect the effects of the empowerment dimensions on the categorized outcomes. Studies in Ethiopia have suggested that macrosomia is rising over time (29,72). The cases of LBW and macrosomia were similar in this study. Further research may help determine whether women's empowerment has brought about lifestyle changes that may be connected to birth weight.

7. Validity and generalizability

7.1. Internal validity

Internal validity examines whether the study design, conduct, and analysis answer the research questions without bias (209). To ensure the internal validity of this study, different circumstances were taken into consideration from design to analysis to reduce the role of bias, chance, and confounders which may affect the internal validity of the study. To increase validity, the questionnaires in this study were prepared after reviewing appropriate existing literature with reliable sources. The questionnaires were pretested. A questionnaire on women's empowerment was developed based on an already existing women's empowerment conceptual framework (31,32). The consistency and accuracy of the questionnaire instrument for measuring women's empowerment part was evaluated by factor analysis. EFA was used to increase the reliability of the questionnaire by identifying less important questions for measuring women's empowerment. CFA was conducted to check the construct validity of the questions that measured women's empowerment. Their reliability (internal consistency) was tested and ensured by their ordinal alpha result since they were binary and ordinal response items. In addition, in papers that performed SEM analysis (Paper III and IV), SEM reliability coefficients were used to ensure internal consistency. Dietary diversity was measured using a validated MDD-W tool. Moreover, to reduce the role of chance, dietary diversity was measured twice in nonconsecutive days and the average was used during analysis. To reduce measurement bias, standardized equipment and procedures were used for measuring hemoglobin levels and MUAC. Blood samples were collected and analyzed based on the standard operating procedures (HemoCue Hb 201+ Operating manual). Besides, hemoglobin values were adjusted for trimester and altitude during analysis. Efforts were made reduce intra-observer variability during MUAC measurement. MUAC was measured triple times and the mean was used during analysis to reduce the role of chance and measurement error. Beam scales used for measuring birth weight were calibrated every week.

To minimize selection bias and ensure representativeness, inclusion in this study was based on random selection at each step and proportional allocation. A tracing mechanism was developed during the design of this study to address the loss to follow-up bias which could occur due to the nature of the follow-up study. Hence, loss to follow-up was minimized in this study by applying

the tracing means i.e. through phone calls and health extension workers. Enough data were collected which met the required sample size for each paper. Therefore, the effect of lost to follow-up bias on the findings of this study was insignificant. Training of all data collectors about data collection tools and techniques was used as a means to reduce bias which might be introduced by data collectors. Interviewers were particularly trained on how to approach respondents, ask questions, record responses and handle their emotions. Qualified professionals were used to collect data on LMP, MUAC, hemoglobin level, and birth weight. Close supervision was also one of the mechanisms used to reduce interviewer bias. Dietary diversity assessment was based on self-report. This might introduce respondent bias. Due to social desirability bias, some respondents might over-report the kind of food items they consumed the previous day. To minimize respondent bias, the respondents were made get the right information about the objective of the study and the confidentiality of their responses by the data collectors.

This study tried to address the potential confounders such as socio-demographic and obstetric factors during design and analysis. Information on the possible confounders for women's empowerment as well as the outcomes of Papers II to IV was gathered during data collection. They were controlled in multivariable regression and SEM analysis models. To increase the validity of results, caution was taken during analysis by applying appropriate data analysis methods and software for each paper. For Papers III and IV, SEM was performed using RStudio over the commonly used regression analysis. SEM is a powerful technique for analyzing hypothesized relations among measured variables and latent variables (178). RStudio is advantageous over STATA or SPSS in conducting SEM since it has useful estimators such as WLSMV and outputs which are not available in both of them. To reduce the role of chance as an explanation for the observed association results, a p-value <0.05 at 95% CI was used for declaring statistical significance for Papers I and II. Also, a range of -1 to 1 standardized beta coefficients in SEM at p-value <0.05 was ascertained to declare a significant association in Papers III and IV.

7.2. External validity (generalizability)

External validity examines whether the study findings can be generalized to other contexts (209). This study randomly selected districts, health facilities, and study participants from the West Shewa Zone. By this, it tried to ensure representativeness. Pregnant women who attended the

ANC unit of the health facilities were randomly selected and enrolled in this study. Therefore, the findings of this study can be generalized to pregnant women in the West Shewa Zone and other areas in Ethiopia with similar settings (including socio-cultural settings). Internal validity is a prerequisite for external validity (210). Hence, the activities performed to ensure internal validity also enhance the generalizability of this study's findings in a similar setting. However, this study was health-facility-based. Thus, the findings of this study might not reflect the experiences of those pregnant women who didn't have ANC visits during their pregnancy and those who delivered at home.

8. Strengths and limitations of the study

8.1. Strengths of the study

First, the multidimensional nature of women's empowerment is addressed during the design and analysis of this study. Second, this study has examined the relationship of multiple dimensions of women's empowerment with nutritional status during pregnancy and birth weight using a large sample size. Most of the available previous studies were conducted on non-pregnant women. Therefore, addressing this part of the population is among the strengths of this study. Third, besides assessing the direct relationships, this study has examined the mediating effects of the multiple dimensions of women's empowerment on dietary diversity during pregnancy using SEM.

8.2. Limitations of the study

This study has some limitations. Only partnered pregnant women were included in this study because the questionnaire on women's empowerment part initially included questions that were related to partners/husbands. Moreover, only pregnant women who were attending antenatal care units in public health facilities were included. These limit the generalizability of the findings to the excluded segments of women. Items for measuring women's empowerment in this study were developed based on existing literature. There could be unmeasured and unaddressed women's empowerment aspects that might be relevant to nutritional status and birth weight in the study area. Pregnant women's nutritional status and birth weight are affected by several factors besides the independent and control variables addressed in this study, hence, this should be considered in interpreting our findings. The gestational age of pregnancy was not confirmed using ultrasound. This might have affected the accuracy of the estimated gestational age. Cross-sectional data may not truly reflect the anemia status of the pregnant woman over her pregnancy period.

9. Conclusions

Around half of the pregnant women were empowered implying the necessity of emphasis on women's empowerment activities in West Shewa Zone. The highest empowerment was in the household decision-making power dimension while the least empowerment was in the communication dimension. On the other hand, pregnant women's empowerment level was a significant determinant of their nutritional status during pregnancy. Anemia and malnourishment (MUAC <23 cm) were lower among empowered pregnant women compared to those who were less empowered. Moreover, the odds of being anemic during pregnancy were lower among economically empowered and assertive pregnant women than their less empowered counterparts in these dimensions. Pregnant women who were empowered in the household decision-making power and psychological dimensions were less malnourished than those who were less empowered in the respective dimensions.

Similarly, higher empowerment in household decision-making power, psychological, and time dimensions were related to the consumption of more diverse diets during pregnancy. More importantly, better education of the pregnant women was significantly related to their higher household decision-making power, psychological and time empowerment suggesting women's empowerment as a pathway by which education contributed to adequate dietary diversity during pregnancy. However, pregnant women's economic empowerment had null direct and indirect effects on their dietary diversity.

This study also found that birth weight was higher among mothers with higher household decision-making power. Contrary to the expectation, it was lower among those who had higher economic empowerment. Psychological and time empowerments of the mothers were not associated with the birth weight of their newborns. The mixed findings imply the need to further examine the mechanisms of the influence of women's empowerment dimensions on birth weight to enhance the effectiveness of empowerment interventions in ensuring normal infant birth weight.

10. Recommendations

To policymakers, the Ministry of Health and Regional Health Bureaus

- Empowering women has been the central aim of the National Women's Policy of Ethiopia (211). Ethiopia has integrated SDGs, including improving nutrition, empowering women and ensuring healthy lives, and promoting wellbeing at all ages, in its national development plan from 2019/2020 to 2029/2030. The national development plan aims at improving maternal health, and empowering women is identified as one of the strategies for its achievement (212). Moreover, improving maternal and child health and nutrition are among the targets of the Ministry of Health of Ethiopia, as they are indicated in its Health Sector Transformation Plan II 2020/2021–2024/2025 (213), which are being implemented in all regions of Ethiopia. Therefore, the Ministry's and West Shewa Health Bureau's efforts to improve pregnant women's nutrition and newborn health through women's empowerment should enhance and implement the empowerment dimensions which were significantly related to pregnant women's nutrition and birth weight in the study area.

- Empowering women can be incorporated as a strategy in intervention programs that aim at improving poor pregnant women's nutritional status and birth outcomes in the study area.

- Policy interventions that aim at reducing poor dietary diversity during pregnancy in the study area can consider increasing availability of formal education to women which is also important for empowering women.

- As poor nutritional status during pregnancy, inadequate dietary diversity, and abnormal birth weight are common in the study area and are also associated with women's empowerment, women should be made aware of these and designing empowerment mechanisms for less empowered women can help to reduce poor pregnancy and birth outcomes.

- Regular assessment of women's empowerment in the community and implementing interventions accordingly at community level, during ANC visit to ensure empowerment for pregnant women.

- Ensure and monitor health information dissemination about nutrition during pregnancy and its consequences are included in the routine educational programs by healthcare providers during ANC visits.

To healthcare providers

- Healthcare providers should strengthen and continue with health information dissemination about nutrition during pregnancy and its consequences to women at health facility as well as community level.

- Healthcare providers should encourage pregnant women to eat more diverse diets to ensure nutrient adequacy for themselves and their fetus.

To women

- Women's empowerment status is among the influencing factors of nutritional status during pregnancy and birth weight. Therefore, pregnant women should take the advantage of any available opportunity that enhances their empowerment level.

- Pregnant women are expected to eat more diverse diets during their pregnancy to ensure their better nutritional status and birth outcome.

Future research

- A qualitative study at community level would help to understand in-depth the contextual nature of the different associations between women's empowerment dimensions and pregnant women's nutrition outcomes and birth weight.

- Items for measuring women's empowerment in this study were developed based on existing literature. Future studies should consider qualitative studies which would help to refine the tool used for measuring women's empowerment by identifying unaddressed women's empowerment items related to pregnant women's nutritional status, dietary diversity, and birth weight in the study area.

- The current study provided empirical evidence on the direct effects of multiple dimensions of women's empowerment on birth weight in the study area. It will be more holistic if further research determines how these dimensions impact the outcomes. Investigating the mediating

factors between the dimensions of women's empowerment and birth weight would help to get a clear picture of different interactions.

- A longitudinal study will be more useful to characterize the association between women's empowerment and nutritional status during pregnancy because a cross-sectional study may not capture the nutritional status throughout the pregnancy period.

- Moreover, the effect of women's empowerment on pregnant women's nutritional status and birth weight will be more appropriately determined by applying interventional studies.

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Annexes

Annex 1. Participant information sheet and consent form in English

Information sheet and consent form for respondents participating in the study titled *Women's empowerment and its association with pregnant women's nutritional status and birth weight in West Shewa Zone, Central West Ethiopia: a follow-up study*

Part I. Information sheet

Introduction

Greetings! My name is _____. I represent the research team from Addis Ababa University, College of Health sciences, School of Public Health. We are conducting a research on *Women's empowerment and its association with pregnant women's nutritional status and birth weight in West Shewa Zone, Central West Ethiopia: a follow-up study*. We have received permission from the Institutional Review Board of College of Health sciences, West Shewa Zone health bureau and respective health offices to conduct this study.

Purpose of the research

Women's empowerment is considered as a means to improve maternal nutritional status and pregnancy outcomes. However, its status and effect on pregnant women's nutritional status and birth weight haven't been well examined in West Shewa Zone. Therefore, this study aims to fill this gap, and the findings will be used as input both for empowering women and improving maternal nutritional status and birth outcomes in the study area as well as at national level for policy makers setting strategies targeting pregnant women and newborns.

Procedures

You are selected by chance. If you agree to participate in this study, information on you will be collected three times until you give birth. We will ask you questions related to your personal, socio-demographic, economic and diet information, and measure your mid upper arm circumference and hemoglobin level at the beginning, which will take a maximum of 50 minutes of your time. In the consecutive two visits, we ask you information on your diet and at delivery we measure your newborn's weight. Each will last within 45 minutes.

Risks for participation

Sharing some personal information may be uncomfortable, but you are free to refuse answering any questions if you feel uncomfortable.

Benefits

There will be no direct benefit to you except knowing your nutritional status, but based on the information you provide us, we will recommend strategies at improving pregnant women's nutritional status and birth outcomes for the community.

Confidentiality

The information we collect from you will be kept confidential. Instead of your name, identification code will be used so that you are not easily identified. The hard copies will also be kept in a locked cabinet. Only the investigators and the research assistants collecting the data will have access to the data. The collected data will be used in aggregated form.

Right to refuse or withdraw

Participation in this study is entirely voluntary. You are perfectly free to withdraw from the study at any time if you feel uncomfortable. However, your active participation and genuine responses are very important in improving maternal and child health.

Results dissemination

The researcher is responsible for the dissemination of findings in different seminars and conferences. Moreover, maximum effort will be made to publish the findings in reputable scientific journals.

Incentive and compensation

There are no financial incentives given for participation in this study. The participation in this study does not have risks that incur compensation.

Person to contact

The participant has the right to ask information that is not clear about the research context and content before and or during the research work. If you have any ambiguity or need clarification, you can contact the principal investigator and/or her supervisors or Addis Ababa University College of Health Sciences Institutional Review Board (IRB).

Principal investigator: Tizita Dengia, Cell no.: +251-946605502, email: tizitadengia@gmail.com

Primary supervisor: Prof. Alemayhu Worku Cell no.: +251-911405652

Addis Ababa University, College of Health Sciences IRB: +251-115512876

Part II. Informed consent form

With due understanding of the aforementioned information, are you willing to participate in the study?

Yes ☐

Having been well explained and informed about the study's aim, procedure, benefits, risks as well as my right to withdraw, I voluntarily consent to participate in the study. I have been given a chance to ask questions which were ambiguous to me and they have been clarified properly.

Signature/finger print of the participant

Signature/finger print _____ Date _____

(Proceed with the data collection)

No ☐ **(Terminate the data collection)**

Signature of the data collector

Name _____ Signature _____ Date _____

Signature of the supervisor

Name _____ Signature _____ Date _____

Annex 2. Participant information sheet and consent form in Afaan Oromo.

Guca odeeffannoo fi waliigaltee hirmaatoota qo'anoo mataduree *Dhiibaa dubartoota angoomsu sirna nyaata dubartoota ulfaa fi ulfina daa'ima yeroo dhalata*

Kutaa 1ffaa. Guca odeeffannoo.

Seensa

Nagaan siif haa tahu! Maqaan koo _____jedhama. Bakka kanatti kanan argamee garee qoratoota Univarsiitii Addis Ababaa, Kollejii Fayyaa Saayinsii**,** Mana Barumsa Fayyaa Hawaasaa bakka bu'udhaani. Nutiis mata duree *Dhiibaa dubartoota angoomsu sirna nyaata dubartoota ulfaa fi ulfina daa'ima yeroo dhalata* irratti qoranno gaggesina. Qoranno kana gaggesuuf Madaaltota Boordii Kollejii Fayyaa, Biroo Eegumsa Fayyaa Shawaa Lixaa fi buufata fayyaa ilaalatu irraa eeyyamni argameeraa.

Kaayyoo qorannichaa

Ga'umsi dubartoota haala nyaata haadholee fi bu'aan ulfina itti fooyya'u dha. Haata'u malee haalii fi dhiibaan dubartootaa angoomsu sirna nyaata dubartoota ulfaa irratti fiduufi dabalata ulfina qaama yeroo ulfaa isaan irra qaqabsiisu godina Shawaa Lixaa kessatti haala gaarii ta'en hin qoratamne. Kanaafuu, kaayyoon qorannoo kanaa qaawa kana guutuf yoo ta'u bu'aa arganno kanas ga'umsa dubartoota fi haala nyaata dubartoota ulfaa itti foyya'u danda'u naanno Shawaa Lixaaf fi akkasumas akka biyyatti qaamoleen polisii fi karoora dubartoota ulfaa fi daa'iman haaraa dhalatan irratti hojjataniif galtee akka ta'uf.

Haala raawusii/adeemsa

Ati akka carraa filtamte. Yoo qorannoo kana keessatti hirmaachuf fedhi kee ta'e oddefannoo adda adda hanga da'umsa keetitti yeroo sadii siraa fudhana. Marsaa duraa irrati daqiqaa shantamaa kessa gaaffii raga bu'uraa, qabenya, haala nyaata fi ga'umsa dubartoota wajjin walqabatu sigaafanna. Dabalatas dheerina fi ulfina qaama fudhana. Marsaa 2ffaa fi 3ffaa irratti waa'ee nyaata fi ulfina daa'ima kee ilaalchise daqiqaa 45 kessatti raga siraa fudhana.

Miidhaa

Qo'annoo kana irratti hirmaachuun miidhaa sirraan gahu homaallee hin qabaatu, wal'aansa ykn adeemsa miidhaa sii fi daa'ima kee irraan gahuu danda'ullee hin qabaatu. Odeeffannoo dhunfaa ofii nama biraaf dabarsuun namatti hintolu ta'a, garuu gaaffille sii dhiyaatan kessa kan deebbisuuf fedhi hin qabne dhiisuuf mirga guutu qabda.

Bu'aa

Bu'aan kan ati argatu hin jiru. Haata'u malee ragoolee ati nu kennitu arratti hundaa'un karoora nyaata haadholee ulfaa fi bu'aa ulfaa fooyyessuuf baasuuf galtee ta'a.

Icittumaa

Odeeffannon issin irra fudhanne hundi icitiin qabamu. Bakka maqaa keeti koodi adda ta'e ijaa fayyadamnu akka salphattti hin beekamtu. Ragaan siraa sassabame saanduqa kessatti qolofamaa. Odeeffannoon ati kennitu kun qaamolee qo'annoo sana gaggeessan irraa kan hafe iccitiin isaa kan eegamu tahuu isaa siif mirkaneessuun barbaada. Ragooleen sassabaman akka waligalaati hojii irra oolu.

Mirga ragaa kennu diiduufi addan kutuu

Qoranno kana kessatti hirmaachun gutuma gututi fedhi irratti kan hundaa'ee dha. Yeroo barbaaddetti hirmaannaa kee dhaabuuf mirga guutuu qabda. Haata'u malee haala gaariin hirmaachu fi ragaa dhugaa ta'an fooya'insa haadholee fi fayyaa daa'imaniif baayyee barbaachisaa dha.

Qaama qunamu

Shakina kam iyyu yoo qabaatan, karaa lakkofsa bilbiilaa 0946605502 yookin e-mail: tizitadengia@gmail.com tiin qorataa dursaa Tizzitaa Dhangiyaa; ykn 0911405652 bilbiluun suparvisarii qorataa Proffesar Alemayo Worku qunamuu dandessu. Dabalatas IRB Univarsiitii Addis Ababaa, Kollejii Fayyaa Saayinsii lakkofsa 0115512876 bilbilu dandessu.

Kutaa II. Goca waligaltee

Yaadolee armaan olitti caqafaman irratti hundaa'udhan qoranno kana kessattihirmaachuuf fedhi keeti?

☐ Eeyyee

Qoranno kana ilaalchise ibsi fi hubanno ga’a ta’e kaayyoo, adeemsa, bu’aa, miidhaa akkasumas mirga hirmaachu irra na kenname fedhi kootin qoranno kana irratti hirmaachuf waligaleera. Waantota na shakisiisan irratti gaaffi koo kaasee ibsi gaha naaf kennamera.

Mallatto hirmaataa (ragaa kenna)

Mallato: _____ Guyya:_____

(Ragaa funaanachu itti fufaa)

Lakki ☐ (Ragaa funaanu dhaabaa)

Mallato ragaa funaanaa

Maqaa:_____ Mallato:_____ Guyyaa:_____

Mallato to’ataa

Maqaa:_____ Mallato:_____ Guyyaa:_____

Annex 3. Checklist for inclusion and exclusion criteria.

Instructions. Show your answer by circling the listed choices. For open-ended questions, give short and precise answer.

Part I. Checklist for inclusion and exclusion criteria			
S.No	Questions	Response categories	Skip
101	How old are you?	____ years	If the answer is less than 18, she is not eligible for the study
102	When did you see your last menstrual period?	Before _____weeks or _____ month	If it is between 26 and 34 weeks, cross check with fundal palpation. If it is <26 weeks or above 34 weeks, she is not eligible
103	What is your marital status?	1. Married 2. Single 3. Divorced 4. Widowed	If she answers options 2 to 4, she is not eligible

Annex 4. Checklist for inclusion and exclusion criteria in Afaan Oromo.

Qajeelfama. Filannoowwan tarreeffaman keessaa deebii kee itti marsuun agarsiisi. Gaaffilee filannoo hin qabne ykn banaa ta'aniif deebii gabaabaa fi ifa ta'e kenni.

Ulaagaalee hirmaataa filachuu			
Lakk	Gaaffilee	Filannoowwan	Yaadachiisa
101	Umuriin kee meeqa? (waggaadhaan)	_____ waggaa	Yoo deebiin wagga 18 gadii ta'e, qoranno kessaa hirmaachuuf gaha miti
102	Yeroo dhumaaf xurii kan argite yoom?	Torban ____ dura ykn ji'a _____dura	Yoo torban 26 fi 34 giddu ta'e, garaa ishii tutuquun mirkaneessa. Yoo turban 26 gadii ykn turban 34 olii ta'e, qoranno kessaa hirmaachuu hin dandessu
103	Haalli gaa'ilaa kee akkami?	1. Kan heerumte/wajjin jiraatan 2. Kan hin heerumne 3. Kan addaan baate 4. Kan abbaan manaa lubbuun darbe	Yoo deebiin filanno 1^{ffaa} ala ta'e, qoranno kessati hirmaachuu hin dandessu

Annex 5. English version questionnaires.

Name of the health center: _____

Respondent's code: _____

Date:_____

Instructions. Show your answer by circling the listed choices. For open-ended questions, please give short and precise answer.

