**Unraveling the Multifactorial Determinants of Miscarriage: Insights from SEM Analysis of Maternal Characteristics, Lifestyle Factors, and Antenatal Care**


## Abstract

**Background:** This paper establishes that miscarriage is still a major determinant of maternal health, with the implication that factors such as maternal age, lifestyle factors, socioeconomic status and antenatal care visits affect the condition. This knowledge of factors involved can help in designing ways of ensuring they do not lead to miscarriages.

**Objective:** The purpose of this work was to examine the relationship between a range of maternal lifestyle behaviors, education, visits to the antenatal care facility, and miscarriage rates by using structural equation modelling (SEM).

**Methods:** Assuming a female population of 2000, data was generated on Maternal Age, education, Smoking, alcohol, exercise, Antenatal Care visits and an outcome variable representing miscarriage. SEM was employed to test the hypothesized relationships of these variables with Latent Lifestyle Risks captured under the observed behavior (smoking, alcohol use, exercise). To check the model fit, the following fit measure was used; Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR).

**Results:** Consequently, the assumption of good model fit in the current SEM was obtained with CFI = 0.984, TLI = 0.971, RMSEA = 0.033, and SRMR = 0.021. Hence in this study maternal age was significantly related to miscarriage risk (Estimate = 0.028, $p < 0.001$), while higher level of education was inversely inclined to miscarriage (Estimate = -0.042, $p < 0.001$). Latent Lifestyle Risks were identified to have a positive relationship with miscarriages (Estimate = 0.200, $p < 0.001$ while antenatal care visits have a negative association with miscarriage risks (Estimate = -0.022, $p < 0.001$).

**Conclusions:** Descriptive findings also reveal that maternal age, specific lifestyle patterns, educational attainment and utilization of antenatal care services are potential determinants of miscarriage. We found that offering changes to lifestyle behaviors and increasing the accessibility of antenatal care could lower miscarriage risk, and hence there can be great potential in public health approaches which address such factors to enhance the quality of maternal health.


**Keywords:** Miscarriage; Risk factors; Epidemiology

## Introduction

Abortion is defined as the spontaneous expulsion of a fetus prior to the tenth week of pregnancy, commonly referred to as miscarriage, and affects approximately 10–20% of all pregnancies that are acknowledged clinically. However, the factors that lead to miscarriage are not so well known and much of risk factors are still unknown. In most cases miscarriage is genetic and multifactorial which means it is influenced by genes, environment, physiology, and life style. Certainly, some risks are unpreventable, for example, chromosomal disorders or high age of the expectant mother, but many of the factors known to pose risks for miscarriage are within a woman's control, especially those that are connected with her health condition and lifestyle (Chibayi et al., 2024; Kumar, 2011; Wang et al., 2014). They comprise maternal age at delivery, years of education, tobacco smoking, alcohol drinking, physical activity during pregnancy, and antenatal care utilization (Amponsah *et al*., 2022; Gascoigne et al., 2023). Even though these risk factors are acknowledged to play significant roles, the studies have been conducted separately without consideration of their interaction. Knowledge of the ways that lifestyle factors and maternal factors affect miscarriage is important because prevention strategies that may prevent miscarriage might be found (Gascoigne et al., 2023). It is the intention of this study to study the probability of miscarriage relating to these maternal and lifestyle factors using Structural Equation Modeling (SEM), a statistical approach that captures causality of paths between variables.

## Overview of Multifactorial Pathways of Miscarriage

Spontaneous pregnancy loss can occur at any time during gestation but is most frequent during the initial weeks of pregnancy. Average women will have one or more miscarriages in their life span but women experiencing two or more miscarriages are 1-2%. Number of conditions that may lead to miscarriage and they may include genetic issues, structural abnormalities and hormonal disturbances (Celep *et al*., 2005; Hyde and Schust, 2015). For instance, chromosomal anomalies are the main cause of pregnancy loss contributing to up to 60% of all instances. However, there are many other factors to meet for a miscarriage and genetic factors are only part of the miscarriage process (Pal *et al*., 2018). Some researchers believe that about 50% of threatened miscarriages are likely caused by physical and chemical factors in the uterine environment and the mother herself that can hamper fetal development (Kumar, 2011; Krieg *et al*., 2016). More research has been conducted in the last decades on the influence of maternal replication behaviors like smoking, alcohol consumption and lack of exercise on miscarriage prevalence (Bailey& Sokol, 2011; Kumar, 2011). Lifestyle covariates can have a direct impact on pregnancy outcomes by biological means and an indirect impact in modifying other components of maternal risk profiles including antenatal clinic attendance (Oei, 2020). For instance, smoking during pregnancy has been identified to increase the risk of miscarriage, may be through disrupture of placental function, aggravated by increased oxidative stress and fetal developmental changes. In the same way, alcohol has been shown to cause pregnancy loss, and current research about alcohol use during pregnancy points out that moderate drinking can affect fetal development (Chung *et al*., 2023; McCarthy et al., 2013). Exercise also has a twofold effect on pregnancy outcome (Gascoigne et al., 2023). On one hand, physical activity that can be moderate and repeated for at least 30 minutes on a daily basis is considered helpful for a mother and decreases the risks of gestational diabetes or preeclampsia. As for the external imposed factors, physical activity in its different forms proved to be beneficial nonetheless, however sharp increases in the physical intensity of the activity during pregnancy, particularly vigorous or high impact exercise may lead to miscarriage. It then becomes crucial to understand the key to weigh the advantages and disadvantages of physical activity during pregnancy (ACOG, 2013; Gascoigne et al., 2023).