Part I. Socioeconomic and demographic characteristics of respondents			
S. No.	Questions	Response categories	Skip
101	District of the respondent	_____	
102	Kebele of the respondent	_____	
103	Residence place of the respondent	1. Urban 2. Rural	
104	How old are you? (in years)	_____ years	
105	What is your education level completed?	1. Illiterate 2. Elementary/ Grade 1-6 3. Primary school/ Grade 7-8 4. Secondary school/ Grade 9-12 5. Diploma 6. Degree 7. Masters 8. Above masters	
106	What is the education level of your husband/partner?	1. Illiterate 2. Elementary/ Grade 1-6 3. Primary school/ Grade 7-8 4. Secondary school/ Grade 9-12 5. Diploma 6. Degree 7. Masters 8. Above masters	
107	What is your occupation?	1. Government employee 2. Private employee 3. Trading/merchant 4. Daily laborer 5. Farmer 6. Housewife 7. Student 8. Other (specify) _____	
108	What is your husband's/partner's occupation?	1. Government employee 2. Private employee 3. Trading/merchant 4. Daily laborer 5. Farmer 6. Student	

		7. Other (specify) _____	
109	For which mass media do you have access to? (check for all responses)	1. Radio 2. Television 3. Newspaper 4. Others specify_____	
110	What is the main source of drinking water for members of your household?	1. Piped water into dwelling 2. Piped water to neighbor 3. Public tap/standpipe 4. Protected well 5. Unprotected well 6. Protected spring 7. Unprotected spring 8. Rainwater 9. Surface water (river/dam/lake/pond/stream/canal/ irrigation channel) 10. Other (specify)_____	
111	What is the main source of water used by your household for other purposes such as cooking and hand washing?	1. Piped water into dwelling 2. Piped water to neighbor 3. Public tap/standpipe 4. Protected well 5. Unprotected well 6. Protected spring 7. Unprotected spring 8. Rainwater 9. Surface water (river/dam/lake/pond/stream/canal/ irrigation channel) 10. Other (specify)_____	
112	How is your residential house ownership?	1. Own home 2. Rented home 3. Other (specify)_____	
113	Do you have a separate room which is used as a kitchen?	1. Yes 2. No	
114	What kind of toilet facility do members of your household usually use?	1. Traditional pit latrine 2. Ventilated improved pit latrine 3. Flush or pour flush toilet 4. Open field 5. Other (specify)_____	
115	Does your household have radio?	1.Yes 2. No	
116	Does your household have television?	1.Yes 2. No	
117	Does your household have refrigerator?	1.Yes 2. No	
118	Does your household have an electric enjera baking plate?	1.Yes 2. No	

119	What type of fuel does your household mainly use for cooking?	1. Electricity 2. Biogas 3. Kerosene 4. Charcoal 5. Wood 6. Straw/shrubs/grass 7. Agricultural crop 8. Animal dung 9. Other (specify)_____	
120	What is the main material of the roof of your dwelling?	1. Thatched 2. Corrugated iron sheet 3. Plastic sheet 4. Other (specify)_____	
121	What is the main material of the floor of your dwelling?	1. Earth/sand 2. Dung 3. Rudimentary floor with wood/bamboo 4. Finished floor with cement 5. Other (specify)_____	
Part II. Obstetrics related questions			
201	What is the gestational age of the pregnancy?	____(weeks)	
202	Is this your first pregnancy?	1. Yes 2. No	If the answer is yes, go to question 301
203	How many child/children do you have?	_____	
204	If the answer for question 203 is above 1, what is the age difference between the current pregnancy and previous pregnancy?	_____year(s)	
Part III. Women's empowerment related questions			
Familial/interpersonal dimension			
301	Who usually makes decisions on what food to buy and consume?	1. You 2. Your husband 3. You and your husband together 4. Mother- or father-in-law 5. Someone else(specify)_____	
302	Who usually makes decisions about what food is prepared every day?	1. You 2. Your husband 3. You and your husband together 4. Mother- or father-in-law 5. Someone else(specify)_____	
303	Who usually makes decisions about health care for yourself?	1. You 2. Your husband 3. You and your husband together 4. Mother- or father-in-law 5. Someone else(specify)_____	

304	Which member of your household usually makes decisions about making household purchases for daily needs (for example: onion, oil,…)?	1. You 2. Your husband 3. You and your husband together 4. Mother- or father-in-law 5. Someone else(specify)_____	
305	Which member of your household usually makes decisions about the number of children to have?	1. You 2. Your husband 3. You and your husband together 4. Mother- or father-in-law 5. Someone else(specify)_____	
306	How often do you and your husband discuss your worries or feelings?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always	
307	How often do you and your husband discuss what to spend household money on?	1. Never 2. Seldom 3. Sometimes 4. Often 5. Always	
308	Do you get help from your husband/partner with the household duties?	1. Always 2. Sometimes 3. Not at all	
Economic dimension			
309	Are you engaged in any activities (jobs) with cash income?	1. Yes 2. No	
310	Do you have any cash savings of your own?	1. Yes 2. No	
311	Do you own any assets (for example, land, house, cattle or shop) that could help you generate income?	1. Yes 2. No	
312	Who usually decides how your husband's/partner's earnings will be used?	1. You 2. Your husband 3. You and your husband together 4. Mother- or father-in-law 5. Someone else(specify)_____	
313	Who usually decides how the money you earn will be used?	1. You 2. Your husband 3. You and your husband together 4. Mother- or father-in-law 5. Someone else(specify)_____	
314	Do you have direct access to household money in your hand to use?	1. Yes 2. No	
315	Is there amount of money you can spend freely?	1. Yes 2. No	
Socio-cultural dimension			

316	Do you think pregnant women should eat more during pregnancy than other times?	1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree	
317	Do you think pregnancy complications (such as preeclampsia) are related with dietary practice of the pregnant mother?	1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree	
318	Do you think birth outcomes (such as birth weight, preterm birth, stillbirth, postpartum hemorrhage) are related with dietary practice of the pregnant mother?	1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree	
319	Do you usually meet with other women in your community to discuss and receive information on health and/or nutrition related issues?	1. Yes 2. No	
Time dimension			
320	For how many hours do you work daily?	_____hours	
321	How long do you usually spend on housework daily?	_____hours	
322	How long did you spend on housework the previous 24 hours?	_____ hours	
323	How would you rate your satisfaction with your time available for leisure activities such as visiting neighbors, time for your own, watching TV, listening to the radio, resting?	1. Very unsatisfied 2. Less unsatisfied 3. Satisfied 4. Less satisfied 5. Very satisfied	
324	Do you have time to participate in community activities in your community?	1. Yes 2. No	
Psychological dimension			
325	How sure are you that you could use family planning, even if your husband did not want to?	1.Not at all sure 2.Somewhat unsure 3.Neither sure/unsure 4.Somewhat sure 5.Completely sure	
326	How sure are you that you could go to the health facility if your husband objected to your going?	1. Not at all sure 2. Somewhat unsure 3. Neither sure/unsure 4. Somewhat sure 5. Completely sure	
327	Do you feel confident to resolve a problem on your own?	1. Always 2. Sometimes 3. Not at all	
328	Do you feel like an important member of	1. Always	

	your household?	2. Sometimes 3. Not at all	
329	Do you think the members of your household listen to you and respect your opinion?	1. Always 2. Sometimes 3. Not at all	

Annex 6. Afaan Oromo version questionnaires.

Maqaa buufata fayyaa:_____

Koodii dubartii ulfaa ragaa kennitu: _____

Guyyaa_____

Qajeelfama. Filannoowwan tarreeffaman keessaa deebii kee itti marsuun agarsiisi. Gaaffilee filannoo hin qabne ykn banaa ta'aniif deebii gabaabaa fi ifa ta'e kenni.

Kutaa 1^{ffaa}. Haala jiruu fi jireenyaa akkasumas waliigalaa namoota ragaa kennani			
Lakk	Gaaffilee	Filannoowwan	Yaadachiisa
101	Aanaa	_____	
102	Ganda	_____	
103	Bakki jireenyaa keetii essa?	1. Magaala 2. Baaddiyaa	
104	Umuriin kee meeqa? (waggaadhaan)	_____	
105	Sadarkaan barnoota keetii akkami?	1. Barreessuu fi dubbisuu kan hin dandeenye 2. Kuutaa 1-6 3. Kuutaa 7-8 4. Kuutaa 9-12 5. Diiplomaa 6. Digrii 1^{ffaa} 7. Digrii 2^{ffaa} 8. Digrii 2^{ffaa} oli	
106	Sadarkaan barnootaa abbaa manaa kee akkami?	1. Barreessuu fi dubbisuu kan hin dandeenye 2. Kuutaa 1-6 3. Kuutaa 7-8 4. Kuutaa 9-12 5. Diiplomaa 6. Digrii 1^{ffaa} 7. Digrii 2^{ffaa} 8. Digrii 2^{ffaa} oli	
107	Hojiin keessan maali?	1. Hojjatu mootummaa 2. Hojjatu dhunfaa 3. Daldaltuu 4. Dafqaan bultuu 5. Qonnaan bultuu 6. Giiftii manaa 7. Baratu 8. Kan biraa (ibsi) _____	
108	Hojiin abbaa manaa kee maali?	1. Hojjataa mootummaa 2. Hojjataa dhunfaa 3. Daldaalaa 4. Dafqaan bulaa	

		5. Qonnaan bulaa 6. Barataa 7. Kan biraa (ibsi) _____	
109	Miidiyaalee hawaasummaa kamitu siif dhiyoodha ykn argatta? (deebii tokkoo ol ni danda'ama)	1. Raadiyoonii 2. Televiiziyinii 3. Barreeffamoota adda addaa 4. Omaa hin fayyadamu 5. Kan biraa yoo jiraate caqasii _____	
110	Maddi guddaan bishaan dhugaati mana keeti maal irrayi?	1. Bonbaa bishaani mana kessaa 2. Bonbaa bishaan olaa 3. Boono 4. Boola eegamu irra 5. Boola hin eegamnee irra 6. Burqaa eegamu irra 7. Burqaa hin eegamnee irra 8. Bishaan roobaa 9. Bishaan yaa'a (laga, burqaa, haaroo, bishaan jallisi) 10. Kan biraa (ibsi) _____	
111	Maddi guddaan bishaan hojii manaf ta'u fakenyaf nyaata bilcheesuufi dhiqachuuf kan oolu essa irra argataa?	1. Bonbaa bishaani mana kessaa 2. Bonbaa bishaan olaa 3. Boono 4. Boola eegamu irra 5. Boola hin eegamnee irra 6. Burqaa eegamu irra 7. Burqaa hin eegamnee irra 8. Bishaan roobaa 9. Bishaan yaa'a (laga, haaroo, bishaan jallisi, burqaa) 10. Kan biraa (ibsi) _____	
112	Haali mana jireenyaa kee maali?	1.Kan kootii 2. Kireefadheti 3. Kan biraa (ibsi) _____	
113	Kutaa adda kushinaaf qabda?	1. Eyyee 2. Lakki	
114	Manni fincaani maatiin kee itti fayyadaman kan akkamiti?	1.Mana fincaani aadaa 2.Mana fincaani foyaa'a (kan tubo qillensa baasuu qabu)-VIP 3.Mana fincaani bishaanidhaan qulqullessan 4.Araddaa 5.Kan biraa (ibsi) _____	
115	Mana jireenyaa kee raadiyooni qabaa?	1. Eyyee 2. Lakki	
116	Mana jireenyaa kee televizinii qabaa?	1. Eyyee 2. Lakki	

117	Mana jireenyaa kee firiiji qabaa?	1. Eyyee 2. Lakki	
118	Mana jireenyaa kee eelee eletrikii qabaa?	1. Eyyee 2. Lakki	
119	Mana jireenyaa kee keessatti nyaata bilcheesuuf humni itti fayyadamtu maalini?	1. Elektrikii 2. Bayoo gaazii 3. Keroosinii 4. Kasala 5. Muka 6. Ciraaroo adda addaa 7. Galabaa qonnaa 8. Koboota 9. Kan biraa ibsi _____	
120	Xaaraa/qooxiin mana jireenyaa kee maal irra hojjatame?	1.Citaa 2. Qorqoorroo 3. Pilaastikii 4. Kan biraa ibsi _____	
121	Lafti mana jireenyaa kee maal irra hojjatame?	1. Biyyoo/Ashewaa 2. Dhoqee loonii 3. Xaawulaa/Muka/Shimala 4. Simintoo 5. Kan biraa ibsi _____	

Kutaa II. Gaaffilee da'umsa wajjin walqabatan			
201	Hanga ulfiina kee meeqaa dha?	_____(Torban)	
202	Ulfini kun siif isa jalqabaatii?	1. Eyyee 2. Lakki	Yoo deebiin "Eyyee" ta'e, gara gaaffii 301 darbi
203	Daa'ima ykn daa'imman meeqa qabda?	_____	
204	Yoo deebiin gaaffii 203 tokko olii ta'e, garaagarrumaan umuri mucaa kee duuraa fi ulfaa kana giduu jiru meeqa?	_____waggaa	

Kutaa III.Gaaffilee ga'umsa dubartoota irratti hundaa'an			
Kallatti maatii/waliigaltummaa			
301	Waan nyaataa bitamuu fi nyaatamu qabu irratti kan murteessu eenyu?	1. Sii 2. Abba mana kee 3. Sii fi abba manaa kee waliin 4. Haadha ykn abbaa abbaa mana koo 5. Kan biraa ibsi_____	
302	Nyaata guyyaa guyyaan qophaa'u irratti murteessan eenyu?	1. Sii 2. Abba mana kee 3. Sii fi abba manaa kee waliin 4. Haadha ykn abbaa abbaa manaa koo 5. Kan biraa ibsi_____	
303	Waa'ee eegumsa fayyaa keeti irratti murteessan eenyu?	1. Sii 2. Abba mana kee 3. Sii fi abba manaa kee waliin 4. Haadha ykn abbaa abbaa manaa koo	

		5. Kan biraa ibsi _____	
304	Miseensota maatii keeti keessa bittaa meeshaalee guyya guyyan bitaman irratti murteessaan eenyu dha (fakenyaaf- qulubbi, zayiitaa,…)?	1. Sii 2. Abba manaa kee 3. Sii fi abba manaa kee waliin 4. Haadha ykn abbaa abbaa manaa koo 5. Kan biraa ibsi _____	
305	Miseensota maatii keeti keessa eenyutu lakkofsa ijoollee dhalachuu qaban kan murteesu?	1. Sii 2. Abbaa manaa kee 3. Sii fi abbaa manaa kee waliin 4. Haadha ykn abbaa abbaa manaa koo 5. Kan biraa ibsi _____	
306	Ati fi abbaan manaa kee ammam waa'ee sodaa ykn yaada keessani irratti mari'attu?	1. Gonkumaa 2. Gaaf tokko tokko 3. Darbee darbee 4. Yeoo baayyee 5. Yeroo hundaa	
307	Abbaa manaakee fi ati ammam wa'ee qarshii baasii mana maal irratti akka oluu mari'attu?	1. Gonkumaa 2. Gaaf tokko tokko 3. Darbee darbee 4. Yeoo baayyee 5. Yeroo hundaa	
308	Raawwii hojii mana keessaa irratti abbaa manaa kee irra gargaarsa ammam argattaa?	1. Yeroo hundaa 2. Darbee darbee 3. Gonkumaa	
Kallattii qabenyaa ilaalchisee			
309	Hojiiwwan galii qarshii argamsiisan keessatti hirmaatta jirtaa?	1. Eyyee 2. Lakki	
310	Qarshi dhunfaa kee kan qusattu jiraa?	1. Eyyee 2. Lakki	
311	Qabeenya galii maddisiisuu danda'an kan akka lafa, mana, horii ykn suuqii… keeti qabdaa?	1. Eyyee 2. Lakki	
312	Galii abbaa manaa kee maal irra akka olu (akkatta itti fayyadamamu qabu) kan murteesuu eenyuu dha?	1. Sii 2. Abbaa manaa kee **3**. Sii fi abbaa manaa kee waliin 4. Haadha ykn abbaa abbaa manaa koo 5. Kan biraa ibsi _____	
313	Galii kan ofii kee argatu akkatta itti fayyadamamu qabu (maal irra akka olu) eenyutu irratti murteesaa?	1. Sii 2. Abbaa manaa kee **3**. Sii fi abbaa manaa kee waliin 4. Haadha ykn abbaa abbaa manaa koo 5. Kan biraa ibsi _____	
314	Qarshii mana keessani sii harka ta'a itti fayyadamuuf?	1. Eyyee 2. Lakki	
315	Qarshiin ati bilisan/fedhii keetin ballesitu/baaftu jiraa?	1.Eeyyee 2. Hin jiru	

Kallattii hawaasummaa fi aadaatiin			
316	Dubartootni yeroo ulfaa'an yeroo hin ulfaa'in caala nyaata baayyee nyaachu qabu jettee yaaddaa?	1.Baayiseen morma 2. Nan morma 3. Hin mormuus hin amanus 4.Ittin amana 5. Baayiseen amana	
317	Yeroo ulfaa, rakkon kan akka ol ba'insa dhiigaa kan mudatu sirna nyaachaa dubartii ulfaa wajjin kan wal qabateti jette amam amantaa?	1.Baayiseen morma 2. Nan morma 3. Hin mormuus hin amanus 4.Ittin amana 5. Baayiseen amana	
318	Hanga mucaa dhalatee, yeroo hin gahiin dhalun, kan du'ee dhaluun, da'umsa booda dhiiga baayyee dhangala'un sirna nyaachaa dubartii ulfaa wajjin kan wal qabateti jette amam amantaa?	1.Baayiseen morma 2. Nan morma 3. Hin mormuus hin amanus 4.Ittin amana 5. Baayiseen amana	
319	Dubartoota biroo hawaasaa keessa jiran wajjiin dhimmoota fayyaa fi nyaata irratti, rakkoo dubartoota irratti mari'achuuf, yaada fudhachuuf wal argataa?	1. Eyyee 2. Lakki	
Kallattii yerootiin			
320	Guyyatti sa'aa meeqa hojjata?	_____	
321	Guyyatti sa'aa meeqaa hojji mana keessaa hojjachuu irratti dabarsita?	1.Sa'ati 5 gad 2. Sa'ati 5-10tti 3. Sa'ati 10 oli	
322	Sa'ati 24 darban keessatti hojji mana keessaa hojjachuf sa'a meeqa fayyadamte?	Sa'ati _____	
323	Quufinsa yeroo keetti ilaalchisee ollaa gaafachuu, televiziini ilaaluu, raadiyoo dhagefachu yeroo qabdu akkamitti ilaalta?	1.Baayyisee na hanqataa 2. Xiqqoshi na hanqataa 3. Gahaa dha 4. Xiqqoshi quufa dha 5. Baayyisee quufa dha	
324	Hawwaasa wajjin jiraatu keessatti sochii tajaajila hawwaasummaa keessatti hirmaachuuf yeroo qabdaa?	1.Eeyyee 2. Hin qabu	
Gara qophii ilaalcha xinsamuu			
325	Abbaan manaa kee illee yoo fedhii kan hin qabaane ta'e karoora qusannaa maatiitti fayyadamutti hangam ofiti amanta?	1. Walumaagala itti hin amanu 2. Hanga ta'e itti hin amanu 3. Gonkumaa ittin amana ykn itti hin amanu 4. Hanga ta'e ittin amana 5. Gutumaa guututti ittin	

		amana	
326	Abbaan manaa keellee akka ati gara dhabbata fayyaa deemtu kan mormu yoo ta'e illee ati hangam gara dhaabbata fayyaa deemuuti amanta?	1. Walumaa gala itti hin amanu 2. Hanga ta'e itti hin amanu 3. Gonkumaa ittin amana ykn itti hin amanu 4. Hanga ta'e ittin amana 5. Gutumaa guututti ittin amana	
327	Rakkoolee umaman furuuf ofiti amantaa?	1. Yeroo kam iyyu 2. Yeroo tokko tokko 3. Itti hin amana	
328	Dhimma mana keessaa irratti akka miseeensa barbaachisaa taatetti sitti dhagahamaa?	1. Yeroo kam iyyuu 2. Yeroo tokko tokko 3. Itti hin amanu	
329	Dhimma mana keessaa irratti maatii keeirraa fudhatamaa fi kabaja qaba jettee yaaadaa?	1. Yeroo kam iyyuu 2. Yeroo tokko tokko 3. Itti hin amanu	

Annex 7. English version Minimum Dietary Diversity-Women (MDD-W) measuring questionnaire

Please describe the foods (meals and snacks) that you ate or drank yesterday during the day and night, whether at home or outside the home. Start with the first food or drink eaten in the morning. For data collectors: Write down all food and drinks mentioned. When composite dishes are mentioned, ask for the list of ingredients. When the respondent has finished, probe for meals and snacks not mentioned.				
Breakfast	Snack	Lunch	Snack	Dinner

Annex 8. Minimum Dietary Diversity-Women measuring questionnaire in Afan Oromo

Sirna nyaata dubartoota ulfaa (Minimum Dietary Diversity-Women) Mee guyyaa kaleessaa gosa nyaataa ganama, guyyaa fi galgalaa manas ta'e alaa nyaate ykn dhugde mee naaf ibsi. Dura waan ganama nyaatan ykn dhugdan irra jalqabaa. **Ragaa sassabdotaaf:** Waantota nyaataa fi dhugaati himatan caqase ykn ibse hundumtu haa barrefaman. Yoo nyaata waan walmakaara hojjatame ibsan ta'e, nyaata sana hojjachuuf (waan nyaata kessa jiru) kan itti fayyadaman hunda gaaffadha.Yeroo hirmaattun dubbatte xumurte, waan akka tursiistu wa'ii yoo nyaate (kan ishin hin ibsin) jira taanan gaaffadha.				
Ciree	Tursiistu	Laaqana	Tursiistu	Hirbaata

Annex 9. Mid upper arm circumference (MUAC) measuring format

MUAC measurement				
Name of the health facility	_____			
Date	Day:____ Month:_____ Year:_____			
Code of the pregnant woman	_____			
Gestational age (weeks)	_____weeks			
MUAC (cm)	1ST round	2nd round	3rd round	Mean
	_____cm	_____cm	_____cm	_____cm

Annex 10. Mid upper arm circumference (MUAC) measuring format in Afaan Oromo.

Madala gingoo ciqilee harkaa walakaa				
Maqaa bufata fayya	_____			
Guyyaa	Guyyaa:_____Ji'a:_____ Bara:_____			
Koodii dubartii ulfaa	_____			
Hanga ulfaa (torban)	Torban_____			
Gingoo ciqilee harkaa walakaa (cm)	Marsaa 1^{ffaa}	Marsaa 2^{ffaa}	Marsaa 3^{ffaa}	Waligala
	_____cm	_____cm	_____cm	_____cm

Annex 11. Hemoglobin level measuring format

Hemoglobin level	
Name of the health facility	_____
Date	Day:____ Month:_____ Year:_____
Code of the pregnant woman	_____
Gestational age (weeks)	_____weeks
Hemoglobin level (g/dl)	_____g/dl

Annex 12. Hemoglobin level measuring format in Afaan Oromo.

Madaala hanga hemoglobin dhiigaa	
Maqaa bufata fayya	_____
Guyyaa	Guyyaa:_____Ji'a:_____ Bara:_____
Koodii dubartii ulfaa	_____
Hanga ulfaa (torban)	Torban_____
Hemoglobin dhiigaa kessa (g/dl)	_____g/dl

Annex 13. English version newborn's birth weight measuring format

Name of the health facility	_____
Code of the pregnant woman	_____
Date of delivery	Day:____ Month:_____ Year:_____
Gestational age (weeks)	_____weeks
Weight of the newborn baby (g)	_____(g)

	Name	Signiture	Date
Data collector:	_____	_____	_____
Supervior:	_____	_____	_____

Annex 14. Afaan Oromo version newborn's birth weight measuring format (Ulfaatiina daa'imaa haaraa dhalate)

Maqaa bufata fayya	_____
Koodii dubartii dhaltee	_____
Guyyaa da'umsa	Guyyaa: _____Ji'a:_____ Bara:_____
Hanga ulfaa (torban)	_____ turban
Ulfaatiina daa'imaa haaraa dhalate (g)	_____(g)

	Maqaa	Mallatto	Guyyaa
Ragaa gaafataa:	_____	_____	_____
Ragaa to'ataa:	_____	_____	_____

Annex 15. Descriptive characteristics of study participants with and without birth weight measurement

Supplemental Table S1. Socio-demographic and empowerment characteristics of enrolled pregnant women with and without birth weight measurement in West Shewa Zone, Ethiopia, 2021 (n=1,453).

Characteristics	Birth weight measurement		p-value[b]
	Measured n(%)/mean(SD)	Missing n(%)/mean(SD)	
Total	1,165	288	
Socio-demographic characteristics			
Age (years)	28(5.39)	29.2(5.43)	0.041
Residence			
Urban	726(62.3)	166(57.6)	0.168
Rural	439(37.7)	122(42.6)	
Education level of respondents			
≤ grade 8	637(54.7)	176(61.1)	0.094
> grade 8	528(45.3)	112(38.9)	
Occupation status of respondents			
Government employee	249(21.4)	51(17.7)	0.225
Private employee	550(47.2)	151(52.4)	
Housewife	366(31.4)	86(29.9)	
Household wealth index			
Low	406(34.9)	103(35.8)	0.189
Middle	372(31.9)	105(36.5)	
High	387(33.2)	80(27.8)	
Women's empowerment dimensions			
Household decision-making	3.5(1.05)	3.6(1.01)	0.336
Economic	2.5(1.37)	2.5(1.38)	0.691
Psychological	4.3 (1.53)	4.3(1.39)	0.749
Time	2.9(0.98)	2.9(1.01)	0.057

Note: [b]p-values were obtained using independent t-tests and chi-squared tests.

Annex 16. Published original papers/ and/or manuscripts

Paper I

Pregnant women's empowerment in West Shewa Zone, Ethiopia: its dimensions, levels and determinants

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Abstract

Background: Empowering women is one of the sustainable development goals. Ethiopia is working for the realization of these goals. Moreover, empowerment status of women influences not only their wellbeing but also their children. In line with this, it is important to know the empowerment status of pregnant women and its determining factors owing to its trans effect along with other reasons.

Methods: A health facility-based cross-sectional study was conducted among 1,453 pregnant women living in West Shewa Zone, Ethiopia. Semi-structured interviewer-administered questionnaire was used to gather data on women's empowerment and its determinants. Exploratory and confirmatory factor analyses were conducted on half of the data samples to identify and validate dimensions of women's empowerment. Bivariable and multivariable logistic regression analyses were used to examine the associations between dimensions of women's empowerment and socioeconomic and demographic factors.

Results: Six dimensions were found to define women's empowerment: household decision-making power, economic, psychological, communication, assertiveness and time. About 54.2% (95% Confidence Interval (CI): 51.66, 56.79) of the pregnant women were empowered. The

highest and least empowerment was in household decision-making power and communication dimensions, respectively. Older women were more empowered in economic (adjusted odds ratio (AOR)= 2.22, 95%CI: 1.23, 4.00) and assertiveness (AOR= 1.88, 95%CI: 1.13, 3.11) dimensions than younger women. Women's higher education level was positively associated with household decision-making power (AOR=2.61, 95%CI: 1.41, 4.86), communication (AOR= 4.94, 95%CI: 2.78, 8.76), psychological (AOR= 1.95, 95%CI: 1.29, 2.93) and time (AOR= 4.03, 95%CI: 2.27, 7.16) dimensions. Being rural women, housewife and multiple children were negatively associated with time dimension.

Conclusions: Women's empowerment levels in West Shewa Zone imply the necessity of emphasis on interventions that promote all the six dimensions as well as socioeconomic and demographic factors particularly wealth, education and working statuses of both women and men.