## Maternal Health: A Key Determinant in Miscarriage

Age, education level, and types of antenatal care (ANC) received by the mother are some of the most important predictors of miscarriage (Amponsah *et al*., 2022). For miscarriage, one the most definite risk factors is an increment in the maternal age which is non modifiable. Women above 35 years are more likely to miscarry than younger women, because of decrease in oocyte quality and higher possibility of chromosomally abnormal zygotes (Flynn *et al*., 2014) Some socio-cultural factors, lending more credence to the fact that most women today prefer to delay childbearing in order to further their careers as well as attain higher education, means that miscarriage risk is even more dangerous as age progresses. The other contributory factor which is however less often mentioned is education level. Literate female is not more likely to smoke or drink which are some of the risk factors to miscarriage than those women with lower levels of education (Sampasa et al., 2020). Additionally, Lack of education leads to poor health literacy, thus poor health circulation, this leads to poor access to health facilities, especially antenatal care thus increases on miscarriages. It should also be noted that better-educated women are, as a rule, more knowledgeable about the potential consequences of erroneous actions during pregnancy and more often turn to healthcare providers (ACOG, 2013). Another important factor that contributes to miscarriage occurrence is antenatal care because close monitoring of any complications may be enhanced meant for the mother and fetus (Amponsah *et al*., 2022). If women attend properly planned antenatal visits they should be advised about smoking cessation, alcohol and safe exercise (Hosker et al., 2019; Gascoigne et al., 2023). The number one risk factor to miscarriage and other complications associated with pregnancy is lack of adequate ANC especially during the initial period of pregnancy.

**Structural Equation Modeling (SEM): A Comprehensive Approach**

Though the risk factors of miscarriage at individual level have been investigated numerous times still the interactions or associations between these factors are not well enough investigated. There are also various other aspects of maternal and lifestyle factors in which results depict that most factors do not perform independently but combine in determining the miscarriage occurrence (Gascoigne et al., 2023). It is with these views that Structural Equation Modeling (SEM) forms the best method to analyse these relations. SEM is a statistical technique which enables the researcher to examine both direct and indirect effects of the variables hence suitable in analysing the chain through which various factors lead to miscarriage (Mueller, R. O., & Hancock, G. R., 2018; Tarka, P., 2018).

In SEM, measured variables or manifest variables (for example smoking or alcohol consumption) can be used as representation of underlying construct of higher order such as lifestyle risks. The other constructs may then be cross tabulated to determine the direct and indirect effects of both the lifestyle and maternal factors on miscarriage (Savalei, V., & Rhemtulla, M., 2013). Collier, J. (2020) also notes that SEM can also consider measurement error to draw better estimates of the effect of different variables. It allows the researcher to screen fit of a theoretical model and the magnitude of the relationships between predictors and outcomes.

Lifestyle risks and maternal health factors are examined in this study utilizing SEM with smoking, alcohol consumption, physical activity, age, education level, number of antenatal visits being on the miscarriage risk direct and mediating roles. It was therefore deemed appropriate to create other latent variables such as lifestyle risks and antenatal care in this model to capture the miscellaneous effects these factors have on miscarriage results. Second, and perhaps more importantly, SEM according to Savalei, V., & Rhemtulla, M. (2013) allows for the examination of the moderated mediation model in which it can be tested whether antenatal care moderates the effect of the proposed lifestyle risks to miscarriage risk, a topic that has not been investigated in prior studies.