Key words: women's empowerment, exploratory factor analysis, confirmatory factor analysis, West Shewa Zone, Ethiopia

Introduction

Empowerment is a process by which the powerless gets greater control over circumstances in terms of both ideology and resources (1). It is the process of increasing the assets and capabilities of individuals or groups to make purposive choices and to transform those choices into desired actions and outcomes (2). Even though there is no single, agreed women's empowerment definition, most of the definitions center around access and control over resources and circumstances for better achievement in quality of life by the women. One of the definitions views it as the process by which women gain greater control over the circumstances of their lives (3) meanwhile it has been defined as an expansion in the range of potential choices available to women so that actual outcomes reflect the particular set of choices which the women value (4). The available women's empowerment frameworks imply the multidimensional nature of it. To mention a few, it is underlined the three dimensions i.e. resources, agency and achievements should be indivisible in measuring women's empowerment (4). On the other hand, economic, socio-cultural, familial/interpersonal, legal, political, and psychological dimensions have been identified in which women can be empowered (5). These dimensions can be categorized under resources, agency and achievements components. The economic and socio-cultural dimensions come under the umbrella of resource, psychological dimension under agency, and the outcomes of wellbeing from any of these dimensions under achievements (4). The various dimensions and items of women's empowerment stress women's empowerment is reflected in their decision making power, ability to access and control resources, sense of self-worth, power to control their own and family lives (4-6).

Though progresses have been reported in the empowerment status of women in Ethiopia, they are still challenged with limited access and control over resources, community participation, decision making power within the household and leisure time (7). Only 19% of married women are involved in regularly paying jobs. Lower percentages of women are house and land owners compared to men. Despite improvements in decision making power of married women over the years, around 9% of them have no say on their husband's/partner's earnings spending, own health, making large household purchases and visiting family and relatives. Women still spend significant number of hours doing household chores. Moreover, rural women are less likely to

be empowered in the different dimensions particularly in the economic and familial aspects. Age and exposure to mass media also play significant role in determining the empowerment status of women (7-9).

Empowering women has been declared significant for development (10). In fact, it is one of the components of sustainable development goals (SDGs) to be achieved by 2030 (11). Ethiopia has approved SDGs and is working for the realization of SDGs targets. Therefore, there is a need of understating the current empowerment status of women to speed the progress towards SDG 5 achievement. More importantly, studies have concluded that empowerment status of women actually influences not only their wellbeing but their children's as well (12-14). For instance, women's empowerment has been positively associated with their higher dietary diversity (15), reduced anemia (16), body mass index (17) and their children's nutritional status (18). Lowest empowerment during pregnancy has been linked with low birth weight (13). Empowered women are more likely to attend antenatal care (19) and use skilled birth attendants (20). Additionally, SDG 3 aims to ensure healthy lives and promote well-being for all at all ages (11). In line with these, it is important to know the empowerment status of pregnant women, being one segment of women, owing to its trans effect along with other reasons. There were no studies which assessed empowerment status of pregnant women in West Shewa Zone. This implied the need for such studies. Therefore, the aim of this study was to determine the level of pregnant women's empowerment status and socio-demographic factors associated with it in West Shewa Zone, Ethiopia.

Methods and materials

Study design, participants and setting

Health facility based cross-sectional study was conducted among second and third trimester pregnant women attending antenatal care in twelve randomly selected public health centers found in West Shewa Zone, Ethiopia from January to June, 2021. Pregnant women <18 years old and without partner were excluded from the study. Details related to the methods of this study are explained elsewhere (21).

Sample size determination

Single population proportion formula was used to determine sample size. There was no previous similar study on pregnant women's empowerment status in Ethiopia. Hence, a proportion of 29.10% of pregnant women's decision making power on own health care (one of the variables assessed under women's empowerment in this study) from Bangladesh study (13) was used. The followings were also considered during sample size calculation: 95% confidence interval (two-sided $\alpha = 0.05$), 3% of margin error, design effect of 1.5 (due to multistage sampling use to identify study participants) and 10% non-response rate; which resulted in total sample size of 1,453 pregnant women. Checking was performed on sample size adequacy for investigating associations.

Sampling procedure

Multistage sampling technique was employed to select the study participants. Out of 22 districts found in West Shewa Zone, 7 of them were selected by lottery method. The 12 public health centers included in this study were selected randomly and proportionally based on the available government health centers in each district. The calculated total sample size was distributed proportionally to the 12 health facilities based on the number of 2nd and 3rd trimester ANC clients they served in past 3 months. Finally, every second pregnant women who fulfilled the inclusion criteria was selected by systematic random sampling and included in the study based on her consent.

Data collection

A semi-structured questionnaire was adapted and developed based on different literatures including demographic and health survey (DHS) questionnaire (22) and was administered face to face by interviewers to collect information on respondents' socioeconomic and demographic characteristics as well as women's empowerment related data. Local language, Afan Oromo, was used to collect data. Data collectors were females who at least completed grade 12 and trained on the techniques of data collection by the principal investigator.

Variables

Dependent variable

Women's empowerment

Items used to measure the dimensions selected for this study were based on previous works (4-6, 22). Their works have implicated women can be empowered at individual and household levels; and resources, agency and achievement as major components of women's empowerment which are reflected in familial/interpersonal, economic, socio-cultural, time and psychological dimensions. Accordingly, 29 items were included in this study. Items which are related to attitude, decision making and self-security were used to measure agency while income and time related items were used to measure resource. To ease interpretation, scores to the items were recoded ensuring higher values designated higher empowerment of women basing on the works of (15, 23, 24) as references during analysis.

Independent variables

The independent variables included pregnant women's educational level, age, occupation, household asset, access to mass media and number of children. Husband/partner's educational and occupation status were also among the control variables. Age and number of children were continuous variables; the rest were categorical. The pregnant women's and partners' educational levels were categorized into illiterate, primary, secondary and diploma, and first degree and above. Occupational status of the women and partners were grouped into government employee, private employee and farmer; housewife was additional option for the women. The pregnant women were also asked if they had access to mass media or not. Households were categorized into high, medium and low quartiles based on their individual household wealth index score. Principal component analysis was applied on the household asset data collected based on the standard demographic and health survey questions (25).

Statistical analyses

Data analysis was done using STATA version 16.0 (Stata Corporation, College Station, Texas). Data analysis was conducted in three steps. Fist, descriptive analysis was conducted. In the second step, exploratory and confirmatory factor analyses were conducted, which identified the number and structure of empowerment dimensions. Third, multivariable logistic regressions

were applied in order to identify the socioeconomic and demographic factors which determine the composite and individual dimensions of women's empowerment levels.

Descriptive analysis was performed to examine the background characteristics of the study participants. Percentages were used to express categorical variables, and means (standard deviation (SD)) were used for continuous variables.

The set of items used for measuring women's empowerment in this study had not been analyzed together. Therefore, exploratory factor analysis (EFA) was conducted to identify the structure of individual items and the dimensions suitable for measuring women's empowerment (26). Then, it was cross validated using confirmatory factor analysis (CFA). The data were split into two using a random uniform distribution. EFA and CFA were conducted on the first and second data samples respectively. The χ 2 for the Bartlett test of sphericity was significant at $p < 0.001$. Also, the Kaiser-Meyer-Olkin test result was 0.782. These indicated the strength of the correlations of the 29 items, which were used to measure women's empowerment, were sufficient for factor analysis. Skewness and kurtosis values were close to zero for the items, indicating they were normally distributed (27). As per recommendation for categorical variables, EFA was conducted on polychoric correlation matrix as input rather than the raw variables (28). Oblique rotation was used to rotate the items. Item with significant negative pattern coefficient, single loader to a factor, item loading on two factors with pattern coefficient > 0.320 (29), and items which contributed for lower reliability coefficient for a factor were removed. Finally, 22 items with a rotated factor loading > 0.5 (30) were used to construct the 6 factors/dimensions of women's empowerment retained based on eigenvalues >1 and interpretability of factors (30, 31).

CFA was conducted to validate the fitness of the factors identified by the EFA. Bentler comparative fit index (CFI) ≥0.90, Tucker-Lewis index (TLI) ≥ 0.90, Root mean square error of approximation (RMSEA) ≤ 0.08, and standardized root mean square residual (SRMR) ≤ 0.1 values were used to determine model fitness (32). The initial model had poor fitness. Items with less than 0.2 R-squared values, sources of very high levels of error (33), were removed to improve it. Finally, the RMSEA, CFI, TLI and SRMR values were 0.063, 0.928, 0.901 and 0.05 respectively indicating the model fit properly to the data. Ordinal alpha values for the 6 factors produced were between 0.75 and 0.93 implying the model had good reliability (34) whereas the factor loadings for the 17 retained items ranged from 0.54 to 0.94.

In this study, women's empowerment was operationalized by the 6 dimensions labeled as household decision making power, economic, communication, psychological, assertiveness and time empowerment. This study is part of a larger study which assessed the status of women's empowerment and its effect on their nutritional status during pregnancy and the weight of newborn babies they delivered in West Shewa Zone, Ethiopia. Hence, details of the dimensions that defined women's empowerment in this study are also presented previously (21). Household decision-making power dimension represented women's involvement in decisions regarding household matters. Four items remained to measure it. The women were given a score of 1 if they involved in the decision making either alone or jointly with their husband/partner about what food to buy and consume, food prepared every day, own healthcare and daily needs household purchases. If decisions were made by their partner or someone else, they were given a score of 0. Four items assessed economic dimension. A score of 1 was assigned if the women engaged in activities that generate cash income, had cash savings of her own and had direct access to household money in her hand to use. Otherwise, a score of 0 was assigned to "no" response. The women were given a score of 1 if they made decisions alone or jointly whereas 0 score was given if others made decisions regarding their earnings. Communication dimension referred to discussions on feelings and household matters between partners. The two dimensions that measured this dimension were frequency of discussion between partners about worries or feelings and household money spending. Scores of 2, 1 and 0 were given for the women who responded "always", "sometimes" and "never" respectively. Psychological dimension addressed issues related to the women's self-esteem and self-confidence. Three items were related to it. The women were asked if they felt confident in solving problems by themselves; being important and respected household member. Scores of 2, 1 and 0 were given for "always", "sometimes" and "not at all" responses, respectively.

Assertiveness dimension assessed the certainty level of women in defending their right. Two items measured it. The items asked the women how sure they were in going to health facility and using family planning even if husband/partner objects. Scores of 4, 3, 2, 1 and 0 were given for "completely sure", "somewhat sure", "neither sure nor unsure", "somewhat unsure" and "not at all sure" answers, respectively. Out of the five questions asked regarding time, two of them remained to explain the time dimension. Values of 0, 1 and 2 were assigned if the women's response to the average time spent on housework daily and the actual time spent on housework

the previous day were greater than 10 hours, between 5 and 10 hours and less than 5 hours respectively. The women were also asked if they had time to participate in community activities (1=Yes, 0=No).

Measurement invariance of the six dimensions confirmed by CFA was assessed using multi-group CFA across age, residence place, and education level of the respondents. The configural, metric, and scalar invariance were all examined across the groups. Age of the study participants was grouped into 1=≤19, 2=20-29 years, and 3= ≥30 years. Residence place was categorized into 1=urban, and 2=rural. Education level was categorized into 1=Illiterate, 2=Grade 1 to 8, and 3=grade 9 and above. Configural, metric, and scalar invariance models can be compared using chi-square ($\chi 2$), CFI, TLI, and RMSEA. $\chi 2$ is likely to be significant as sample size increases due to its sensitivity to sample size. Therefore, measurement invariance was assessed based on ΔRMSEA, ΔCFI, and ΔTLI. The equivalent model is considered to be acceptable when $\Delta RMSEA \leq .015$, $\Delta CFI \leq 0.010$ and $\Delta TLI \leq 0.010$ (35). The results of the measurement invariance are presented in Table 1. As the results showed measurement equivalence was met across the different groups. The results suggested that women's empowerment measuring tool was approved to be valid (construct validity) separately for the different age, living area, and education level groups of the pregnant women.

Table 1. Measurement invariance findings of multi-group confirmatory factor analysis for residence place, age, and education level groups.

Model	Invariance	Model compared	RMSEA	Δ RMSEA	CFI	Δ CFI	TLI	Δ TLI
Residence place								
M1	Configural		0.059		0.917		0.902	
M2	Metric	M1	0.058	0.001	0.918	-0.001	0.904	-0.002
M3	Scalar	M2	0.058	0.001	0.916	0.002	0.904	0.000
Age								
M1	Configural		0.057		0.915		0.903	
M2	Metric	M1	0.055	0.002	0.915	0.000	0.905	-0.002
M3	Scalar	M2	0.054	0.001	0.914	0.001	0.906	-0.001
Education level								
M1	Configural		0.059		0.920		0.903	
M2	Metric	M1	0.056	0.003	0.919	0.001	0.906	-0.003
M3	Scalar	M2	0.054	0.002	0.916	0.003	0.907	-0.001

High and low values to the items' responses represented high and low empowerment respectively. The individual and composite women's empowerment dimensions were categorized into empowered and less empowered based on the proportion of women with total scores above the mean versus those with scores at or below the mean.

Binary logistic regression was conducted to assess the association between socio-economic, demographic as well as obstetric related variables and composite and individual women's empowerment dimensions. Predictor variables significant at p-value<0.25 were included in multivariable logistic regression analysis. Two models were used. In the first model, the composite women's empowerment score was used to assess its association with the predictor variables. The association of the individual dimensions with the predictor variables was investigated in the second model. Pseudo-R^2 was used to assess model fit. p-value < 0.05 and 95% confidence intervals were used to declare significant association of results.

Ethical approval and consent to participate

The study obtained ethical approval from Addis Ababa University, College of Health Sciences Institutional Review Board (protocol number: 107/19/SPH). Permission was also obtained from the respective public health facilities. Participation in the study was based on informed written consent of the pregnant women.

Results

Descriptive results

Out of 1,453 pregnant women, most 1,143 (78.7%) of them had received formal education. The mean age of the pregnant women was 28.1 years (SD=5.34) with a range of 18 to 44 years. About 1,308 (90%) had access to at least one form of mass media. The current pregnancy was their first for 606 (41.7%) of them. The mean number of children the pregnant women had was 2.4 (SD=1.47) ranging between 1 and 8. Descriptive results are presented in Table 2.

Table 2. Socioeconomic and demographic characteristics of study participants in West Shewa Zone, Central West Ethiopia, 2021 (n=1,453).

Characteristics		Frequency	%
Socio-demographic characteristics			
Residence place	Rural	564	38.8
	Urban	889	61.2
Respondents' education level	No formal education	310	21.3
	Primary	503	34.7
	Secondary and diploma	490	33.7
	First degree and above	150	10.3
Partner's education level	No formal education	175	12.0
	Primary	394	27.1
	Secondary	344	23.7
	Diploma	261	18.0
	First degree and above	279	19.2
Respondents' occupation	Government employee	300	20.7
	Private employee	395	27.2
	Farmer	306	21.1
	Housewife	452	31.1
Partner's occupation	Government employee	419	28.8
	Private employee	621	42.7
	Farmer	405	27.9
	Other	8	0.6
Household wealth index	Low	489	33.7
	Middle	495	34.1
	High	469	32.3

Level of women's empowerment

Out of 1,453 pregnant women, 788 (54.2 %) (95% CI: 51.66, 56.79) of them were empowered. The pregnant women were highly empowered in household decision-making power dimension while they were the least empowered in communication dimension. Only 34% of the women had cash savings of own. Similarly, the number of women who were assertive enough in accomplishing their desires even in the presence of obstacle were very low (<31%). Around half of the women had good sense of self- and self-confidence. About 54.3% of the women spent more than 6 hours on housework daily where around 3% of them spent more than 10 hours on housework daily. The pregnant women's empowerment status is presented in Table 3. The percentages in the Table are for item responses with highest score as per recoding.

Table 3. Level of pregnant women's empowerment in West Shewa Zone, Central West Ethiopia, 2021.

Empowerment dimensions	Items	n=1,453 n(%)	Mean(SD)
Household decision making power	Decision on what food to buy and consume	1,248(85.9)	
	Decision on food prepared everyday	1,323(91.1)	
	Decision on own healthcare	1,318(90.7)	
	Decision on daily needs household purchases	1,271(87.5)	
	Mean score of decision making power (out of 0-4 total points)		3.6 (1.04)
	% women > mean	1,149(79.1)	
Economic	Engagement with cash income activities	978(67.3)	
	Cash savings of own	498(34.3)	
	Decision on own earning use	1,049(72.2)	
	Direct access to household money for use	1,099(75.6)	
	Mean score of economic dimension (out of 0-4 total points)		2.5 (1.34)
	% women > mean	866(59.6)	
Communication	Discussion between partners about worries or feelings	359(24.7)	
	Discussion between partners on household money spending	485(33.4)	
	Mean score of communication (out of 0-4 total points)		2.4(1.03)
	% women > mean	564(38.8)	
Psychological	Self confidence in problem solving	574(39.5)	
	Feeling as important household member	958(65.9)	
	Feeling household members respect your opinion	729(49.9)	
	Mean score of psychology		1.6(1.2)
	% women > mean (out of 0-3 total points)	772(53.1)	
Assertiveness	Sure in going to health facility in the presence of partner's objection	372(25.6)	
	Sure in using family planning even if partner objects	444(30.6)	
	Mean score of assertiveness		1.7(1.53)
	% women > mean (out of 0-4 total points)	741(51.0)	
Time	Daily time expenditure on housework	664(45.7)	
	Time spent on housework the previous day	790(54.3)	
	Mean score of time		3.0 (0.99)
	% women > mean(out of 0-4 total points)	854(58.8)	
Total women's empowerment mean score (out of 2-23 total points)			14.7(4.13)
% women > mean		788(54.2)	

Distribution of women's empowerment by background characteristics

Higher percentage of pregnant women who were older, residing in urban area, in high wealth index, educated and civil servants were empowered (Table 4).

Table 4. Distribution of pregnant women's empowerment by socioeconomic and demographic characteristics in West Shewa Zone, Central West Ethiopia, 2021.

Characteristics		Empowerment status	
		Less empowered (%)	Empowered (%)
Age of women (years)	≤19	60(72.3)	23(27.7)
	20-29	342(42.9)	455(57.1)
	≥30	263(45.9)	310(54.1)
Residence place	Urban	328(36.9)	561(63.1)
	Rural	335(59.8)	229(40.3)
Household wealth index	Low	285(58.3)	204(41.7)
	Middle	223(45.1)	272(55.0)
	High	157(33.5)	312(66.5)
Respondents' education level	No formal education	205(66.1)	105(33.9)
	Primary	247(49.1)	256(50.9)
	Secondary	149(54.8)	123(45.2)
	Diploma	37(17.0)	181(83.0)
	First degree and above	27(18.0)	123(82.0)
Partner's education level	No formal education	119(68.0)	56(32.0)
	Primary	204(51.8)	190(48.2)
	Secondary	161(46.8)	183(53.2)
	Diploma	97(37.2)	164(62.8)
	First degree and above	84(30.1)	195(69.9)
Respondents' occupational status	Government employee	40(13.3)	260(86.7)
	Private employee	139(35.2)	256(64.8)
	Farmer	202(66.0)	104(34.0)
	Housewife	286(63.2)	166(36.8)
Partner's occupational status	Government employee	120(28.6)	299(71.4)
	Private employee	303(48.8)	318(51.2)
	Farmer	237(58.6)	168(41.4)
Access to mass media	Yes	582(44.5)	726(55.5)
	No	84(57.8)	61(42.3)

Associations between women's empowerment and socio-demographic characteristics of pregnant women

The multivariable logistic regression analysis revealed residence place, age, educational status of the pregnant women, occupational status of the pregnant women and partners were significantly

associated with composite pregnant women's empowerment. Those pregnant women who lived in rural areas were less empowered compared to those pregnant women who lived in urban areas.

Pregnant women who were older and had formal education were more empowered than those pregnant women who were younger and without formal education, respectively. Farmer and housewife pregnant women were 81.7% and 74.9% less empowered compared to women who were working in government and private sectors, respectively. On the other hand, empowerment was higher among pregnant women with farmers as partners than those pregnant women whose partners were working in government and private sectors (Table 5).

Table 5. Socio-demographic factors associated with composite women's empowerment in West Shewa Zone, Central West Ethiopia, 2021. (n=1,453)

Characteristics	COR (95% CI)	AOR (95% CI)	p-value
Age			
≤19	Ref.		
20-29	3.47(2.10, 5.73)*	2.48(1.45, 4.24)	0.001
≥30	3.08(1.85, 5.11)*	2.24(1.25, 4.02)	0.007
Residence place			
Urban	Ref.		
Rural	0.39(0.32, 0.49)	0.64(0.44,0.93)	0.021
Household wealth index			
Low	Ref.		
Middle	1.70(1.32, 2.19)*	0.72(0.51, 1.04)	0.077
High	2.78(2.14, 3.61)*	0.73(0.46, 1.16)	0.187
Pregnant women's education level			
No formal education	Ref.		
Primary + Secondary	1.87(1.42, 2.46)*	1.50(1.03, 2.20)	0.036
Diploma and above	9.27(6.49, 13.26)*	4.86(2.83, 8.33)	<0.001
Husband/partner's education level			
No formal education	Ref.		
Primary + Secondary	2.17(1.53, 3.08)*	1.46(0.92, 2.30)	0.108
Diploma and above	4.22(2.93, 6.07)*	1.19(0.67, 2.10)	0.556
Pregnant women's occupational status			
Private and government employee	Ref.		
Farmer	0.49(0.21, 0.71)*	0.18(0.11, 0.30)	<0.001
Housewife	0.65(0.39, 0.84)*	0.25(0.19, 0.34)	<0.001
Husband/partner's occupational status			
Private and government employee	Ref.		
Farmer	2.71(2.10,3.52)***	2.36(1.55, 3.60)	<0.001
Access to mass media			

Yes	1.71(1.20, 2.42)**	0.78(0.52, 1.18)	0.243
No	Ref.		

*p<0.001, **p<0.01, ***p<0.05

Note: Pseudo-R^2 = 0.16, p < 0.001

Table 6 summarizes the multivariable logistic analysis results between socio-demographic variables and individual women's empowerment dimensions. Pregnant women's education level, occupational status, household wealth index and pregnancy order were significantly associated with their household decision-making power. Age and household wealth index of the pregnant women were positively associated with their economic empowerment while farmer and housewife pregnant women were 94.4% and 93.3% less empowered in economic dimension as compared to women working in government and private sectors, respectively. Pregnant women with farmer as partners were economically better empowered than women whose partners were employed in government and private sectors.

Rural women were less empowered in communication dimension than urban women. Household wealth index and education level of the pregnant women were positively associated with their communication empowerment. On the other hand, housewife pregnant women were less empowered in communication dimension than working pregnant women. Women with farmer husband were highly empowered in communication dimension than women whose husbands were employed in government and private sectors. Pregnant women who were in high wealth index and higher education level were psychologically better empowered than those in low wealth index and had no formal education, respectively. Farmer and housewife pregnant women were less empowered in psychological dimension than government and private employed pregnant women. Pregnant women with farmer as partner had higher chance of being empowered in psychological dimension than women whose partners were working in government and private sectors.

Age of the pregnant women, education level of the women and their partners, household wealth index, residence place and access to mass media were associated with assertiveness of the pregnant women. Women who lived in rural areas were less empowered in time dimension as compared to women who lived in urban areas. As educational level of the women increased, empowerment in time dimension also increased. Time empowerment was lower among farmer

and housewife pregnant women than those pregnant women working in government and private sectors. Access to mass media was negatively related to time empowerment of the pregnant women. Time empowerment was lower among pregnant women who had multiple children than those women whose current pregnancy was their first.

Table 6. Associations of individual women's empowerment dimension with socio-demographic characteristics in West Shewa Zone, Central West Ethiopia, 2021. n=1,453

Characteristics	Decision making AOR (SE)	Economic AOR (SE)	Communication AOR (SE)	Psychological AOR (SE)	Assertiveness AOR (SE)	Time AOR (SE)
Age of respondents (years)						
≤19	Ref	Ref		Ref	Ref	
20-29	1.22(0.32)	2.65(0.77)**		1.49(0.36)	1.92(0.48)**	
≥30	1.12(0.33)	2.22(0.67)**		1.54(0.38)	1.88(0.49)***	
Residence place						
Urban	Ref	Ref	Ref	Ref	Ref	Ref
Rural	0.70(0.14)	1.18(0.26)	0.58(0.12)**	0.91(0.16)	1.45(0.27)***	0.42(0.08)*
Household wealth index						
Low	Ref	Ref	Ref	Ref	Ref	Ref
Middle	1.05(0.20)	1.26(0.25)	1.72(0.33)**	1.01(0.17)	0.58(0.10)**	0.93(0.18)
High	1.74(0.45)***	1.69(0.45)***	1.55(0.37)	1.73(0.37)***	0.36(0.08)*	0.85(0.21)
Respondents' education level						
No formal education	Ref	Ref	Ref	Ref	Ref	Ref
Primary + Secondary	1.01(0.21)	0.81(0.17)	2.43(0.57)*	1.39(0.22)***	0.86(0.16)	1.67(0.34)***
Diploma and above	2.61(0.83)**	1.70(0.53)	4.94(1.44)*	1.95(0.41)**	1.42(0.36)	4.03(1.18)*
Husband/partner's education level						
No formal education	Ref	Ref	Ref		Ref	Ref
Primary + Secondary	1.02(0.26)	1.20(0.29)	0.78(0.21)		1.71(0.38)***	1.14(0.29)
Diploma and above	0.86(0.26)	0.75(0.23)	1.25(0.40)		2.28(0.62)**	0.89(0.27)
Respondents' occupational status						
Government and private employee	Ref	Ref	Ref	Ref	Ref	Ref

Farmer	1.81(0.41)**	0.06(0.02)*	0.86(0.22)	0.53(0.12)**	0.57(0.13)**	0.24(0.06)*
Housewife	0.84(0.14)	0.07(0.01)*	0.56(0.09)*	0.73(0.10)***	0.90(0.13)	0.26(0.04)*
Husband/partner's occupational status						
Government and private employee		Ref	Ref	Ref	Ref	Ref
Farmer		2.17(0.49)**	2.98(0.69)*	3.12(0.63)*	0.77(0.16)	0.81(0.17)
Access to mass media						
Yes		1.22(0.27)	1.37(0.33)		0.49(0.10)*	0.56(0.12)**
No		Ref	Ref		Ref	Ref
Pseudo-R^2	0.06	0.26	0.11	0.04	0.04	0.23

*p<0.001, **p<0.01, ***p<0.05

Discussion

This study examined the multiple dimensions of women's empowerment which measured the resource and agency aspects of women's empowerment. EFA and CFA were conducted to identify the items and dimensions appropriate for measuring women's empowerment for this study.