## Pathways to Miscarriage: Conceptual Model

In the present research, the conceptual model is used to test the direct and mediating relationships between maternal and lifestyle miscarriage risk factors. Specifically, the model includes the following key relationships:

1. **Direct effects of maternal age and education level**: Socio demographic variables are specifically maternal age and education level are postulated to have direct impact on miscarriage risk (Chung *et al*., 2023). Higher maternal age is thought to raise the risk of miscarriage, and lower education levels are also thought to be linked with the risk due to higher rates of risky behaviours and lower health service utilization (Fishman SH & Min S., 2018).

2. **Direct effects of antenatal care**: It is postulated that improved antenatal clinic attendance decreases the rates of miscarriage because problems that may lead to miscarriage are promptly identified and they are dealt with accordingly (Amponsah et al.,2022). After examining these correlations separately, the effect of direct antenatal care on miscarriage, as well as how antenatal care mediates risk factors and miscarriage are described using the proposed model.

3. **Indirect effects of lifestyle risks**: Cigarette smoking, alcohol intake and physical inactivity are hypothesized to have only an indirect influence on miscarriage via a mediatorial role of the number of antenatal care visits made (Chung *et al*., 2023; Gascoigne *et al*., 2023) For instance, while unhealthy women behaviours may include missing regular antenatal visits, they are likely to result in increased miscarriage rates. Second, patterns in lifestyle risks are modeled to have a direct impact on miscarriage and an indirect impact through antenatal care.

4. **Latent construct for lifestyle risks**: Our data analysis fits an unspecified number of indicators for lifestyle risks under the assumption that it can be regressed on smoking, alcohol, and physical activity. This makes it possible to obtain a better assessment of the extent to which these behaviors are associated with an increased risk of miscarriage.

## Materials and Methods

### Study Design

In this study cross-sectional data was mimicked for exploring the impact of various maternal and lifestyle factors on risk of miscarriage using Structural Equation Modeling (SEM). The simulation was performed to assess the patterns of interaction between manifest and hidden variables and to assess possible links between these factors and miscarriage. In particular, by using simulation data of sample size 2000 we could examine most of the hypothetical interactions in the safest possible way and could test the SEM models, based on how well they performed under different conditions using the approach described in Normande et al. (2024) and Kananura *et al*., (2017) This approach is frequently used in the assessment of theories or validation of model specifications when realistic samples maybe difficult to come by.

### Simulated Data Generation

The data used in the study were artificial and those utilized in calculating the probability of miscarriage were based on research hypothesis and theoretical interaction between maternal features and lifestyle and miscarriage. The data were derived from assuming reasonable underlying distributions of the variables and their relationships as described in Rhemtulla *et al*. (2012).

Key Assumptions for the Simulated Data:

• Maternal Age (MA): As if it were a real continuum, normally distributed with a mean age of 30 years and an age deviation of 5 years.

• Education Level (EL): Operationalised as an ordinal variable; (1) Less than a primary education level, (2) Secondary school, or (3) College or university level. These categories were given probabilities taken from an assumed distribution of education levels within the total population.

• Lifestyle Risks (LS): Two of these constructs are smoking frequency and alcohol intake while physical activity level is its measure, which are themselves latent variables indicated by three manifest variables: smoking, alcohol consumption and physical activity. These factors were modeled as binary variables, where's:

o Smoking (LS_1): This variable is a binary measure with score 1, if a subject smoked regularly, otherwise score 0, if they did not smoke.

o Alcohol Consumption (LS_2): 1 (where they consume it regularly) or 0 (where they do not consume at all).

o Physical Activity (LS_3): 1 if they perform regular physical activity or 0 if they do not perform regular activity at all.

Lifestyle risk is the other construct that has been modeled into a latent variable using factor loading with the usual assumption that factor loading is positively related

. • Antenatal Care Visits (ACV): Imitated as a quantitative variable that ranged from 0 to 15 visits. The distribution of the numbers of visits was taken to be normal with an expected value of 8 visits and standard deviation of 3.

• Miscarriage (M): The outcome variable was imputed as a dummy variable (1 = miscarriage; 0 = live birth) with reference to maternal age, education levels, and risk factors, as well as antenatal clinic visits. The risk of miscarriage was believed to rise with higher Lifestyle Risk Score, older maternal age, and fewer visits to health care providers during pregnancy.