Out of the 6 dimensions of women's empowerment, significant proportions (79%) of the pregnant women were empowered in household decision-making power dimension. In fact, studies in Ethiopia have discovered that decision-making power of women have been showing progress through time (7). For instance, only 9% of the women said their partners made decisions regarding their own health care in this study, which was lower than from 2016 EDHS (8) finding which was 18%. This could be due to time differences and improvements in awareness brought by environmental changes.

A woman is economically empowered when she has both the ability to succeed and advance economically and the power to make and act on economic decisions. Economic empowerment promotes women's agency (36). Even though higher percentage of the pregnant women were involved in cash generating activities in this study, the percentage of the women who reported they had no say on the use of their cash earnings were higher compared to Oromia region and the national figure (8) which may implicate the need for intervention for sustaining the achieved progresses. Greater control of income by women can strengthen household decision-making power of women which contributes for improving their well-being (37). Working and generating income alone doesn't ensure empowerment unless there is control over it (38, 39). Women should participate in decisions regarding household resources management. Women's control over resources can reduce gender inequality, increase self-confidence and have control over life options (39).

Communication helps women to express and share needs and thoughts. It must be heard, listened to, and acted on. Empowered communication helps the women to enhance their decision making power, economically and politically (37, 40). Moreover, inter-spousal communication has been linked with health outcomes (37, 41). The least empowerment score (38.8%) was reported for communication dimension in this study. This signifies the importance of improving

communication skills between partners owing to its contribution for the other women's empowerment aspects.

Psychological empowerment is referred as an individual's ability to make decisions and have control over its personal life and characterized by a sense of perceived control, competence and goal internalization (42). A person cannot be empowered unless the belief that one can change the situation of one's own and will be willing to engage in activities that are geared towards changing ones situation. Psychologically empowered women will have the necessary motivation to pursue things on their own (43). Until and unless women are mentally strong and psychologically sound, they will not be able to overcome the hindrances in the path of their empowerment (44). In this study, women were found to have low self-confidence and self-esteem. Similar results were obtained in a study conducted in Benin, where only 54% of the women were reported to have good self-confidence and self-esteem (15). Both Benin and Ethiopia are developing countries which acknowledge and share the necessity of addressing women's empowerment which has highly been influenced by existing socio-cultural circumstances.

Assertive women are strong enough to stand up for their right, say what they want or believe in and object unreasonable request (45). Assertiveness empowers women's self-efficacy and self-esteem. Assertive women are confident and self-assured. They are more likely to be empowered psychologically. This is important for other women's empowerment dimensions to be effective (43). Around half of the women were assertive enough in this study, which suggests implementation of programs to increase assertiveness level of women which is fundamental for achieving the goal of overall empowerment of women.

When both paid and unpaid works are considered, women work longer hours compared to men (46). Besides, the longer time women spent on unpaid work in undermined because it doesn't generate income (47). On the other hand, it has been pointed out reducing the time spent on unpaid work enhances women's empowerment (48). This study has revealed around 54% of the women spent between 6 and 16 hours daily on housework. It has been documented that women in Ethiopia are involved in unpaid, tiresome household work, making them to be the most disadvantaged section of society (9, 49). Empowerment is seen as a function of the amount of

time spent on different types of activities (50). A woman may be considered as less empowered if she spends more than 10.5 hours in a day on paid and unpaid work (51). Time use has been noted to influence on agency of women (50).

The fact that different item and dimensions are used for measuring women's empowerment makes it difficult to make comparisons across studies. However, among studies which considered multidimensionality, approachable empowerment result was found with the study conducted in Benin (15). About 55.8% of the women were empowered whereas 54.2% of the women were empowered in the current study. This result is an indication of the need for further work in empowering women. Likewise, Ethiopia has accepted and been working for the achievement of SDGs, which highlights the promotion of women's empowerment (11). On the other hand, only 6% of women with partners were empowered in Ethiopia according to EDHS 2016 (7), which was significantly low compared to the current study. Besides the differences in item used for measuring women's empowerment, the EDHS result represented national figure and time of study could have contributed for the differences.

Socio-demographic factors are fundamental in women's empowerment. Different previous studies have shown that rural women were more disadvantaged than urban women in terms of empowerment (8, 52). This has been supported in this study as well where rural women showed less empowerment than urban women. Particularly, rural women were less empowered in communication and time dimensions. Interestingly, rural women were found to be more assertive than urban women. This is contradictory to the fact that women in rural areas face higher influence from partners and the socio-cultural factors which acknowledge male dominancy and force women to undermine their rights. Place of residence was not associated with women's household decision making capacity and economic empowerment. However, associations have been found in studies conducted in Asian countries (53). This may be owing to differences in geographical locations with different socio-cultural settings.

Older women were generally more empowered than younger women. Similar findings were reported in previous studies (8, 52). This may be in relation to changes in the rights and duties of women in different phases of age (54). Older women were more economically empowered and assertive than younger women. This was comparable with previous studies in Bangladesh (55)

and Ethiopia (56). There are reports which declared older women were more empowered in decision-making capacity compare to younger women (57, 58). Age provides experience and some leverage for women thereby enhancing their decision-making capacity within households (59). Nevertheless, age was insignificantly associated with women's household decision making power in this study. Rather than age, it was their empowerment in economic dimension which enhanced their decision making power.

Moreover, empowerment in decision making power, economic, psychological and assertiveness dimensions increased as the wealth index of the women increased though the composite empowerment level was not affected by it. Likewise, findings from Myanmar (52), Kenya (60) and Ethiopia (8) have outlined wealth status as a determining factor for women's empowerment. Women in higher wealth quintiles were more likely to have a final say in large household and daily purchases, and their own health care (61). Increased wealth was also positively and significantly associated with higher decision-making power according to Kenyan study (60). Having better wealth status gives some power influencing choices and decisions (62). Additionally, women in better wealth rank are more likely to have better educational achievements (63).

Existing literatures underline education as pivotal for women's empowerment (64-67). Higher education has been linked with higher economic and household decision-making power (55). Education is known to enhance women's self-esteem, confidence and practice their rights (67, 68). Supporting and strengthening result was found in this study as well. Women's education level was a significant predictor of their composite empowerment. Women with higher education were highly empowered. As education level of the women increased, their household decision making power, inter-spousal communication, self-confidence and self-esteem increased considerably. They were also less likely to spend more time on housework duties. In addition, their partners' education level was found to influence their assertiveness level. They were more assertive as their partners' education level improved. Education has been highlighted as enhancing factor for women's economic empowerment (67). Education is believed to increase employment chances, which enables women to generate income. Educated women with their own income are assumed to have control on economic resources and have better decision making power and self-esteem. However, education was not influencing women's economic

empowerment in this study in contrary to previous studies' (67, 69) findings. It has been pointed out that low educational level of women was a hindering factor for their economic empowerment (70).

Occupational status was one of the determinants of women's empowerment. Employment has been found to enhance women's empowerment (57, 71). All over, working women were more empowered compared to non-working and farmer women. The unexpected result was that women with farmers as partners were more empowered than women whose partners were working in government and private sectors. They were more empowered in economic, psychological and communication dimensions. An argument which can be brought here is that working men are more likely to maintain control over incomes in order to fulfill society's expectation that men should provide for their family. This may undermine women's control over resources and self-reliance. Similarly, farmer women were also more empowered in household decision-making dimension compared to women employed in the government and private organizations. Farming is the major livelihood in rural parts of the country. Rural women were less empowered than urban women. Since it is assumed rural areas are disadvantaged socio-culturally in terms of education, mass media exposure, working hours, male dominance and other factors to score less empowerment. Being housewife didn't have relationship with their decision-making power. Other than household decision-making dimension, farmer and housewife women were less empowered in other dimensions compared to working women. Working women can be empowered in multiple ways. Participating in income generating activities can lead to improved access and control over resources. This enhances their decision-making power and control over their and family's life. Having personal income improves self-confidence and self-esteem (72). Besides, working outside home increases their exposure to the wider public which may contribute for improving their self-assurance. Farmer women are expected to cover work at home and in the field. They face triple burden. In addition to agricultural work, the responsibility of household chores and taking care of children falls on them. They are subjected to work for long hours, laborious, unpaid and undervalued work; making them more disadvantaged than men. Farming is common in rural areas. As a result, farmer women live in rural areas where access to services is low. Rural women are less educated than urban women. All these may render their economic power, self-confidence and time satisfaction. On the other hand, reliance on partner's

income and participating in unpaid housework can make housewife women less empowered in economic dimension, lack self-esteem and time deprived.

Mass media's contribution to women's empowerment is profound (73). Mass media can back the empowerment process of women by generating and increasing awareness regarding women's rights, challenging socio-cultural norms which lead to discrimination and gender stereotyping (74, 75). A study in Sub-Saharan African countries has revealed that mass media plays a role in women's empowerment by enhancing their household decision making ability (59). However, contrary to expectations, mass media exposure was only associated with assertiveness and time dimensions negatively in this study. Women who had mass media exposure were less empowered in assertiveness and time dimensions. Moreover, mass media exposure didn't influence the composite empowerment of women. The insignificant as well as negative associations between mass media exposure and individual dimension of women's empowerment imply the need for further investigation.

Women whose current pregnancy was not their first were better empowered in household decision-making power than women whose current pregnancy was their first. This may be due to their young age where women who had given birth to a number of children were more likely to be older than women who were pregnant with their first child. On the other hand, women who had given birth to a number of children were less empowered in time dimension than women who were pregnant with their first child. This may be implicated with an increase in household responsibilities and chores as the number of children increases which can lead to time poverty. Generally, number of living children was not associated with the composite and individual women's empowerment dimensions.

The results confirm to the literatures which highlight multidimensional nature of women's empowerment. At the same time, unexpected results force to raise questions. How does women partners' occupational status influence their empowerment? Why did access to mass media lead to lesser women's empowerment? Further investigations are needed to address such gaps.

This study has limitations. Cross-sectional data was used for this study. Hence, the causal effects are tentative. Partnered pregnant women only were included in this study. Empowerment among pregnant women who were divorced, widowed or single was not assessed. Moreover, only

pregnant women who were attending antenatal care unit in public health facilities were included. These limit the generalizability of the findings to the excluded segments of women. Even though the study used multiple dimensions to assess women's empowerment, there may be unaddressed aspects of it. Particularly, the contribution of culture to women's empowerment was not assessed. In relation to this, items for women's empowerment measurement in this study were developed based on existing literatures, and didn't consider the socio-cultural factors of the study area. It is useful to have understanding how women's empowerment is perceived and understood among the women and the surrounding community they are part of. This can help identify significant and unmeasured women's empowerment aspects.

Conclusions

Around half of the pregnant women were empowered suggesting the necessity of emphasis on women's empowerment activities in West Shewa Zone. The highest empowerment was in decision-making dimension while the least empowerment was in communication dimension. Most of the socio-economic and demographic factors were significantly associated with the composite and individual dimensions of women's empowerment. However, unexpected and null findings imply the necessity of additional qualitative investigations which provide in-depth understanding of the underlying causes and whether there are indeed no associations or not.

The findings imply enhancing women's empowerment in West Shewa Zone may require interventions that promote all the six dimensions with special focus on promotion of inter-spousal communication, self-confidence and paid work engagement as well as promotion of wealth, education and working status of both women and men.

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Predicting nutritional status during pregnancy by women's empowerment in West Shewa Zone, Ethiopia

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Background: Considerable proportions of pregnant women are affected by poor nutrition outcomes in Ethiopia. Women's empowerment, on the other hand, is highly recognized as a means to achieve better maternal nutrition outcomes. However, the role of pregnant women's empowerment in nutritional status during pregnancy has not been empirically examined in Ethiopia. This study aimed to address this gap.

Objective: To assess the association of individual and composite women's empowerment dimensions with pregnant women's nutrition outcomes in West Shewa Zone, Ethiopia.

Methods: A health facility-based cross-sectional study was performed on 1,453 pregnant women living in West Shewa Zone, Ethiopia, in 2021. Exploratory and confirmatory factor analyses were conducted on half of the samples to identify and validate dimensions of pregnant women's empowerment. The associations between pregnant women's empowerment dimensions and anemia status and mid upper arm circumference levels were examined by logistic regressions.

Results: Composite pregnant women's empowerment was positively associated with both anemia status and mid-upper-arm circumference level. The odds of not being anemic were higher among pregnant women empowered in economic [adjusted odds ratio (AOR) = 1.7, 95% confidence interval (CI): 1.26, 2.22] and assertiveness (AOR = 1.9, 95% CI: 1.46, 2.38) dimensions than those not empowered in these dimensions. Empowered pregnant women in household decision-making (AOR = 1.6, 95% CI: 1.19, 2.22) and psychological (AOR = 1.4, 95% CI: 1.04, 1.85) dimensions had higher odds of having normal mid-upper-arm circumference measures than those not empowered in the respective dimensions. Communication and time dimensions were not significantly associated with any of the nutrition outcomes.

Conclusions: This study suggests that empowered pregnant women are nutritionally better off than their less empowered counterparts. This is also important in child health outcomes. Policies and programs that aim to improve maternal and child health in the study area need to consider interventions that promote the decision-making power, economic, psychological, and assertiveness dimensions of pregnant women.

KEYWORDS

women's empowerment, nutritional status, pregnant women, West Shewa, Ethiopia

Abbreviations
ANC, antenatal care; CFA, confirmatory factor analysis; EFA, exploratory factor analysis.

1. Introduction

Adequate nutrition during pregnancy is an important factor for the health of the mother and the health, growth, and development of the fetus (1–3). Maternal nutrition may affect not only the immediate pregnancy outcomes but also the long-term health of infants, including a higher risk of hypertension in adults (4) and stunting in those born with a low birth weight (5). Even though it is preventable, poor nutritional status affects millions of pregnant women around the world (6). Anthropometric, biochemical, and dietary assessments in developing countries reveal that pregnant women are affected by poor nutritional status (7–9). For instance, the prevalence of anemia among pregnant women has decreased slightly over the years in low- and middle-income countries. In fact, around 40.1% of the pregnant women in these countries are anemic (10). According to the World Health Organization (WHO), anemia, as measured by hemoglobin concentration, is considered to be a public health problem if population studies find an anemia prevalence of 5.0% or higher (11), and WHO has planned to reduce anemia by 50% by 2025 (12).

The National Nutrition Strategy designed by the Ethiopian Government prioritizes improving pregnant women's nutritional status (13). Despite the efforts to address undernutrition at the national level, Ethiopia has a significant proportion of malnourished pregnant women. For instance, the 2016 Ethiopian Demographic and Health Survey (DHS) result shows that 29.1% of Ethiopian pregnant women were anemic (14). The findings in different regions of Ethiopia also confirm that anemia based on hemoglobin measurement during pregnancy is a public health problem (8, 15–17). Poor birth outcomes and adverse maternal outcomes such as preterm birth, stillbirth, small-for-gestational-age, postpartum hemorrhage, and preeclampsia have been associated with low maternal hemoglobin (<11 g/dL) during pregnancy (2). Moreover, pieces of evidence from different regions of Ethiopia indicate undernourishment, which is measured based on mid-upper circumference (MUAC) measurement <23 cm, affecting a large number of pregnant women in the country (7, 9, 18).

Women's empowerment is the process by which women gain greater control over the circumstances of their lives (19). It is underlined that the three dimensions of resources, agency, and achievements should be indivisible in measuring women's empowerment (20). On the other hand, economic, sociocultural, familial/interpersonal, legal, political, and psychological dimensions have been identified as factors that affect women's empowerment (21). The various dimensions and indicators of women's empowerment stress women's empowerment are reflected in their decision-making power, ability to access and control resources, sense of self-worth, and power to control their own and family lives (20–22). Besides being an end goal by itself (23), women's empowerment is considered a means to achieve other important development outcomes such as improvements in maternal nutritional status (24–26). The different dimensions of women's empowerment are reported to affect their nutritional status differently. For instance, a study in the Kalal'e District of northern Benin found a positive association between women's composite empowerment and nutritional status of women. In this study, the leadership dimension was significantly associated with nutritional status measured by body mass index, while decision-making, mobility, economic security, and male involvement in housework did not show a significant association with women's nutritional status (27). In Ethiopia, women with low decision-making autonomy were more likely to be malnourished than those with high decision-making autonomy (28). In another Ethiopian study, which measured women's empowerment using Women's Empowerment in Agriculture Index, control over income and the number of work hours were positively related to women's nutritional status (29).

Most studies in Ethiopia have addressed the determinants of nutritional status of pregnant women from sociodemographic and dietary practice perspectives (7–9, 15–18). However, the role of women's empowerment in pregnant women's nutritional status has not been empirically examined in Ethiopia. Furthermore, the focus on women's empowerment at this particular period lies not only in the concern for the mother's health but also at the heart of newborn's lifelong wellbeing, which is highly dependent on the mother's wellbeing during pregnancy. Also, the dimensions of empowerment give useful information when analyzing associations and setting targets for possible intervention programs to improve health outcomes (30). Thus, it is essential to identify the setting-specific and holistic dimensions of pregnant women's empowerment that are more significant regarding their nutritional status since they are poorly understood in the study area and it is unclear to what extent they contribute to the study's outcomes. This study, therefore, aimed to investigate association between pregnant women's empowerment and their nutritional status.

2. Materials and methods

2.1. Study design, period, and setting

A health facility-based cross-sectional study was conducted at public health facilities found in West Shewa Zone, Ethiopia, between January and June 2021. According to West Shewa Zone Health Bureau, the zone had nine hospitals and 93 health centers with an estimated total population of 2,869,314.

2.2. Study participants

The study participants were randomly selected pregnant women with gestational age between 26 and 34 weeks attending antenatal care (ANC) follow-up at randomly selected public health facilities found in West Shewa Zone during the study period. Assessment in six public health centers and discussions with the health professionals working in the ANC unit in the study area showed that most pregnant women tended to have one or two ANC visits and come for delivery. In addition, most ANC visits occurred during the second and

third trimesters. Conversely, hemoglobin concentrations decline in the second trimester and start to increase in the third trimester (11). Therefore, the gestational age between 26 and 34 weeks was chosen to reduce the inclusion of a large number of pregnant women with low hemoglobin levels because of the trimester they are in and to get the required sample size within a relatively shorter period of time. Pregnant women <18 years old, without a partner, and unable to provide valid information because of mental problems and had been living in the study area for less than 6 months before the survey were excluded.

2.3. Sample size determination and sampling procedure

This study is part of a prospective follow-up study that assessed the effect of women's empowerment on nutritional status and birth weight among pregnant women attending ANC at public health facilities found in the West Shewa Zone, Ethiopia. Hence, all the pregnant women who participated in the determination of empowerment level among pregnant women were included in this study. The sample size was determined using the single population proportion formula. There was no previous similar study on pregnant women's empowerment status in Ethiopia. Therefore, we took 29.1% (31) as the prevalence of women's decision-making power as one variable from a Bangladesh study to calculate the sample size for this objective. In addition, a 95% confidence interval (CI) (two-sided $\alpha = 0.05$), a 3% margin error, a 1.5% design effect (owing to multistage sampling use), and a 10% non-response rate were considered. The final total sample size was 1,453 pregnant women. The adequacy of the sample size for assessing associations was checked.

Seven districts were randomly selected from the 22 districts found in the West Shewa Zone. A total of 12 government health centers were proportionally selected using a lottery method by considering the number of public health facilities in each district. The total sample size was distributed proportionally based on the average number of second- and third-trimester pregnant women who presented for ANC follow-up in the last 3 months in each health center. Finally, data were collected from every second willing pregnant woman until the required sample size ($n =$ 1,453) was met. Data were collected after the women had received ANC services. Public health facilities that did not provide hemoglobin tests and MUAC measurements were excluded from the study.

2.4. Data collection

A structured questionnaire was administered face to face by interviewers to collect information on respondents' socioeconomic and demographic factors, obstetric characteristics, and women's empowerment-related data. The questionnaire was initially prepared in English (**Supplementary Table S1**) and translated into the local language Afan Oromo. Data were collected by women who had completed grade 12 and were trained on the tools and procedures of data collection by the principal investigator. To ensure the validity and reliability of the questionnaire, a pretest was conducted on 30 pregnant women found in one of the districts in the study area but which was not included in the study. Amendments were done on confusing words, sentences, and questions based on the pretest's findings. Qualified and trained midwives and/or nurses working permanently at the antenatal care service provision unit at the selected health facilities were used to inform and link those women who fulfilled the inclusion criteria to the data collectors. In addition, they were responsible for collecting data on the MUAC of pregnant women. Experienced medical laboratory technologists working at the selected health centers took blood samples and conducted hemoglobin tests based on the standard operating procedures (32).

2.5. Variables

2.5.1. Dependent variables

The nutritional status of pregnant women, which was determined by their hemoglobin and MUAC levels, was the outcome of this study. Standardized equipment and procedures were used for measuring hemoglobin and MUAC values. Hemoglobin concentration was measured by taking a finger-prick blood sample of each pregnant woman using a HemoCue Hb 201 (HemoCue AB, Angelholm, Sweden).After the site was cleaned with disinfectant, a prick was made on the tip of the middle finger. The first drop of blood was cleaned off, and the second drop was collected to fill the microcuvette, which was then placed in the cuvette holder of the HemoCue Hb analyzer for measuring hemoglobin concentration (32). Pregnant women are considered anemic if their hemoglobin level is below 11 g/dL in the first and third trimesters and 10.5 g/dL in the second trimester of pregnancy. The severity of anemia during pregnancy is classified into three: mild anemia (10–10.9 g/dL), moderate anemia (7.0–9.9 g/dL), and severe anemia (<7.0 g/dL). As per WHO recommendation, hemoglobin values were adjusted for every 500 m for altitudes exceeding 1,000 m above sea level (11). The altitude of the study area ranges from 1,735 to 2,917 m above sea level (33). As a result, 0.5–1.3 g/dL were deducted from the individual hemoglobin measurement values. MUAC of the left arm was measured using an adult MUAC non-stretchable measuring tape with no clothing on the arm. The women were asked to sit and bend their left arm at 90°. The measuring tape was placed at the tip of the shoulder (acromion) and the tip of the elbow (olecranon process). The midpoint of the tips was marked, and its circumference was measured to the nearest 0.1 cm. This measurement was repeated three times, and the mean of three measurements was taken. Pregnant women with MUAC measurements below 23 cm were classified as malnourished (34).

TABLE 1 Level of pregnant women's empowerment in West Shewa Zone, Central West Ethiopia, 2021(n = 1,453).[a]

Dimensions	Indicators	Mean (SD)	n (%)
Household decision-making power	Decision on what food to buy and consume		1,248 (85.9)
	Decision on food prepared every day		1,323 (91.1)
	Decision on own healthcare		1,318 (90.7)
	Decision on daily needs household purchases		1,271 (87.5)
	Mean score of decision-making power (out of 0–4 total points)	3.6 (1.1)	
	% women > mean		1,149 (79.1)
Economic	Engagement with cash income activities		978 (67.3)
	Cash savings of own		498 (34.3)
	Decision on own earning use		1,049 (72.2)
	Direct access to household money for use		1,099 (75.6)
	Mean score of economic dimension (out of 0–4 total points)	2.5 (1.2)	
	% women > mean		866 (59.6)
Communication	Discussion between partners about worries or feelings		359 (24.7)
	Discussion between partners on household money spending		485 (33.4)
	Mean score of communication (out of 0–4 total points)	2.4 (1.1)	
	% women > mean		564 (38.8)
Psychological	Self-confidence in problem solving		574 (39.5)
	Feeling like an important household member		958 (65.9)
	Feeling household members respect your opinion		725 (49.9)
	Mean score of psychology	1.6 (1.2)	
	% women > mean (out of 0–3 total points)		772 (53.1)
Assertiveness	Sure of going to a health facility in the presence of partner's objection		372 (25.6)
	Sure of using family planning, even if the partner objects		444 (30.6)
	Mean score of assertiveness	1.7 (1.5)	
	% women > mean (out of 0–4 total points)		741 (51.0)
Time	Daily time expenditure on housework		664 (45.7)
	Time spent on housework the previous day		790 (54.4)
	Mean score of time	3.0 (1.0)	
	% women > mean (out of 0–4 total points)		854 (58.8)
Total women's empowerment mean score (out of 2–23 total points)		14.7 (4.1)	
% women > mean			788 (54.2)

[a]Descriptive analysis was conducted on women's empowerment indicators and dimensions obtained from factor analysis. Categorical variables were expressed as frequencies and percentages, while used for continuous variables were expressed as means (standard deviations).
SD, standard deviation.

2.5.2. Independent variables

Indicators used to measure women's empowerment for this study were based on previous work (20–22, 35). This suggested that women can be empowered at individual and household levels; agency and resources as pillars of women's empowerment are reflected in familial/interpersonal, economic, sociocultural, time, and psychological dimensions. Twenty-nine items were included in the survey to capture women's empowerment. Questions relating to attitude, decision-making, and self-security powers were used to measure agency, whereas resource was measured using income- and time-related indicators. All the variables were recoded to make them suitable for analysis and interpretation. Scores to the indicators were given, assuring higher values indicate a higher empowerment level (27, 36–38).

2.5.3. Control variables

Pregnant women's characteristics (educational level, age, occupation, place of residence, and access to mass media), partner's educational and occupation statuses, household characteristics (household wealth index), and obstetric factors such as parity (number of children), gestational age, and pregnancy gap were the potential control variables. Age, gestational age, parity, and pregnancy gap were continuous variables; the rest were categorical. The pregnant women's and partners' educational levels were categorized into illiterate, primary, secondary, diploma, first degree, second degree, and above. The occupational status of the women and partners were grouped into government employee, private employee, farmer, merchant, daily laborer, and student; housewife was an additional option for women. Place of residence was dichotomized: if the respondent lived in an urban or rural area. The pregnant women were also asked whether they had access to either electronic media or written material or if nothing was used to assess their access to mass media.

Data on household assets were collected based on DHS questions. The 12 questions considered for wealth index calculation were recoded into binary variables i.e., 0 and 1. Questions with "yes" and "no" options and with more than two options were transformed into bivariate variables. Drinking, cooking, and washing water source, toilet facility, and roof and floor materials were categorized into improved and unimproved, while cooking fuel was considered solid and clean based on DHS classification (39). Then, principal component analysis was

conducted to calculate the household wealth index. Households were categorized into high, medium, and low quartiles based on their household wealth index score.

2.6. Statistical analyses

Data were entered using EpiData 3.1. Data cleaning and analyses were done using STATA version 16.0 (Stata Corporation, College Station, TX). A descriptive analysis was conducted to examine the background characteristics of the study participants. Exploratory factor analysis (EFA) was conducted to identify the structure of individual items and dimensions suitable for measuring women's empowerment (40). Then, it was cross-validated using confirmatory factor analysis (CFA). A correlation test was first conducted on the 29 items, which measured empowerment to see their strength for factor analysis. The data were divided into two groups using a random uniform distribution to conduct EFA with one data sample and CFA with the second data sample. Running the factor test showed that the x^2 for the Bartlett test of sphericity was significant at $p < 0.001$, and the Kaiser–Meyer–Olkin test result was 0.782, which implied that the strength of variables correlation was sufficient for factor analysis. Then, the polychoric correlation was calculated, which is recommended for categorical variables (41). EFA was conducted on the polychoric correlation matrix as input rather than the raw variables. Oblique rotation was used to rotate the indicators. Individual indicators with a rotated factor loading >0.5 (42) were used to construct the different dimensions of women's empowerment. Indicators with significant negative pattern coefficients, single loaders to a factor, and cross loaders to more than one factor were removed. Moreover, indicators that contributed to a lower reliability coefficient for a factor (Cronbach's alpha <0.7) were removed one at a time. A factor with poor reliability was removed at the end. As one indicator was removed, analysis was done on the remaining indicators. Finally, six factors were obtained based on eigenvalues >1 and the interpretability of factors (42, 43). The number of indicators was reduced to 22. Cronbach's alpha coefficients for the six factors were between 0.74 and 0.84.

CFA was conducted on the remaining randomly split half data sample to validate the fitness of the factors identified from the EFA. Model fitness was determined based on acceptable cutoff values of the root-mean-square error of approximation (RMSEA) < 0.08, Bentler comparative fit index (CFI) ≥ 0.90, Tucker–Lewis index (TLI) ≥ 0.90, and standardized root mean square residual (SRMR) < 0.08 (44, 45). To improve the initial model fitness, four indicators with *R*-squared values less than 0.2 were removed since they were sources of very high error levels (44). When correlation occurred in the error terms of individual indicators measuring the same factor, the one with the lower factor loading indicator was removed. Hence, one indicator was removed. Finally, the RMSEA, CFI, TLI, and SRMR values were 0.063, 0.928, 0.901, and 0.05, respectively, implying that the model fit to the data was acceptable. The CFA confirmed the six factors, and 17 indicators were retained with pattern coefficients ranging from 0.54 to 0.94. The total variance explained by the dimensions was 83.5%.

The six factors/dimensions, which operationalized women's empowerment, were identified as "household decision-making power, economic, communication, psychological, assertiveness and time." Details of the indicators that measured the six dimensions are found in **Table 1**. The *decision-making* dimension refers to the participation of women in household matter decisions. A score of 1 was given if the woman participated in the decision-making either alone or jointly with her husband/partner, and a score of 0 was assigned if decision was made by her partner or someone else. The scoring of answers for *economic dimension* was regarding women's engagement in cash income activities, having savings of their own, and access to household money (1 = yes; 0 = no). A woman was given a score of 1 if she made decisions alone or jointly, while 0 score was given if others made decisions regarding her earnings. The *communication* dimension deals with discussions on feelings and household matters between partners. Scores of 2, 1, and 0 were given for the indicators' responses of "always," "sometimes," and "never," respectively. The *Psychological* dimension addresses issues related to the women's self-esteem and self-confidence. Response of "always" was assigned 1, while "not at all" and "sometimes" were assigned 0 for the indicators that examined this dimension. *The assertiveness* dimension assessed the certainty level of women in defending their rights. The women who answered "completely sure" were given a score of 2, whereas "somewhat sure" got a score of 1. Those who were "neither sure nor unsure," "somewhat unsure," and "not at all sure" were given a score of 0. To assess the *time* dimension, values of 0, 1, and 2 were assigned if the indicators' response to the average time spent on housework daily and the actual time spent on housework the previous day was greater than 10 h, between 5 and 10 h, and less than 5 h, respectively.

The six dimensions were used to calculate the composite women's empowerment. Higher values of the indicator questions under each dimension represented high empowerment, whereas lower values denoted low empowerment. A cutoff point was applied for each dimension and composite dimensions to categorize the women into two, empowered and not empowered, based on the proportion of women with total scores above the population mean vs. those with scores at or below the population mean. Each dimension and indictor was given equal weight during the calculation of women's empowerment status.

First, the socioeconomic and demographic characteristics of the women and households and obstetric-related variables significantly associated with the women's nutritional status were identified in bivariate analysis and included in a model as control variables. Then, multiple logistic regression analysis was conducted. Control variables significant at $p < 0.2$ were included in multiple logistic regression analysis. Two models were used. In the first model, the composite women's empowerment score was used to assess its association with outcome variables. The associations of the individual dimensions of women's empowerment with pregnant women's nutritional status were investigated in the second model. The variation inflation factor of the independent variables in the models was below 10. The likelihood-ratio chi-square and R^2 tests were used to assess model fit. $p < 0.05$% and 95% confidence intervals were used to declare a significant association of results.

3. Results

3.1. Descriptive characteristics of study participants

Out of 1,453 pregnant women, the majority (61.2%) resided in urban areas. Their mean age was 28.1 (SD 5.3) years, with a range of 18–44 years. The mean number of children the pregnant women had was 2.4 (SD 1.5), with a minimum of 1 and a maximum of 8. The mean birth interval between the current and previous pregnancies was 2.9 (SD 1.7) years, with a range of 1–15 years (Table 2).

TABLE 2 Descriptive statistics of sociodemographic and obstetric characteristics of pregnant women in West Shewa Zone, Central West Ethiopia, 2021 ($n = 1,453$).

Characteristics	Frequency	%
Sociodemographic characteristics		
Age in years		
<19	83	5.7
20–29	797	54.9
>30	573	39.4
Residence		
Rural	564	38.8
Urban	889	61.2
Women's education level		
Illiterate	310	21.3
Elementary	343	23.6
Primary	160	11.0
Secondary	272	18.7
Diploma	218	15.0
First degree and above	150	10.3
Women's occupation		
Government employee	300	20.7
Private employee	164	11.3
Trading/merchant	171	11.8
Daily laborer	60	4.1
Farmer	306	21.1
Housewife	421	29.0
Student	31	2.1
Household wealth index		
Low	489	33.7
Middle	495	34.1
High	469	32.3
Obstetric characteristics		
First pregnancy		
Yes	606	41.7
No	847	58.3
Gestational age		
2nd trimester	108	7.4
3rd trimester	1,345	92.6
Number of living children		
<2	516	60.9
3–4	243	28.7
>5	88	10.4
Birth interval between the current and previous pregnancies in years		
<3	396	46.8
>3	451	53.3

3.2. Nutritional status of pregnant women

Of 1,453 pregnant women, 18.5% (269) (95% CI: 16.60, 20.60) were anemic (hemoglobin < 11 g/dL) without altitude adjustment. After altitude adjustment, the prevalence increased to 32.1% (466) (95% CI: 29.72, 34.52). Of the 466 anemic pregnant women, 10 (2.2%) had severe, 250 (53.6%) had moderate, and 206 (44.2%) had mild anemia. About 34 (7.3%) and 432 (92.7%) of them were in the second and third trimesters, respectively. The mean hemoglobin value was 12.4 g/dL (SD 1.7). Of 1,453 pregnant women, 306 (21.1%) (95% CI: 19.04, 23.24) were malnourished (MUAC <23 cm). The mean MUAC value was 25.0 cm (SD 2.2).

3.3. Women's empowerment status

Of 1,453 pregnant women, 788 (54.2%) (95% CI:51.66, 56.79) were empowered overall. The highest and least empowerment levels of pregnant women were identified in household decision-making power and communication dimensions respectively. Most of the pregnant women were empowered to make decisions regarding food prepared for the household. However, of 1,453 pregnant women, only 498 (34.3%) had cash savings of their own. Less than half of them had frequent communication with their partners. Similarly, the number of pregnant women who were assertive enough to accomplish their desires even in the presence of obstacles was very low (<31%). Around half of them had a good sense of self and self-confidence. Of 1,453 pregnant women, about 756 (54.3%) spent more than 6 hours on housework daily, whereas around 33 (3%) spent more than 10 hours on housework daily. Table 1 summarizes the results of the empowerment level of pregnant women. The percentage in the table is for indicators' responses with the highest score per recording.

3.4. Associations between women's empowerment and pregnant women's nutritional status

In bivariate analysis, except age, gestational age, and pregnancy gap, all the rest control variables (residence place, wealth index, women's and their partners' educational level and occupational status, access to mass media, first pregnancy, and parity) were significantly associated with the anemia status of the pregnant women ($p < 0.05$). Age, residence place, wealth index, women's educational level and occupational status, partners' occupational status, and first pregnancy had a significant association with the MUAC level of the pregnant women, while educational status of partner, mass media exposure, pregnancy gap, gestational age, and parity had p-values above 0.2.

TABLE 3 Associations of women' empowerment with pregnant women's anemia status and MUAC level in the West Shewa Zone, Ethiopia. (n = 1,453).[a]

	Anemia status[b]				MUAC[c]			
Model	Anemic	Not anemic	AOR (95% CI for AOR)	P	MUAC <23 cm	MUAC ≥ 23 cm	AOR (95% CI for AOR)	p
Model I								
Composite women's empowerment								
Not empowered	275 (18.9)	390 (26.8)	Ref		183 (12.6)	482 (33.2)	Ref	
Empowered	191 (13.2)	597 (41.1)	1.9 (1.47, 2.43)	0.000	123 (8.5)	665 (45.8)	1.8 (1.32, 2.35)	0.000
Model statistics								
LR (Chi-square)	89.2				110.4			
R^2	0.049				0.074			
p	0.000				0.000			
Model II								
Decision-making power								
Not empowered	120 (8.3)	184 (12.7)	Ref		95 (6.5)	209 (14.4)	Ref	
Empowered	346 (23.8)	803 (55.3)	1.2 (0.92, 1.63)	0.164	211 (14.5)	938 (64.6)	1.6 (1.19, 2.22)	0.003
Economic								
Not empowered	246 (16.9)	341 (23.5)	Ref		159 (10.9)	428 (29.5)	Ref	
Empowered	220 (15.1)	646 (44.5)	1.7 (1.26, 2.22)	0.000	147 (10.1)	719 (49.5)	1.3 (0.91, 1.73)	0.172
Communication								
Not empowered	314 (21.6)	575 (39.6)	Ref		200 (13.8)	689 (47.4)	Ref	
Empowered	152 (10.5)	412 (28.4)	1.1 (.87, 1.50)	0.340	106 (7.3)	458 (31.5)	1.1 (0.77, 1.43)	0.764
Psychological								
Not empowered	246 (16.9)	435 (29.9)	Ref		169 (11.6)	512 (35.2)	Ref	
Empowered	220 (15.1)	552 (38.0)	1.2 (0.92, 1.53)	0.186	137 (9.4)	635 (43.7)	1.4 (1.04, 1.85)	0.027
Assertiveness								
Not empowered	281 (19.3)	431 (29.7)	Ref		165 (11.4)	547 (37.7)	Ref	
Empowered	185 (12.7)	556 (38.3)	1.9 (1.46, 2.38)	0.000	141 (9.7)	600 (41.3)	1.1 (0.80, 1.39)	0.702
Time								
Not empowered	236 (16.2)	363 (25.0)	Ref		151 (10.4)	448 (30.8)	Ref	
Empowered	230 (15.8)	624 (43.0)	1.2 (0.89, 1.54)	0.273	155 (10.7)	699 (48.1)	1.3 (0.98, 1.82)	0.070
Model statistics								
LR (chi-square)	124.1				120.7			
R^2	0.068				0.081			
p	0.000				0.000			

[a]Multiple logistic regression analyses were done to find the associations of individual and composite women's empowerment dimensions with anemia and MUAC status during pregnancy.
[b]Adjusted for age, residence place, wealth index, women's and their partners' educational level and occupational status, access to mass media, and first pregnancy.
[c]Adjusted for age, residence place, wealth index, women's educational level, occupational status of women and their partners, and first pregnancy.
AOR, adjusted odds ratio; CI, confidence interval.

The association results of composite and individual dimensions of women's empowerment with pregnant women's nutritional outcomes are presented in Table 3. Pregnant women's composite empowerment score was significantly and positively associated with the anemia status and MUAC level. Empowered pregnant women were more likely not to be anemic (AOR = 1.9, 95% CI: 1.47, 2.43) and have MUAC ≥ 23 cm (AOR = 1.8, 95% CI: 1.32, 2.35) than not-empowered women. On the other hand, only economic and assertiveness dimensions were significantly associated with pregnant women's anemia status. Economically empowered pregnant women had 1.7 higher odds of being free from anemia than those not empowered (AOR = 1.7, 95% CI: 1.26, 2.22). Pregnant women who were empowered in the assertiveness dimension were 1.9 times more likely to be anemia-free (AOR = 1.9, 95% CI: 1.46, 2.38) than women who were not empowered in the assertiveness dimension. Similarly, only two dimensions were positively and significantly associated with the MUAC level of pregnant women. Pregnant women empowered in household decision-making power had higher odds of having MUAC ≥ 23 cm (AOR = 1.6, 95% CI: 1.19, 2.22) than those not empowered in this dimension. Pregnant women empowered in the psychological dimension were 1.4 times more likely to have MUAC ≥ 23 cm (AOR = 1.4, 95% CI: 1.04, 1.85) than those not women in the psychological dimension.

4. Discussion

This study used multiple dimensions of pregnant women's empowerment to examine its relationship with their nutrition outcomes in West Shewa Zone in Ethiopia. It used the resource–agency–achievement framework to assess pregnant women's nutrition outcomes. The contributions of the composite and the six individual dimensions of women's empowerment, including

household decision-making power, economic, communication, psychological, assertiveness, and time, were analyzed.

Key findings of this study pointed out that poor nutritional status of pregnant women was common in the study area. Moreover, the overall empowerment of pregnant women was significantly and positively associated with pregnant women's nutritional status. Household decision-making power, economic, psychological, and assertiveness dimensions of pregnant women's empowerment showed a positive association with one of the nutrition outcomes, while communication and time dimensions were not significantly associated with any of the nutrition outcomes.

The current study revealed that 32.1% of pregnant women were anemic. Similar results were reported by studies conducted in different regions of Ethiopia. For instance, 33.1% of pregnant women in Eastern Ethiopia (8) and 32.8% of pregnant women in Arba Minch (46) were found to be anemic after altitude adjustment. However, lower prevalence has been reported by studies in Western Ethiopia (17.8%) (47) and Southeast Ethiopia (27.9%) (48). Not considering altitude adjustment might be among the reasons for differences. Anemia is a moderate public health problem in the study area according to the WHO classification of the public health significance of anemia (11). In this study, 21.1% of the pregnant women were malnourished (MUAC < 23 cm). Other studies in Ethiopia have also reported a significant proportion of pregnant women as malnourished (7, 9, 18). This implies the necessity to develop effective interventions and nutritional status improvements among pregnant women.

Significant and positive associations were found between composite pregnant women's empowerment, anemia status, and MUAC level. Overall empowered pregnant women had fewer odds of being anemic or malnourished than not-empowered pregnant women. The results suggest that increasing the overall empowerment level of pregnant women is crucial for reducing malnutrition among them. As women's empowerment levels increase, they have greater knowledge of nutrition and health and greater decision-making power, income control, and time to exercise that knowledge in their self-care (49). Supporting findings have been reported in other studies investigating the associations between non-pregnant women's empowerment and their nutritional status even if different women's empowerment indicators were utilized. For instance, in India, women's empowerment in the nutrition index was significantly associated with women's anemia status (50). Another Indian study that used women's empowerment in the agriculture index for measuring women's empowerment has pointed out a significant positive association between women's empowerment in the agriculture score and the anemia status of women (51). Women's hemoglobin level was positively associated with their instrumental agency (influence in household decision-making) among East African women (52).

Only economic and assertiveness dimensions were significantly associated with anemia status, whereas the two dimensions significantly associated with the MUAC level of pregnant women were decision-making power and psychological dimensions, suggesting that the different dimensions of pregnant women's empowerment have varying influences on the nutritional status of pregnant women.

Association results between decision-making power and maternal nutrition outcomes have been inconsistent. Empowerment in household decision-making was associated with better maternal nutritional status (27, 28, 53), while null associations were also reported (54). In this study, pregnant women who were empowered in the household decision-making dimension were less likely to be malnourished than those who were not empowered. Empowerment in women's decision-making can ensure improved nutritional status by allowing to make decisions regarding purchases, preparation, and consumption of food items for the household. However, the absence of any association between household decision-making power and anemia status was unexpected. This can be owing to the multifactorial causes of anemia, including micronutrient deficiencies, parasitic and chronic infections, geographical location, and dietary practice. Moreover, women in Ethiopia are responsible for most of the household chores, including the management of food-related issues, as evidenced in this study. Therefore, better decision-making power of the women can lead to better nutritional status at the household level in their family and may not be directly observed in the nutritional status of the pregnant women. The result of this study also implies that pregnant women's decision-making power may also be influenced by other dimensions of women's empowerment, for instance, economic empowerment. Having higher household decision-making power may not lead to improved nutritional status among pregnant women if there is no economic empowerment. Women's economic empowerment may enable women to afford quality food; it can strengthen their household decision-making power, which contributes to improving their wellbeing (55). Interventions targeting these women would benefit by promoting empowerment in multiple dimensions and encouraging them to transfer their decision-making power to self-care as well. Yet, a similar result was found in the analysis of the 2016 Ethiopia Demographic and Health Surveys data, which indicated that women's decision-making does not influence their anemia status (56). On the contrary, a study in five East African countries found that women's household decision-making is positively associated with their blood hemoglobin level (52). Differences in indicators used for decision-making measurements, study settings, and study participants may contribute to varying results. In the current study, only pregnant women were included instead of non-pregnant women in the referred studies (52, 56).

Economically empowered pregnant women were less likely to be anemic in this study. A related study on non-pregnant women's empowerment and their nutritional status indicated that control over income was linked with the better nutritional status of women (53). For instance, the greater magnitude of anemia has been linked to the low decision-making capacity of women to access resources and health information (56). Participating in income-generating activities can improve access and control over resources. This enhances their decision-making power and

control over their and family's life. Income improves self-confidence and self-esteem (57). Women's participation in household decision-making and their ability to purchase food positively impact the availability of diverse and nutrient-rich diets in the household and, consequently, adequate dietary diversity intake among women (58, 59), reducing the likelihood of being anemic. On the other hand, the MUAC status of the pregnant women was not related to their economic empowerment status. Nutritional status during pregnancy depends not only on adequate dietary intake but also on sociocultural factors, energy expenditure, and nutrition knowledge (60, 61). For instance, women work longer hours when both paid and unpaid work is considered (62). Women in Ethiopia are involved in unpaid and tiresome household work, making them the most disadvantaged members of society (63). This circumstance may increase the probability of energy expenditure, resulting in low MUAC. Women may also face time poverty for self-care due to heavy workloads. Unemployed and farmer women in Ethiopia were particularly identified as the most malnourished (28).

The significant and positive association of psychological empowerment with MUAC status in this study shows the important role pregnant women's self-confidence and esteem have on nutrition outcomes during pregnancy. Other related studies also found that women's self-confidence was related to their and their children's nutritional status (27, 64, 65). Psychological empowerment is characterized by a sense of perceived control, competence, and goal internalization (66). Hence, it promotes the chance of engaging in healthy behaviors including healthy food choices and healthy dietary practices, thereby contributing to better nutritional status. They have reported increased self-confidence to positively influence nutrition outcomes. On the other hand, the insignificant association between the psychological dimension and the anemia status of pregnant women in this study implies the need for further investigation. The result may reflect the presence of other relevant factors in the middle concealing the relationship between pregnant women's psychological empowerment and anemia status during pregnancy.

This study shows that assertive pregnant women were less likely to be anemic than non-assertive pregnant women. Assertive women are likely to stand up for their rights, say what they want or believe in, and object to unreasonable requests (67). This can be reflected in their access to resources and health service utilization, which in turn can be manifested in their nutritional status. It is evidenced that assertive women are confident and self-assured. They are more likely to be empowered psychologically. Hence, the assertiveness dimension was expected to associate with the MUAC level of pregnant women, in line with the psychological dimension. Nevertheless, empowerment in the assertiveness dimension was found not to relate to MUAC status. The opposing association results of the specific dimensions with the outcome variables suggest the unique influences of the dimensions on nutrition outcomes. Assertiveness is important for other women's empowerment dimensions to be effective (68). However, assertiveness alone may not ensure better nutritional status, as evidenced in this study. Self-confidence may enhance the capability of using the available resources and circumstances, but assertiveness alone may not bring the expected outcome without such conditions. Even if the pregnant women were assertive, they might not be empowered in the other empowerment dimensions. This may be the reason for the null association observed in this study.

Communication and time dimensions were not associated with pregnant women's nutrition outcomes in this study. On the contrary, related studies pointed out that, generally, high women's workload was linked with poor nutritional status of the women (53, 69). Women may work more to increase the quantity and quality of food available to their households, but longer work hours may also increase their energy expenditure, resulting in poor nutrition outcomes (69). It was also noted that intrahousehold communication may help achieve improved maternal nutrition outcomes (36). Communication helps women to express and share needs and thoughts. Empowered communication helps women to enhance their decision-making power, economically and politically (55, 70). The unexpected results in this study may imply that the better nutritional status of pregnant women is not necessarily related to empowerment in all dimensions of women's empowerment. In line with the above explanations, the interconnectedness of the empowerment dimensions may be one of the reasons for the insignificant association results. Empowerment in a specific dimension that may not necessarily guarantee better nutritional status among pregnant women; rather, it is the cumulative empowerment of the different dimensions. This is reflected in this study considering significant relations between overall empowerment and nutrition outcomes of pregnant women. Moreover, it has been underlined that the nutritional status of pregnant women depends on multiple factors such as dietary habit, access to health services, infectious diseases, and knowledge (71) besides the independent and control variables considered in this study. Excluding these factors may have affected our study results. In general, the contextual nature of the different associations between women's empowerment dimensions and pregnant women's nutrition outcomes may be understood in-depth by qualitative research. Moreover, qualitative investigations may help identify crucial and unmeasured women's empowerment features that are related to pregnant women's nutrition outcomes and determine the appropriateness of the indicators used for capturing women's empowerment in this study. Several indicators were dropped during factor analysis. This may have affected our results.