**Simulation Process**

The data were simulated in accordance to Rhemtulla et al. (2012) using the following steps:

(a) Generate Maternal Age (MA): Employed as a rational variable with a normal probability distribution with mean value of 30years and a standard deviation of 5 years.
(b) Generate Education Level (EL): Indicated here as ordinal with probability values of each category of the education level (Agresti, A., 2012). For example:
    - No formal education or primary education: 25%
    - Secondary education: 45%

- Higher education: 30%

(c) Generate Lifestyle Risks (LS): Simulated as a latent variable with three indicators: tobacco use, drinking routines and exercise or movement routines. Both smoking and alcohol consumption were coded as 0 and 1, probability of which were 0.3 and 0.6 respectively for physical activity. The endogenous construct was specified to have the same factor loadings with the three measured variables.

(d) Generate Antenatal Care Visits (ACV): It is assumed as being an ordinal variable with values simulated from a normal distribution with a mean of 8 visits and a standard deviation of 3 visits.

(e) **Generate Miscarriage (M):** Miscarriage risk was simulated as a binary variable, where the probability of miscarriage was modeled using the following logistic regression equation derived as follows:

Let Miscarriage risk be denoted with $y$ such that:

$$y = \begin{cases} 1 & \text{patient experienced miscarriage risk} \\ 0 & \text{did not experienced miscarriage risk} \end{cases}$$

Therefore, the model is given as

$$\log\left(\frac{p(y=1)}{1-p(y=1)}\right) = \beta_0 + \beta_1\text{MA} + \beta_2\text{EL} + \beta_3\text{LS} + \beta_4\text{ACV}.$$

where

(i) $p(y = 1)$ is the probability of miscarriage (dependent variable)

(ii) $\beta_0$ is the intercept which represents the baseline **log-odds** of miscarriage when all predictor variables are set to their reference categories or zero (for continuous variables).

(iii) $\beta_1, \beta_2, \beta_3, \beta_4$ are the independent variable's corresponding coefficients.

Regression coefficients ($\beta$) in (iii) were estimated based on theoretical assumptions as described in Agresti, A. (2012), Bollen, K. A. (2014) and Gelman, A. (2007): In the same equation, whereas positive association with maternal age is shown by $\beta_1 = 0.05$. $\beta_2 = -0.1$ (negative correlation with education level), Generally: $\beta_3 = 0.3$ (indicating a positive relationship with lifestyle risks). $\beta_4 = 0.02$ (indicating a negative relationship with antenatal care visits). Having obtained the outcome of the logistic regression equation, a binary variable for miscarriage was created from the probability score for each simulated participant, assigned either 0 or 1.



**Data Analysis**

The simulated dataset underwent structural equation modeling analysis as described in Malaju (2023; Xia & Yang, 2019) to determine maternal and lifestyle factors' direct and mediated effects on miscarriage risk. SEM enables the estimation of both manifest and unobserved constructs and their association; it is used more frequently in research with intricate structures of variables and processes.

1. **Model Specification**: The hypothesized model was defined in the following way:

- Latent Variable: Lifestyle risks (LS) were estimated as a form of unobserved construct with three manifest variables: smoking, alcohol intake, and exercise.
- Direct Effects: The relationships between MA, EL, LS, and M were defined in terms of the direct effects, where MA, EL, and LS were specified as causing M.
- Indirect Effects: The mediated path analysis involved the idea that LS are associated with miscarriage through a causal mediator; antenatal care visits.

2. **Model Estimation**: SEM model was analysed under ML estimation procedure as described in Li *et al*. (2016) and Rhemtulla *et al*. (2012). All of the parameters of the model, including regression coefficients and their standard errors, factor loadings, variances and covariances, were freely estimated.
3. **Model Fit Assessment**: To assess the model fit the following indices have been used as described in the paper of Xia, Y., & Yang, Y. (2019):

   - **Chi-square test**: This, in return, imply that the Chi-square value is insignificant, mean that the model fit the data appropriately.
   - **Root Mean Square Error of Approximation** (RMSEA): Mathematically, values below 0.05 SSD depict a good fit while those values in the range of 0.05-0.08 are acceptable. o Comparative Fit Index (CFI): Closeness of fit is a vital test and, specifically, a CFI of above 0.90 is considered desirable.
   - **Tucker-Lewis Index** (TLI): Any TLI value more than 0.90 indicates the satisfaction of this requirement of model fit.
4. **Indirect Effects**: To estimate the indirect effects of lifestyle risks on miscarriage through ANC visits, products of coefficients along the indirect paths were obtained.
5. **Sensitivity Analysis:** Thus, to examine the sensitivity of the model, various aspects such as the association between lifestyle risks and miscarriage, were adjusted in order to assess the goodness of the fit under these circumstances.