Empowering women has been the central aim of the National Women's Policy of Ethiopia through enhancing women's participation and benefit from the economic, social, and political activities by creating an enabling environment for women (72). Ethiopia has integrated sustainable development goals (SDGs), including SDG 5 on women's empowerment, in its national development plan from 2019/2020 to 2029/2030. The national development plan aims at improving maternal health, and empowering women is identified as one of the strategies for its achievement (73). Moreover, improving maternal health and

nutrition is among the targets of the Ministry of Health of Ethiopia, as they are indicated in its Health Sector Transformation Plan II 2020/2021–2024/2025 (74). The plan is prepared to be implanted in all regions of Ethiopia. Therefore, the ministry's effort to improve pregnant women's nutrition in the study area could benefit from this study's findings by considering the significant women's empowerment components related to nutrition for implementation.

This study has limitations. Cross-sectional data were used, so causality could not be inferred. Any causal inference is tentative. Reciprocal effects may exist. Only partnered pregnant women attending antenatal care units in public health facilities were included in this study. This limits the generalizability of the findings to the excluded segments of women. The study tried to use multiple dimensions to assess women's empowerment, and indicators for women's empowerment measurement in this study were developed based on existing literature. However, the sociocultural factors of the study area were not considered. Hence, there may be unaddressed aspects of women's empowerment. There are limited studies that assessed the link between pregnant women's empowerment and their nutrition outcomes. As a result, most of the comparisons in this study were with non-pregnant women.

The findings of this study suggest that overall empowerment of pregnant women was positively associated with anemia status and MUAC level during pregnancy. Policies and programs that aim to reduce poor nutrition outcomes among pregnant women in the study area may benefit from interventions that promote, particularly, decision-making power, economic, psychological, and assertiveness dimensions of pregnant women.

Data availability statement

The original contributions presented in the study are included in the article/**Supplementary Materials**, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the study's protocol from Addis Ababa University, College of Health Sciences Institutional Review Board (IRB) (Protocol number: 107/19/SPH). Affiliation of the IRB was with the School of Public Health, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia. The participants provided their written informed consent to participate in this study.

Author contributions

TE, AY, and MS contributed to the conception and design of the study. TE performed the statistical analysis and drafted the manuscript. AY and MS reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fgwh.2023.1147192/full#supplementary-material

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Mediating effects of women's empowerment on dietary diversity during pregnancy in Central West Ethiopia: A structural equation modelling

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ABSTRACT

Background: Considerable proportions of pregnant women consume inadequately diversified diets in Ethiopia. On the other hand, women's empowerment is identified as a means of achieving maternal nutrition improvement. However, evidence on the relationship between multiple dimensions of women's empowerment and dietary diversity during pregnancy is limited in Ethiopia.

Objective: This study aimed to assess the mediating effects of women's empowerment in the pathway between women's education and dietary diversity during pregnancy in West Shewa zone, Ethiopia.

Methods: A health facility-based cross-sectional study was conducted among 1,383 pregnant women in 2021. Dietary diversity was measured using the minimum dietary diversity for women (MDD-W) tool. Exploratory and confirmatory factor analyses were employed to identify and validate women's empowerment dimensions. Structural equation modelling (SEM) was used to examine the pathways linking pregnant women's education and empowerment to dietary diversity during pregnancy.

Results: From the latent dimensions of women's empowerment produced by factor analyses, pregnant women's education was directly associated with household decision-making power, psychological and time dimensions. In turn, household decision-making power, psychological and time dimensions were associated with dietary diversity during pregnancy. The direct relationship between pregnant women's education and dietary diversity was insignificant, but the total indirect effect and total effect were significant. Household decision-making power, psychological and time dimensions were significant mediators in the relationship between pregnant women's education and dietary diversity. However, economic dimension was related to neither pregnant women's education nor dietary diversity.

Conclusion: This study highlights pregnant women with better education are more likely to be empowered in household decision-making, psychological and time dimensions; and those empowered pregnant women are more likely to consume more diverse diets, suggesting women's access to higher education could have a positive indirect effect on consumption of more diverse diets during pregnancy by empowering women in the study area.

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Introduction

Consumption of diverse food can help meet the increased nutrient requirements during pregnancy to support the needs of the pregnant woman, the fetus and for future lactation [1–3]. Pregnant women with inadequate dietary diversity are likely to be consuming less amounts of nutrients than their requirements. The adverse health outcomes of nutritional deficiencies during pregnancy affect both pregnant women and their offspring, including a higher risk of obstructed labour and death due to postpartum haemorrhage [4], preterm birth [5] and low birth weight [5,6]. In developing countries, a large number of pregnant women do not consume adequately diversified diets during their gestational period [7]. Studies in different regions of Ethiopia show that 49.0% to 84.4% of pregnant women consumed inadequately diversified diets [8–13]. These studies indicated that cereal or grain food groups comprised the highest proportion of pregnant women's diet, whereas meat, egg and dairy products consumption were very low. The pooled prevalence of inadequate dietary diversity among Ethiopian pregnant women is 59% [7], implying the necessity of addressing the problem.

Understanding the importance of the issue, the United Nations put both empowering women and addressing the nutritional needs of pregnant women among its priority agendas of the Sustainable Development Goals (SDGs) [14]. Moreover, it is suggested that maternal nutrition improvement can be

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achieved through women's empowerment [15–17]. Women's empowerment is defined as 'the process by which women gain greater control over the circumstances of their lives' [18]. The various dimensions and indicators of women's empowerment point out that it is reflected in their decision-making power, ability to access and control resources, a sense of self-worth and power to control their own and family lives [19–21]. It is emphasised that resources, agency and achievements should be indivisible in measuring women's empowerment. Resource is described as 'preconditions that enhance the ability to exercise choice', which includes material, human and social resources. Agency is 'the ability to define one's goals and act upon them', which is reflected in the ability to control resources and decisions that affect important life outcomes including decision-making power and psychological empowerment. Achievement is an outcome of choices including well-being outcomes [19].

Although different indicators and dimensions were used to measure women's empowerment, some of the available studies reported positive and significant associations of women's empowerment with dietary diversity of reproductive age women [22–26]. Negative [27] and null associations [22] were also found. According to a study in Ethiopia, women's empowerment which was measured by Women Empowerment in Agricultural Index was positively associated with women's dietary diversity [28]. Women's empowerment was also linked to dietary diversity during pregnancy. For instance, a higher level of empowerment was a predictor in the consumption of more diverse diets among pregnant women. Pregnant women who had greater household decision-making power and economic empowerment were more likely to consume more diverse diets than those with low empowerment level [29]. Besides identifying the direct relationships between women's empowerment and dietary diversity, generating evidence on pathways to dietary diversity through women's empowerment provides better insight in solving nutrition related problems. In relation to this, a Bangladesh study which examined the mediating effect of women's agency found that women's voice (one of the dimensions of agency) significantly mediated the relationship between schooling and dietary diversity among women [22]. However, there are inadequate studies which examined how the multiple dimensions of women's empowerment may influence dietary diversity during pregnancy in the Ethiopian context.

On the other hand, women's higher education status has been identified as one of the significant determinants in the consumption of adequately diversified diets among pregnant women in Ethiopia [7,11,13], education can be used to improve the quality of diet among pregnant women. At the same time, existing literatures underline education as pivotal for women's empowerment [30–32]. Women's higher education has been linked to higher economic and household decision-making power [33]. It is known to enhance women's self-esteem, confidence and practice their rights [32,34].

Even if adequate dietary diversity during pregnancy is positively associated with better pregnancy and birth outcomes, poor dietary diversity contribution to maternal undernutrition during pregnancy is a reality in developing countries including Ethiopia [5]. Nonetheless, little is known in Ethiopia about the role the various dimensions of women's empowerment play in the dietary diversity of pregnant women. Therefore, this study aimed to examine the mechanism linking pregnant women's education, empowerment and dietary diversity by using structural equation modelling (SEM). It examined the direct relationships of pregnant women's education and multiple dimensions of women's empowerment with dietary diversity during pregnancy. It further assessed the mediating effects of women's empowerment dimensions in the pathway between pregnant women's education and their dietary diversity in Central West Ethiopia. We hypothesised that pregnant women with higher education would have higher dietary diversity during pregnancy, and women's empowerment would mediate this relationship.

Methods

Study participants, setting and data

Data for this study were obtained from a prospective follow-up study which enrolled 1,453 pregnant women to assess the effect of women's empowerment on nutritional status and birth weight among pregnant women attending antenatal care (ANC) at public health facilities found in West Shewa zone, Central West Ethiopia. The study participants were pregnant women in their second and third trimester attending ANC follow-up at 12 randomly selected public health facilities located in West Shewa zone. Those pregnant women <18 years old and without partner were excluded from the study interviewer administered, pretested, structured questionnaire was used to collect data on pregnant women's socio-demographic and obstetric characteristics, empowerment and dietary diversity. The local language, Afan Oromo, was used to collect the data. Data collectors were females who had completed grade 12 and trained on the techniques of data collection. Midwives and/or nurses working at antenatal care service provision unit identified and linked the pregnant women who fulfilled the inclusion criteria to the data collectors. The data were collected from January to August 2021. Details related to the methods of the study are explained by the authors elsewhere [35].

Sampling procedure

Multistage sampling technique was applied in this study. Seven districts were randomly selected using lottery method from the 22 districts found in West Shewa Zone. Twelve public health centres were proportionally selected using lottery method by taking into account the number of public health centres in each district. Health facilities ANC client registries consisting list of second and third trimester ANC follow-up clients were used as a sampling frame. According to the ANC registry records of the health facilities, the total number of second and third trimester pregnant women who attended ANC was 2,209. Then, the total sample size was distributed proportionally based on the number of second and third trimester pregnant women who received ANC service in the previous 3 months in each health centre (Supplementary Table S1). A systematic random sampling method was used to select the study participants. Data were collected from every second willing pregnant women after they had received ANC services.

Variables and analytical strategy

SEM was used for this study, which consisted of measurement and structural parts [36]. The endogenous variables were pregnant women's dietary diversity and women's empowerment. Exogenous variables included pregnant women's education, sociodemographic and obstetric characteristics.

Endogenous variables

Pregnant women's dietary diversity

Pregnant women's dietary diversity was the outcome of this study. It was measured using MDD-W tool [2] to reduce recall bias. Pregnant women were asked to recall and list the foods they consumed in the past 24 h including snacks. In affirmation consumption was ≥15 g, the women were asked if they had eaten at least a spoonful of the food item throughout the day. The foods consumed were categorised into 10 major food groups: 1) Grains, white roots and tubers, and plantains; 2) Pulses (beans, peas and lentils); 3) Nuts and seeds; 4) Dairy; 5) Meat, poultry and fish; 6) Eggs; 7) Dark green leafy vegetables; 8) Other vitamin A-rich fruits and vegetables; 9) Other vegetables; 10) Other fruits.

Dietary diversity was used as a continuous variable in SEM analysis. For descriptive analysis purpose, it was categorised into adequate and inadequate. A score of 1 was given for a particular food category consumed in the past 24 h and 0 if not consumed. A score ≥5 was categorised as adequate and <5 as inadequate dietary diversity [2]. Special occasions such as holidays or fasting days can inflate or deflate dietary diversity scores. In order to minimise their effect, MDD-W was measured twice in nonconsecutive days, i.e. at enrolment and after a month. Then, the average of the two round measurements was used for analysis purposes. Complete data were collected on 1,383 pregnant women.

Women's empowerment

Previous works [19–21] have highlighted resources and agency as important women's empowerment components; and women can be empowered in multiple dimensions including decision-making, economic, psychological and time dimensions. Hence, 22 items were initially included based on these works in order to capture women's empowerment for this study. These items and others were used to measure women's empowerment by the authors elsewhere [35]. Six questions were asked to measure the household decision-making power of the women. The women were asked if they participated in decisions regarding what food to buy and consume, food prepared every day, daily needs household purchases, own healthcare, number of children to have and household money use. A score of 1 was given if the woman participated in the decision-making either alone or jointly with her husband/partner, and a score of 0 was assigned if decision was made by her partner or someone else. The six items used to measure economic dimension assessed whether the woman was engaged in activities with cash income, had cash savings of her own, owned any assets that could help generate income, had direct access to household money in her hand to use, involved in decisions on her earning use and had access to money that can be spent freely. Responses for the questions were dichotomised into 1 = Yes and 0 = No. However, the woman was given a score of 1 if she made decisions alone or jointly, while 0 score was given if others made decisions regarding her earning's use. Five self-esteem and self-confidence related questions were asked to measure psychological dimension. The women were asked if they felt confident in solving problems by themselves, being an important and respected household members. A score of 2 was given for the response of 'always' while 'sometimes' and 'not at all' were given 1 and 0 scores, respectively. Scores of 4, 3, 2, 1 and 0 were given for 'completely sure', 'somewhat sure', 'neither sure nor unsure', 'somewhat unsure' and 'not at all sure' answers, respectively, to questions asking the confidence level of women in going to health facility and using family planning even if husband/partner objects. Five items were used to assess time dimension. Values of 0, 1 and 2 were assigned if the indicators' response to the average time spent on housework daily and the actual time spent on housework the previous day were greater than 10 h, between 6 and 10 h and less than 6 h, respectively. The women were also asked if they had time to participate in community activities (1 = Yes,

0 = No). Responses to women's satisfaction with time availability for leisure activities were summarised into: 1 'satisfied' and 0 'unsatisfied'. Higher values of the items' responses represented a higher empowerment level. Items related to decision-making and psychological dimensions were used to measure agency, whereas resource was measured using economic and time-related items. These dimensions were used as latent constructs. Details are presented under statistical analysis.

Exogenous variables: independent and control variables

Independent variables

Pregnant women's education

Completed grade level was used to measure pregnant women's education. It was treated as a continuous variable.

Control variables

Pregnant women's, household and obstetric characteristics were considered as confounders. The variables were included as control variables because of their potential effect on either or both dietary diversity and women's empowerment. Age of respondent, parity, occupational status of the respondent and her partner, and educational status of respondent's partner were measured as continuous variables. Place of residence was dichotomised into urban and rural areas. The respondents were asked if they had access to mass media (electronic media or written material) or not (1 = Yes, 0 = No). Principal component analysis was conducted on the standard demographic and health survey questions used to create household wealth index. The questions were transformed into bivariate variables. Drinking, cooking and washing water sources, toilet facilities, roof and floor materials were categorised into improved and unimproved, while cooking fuel as solid and clean fuels based on demographic and health survey classification [37]. Households were categorised into high, medium and low tertile based on their wealth index score.

Statistical analysis

First, descriptive analysis was done using STATA version 16.0 (Stata Corporation, College Station, Texas). Next, exploratory and confirmatory factor analyses were conducted to identify the underlying dimensions of women's empowerment and confirm their generalisability. At last, SEM was used to examine the pathways from pregnant women's education level to their dietary diversity through multiple dimensions of women's empowerment. Both factor analyses and SEM were conducted using RStudio version 4.2.3.

Factor analyses were conducted on the 22 items used to measure women's empowerment since they had not been analysed together priorly. The dataset was divided into two using a random uniform distribution in order to conduct exploratory factor analysis (EFA) with one data sample and confirmatory factor analysis (CFA) with the second data sample. A correlation test was conducted on the items to determine their strength for factor analyses. The Kaiser–Meyer–Olkin test result was 0.77, and the chi-square for the Bartlett test of sphericity was significant at $p < 0.001$. EFA was done to identify the structure and dimensions of women's empowerment [38]. Weighted least squares estimator was used for EFA, which is appropriate for categorical variables [36,39]. Four factors with eigenvalues >1.0 were produced by EFA and interpreted after oblique (oblimin) rotation. Individual items with a rotated factor loading ≥0.4 were used to construct the different factors [40]. Cross loader item (item loading on two or more factors with pattern coefficient >0.32) [41] and item which contributed for lower reliability coefficient (Cronbach's alpha <0.7) for a factor were removed step by step. Finally, the four factors were retained based on eigenvalues >1 and interpretability of factors [42,43]. The number of items were reduced to 13.

CFA was done on the four factors identified by the EFA using the second randomly split half data sample to confirm their fitness. Weighted least squares means and variance adjusted (WLSMV) estimator was used, which is the preferred approach for categorical variables analysis [36].

SEM was used to examine the mediating effect of women's empowerment on dietary diversity during pregnancy. Control variables significant at p-value <0.2 in bivariate analysis were included in the final SEM model as confounders. Estimation for SEM was based on WLSMV, which takes into account categorical variables during analysis [36]. Standardised results were reported.

Bentler comparative fit index (CFI) ≥0.90, Tucker-Lewis index (TLI) ≥0.90, root mean square error of approximation (RMSEA) ≤0.08, and standardised root mean square residual (SRMR) ≤0.1 values were used to determine model fitness for both factor analysis and SEM [40].

Results

Descriptive characteristics of study participants

Results of descriptive characteristics of the study participants are presented in Table 1. The mean age of the 1,383 pregnant women was 28.1 years (standard deviation (SD) = 5.3) with a range of 18–44 years. Out of 1,383 pregnant women, the current pregnancy was their first for 586 (42.4%) of them. The mean number of children the pregnant women had was 2.4 (SD = 1.5) with a minimum of 1 and a maximum of 8. The highest and least empowerments for the pregnant women were in

Table 1. Descriptive characteristics of pregnant women in West Shewa zone, Ethiopia ($n = 1,383$).

Variables	Frequency	Percentage/ Mean (SD)
Demographic characteristics		
Women's education level		
Illiterate	283	20.5
Primary	484	35.0
Secondary and above	616	44.5
Residence		
Rural	531	38.4
Urban	852	61.6
Women's occupation		
Government employee	290	21.0
Private employee	376	27.2
Farmer	285	20.5
Housewife	402	29.1
Student	30	2.2
Household wealth index		
Low	487	35.2
Middle	446	32.3
High	450	32.5
Women's empowerment dimensions		
Household decision making power (mean, out of 0–4 total points)		3.6 (1.1)
Economic (mean, out of 0–4 total points)		2.5 (1.4)
Psychological (mean, out of 0–6 total points)		4.3 (1.5)
Time (mean, out of 0–4 total points)		2.9 (1.0)

household decision-making and psychological dimensions, respectively. Out of 1,383 pregnant women, majority 1,260 (91.1%) of them had involved in decisions on food prepared for the household every day. However, only 550 (39.8%) of them were self-confident to solve problems on their own. About 738 (53.4%) of them spent more than 6 h on housework daily.

The mean for the 10 food groups consumed by the pregnant women in the previous 24 h was 4.5 (SD = 0.7) with a range of 2.5 to 6.5 food groups. Of 1,383 pregnant women, about 855 (61.8%) (95% CI: 59.2, 64.4) of them consumed inadequately diversified diets (Table 2).

Factor analyses results

Four factors/dimensions were retained based on EFA result. Four items loaded to household decision-making power and economic dimensions; three items loaded to psychological dimension; and two items loaded to time dimensions (Table 3). These factors were modelled as mediator variables in SEM. Reliability (Cronbach's alpha) test result for household decision-making power, economic, psychological and time dimensions were 0.76, 0.84, 0.74, and 0.81, respectively. Fit indices for the final EFA model were RMSEA = 0.035; TLI = 0.977; and SRMR = 0.02. The correlations among the four factors were significant ($p < 0.05$) and less than 0.42. Fit was acceptable for the final CFA model as well: RMSEA = 0.042; CFI = 0.996; TLI = 0.994; and SRMR = 0.069.

SEM results

Figure 1 shows the adjusted SEM result. The model fit statistics (RMSEA = 0.039, CFI = 0.989, TLI = 0.983, SRMR = 0.072) indicated acceptable fit. Pregnant women's education level was not directly associated with their economic empowerment dimension ($\beta = 0.032$, $p > 0.05$) and dietary diversity during pregnancy ($\beta = 0.003$, $p > 0.05$). However, it showed positive direct relations with their household decision-making power ($\beta = 0.196$, $p < 0.05$), psychological ($\beta = 0.314$, $p < 0.001$) and time ($\beta = 0.109$, $p < 0.05$) dimensions. In turn, the three dimensions of pregnant women's empowerment were directly and positively associated with dietary diversity of pregnant women: household decision-making power ($\beta = 0.131$, $p < 0.05$), psychological empowerment ($\beta = 0.237$, $p < 0.001$); and time dimension ($\beta = 0.146$, $p < 0.01$). Pregnant women's economic empowerment (β=-0.108, $p > 0.05$) was not associated with their dietary diversity.

The total indirect effect of pregnant women's education on dietary diversity during pregnancy was positive and significant. Household decision-making power, psychological and time dimensions of women's empowerment were significant mediators in the relationship between pregnant women's education and dietary diversity during pregnancy. The total effect of pregnant women's education on their dietary diversity during pregnancy was also significant (Table 4).

Table 2. Dietary diversity of pregnant women in West Shewa zone, Ethiopia ($n = 1,383$).

Variables	Frequency (n)	Percentage (%)	
Dietary diversity			
Inadequate	855	61.8	
Adequate	528	38.2	
Consumed food groups	First round n (%)	Second round n (%)	Both rounds n (%)
Grains, white roots and tubers, and plantains	1,383 (100)	1,382 (99.9)	1,382 (99.9)
Pulses	1,182 (85.5)	1,110 (80.3)	953 (68.9)
Nuts and seeds	2 (0.1)	22 (1.6)	0 (0.00)
Dairy	586 (42.4)	578 (41.8)	243 (17.6)
Meat, poultry and fish	296 (21.4)	317 (22.9)	80 (5.8)
Eggs	275 (19.9)	312 (22.6)	67 (4.9)
Dark green leafy vegetables	452 (32.7)	463 (33.5)	175 (12.7)
Other vitamin A-rich fruits and vegetables	356 (25.7)	471 (34.1)	113 (8.2)
Other vegetables	1,374 (99.4)	1,300 (94.0)	1,291 (93.4)
Other fruits	273 (19.7)	432 (31.2)	120 (8.7)

Table 3. Factor analyses results of women's empowerment items in West Shewa zone, Ethiopia, 2021 ($n = 1,383$).

Dimensions	Items	Factor loadings (EFA)	Factor loadings (CFA)
Household decision-making power	Decision on what food to buy and consume (d1)	0.732	0.918
	Decision on food prepared every day (d2)	0.784	0.991
	Decision on own healthcare (d3)	0.663	0.927
	Decision on daily needs household purchases (d4)	0.763	0.943
Economic	Engagement with cash income activities (ec1)	0.891	0.867
	Cash savings of own (ec2)	0.574	0.797
	Decision on own earning use (ec3)	0.692	0.933
	Direct access to household money for use (ec4)	0.591	0.778
Psychological	Self confidence in problem solving (p1)	0.514	0.733
	Feeling as important household member (p2)	0.790	0.933
	Feeling household members respect your opinion (p3)	0.822	0.876
Time	Daily time expenditure on housework (t1)	0.810	0.992
	Time spent on housework the previous day (t2)	0.884	0.847

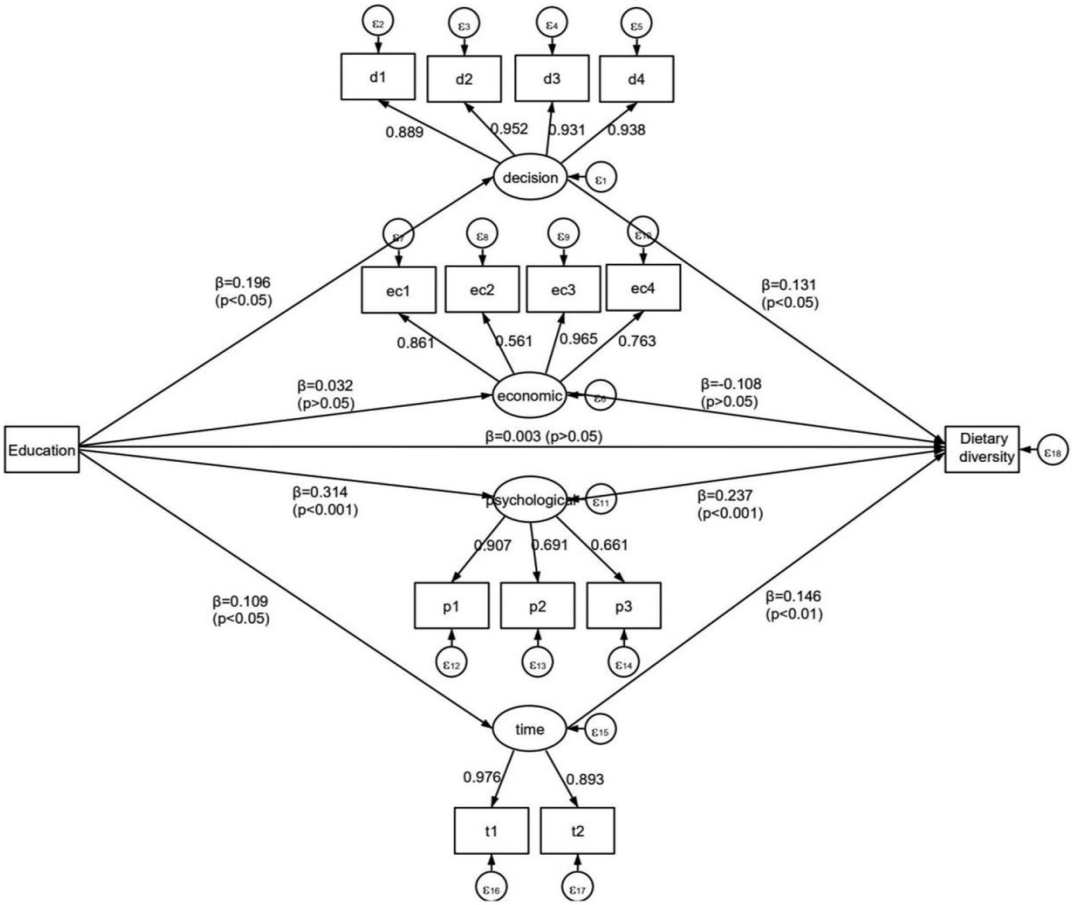

Figure 1. SEM results of the mediation effects of women's empowerment in the relation between pregnant women's education and dietary diversity during pregnancy.

Discussion

This study used SEM to examine the pathways to dietary diversity during pregnancy in West Shewa zone, Ethiopia. It analysed the direct and indirect effects of women's educational status on dietary diversity during pregnancy through women's empowerment dimensions.

Pregnant women's education was positively associated with their household decision-making power, psychological and time dimensions, but it was

Table 4. Direct and indirect effects of pregnant women's education on dietary diversity during pregnancy in West Shewa zone, Ethiopia ($n = 1,383$).

Effect	Empowerment dimension	Coefficient	p value
Total effect		0.115	<0.05
Direct effect		0.003	>0.05
Total indirect effect		0.113	<0.001
Indirect effect through	Household decision making power	0.026	>0.05
	Economic	−0.003	>0.05
	Psychological	0.074	<0.001
	Time	0.016	<0.05

insignificantly related with their economic empowerment dimension. Except economic dimension, household decision-making power, psychological and time dimensions were positively associated with dietary diversity of the pregnant women. The direct relation between pregnant women's education and dietary diversity during pregnancy was insignificant, but it had positive indirect association through mediation effects of household decision-making power, psychological and time dimensions.

The finding of this study showed that about 61.8% of the pregnant women did not consume adequately diversified diets. Other studies in Ethiopia also indicated that more than half of women consumed inadequately diversified diets during their pregnancy [9–13]. It has been pointed out that low dietary diversity may result in micronutrient deficiency among reproductive age women [3,44], which is implicated in negative outcomes for both the mother and fetus [45,46].

The insignificant association of pregnant women's education status with dietary diversity of pregnant women was unexpected though similar finding was reported from other study in Ethiopia [8]. Better maternal education has been linked with better maternal health and nutrition literacy, and simultaneously converting the acquired knowledge into practice [47,48]. This can be reflected in higher dietary diversity [22]. On the other hand, Ethiopian studies have identified socio-cultural factors such as food taboos, cultural prohibitions to negatively affect dietary practices during pregnancy irrespective of maternal educational status [49,50]. The finding from our study implies the need for further investigations to answer whether education had brought improvements in health and nutrition literacy or not, if there were hindering factors including socio-cultural factors in implementing nutrition knowledge into practice, and whether working outside as educated women had led to double responsibilities forcing less priority to self-care.

In the present study, there was significant association between pregnant women's education and their household decision-making power. Better education may lead to better household decision-making power [33]. Supporting evidence was found in this study as well. Pregnant women's decision-making power was also significantly related with their dietary diversity during pregnancy. It is expected that as women's participation in decisions about food purchase and preparation for household increases, the availability of diverse diet in the household to increase as well; which in turn leads to adequate dietary diversity among the household members including the pregnant women. Majority of the pregnant women were responsible for food management at household level in this study. This may be reflected on dietary diversity of the pregnant women. On the other hand, different factors including nutrition information, socio-cultural factors influence dietary diversity during pregnancy according to Ethiopian studies [7,49,50]. Hence, it is important to understand the mechanisms how these factors influence decision-making power of the pregnant women in relation to the consumption of diverse diets during pregnancy in such culture influenced society. Consistent with this study's finding, a study in Ghana pointed out women's decision-making power as a significant contributor to consumption of diverse diets. Women who made decisions regarding household purchases were more likely to eat diverse diet [51]. Yet, Bangladesh study found null association between women's decision-making power and dietary diversity [22]. Differences in setting and study participants may contribute for varying results. Only pregnant women were included in this study, whereas the referred study was on non-pregnant women.

Pregnant women's educational status was not associated with their economic empowerment. Furthermore, the direct and indirect null effect of women's economic empowerment on their dietary diversity was unexpected. It has been highlighted that education enables women to generate their own income by increasing their employment opportunities [32]. In turn, having access and control over economic resources by the women has been linked with consumption of diverse diets [26,52]. The contradicting findings in this study may suggest that (1) pregnant women can involve in income generating activities and have control over resources irrespective of their educational status in the study area; (2) economic empowerment may require the pregnant women work outside for income generation. The tradition role also dictates them to cover household chores. Consequently, the pregnant women may face time poverty for self-care due to heavy workloads. Even if their economic empowerment enables them to afford diverse diets, it may not be transferred to practice. Investigation on the values given for economic empowerment and dietary diversity by the pregnant women may help to better understand the association between them. On the contrary, the finding may suggest that the

economic empowerment may not be enough which enables to afford diverse diets rather have the minimum diverse diets per day. The findings may also imply adequate dietary diversity during pregnancy may not necessarily be related with empowerment in every women's empowerment dimensions. Besides, the interdependences of the empowerment dimensions may have contributed for the insignificant results. Economic empowerment merely may not be a guarantee for adequate dietary diversity among the pregnant women. It may require them simultaneously to be empowered in their either decision-making power or time or psychological dimensions. In order for pregnant women's economic empowerment to result in adequate diversity during their pregnancy, they may need to involve in decisions regarding food purchase and preparation; have self-worth and the time for self-care.

The significant direct and indirect influence of psychological empowerment on pregnant women's dietary diversity in this study highlights the crucial role self-confidence and esteem have on consumption of adequately diversified diets during pregnancy. This finding is in-line with the existing evidences that reported significant relations between women's self-confidence and nutritional status [25,53]. Education enables women to enhance their self-esteem, confidence and practice their rights [32,54]. Supporting result was also found in this study. Such conditions may promote their ability of taking advantage of circumstances and available resources. Therefore, psychologically empowered pregnant women are believed to have the determination to engage in healthy dietary practices including consumption of adequately diversified diets.

This study found out that as education level of the pregnant women increased, the time they spent on housework decreased. Educated women are more likely to be empowered economically [32] because education is believed to increase employment opportunities, thereby decreasing the time women spend on unpaid housework. Working housework for long hours can be tiring. This may in turn reduce the time for self-care. It has been pointed out reducing the time spent on unpaid work enhances women's empowerment [55]. This study has revealed around 54% of the pregnant women spent between 6 and 16 h daily on housework. Those pregnant women who spent lesser time on housework were more likely to eat adequately diversified diet. The plausible explanation for this may be the pregnant women may be spending more time on income generating activities which enables them afford diverse foods. More importantly, time use has been noted to influence women's agency [56]. As evidenced in this study as well, educated women are believed to have better decision-making power and self-confidence. Hence, the synergistic interaction of time empowerment with the other empowerment dimensions may have contributed for adequate dietary diversity among the pregnant women empowered in time dimension. Consistent to this study's finding, reduced working hours among non-pregnant women was significantly associated with their dietary diversity in Nepalese and Ethiopia studies [28,52].

The significant indirect and total effects of pregnant women's education on their dietary diversity in this study are evidences to the different mechanisms education affects dietary diversity. Pregnant women's education had indirect significant and positive effect on dietary diversity during pregnancy through pregnant women's empowerment dimensions. This is an implication that greater dietary diversity among pregnant women may be assured by promoting education which enables empowerment in multiple dimensions. Pregnant women's education led to adequate dietary diversity among them by empowering their household decision-making ability, psychological and time aspects. As highlighted above, better women's education may lead to empowerment in decision-making, time and psychological dimensions which may indirectly lead to adequate dietary diversity. A related study in rural Bangladesh indicated that women's empowerment mediated the significant indirect effect of women's education on their dietary diversity though different empowerment dimension and non-pregnant women were used [22]. Overall, the significant total effect finding in this study emphasises the crucial role education plays in improving dietary diversity among pregnant women in the study area.

Simultaneous analysis of the different women's empowerment dimensions on dietary diversity during pregnancy using SEM in this study indicated the differences in the effect of each dimension. The findings suggest intervention programmes which target to improve pregnant women's dietary diversity in the study area may benefit from strengthening the women's decision-making power, self-confidence, self-esteem and reducing housework loads. The gender-based division of labour in Ethiopia forces women to spend more time on domestic tasks than men [57] irrespective of women's employment status, income or education levels [58]. Rural Ethiopian women work up to twice as many hours per day compared to men. Besides the household tasks, they assist their husbands in agricultural activities [59]. However, working with the women's partners may also help to share household chores responsibilities proportionately between the couples [60]. On the other hand, qualitative study may help explain the contextual nature of the different associations found in this study. Furthermore, it may help to refine the tool used for measuring women's empowerment by identifying important and unaddressed women's

empowerment items related with pregnant women's dietary diversity in the study area, and determining the relevance of the indicators included in the study.

This study has some limitations. Self-reported, 24-h recall was used to measure dietary diversity. This may entail social desirability bias as well as it may not reflect the usual consumption. Cross-sectional data were used, so causality could not be inferred. Only partnered pregnant women who were attending antenatal care unit in public health facilities were included in this study. This limits the generalisability of the findings to the excluded segments of women. In Ethiopia, dietary diversity during pregnancy is dependent on multiple factors including nutrition information, dietary diversity knowledge, ANC visits, food security [7,8,11]. Not controlling these factors in this study may be considered as a limitation. Women's empowerment measuring indicators for this study were developed from existing literatures. There may be missed women's empowerment aspects relevant to dietary diversity during pregnancy in the study area.

Conclusion

This study highlights women's empowerment could be a pathway by which education contributed to adequate dietary diversity during pregnancy in West Shewa zone, Ethiopia. Pregnant women with better education were more likely to be empowered; and those empowered pregnant women were more likely to consume adequately diversified diets. The direct and indirect findings of this study suggest pregnant women's dietary diversity could be improved through intervention programmes and policies that promote women's access to better education and women's empowerment particularly by promoting pregnant women's household decision-making power, psychological and time empowerment.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Authors contributions

All authors contributed to the conception, design of the work, analysis of data, interpretation of data and revision of the draft work. TE was responsible for acquisition, drafting the manuscript and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors read and approved of the final manuscript to be published.

Ethics and consent

The study was conducted after getting approval from Addis Ababa University, College of Health Sciences Institutional Review Board (protocol number: 107/19/SPH). Permission was obtained from the respective public health facilities. Written informed consent was obtained from all participants before entering the study.

Paper context

Poor dietary diversity affects large proportions of pregnant women. Despite the recognition of women's empowerment for maternal nutrition improvement, its pathways and effects on dietary diversity during pregnancy are understudied. We observed that pregnant women with better education were more empowered; and those empowered pregnant women were more likely to consume adequately diversified diets. Pregnant women's household decision-making power, psychological and time empowerment should be considered for improving dietary diversity during pregnancy.

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Original Article

A Structural Equation Modeling Analysis of Women's Empowerment Influence on Birth Weight of Infants in West Shewa Zone, Ethiopia

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Abstract

Background: Infant birth weight is one of the major determinants of morbidity and mortality in children and adults. The proportion of low birth weight is 13% in Ethiopia, while macrosomia is rising over time. The importance of empowering women to achieve maternal and child health outcomes is highly acknowledged. Nevertheless, this aspect has not been sufficiently documented in Ethiopia.

Objective: Th is study aimed to assess the effect of women's empowerment on the birth weight of infants in West Shewa Zone, Ethiopia.

Methods: A health facility-based prospective follow-up study was conducted from January to December 2021. Multistage sampling was applied to enroll pregnant women in the study who were followed up until delivery. Women's empowerment data were collected using an interviewer-administered questionnaire. Analysis was performed among 1,165 mother-newborn pairs, where birth weight was abstracted from the mother's medical chart. A confirmatory factor analysis was conducted to validate the women's empowerment measuring tool. Structural equation modeling was employed to investigate the direct effect of women's empowerment dimensions on birth weight.

Results: From the four latent dimensions of women's empowerment, a positive association was found between pregnant women's household decision-making power and the birth weight of the infants they delivered (β= 0.091, p=0.040), whereas higher economic empowerment of the women was related to delivering lower birth weight infants (β= -0.444, p < 0.001). Pregnant women's psychological and time empowerment were not significantly associated with newborn birth weight.

Conclusions: The findings of this study illustrated the substantial correlation between women's agency in decision-making realms and their economic independence with the birth weight of their offspring. Augmenting the influence wielded by women in decision-making processes may prove instrumental in augmenting infant birth weights. Nevertheless, the variegated results of this research underscore the imperative for a more comprehensive exploration of the mechanisms underlying the impact of diverse dimensions of women's empowerment on birth weight to optimize the efficacy of empowerment initiatives in safeguarding optimal infant birth weight outcomes.
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Keywords: birth weight, women's empowerment, structural equation modeling, Ethiopia

Introduction

Birth weight is an important predictor of morbidity and mortality in childhood and adulthood (1, 2). Based on birth weight, newborns are classified as having low birth weight (LBW) (<2,500g), normal birth weight (2,500g to 3,999g), and macrosomia (≥4,000g) (1, 3). Both LBW and macrosomia have been associated with higher short- and long-term risks for newborns. LBW increases the risks of infant mortality (4), poor cognitive development (5), and chronic diseases in adult life (6). On the other hand, macrosomia increases the risks of perinatal asphyxia (7) and neonatal hypoglycemia (8). The macrosomic infant has higher long-term risks of type 2 diabetes (9) and cancer (10). Globally, an estimated 19.80 million newborns weighed low at birth in 2020 (1). Recognizing it as a global public health problem, the World Health Organization (WHO) has aimed to reduce LBW by 30% by 2025 (11). Evidence shows that abnormal birth weight is prevalent in Ethiopia. Although a national survey of Ethiopia showed that 13% of births were low in weight (12), a range of 8.8% (13) to 23.3% (14) LBW have been reported in different regions of the country. The prevalence of macrosomia in Ethiopia has increased over time. Recent studies have indicated the prevalence of macrosomia ranges from 7.5% (15) to 19.1% (16) in the country.

The concept of women's empowerment involves enhancing the chances and possibilities available to women, giving them the freedom to make their own set of choices which they value (17). Women's empowerment can be observed in the process of decision-making, psychological wellbeing and capacity to access and manage resources as well as their own and family lives (17-20). In fact, empowering women and ensuring healthy lives and promoting wellbeing for all at all ages are among the sustainable development goals (21). Moreover, women's empowerment has been recognized as one of the significant factors for achieving better maternal and child health and nutrition outcomes (22, 23).

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Empowered women have control over resources and decisions (17, 18) regarding their own health and household resource allocation, including food purchase and preparation (24). Consequently, women's empowerment can result in better maternal healthcare utilization (25, 26) and improved maternal nutrition (27). Maternal nutrition and antenatal care visits during pregnancy are significant determinants of the health of the expectant mother and birth weight (28, 29). Economic empowerment ensures women's access to and control over financial resources (30). Women's economic empowerment enhances household food security (31). Economically empowered women are more likely to allocate more resources to food (32). Thus, they are more likely to eat diverse diets (33) and have better nutritional status (34). Women who are more empowered are less likely to experience stress (35). Stress during pregnancy is known to affect birth weight (36, 37). Psychologically empowered women have higher self-confidence and esteem (38). They are determined to practice their rights and use available resources around them, which are linked to their better nutritional status (39) and less stress (35). In turn, these factors are implicated in birth weight. The long working hours of women have been linked to their poor nutritional status due to high energy expenditure and time constraints for self-care (34, 40). It has also been reported that working long hours during pregnancy increases the risk of delivering LBW (41). Overall, women's empowerment is believed to promote the health and nutritional status of women before and during pregnancy, thereby increasing the chance of delivering normal-weight babies. Based on this, we hypothesized that pregnant women who were empowered would have a higher chance of giving birth to normal-weight babies.

Although women's empowerment is recognized as a significant factor in maternal and child nutrition and health improvement, its impact may vary across countries with different cultures. There has been limited research on the influence of various dimensions of women's empowerment on infant birth weight in Ethiopia. Therefore, this study aimed to fill this gap and provide valuable evidence to improve maternal and child health interventions in the country by examining the direct effects of women's empowerment dimensions on birth weight.

Methods and Materials

Study participants and data source

This study was part of a health facility-based prospective follow-up investigation conducted to evaluate women's empowerment effects on pregnant women's nutritional status and the weight of their newborns. The study was conducted in public health facilities found in West Shewa Zone, Central West Ethiopia. Pregnant women in the second or third trimester who attended antenatal care (ANC) in randomly selected public health facilities in the Zone were enrolled in the study and followed up until delivery. Pregnant women who were less than 18 years and had no partner were not included in this study. A structured questionnaire, which was prepared by the local language, Afan Oromo, was used to collect data on socio-demographic characteristics, obstetric history, women's empowerment, and dietary diversity at enrolment. Dietary diversity measurements were repeated after a month. Women who had completed grade 12 and trained on the data collection tools and techniques were responsible for collecting the data. Data on gestational age, mid-upper arm circumference (MUAC), and hemoglobin level were collected at enrolment by midwives and/or nurses at the ANC provision unit and medical laboratory technologists working at the selected public health centers, respectively. Besides, the midwives and/or nurses were responsible for identifying those who fulfilled the inclusion criteria and linking them to the data collectors. Birth weight was measured immediately after delivery by skilled birth attendants who assisted in delivery at the health facilities. Twins, preterm births, and stillbirths were excluded from the analysis. The data were collected between January and December 2021. Details of the study methods have been described elsewhere (24).

Sample size

Epi-Info version 7.2.2.6 was used to calculate the sample size required to examine the association between women's empowerment and birth weight. Thirty-two percent of LBW among unexposed (women with the lowest decision-making power) (42), a ratio of unexposed to exposed 1:1, 95% confidence level, 80% statistical power, and odds ratio of 0.6 (42) was used, resulting in a sample size of 622. Considering 10% for nonresponse and miss to follow-up and a design effect of 1.5 because of the multistage sampling nature of the study, the required total sample size was 1,026 pregnant women-newborn pairs. This study was a component of a broader investigation that enrolled 1,453 pregnant women; hence, the required sample size for this study was met. Data were collected from 1,453 pregnant women at enrolment. Among these, 70 pregnant women dropped out owing to missing data on second-round dietary diversity measurements and 194 with missing birth weight measurements. Reasons for missing birth weight included miscarriage (n=5), abortion (n=9), stillbirth (n=5), leaving the study area due to workplace change and delivery at relatives outside the study area (n=37), home delivery (n=75) and birth weight not recorded (n=63). Among the 1,189 participants with complete data on birth weight, 15 women with twin births and 9 preterm cases were excluded. Consequently, the final analysis included a size of 1,165 participants.

Sampling procedure

Multistage sampling was employed in this study. Out of 22 districts in the West Shewa Zone, 7 of them were selected by a lottery method. A total of 12 public health centers were proportionally selected using a lottery method based on the number of public health centers in each selected district. The sampling frame was prepared using ANC client registries' list of 2nd and 3rd trimester pregnant women who received ANC service in the selected public health facilities. A total of 2,209 2nd and 3rd trimester pregnant women attended ANC follow-up services in the past 3 months in the health facilities. Then, the total sample size was distributed

proportionally to the health facilities based on the number of those 2nd and 3rd trimester pregnant women who presented to the facilities to receive ANC service in the last 3 months. Finally, a systematic random sampling was used to select every second willing pregnant woman.

Variables and measurements

Dependent variable

Birth weight

Birth weight was the outcome of this study. Full-term newborn babies (infants born between 37 and 42 weeks of gestational age) were weighed naked within 1 hour of delivery by using beam scales to the nearest 10.00g. Birth weight was categorized into low, normal, and macrosomia (1, 2) for descriptive analysis. Birth weight was examined as a continuous variable in the structural equation modeling (SEM) analysis.

Independent variables

Women's empowerment

Resources, agency, and achievements are pillars of women's empowerment (17), which can be expressed in multiple dimensions, including decision-making, economic, psychological, and time dimensions (17-20). These four dimensions were used to operationalize women's empowerment in this study.

Household decision-making power

Four items were used to measure the household decision-making power of pregnant women. Respondents were asked if they participated in decisions on what food to purchase and eat, food prepared every day, household purchases of daily needs, and their healthcare. The responses were dichotomized into 1 if the woman participated in the decision-making either alone or jointly with her husband/partner, and 0 if the decision was made by her partner or someone else.

Economic empowerment

The four items used to measure the economic dimension asked respondents whether they were engaged in activities with cash income, had their cash savings, had direct access to household money in their hands to use, and were involved in decisions on the use of their earnings. Responses to the questions were dichotomized as 1=Yes and 0=No. Respondents were given a score of 1 if they were involved in decision-making, while a 0 score was given if they were not involved in decisions regarding their own earnings use.

Psychological empowerment

The psychological dimension was assessed using three items that asked women whether they felt confident in solving problems by themselves, being an important and respected household member. Scores of 2, 1, and 0 were given for 'always,''sometimes', and 'not at all' responses, respectively.

Time empowerment

For the items used to evaluate the time dimension, values of 0, 1, and 2 were allotted if the indicators' responses to the average time spent on housework daily and the actual time spent on housework the previous day were above 10 hours between 5 and 10 hours and below 5 hours, respectively.

Scores on the items' responses were given such that higher values indicated a higher empowerment status of women. For descriptive analysis purposes, the empowerment status of the women for each dimension was categorized as empowered or not empowered according to the proportion of women with total scores greater than the mean versus those with scores at or lower than the mean.

Covariates

Pregnant women's socio-demographic, household and obstetric characteristics, nutritional status, dietary diversity during pregnancy, and sex of the newborn were identified as control variables because of their potential confounding effects on either or both birth weight and women's empowerment. The age of the respondents, parity, and gestational age in weeks were examined as continuous variables. Gestational age (the number of gestation weeks) at enrolment was assessed based on the last normal menstrual period and physical examination. The educational status (completed grade level) of the respondent and her partner were categorized as having no formal education, primary, secondary, or diploma and above. The occupational status categories of respondents were government employees, private employees, farmers, and housewives.

Similarly, the occupational status of the respondents' partners was categorized as government employees, private employees, and farmers. Binary control variables included place of residence (urban/rural), access to mass media (yes/no), birth order (first/second and above), and sex of the newborn (female/male). The household wealth index was created by applying principal component analysis using standard demographic and health survey (DHS) questions. Drinking, cooking, and washing water sources, toilet facilities, roofs, and floor materials were classified as improved and unimproved, whereas cooking fuel was classified as solid and clean fuels according to the DHS classification (43). Individual household wealth index scores were used to classify households into high, medium, and low quartiles.

The minimum dietary diversity for women (MDD-W) tool was used to measure the dietary diversity during pregnancy. Pregnant women were asked to recall and list the foods they had consumed in the past 24 hours, including snacks. Consumption was determined to be≥ 15g if they had eaten at least one spoonful of the food item throughout the day. The foods consumed were categorized as) grains, white roots and tubers, and plantains; 2) pulses (beans, peas, and lentils); 3) nuts and seeds; 4) dairy; 5) meat, poultry, and fish; 6) eggs; 7) dark green leafy vegetables; 8) other vitamin A-rich fruits and vegetables; 9) other vegetables; and 10) other fruits. A score of 1 was given for a particular food category consumed in the past 24 hours and 0 if not consumed (44). To reduce the inflation or deflation effects of occasions such as holidays or fasting days, dietary diversity was measured twice, and the average

was used during the analysis. In the descriptive analysis, dietary diversity was categorized into adequate and inadequate if ≥ 5 and < 5 food groups consumed, respectively (44). It was included as a continuous variable in SEM analysis.

Hemoglobin and MUAC measurements were applied to evaluate the nutritional status of pregnant women. A finger-prick blood sample was obtained from the pregnant woman and analyzed using HemoCue Hb 201 (HemoCue AB, Angelholm, Sweden) to measure the hemoglobin concentration. Altitude adjustment was performed on the values obtained as per the WHO recommendations (45). An adult MUAC non-stretchable measuring tape was used to measure the middle circumference of the left arm. Measurements were performed thrice, and the mean values were used in the analysis. Details of the hemoglobin and MUAC measurements are described elsewhere by the authors (24). Both hemoglobin and MUAC levels were treated as continuous variables in the SEM analysis.

Hypothesized model

Figure 1 shows the hypothesized model of this study. It was developed based on the existing abovementioned literature. The resource and agency aspects of women's empowerment are expected to positively affect achievement, which is depicted as birth weight in this study. The economic and time dimensions represented resources, whereas agency was represented by the decision-making and psychological dimensions. The socio-demographic characteristics of the pregnant women and their households were expected to affect the dimensions of empowerment. In addition to the baseline characteristics, the nutritional status of the pregnant women, obstetric factors, dietary diversity during pregnancy, and sex of the newborn were considered to have a relation with birth weight. Hence, they were controlled for their potential confounding effects.

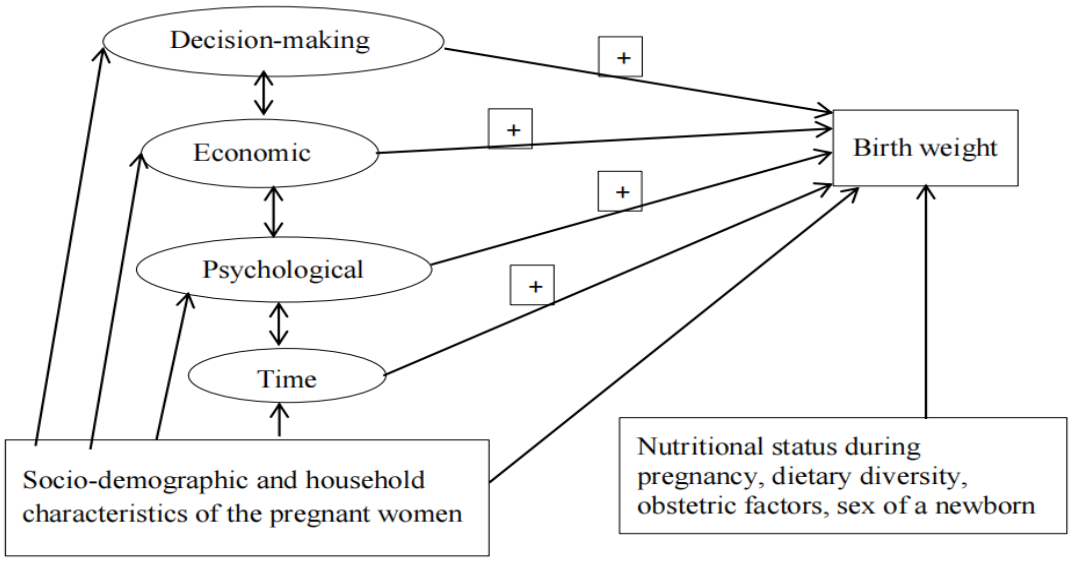

Figure 1: **Hypothesized model on women's empowerment, birth weight and control variables.**

Statistical analyses

Descriptive analyses were conducted utilizing STATA software version 16.0 (Stata Corporation, College Station, Texas). Percentages were used to express categorical variables, whereas means (standard deviation (SD)) were used for continuous variables. To analyze the disparities in socio-demographic characteristics and women's empowerment dimensions between participants who had birth weight measurements and those who did not, an independent t-test for continuous variables and Pearson's chi-square test for categorical variables were employed. The mean birth weight values were compared using t-tests and one-way analyses of variance.

Confirmatory factor analysis (CFA) was performed to validate the latent constructs used to measure women's empowerment using RStudio version 4.2.3. Weighted least squares mean and variance adjusted (WLSMV) estimator was used owing to the categorical nature of the variables (46). The items were tested and used to measure women's empowerment in separate analyses by the authors (24). SEM was applied to examine whether women's empowerment predicts birth weight using RStudio version 4.2.3. SEM is powerful in analyzing the relations between measured and latent variables (46). The four women's empowerment dimensions were used as latent variables. The latent constructs comprised the SEM measurement model, whereas the structural model included the measured variables. The endogenous variables in the SEM were

birth weight and women's empowerment dimensions, whereas the exogenous variables included control variables. The control variables that were significant at p<0.25 in the bivariate analysis were included in the SEM model as potential confounders. Socio-demographic factors related to women and households are fundamental to women's empowerment (47). Besides the characteristics of women and households, obstetric factors, nutritional status, dietary diversity, and the sex of the newborn were related to birth weight in our analysis. The analysis was performed using the WLSMV estimator. Standardized path coefficients for the direct effects of the variables were reported. The model fit for the CFA and SEM models was determined based on the following indices: Bentler comparative fit index (CFI) ≥0.90, Tucker-Lewis index (TLI) ≥ 0.90, root mean square error of approximation (RMSEA) ≤ 0.08, and standardized root mean square residual (SRMR) ≤ 0.1 (48).

Ethical considerations

Ethical approval was obtained from the Institutional Review Board of the College of Health Sciences, Addis Ababa University (protocol number 107/19/SPH). Permission was granted from the respective public health facilities. Pregnant women were included in the study after providing informed written consent.

Results

Descriptive results

The analysis was based on 1,165 participants with complete data on covariates, women's empowerment, and birth weight. There were no significant differences in background characteristics and main exposure of the study, which was women's empowerment status, between the women enrolled in the large follow-up study and those women excluded from the analysis except for age. Women with missing data on birth weight were slightly older (Table 1).

Table 1: Socio-demographic and empowerment characteristics of enrolled pregnant women with and without birth weight measurement in West Shewa Zone, Ethiopia, 2021 (n=1,453).

Characteristics	Birth weight measurement		*p*-value[a]
	Measured n(%)/mean(SD)	Missing n(%)/mean(SD)	
Total	1,165	288	
Socio-demographic characteristics			
Age (years)	27.98(5.39)	29.18(5.43)	0.041
Residence			
Urban	726(62.32)	166(57.64)	0.168
Rural	439(37.68)	122(42.36)	
Education level of respondents			
≤ grade 8	637(54.68)	176(61.11)	0.094
> grade 8	528(45.32)	112(38.89)	
Occupation status of respondents			
Government employee	249(21.37)	51(17.71)	0.225
Private employee	550(47.21)	151(52.43)	
Housewife	366(31.42)	86(29.86)	
Household wealth index			
Low	406(34.85)	103(35.76)	0.189
Middle	372(31.93)	105(36.46)	
High	387(33.22)	80(27.78)	
Women's empowerment dimensions			
Household decision making	3.54(1.05)	3.60(1.01)	0.336
Economic	2.50(1.37)	2.47(1.38)	0.691
Psychological	4.34 (1.53)	4.32(1.39)	0.749
Time	2.99(0.98)	2.91(1.01)	0.057

Note: [a]*p*-values were obtained using independent t-tests and chi-squared tests.

Table 2 summarizes the descriptive statistics of the 1,165 participants included in this study. The mean age of the 1,165 mothers was 27.98 years (SD=5.39), ranging from 18 to 44 years. For 512(43.95%) of them, the current delivery was their first. For the rest, 653(56.02%) of the mothers, the mean birth interval between the current and previous pregnancy was 2.90 years (SD=1.64) with a range of 1 to 13 years. Of 1,165 mothers, 914(78.45%) of them were empowered in the household decision-making dimension, while 600(51.50%) were empowered in the psychological dimension. The majority, 992(85.15%), of them were decision-makers on food bought and consumed by the household. However, only 400(34.33%) of them had cash savings of their own, and 462(39.66%) of them were self-confident in solving problems on their own. About 521(44.72%) of them spent more than six hours on housework daily. The mean maternal MUAC was 25.02 cm (SD=2.17). The mean hemoglobin level during pregnancy was 11.62 g/dL (SD=1.69).

Table 2: **Descriptive characteristics of study participants in West Shewa Zone, Ethiopia (n=1,165).**

Variables	Frequency	Percentage/ Mean (SD)
Demographic characteristics		
Women's education level		
Illiterate	228	19.57
Primary	409	35.10
Secondary and above	528	45.33
Residence		
Rural	726	62.32
Urban	439	37.68
Women's occupation		
Government employee	249	21.37
Private employee	550	47.21
Housewife	366	31.42
Household wealth index		
Low	406	34.85
Middle	372	31.93
High	387	33.22
Women's empowerment dimensions		
Household decision-making power (mean, out of 0-4 total points)		3.54(1.05)
Economic (mean, out of 0-4 total points)		2.50(1.37)
Psychological (mean, out of 0-6 total points)		4.34 (1.53)
Time (mean, out of 0-4 total points)		2.99(0.98)
Dietary diversity		
Adequate	457	39.23
Inadequate	708	60.77

Birth weight

The mean birth weight among 1,165 singleton newborns was 3,168.47g (SD=460.57) (95% CI: 3,142.00, 3,194.95) with a minimum of 2,030g and a maximum of 4,700g (Table 3). About 73 (6.27%) (95% CI: 5.01, 7.81) of the newborns had LBW, whereas 81 (6.95%) (95% CI: 5.63, 8.57) of them were macrosomic.

Table 3: **Mean birth weight of newborns by socio-demographic, obstetric, and nutritional status of their mothers in West Shewa Zone, Ethiopia, 2021.**

Characteristics	n(%)	Mean BW (g)	95% CI	*p*-value[b]
Age (years)				
18-20	122(10.47)	3057.14	2975.54 - 3138.74	0.018
21-30	712(61.12)	3180.43	3146.65 - 3214.21	
≥31	331(28.41)	3183.80	3134.25 - 3233.34	
Residence				
Urban	726(62.32)	3193.55	3160.38 - 3226.71	0.017
Rural	439(37.68)	3127.01	3083.21 - 3170.81	
Education level of respondent				
Illiterate	228(19.57)	3131.08	3071.32 - 3190.83	0.059
Primary	409(35.11)	3144.37	3099.76 - 3189.00	
Secondary and above	528(45.32)	3203.30	3164.03 - 3242.56	
Occupation of respondent				
Government employee	249(21.37)	3256.29	3199.26 - 3313.31	0.003
Private employee	550(47.21)	3149.68	3111.31 - 3188.05	
Housewife	366(31.42)	3136.98	3089.94 - 3184.02	
Household wealth index				
Low	406(34.85)	3136.47	3091.65 - 3181.30	0.213
Middle	372(31.93)	3180.48	3133.65 - 3227.31	
High	387(33.22)	3190.51	3144.59 - 3236.42	
MUAC				
<23 cm	241(20.69)	3029.10	2974.81 - 3083.39	0.000
≥ 23 cm	924(79.31)	3204.83	3174.99 - 3234.66	
Hemoglobin concentration				
< 11 g/dl	361(30.99)	3101.59	3057.41 - 3145.76	0.001

≥ 11 g/dl	804(69.01)	3198.51	3165.82 - 3231.19	
Birth order				
First	512(43.95)	3199.18	3163.93 - 3234.43	0.010
Second and above	653(56.05)	3129.31	3089.34 - 3169.28	
Birth interval between the current and previous pregnancy in years				
<3	305(46.71)	3199.08	3149.54 - 3248.61	0.996
≥3	348(53.29)	3199.27	3149.14 - 3249.41	
Sex of newborn				
Male	501(43.00)	3172.53	3132.96 - 3212.10	0.794
Female	664(57.00)	3165.42	3129.74 - 3201.09	
Dietary diversity				
Adequate	457(39.23)	3333.07	3292.88 - 3373.26	0.000
Inadequate	708(60.77)	3062.23	3029.47 - 3094.99	

Note: [b]*p*-values were obtained from t-test and one-way analysis of variance.

The mean birth weight was significantly higher among newborns of psychologically empowered women than among those not empowered in this dimension (Table 4).

Table 4: **Mean birth weight of newborns by empowerment status of their mothers in West Shewa Zone, Ethiopia, 2021 (n=1,165).**

Empowerment dimensions	n(%)	Mean BW (g)	95% CI	*p*-value[c]
Household decision making power				
Not empowered	251(21.55)	3119.21	3061.77 - 3176.64	0.056
Empowered	914(78.45)	3182.00	3152.16 - 3211.83	
Economic				
Not empowered	468(40.17)	3157.09	3114.22 - 3199.96	0.490
Empowered	697(59.83)	3176.12	3142.43 - 3209.80	
Psychological				
Not empowered	565(48.50)	3126.03	3087.17 - 3164.88	0.002
Empowered	600(51.50)	3208.45	3172.53 - 3244.37	
Time				
Not empowered	464(39.83)	3152.91	3110.70 - 3195.13	0.348
Empowered	701(60.17)	3178.78	3144.73 - 3212.82	

Notes: [c]*p*-value was obtained from the t-test

Confirmatory factor analysis result

The model fit indices for the CFA model (RMSEA=0.049, CFI=0.992, TLI=0.989, and SRMR=0.072) were within the recommended values, suggesting a good fit of the model to the data. The standardized factor loadings of each item and Cronbach's alpha for each dimension are presented in Table 5. Cronbach's alpha results were higher than 0.70 for all the dimensions, suggesting the model had good reliability (49). The correlations among the four dimensions were significant (p=0.000) and less than 0.556.

Table 5: **Standardized factor loadings and reliability results of confirmatory factor analysis.**

Dimensions	Items	Standard loadings	Cronbach's alpha
Household decision-making power	Decision on what food to buy and consume (d1)	0.849	0.959
	Decision on food prepared every day (d2)	0.943	
	Decision on own healthcare (d3)	0.913	
	Decision on daily needs household purchases (d4)	0.953	
Economic	Engagement with cash income activities (ec1)	0.819	0.901
	Cash savings of own (ec2)	0.662	
	Decision on own earning use (ec3)	0.979	
	Direct access to household money for use (ec4)	0.838	
Psychological	Self- confidence in problem solving (p1)	0.982	0.868
	Feeling as an important household member (p2)	0.534	
	Feeling household members respect your opinion (p3)	0.626	
Time	Daily time expenditure on housework (t1)	1.000	0.929
	Time spent on housework the previous day (t2)	0.867	

SEM results

The fit indices results of the SEM indicated a good fit of the hypothesized model: RMSEA=0.042, CFI=0.966, TLI=0.989, and SRMR=0.078. The adjusted SEM results are presented in Figure 2. Household decision-making power and economic dimensions predicted the birth weight of newborns. The household decision-making power of the mothers

(β=0.091, p=0.040) was directly and positively related to the birth weight of newborns. In contrast, the economic empowerment of the mothers (β=-0.444, p=0.000) was negatively correlated to the birth weight of newborns. The psychological (β=0.063, p=0.140) and time (β=0.052, p=0.189) empowerment dimensions were not associated with birth weight.

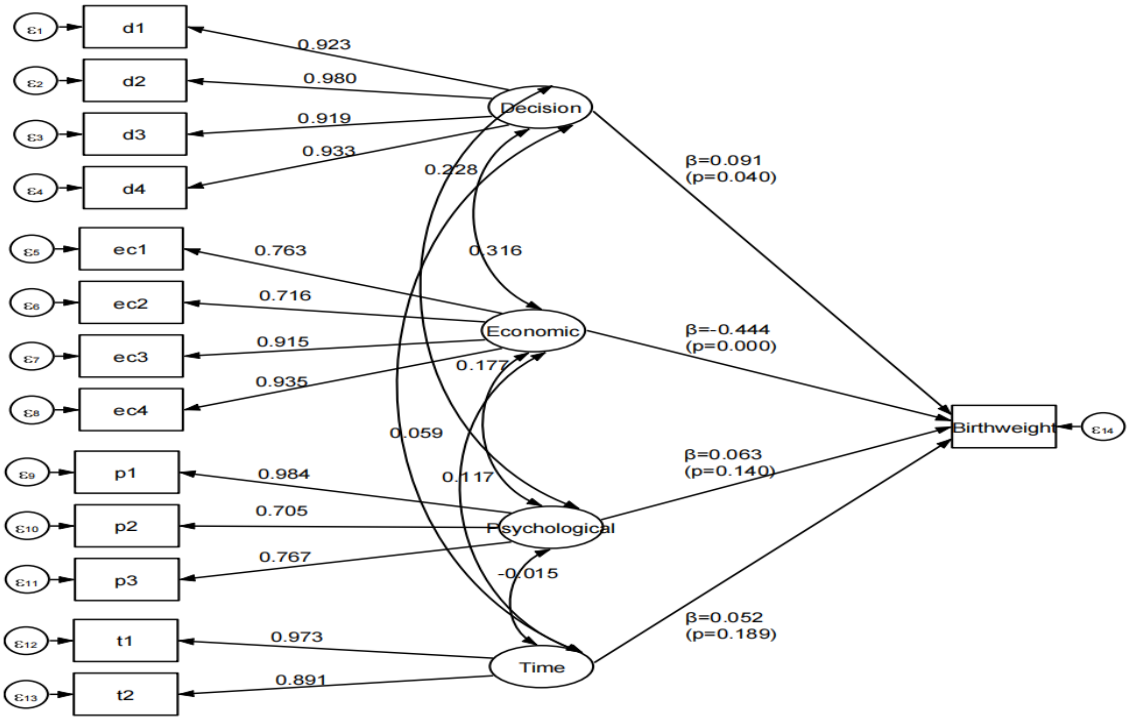

Figure 2: **SEM results of the effects of women's empowerment dimensions on birth weight in West Shewa Zone, Ethiopia, 2021.**

Discussion

This study examined the direct effects of multiple dimensions of women's empowerment on birth weight in Ethiopia using SEM. The finding of this study was consistent with the hypothesis that the household decision-making power of the mothers was positively related to birth weight. Contrary to our hypothesis, the mothers' economic empowerment was negatively related to birth weight. Psychological and time empowerment of the mothers were not associated with birth weight.

The results of this study demonstrated that the prevalence of LBW and macrosomia was comparable, suggesting the need for interventions not only for LBW but also for macrosomia. A significant and positive effect of the mothers' household decision-making power on birth weight was observed in this study. This is consistent with other studies that reported higher decision-making power of women, resulting in higher birth weight (42, 50). The decision-making power of women can affect their health service utilization (25, 26) and nutritional status (24, 27, 51). This may influence fetal growth, which has implications for birth weight. In this study, women who had the freedom to make decisions regarding their healthcare, food purchases, and preparation had higher birth weight babies than those who did not have these privileges. Better health service utilization among women may improve their health knowledge. They are more likely to have adequate antenatal care visits (52), which help them access micronutrients, including iron and folic acid supplements, regulate their nutritional status, and check their health and overall pregnancy status. These factors contribute significantly to averting poor birth outcomes, including poor birth weight. Women with better household decision-making power are more likely to consume adequately diverse diets (53), which reduces micronutrient deficiency (44). Dietary diversity during pregnancy can determine the nutritional status of the mother (44, 54). This, in turn, is known to affect birth weight (28, 55).

Studies have reported that women's economic empowerment is positively associated with better maternal nutrition (34), higher maternal health service utilization (56), and lower parity (57). Besides, women's economic empowerment is known to enhance the household decision-making power of women (58). These evidence suggest that economic empowerment contributes to better birth weight. However, the negative association between mothers' economic empowerment and birth weight was an unexpected finding in this study. This may be owing to the mediating effect of other variables on the relationship between economic empowerment and birth weight. It is

a fact that women have to work to be able to generate income. In addition, the gender role in Ethiopia forces women to accomplish unpaid and tiresome household work (59). These burdens may result in time deprivation to care for themselves. In addition, a heavy workload may increase energy expenditure. Long working hours and heavy workloads have been associated with poor nutritional status (40) and lower birth weight (41, 60). Time use is also reported to impact the agency of women (61). Women who had to work outside for long hours for income generating purposes might not be actively involved in decisions regarding household food purchase and preparation. On the other hand, even if women are involved in income-generating activities, their economic empowerment is sufficient only to allow them to lead subsistence lives. It may not be sufficient to allow them to afford good quality and quantity of food for themselves and their households. This may result in poor nutritional status in women.

Psychologically empowered women are determined to use available resources and services, including maternal health services. They have the strength to cope with stressful situations (35), which contributes to better birth outcomes (36, 37). Some studies have shown that the psychological empowerment of women is positively associated with their nutritional status (24, 39). This has been positively associated with birth weight (28). As pointed out above, time empowerment was linked with better maternal nutritional status (40) and household decision-making power (61). Hence, time empowerment was expected to result in better birth weight. However, neither psychological nor time empowerment was associated with birth weight in this study. These findings imply interconnectedness among the empowerment dimensions. Empowerment in the psychological dimension alone may not significantly affect birth weight unless there is economic empowerment, which enables women to afford good quality and quantity of food and access maternal health services.

Similarly, women's time empowerment may require simultaneous empowerment in other dimensions to result in an expected outcome. Even if a woman is empowered in the time dimension, it does not necessarily imply that she is empowered in the household decision-making, economic, or psychological dimensions. Further investigations are needed to determine whether women who are empowered in the time dimension are financially reliant on their partners and whether this has contributed to less empowerment in household decision-making and psychological dimensions among women.

Birth weight was categorized into LBW or not, as well as macrosomic or not. Separate analyses were conducted to examine the effect of the multiple dimensions of women's empowerment on these categorical variables. None of the dimensions were significantly associated with LBW or macrosomia. This may be because there were relatively few LBW and macrosomic infants, which reduced the statistical power to detect the effects of the empowerment dimensions on the categorized outcomes. Studies in Ethiopia have suggested that macrosomia is rising over time (15, 16). The cases of LBW and macrosomia were similar in this study. Further research may be helpful in determining whether women's empowerment has brought about changes in lifestyle that may be connected to birth weight.

This study is novel in providing empirical evidence of the effects of multiple dimensions of women's empowerment on birth weight in the study area. However, further research is needed to determine how these dimensions impact the outcomes. Investigating the mediating factors between the dimensions of women's empowerment and birth weight is important for developing more effective interventions.

This study has some limitations. The gestational age was not confirmed using ultrasound. This may have affected the accuracy of the estimated gestational age. Birth weight can be affected by several factors, including maternal medical conditions (62), besides the dependent and control variables analyzed in this study. Uncontrolling for these factors may have affected the findings of this study. A tool to measure women's empowerment was developed based on previous studies. There may be unmeasured aspects of women's empowerment that are important to birth weight in the study area. Although the women who were excluded from this study were slightly older, they had no significant difference in the study's main exposure (women's empowerment dimensions) and other background characteristics with the women included in this study. Hence, this is less likely to have affected the results of this study.

Conclusions

Our findings highlight that women's household decision-making power is positively associated with birth weight, while the economic empowerment of women is negatively associated with birth weight. Policies and programs aimed at improving birth weight can benefit from the promotion of women's decision-making power. However, the negative association found in this study signifies the need to pursue further research. Overall, the positive, negative, and insignificant findings of this study suggest the need for pathway analysis and qualitative research to answer the contexts of how and why different associations exist between women's empowerment dimensions and birth weight.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Disclosure

The authors declare that they have no competing interests.

Authors' contributions

TE, AY , and MS contributed to the conception, design of the work, analysis of data, interpretation of data, and

revision of the draft work. TE was responsible for the acquisition of data and drafting the manuscript. All authors read and approved the final manuscript to be published and have agreed on the journal to which the article has been submitted.

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Annex 17. Ethical clearance letter

ADDIS ABABA UNIVERSITY, COLLEGE OF HEALTH SCIENCES (IRB)
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Institutional Review Board

ANNEX 3
Form AAUMF 03-008

IRB's Decision

Meeting No: 10/2019 Date: December 11, 2019
Protocol number: 107/19/SPH

Protocol Title: The effect of women's empowerment on pregnant women's nutritional status and birth weight in West Shewa zone, Central West Ethiopia		
Principal Investigator:	Tizeta Dengia	
Institute:	College of Health Sciences, AAU	
Elements Reviewed (AAUMF 01-008)	☑ Attached	☐ Not attached
Review of Revised Application ☐ Yes ☐ No	Date of Previous review:	
Decision of the meeting:	☑Approved ☐Approved with Recommendation ☐Resubmission ☐ Disapproved	

I. Elements approved-
1. Protocol Version No: 2
2. Protocol Version Date:
3. Informed consent Version No. 2
4. Informed Consent Version Date:

II. Obligations of the PI-
1. Should comply with the standard international & national scientific and ethical guidelines
2. All amendments and changes made in protocol and consent form needs IRB approval
3. The PI should report SAE within 10 days of the event
4. End of the study, including manuscripts and thesis works should be reported to the IRB
5. The PI should report non-compliance and unanticipated events

III. TO NERC ☐

Institution Review Board (IRB) Approval: Period from: January 27, 2020 to January 26, 2021
Follow up report expected in
3 Months ___ 6 months ___✓___ 9 months_____ one year_____

Chairperson, IRB
Dr. Adamu Addissie

Signature _____
Date: 27/01/2020

Institutional Review Board Office (IRB) Faculty of Medicine ADDIS ABABA UNIVERSITY

Annex 18. Declaration

I, the undersigned, declare that this is my original work, has never been presented in this or any other University, and that all the resources and materials used for the dissertation, have been fully acknowledged.

Name: Tizita Dengia Etea

Signature: 

Date: March 28, 2025

Place: School of Public Health, College of Health Sciences, Addis Ababa University

Date of examination: February 17, 2025

This dissertation has been submitted for examination with my approval as University supervisor.

Name: Prof. Alemayehu Worku Yalew (PhD)

Signature: 

Date: March 28, 2025