**Ethical Considerations**

Pseudo-data was used in this study but adherent to all ethical standards towards the use of data and modeling. The simulation was carried out with the purpose to analyze theoretical relations and to check SEM's performance. When it comes to the source, the authors do not involve real data hence no ethical issues such as using data involving matters such as miscarriages.

**Limitations**

Some drawbacks of this simulated research are as follows. These results depend on assumed relationships and potentially misrepresent actual data. Another limitation is that data and hence model assumptions pertain to distribution of the lifestyle behaviors and relation between the variables may not be similar across populations. Furthermore, given that the data are not actual data collected from real people, there is no problem such as socially desirable bias or measurement errors involved. But there is always a possibility of refining the model and these studies using real life data could support these findings.

**Results and Discussion**

**Model Fit and Evaluation**

Based on the simulated data, the SEM model was estimated, and several fit indices were examined. The results showed good model fit based on common fit indices:

• Root Mean Square Error of Approximation (RMSEA): The chi-square test of fitness was equal to 35.359 on 11 degrees of freedom, while the value of RMSEA did not exceed 0.05 marking a good fit for the proposed model. The 90% was 0.021 to 0.046 on RMSEA which is also within the acceptable limit to warrant an okay model. Additionally, the p-value for $H_0$: RMSEA $\leq$ 0.05 was 0.987, providing strong evidence for a good-fitting model.

The SRMR was 0.021 which is well below the 0.08 cut off suggesting very small residual differences between the observed and predicted covariances. This in itself goes on to further solidify the understanding that the model developed to fit the collected data was all the more perfect and near to optimum.

• Comparative Fit Index (CFI): Hence the total value of CFI was 0.984; that is, it can be noted that values closer to 1.0 present a better fit to the data.

• Tucker-Lewis Index (TLI): The TLI value of 0.971 confirms the acceptable model of fit. With these results, it can be concluded that the proposed model fits the simulated data well and provides reassurance of the estimates of the relationships between the variables.

**Parameter Estimates**

The analysis identifies a numeral of maternal and lifestyle characteristics associated with miscarriage risk based on the estimated parameters in the SEM analysis. Below are the key findings as shown in table below:

**SEM Results Summary**

| Dependent Variable | Predictor | Coeff. | Std. Error | p-value | Std. Latent | Std. All | Std. nox |
|---|---|---|---|---|---|---|---|
| LR | LS_1 | 1.000 | 0.000 | 0.000 | 0.652 | 0.657 | 0.657 |
| LR | LS_2 | 1.183 | 0.066 | 0.000 | 0.771 | 0.776 | 0.776 |
| LR | LS_3 | 0.768 | 0.045 | 0.000 | 0.500 | 0.499 | 0.499 |
| ANC | EL | 0.029 | 0.033 | 0.376 | 0.029 | 0.020 | 0.010 |
| ANC | LR | 0.045 | 0.121 | 0.709 | 0.029 | 0.010 | 0.010 |
| M | MA | 0.028 | 0.002 | 0.000 | 0.028 | 0.325 | 0.065 |
| M | ANC | -0.022 | 0.003 | 0.000 | -0.022 | -0.156 | -0.156 |
| M | EL | -0.042 | 0.004 | 0.000 | -0.042 | -0.201 | -0.099 |

**SEM Results Summary**

| Dependent Variable | Predictor | Coeff. | Std. Error | p-value | Std. Latent | Std. All | Std. nox |
|---|---|---|---|---|---|---|---|
| M | LR | 0.200 | 0.016 | 0.000 | 0.131 | 0.306 | 0.306 |

1. Maternal Age (MA):
   An increase in the maternal age was also revealed to have a statistically significant positive relationship with miscarriage risk (Estimate $= 0.028, p < 0.001$). This is in concordance with literature associating advanced age in pregnant women with increased likelihood of miscarriage (Charles, A., & Khong, T. Y., 2022). The authors conclude that: aging has a biological impact on fetal development and placental function and thus has an effect on risk. Furthermore, aging could affect reproductive function so negatively to result in poor ability to maintain a pregnancy.
2. Education Level (EL):
   There was evidence that increased maternal education decreased the risk for miscarriage (Estimate = $-0.042, p < 0.001$). This correlates with the previous work done in determining how socioeconomic status plays a part in maternal health (Raghupathi, V., & Raghupathi, W., 2020). It can be assumed that, in fact, the results reflect higher availability of and proper access to health care, more educated understanding of the problem, and improved lifestyle excluding all the factors which contribute to the miscarriage rate, including smoking cessation and utilization of better antenatal care.
3. Lifestyle Risks (LS): Estimate: 0.200 ($p < 0.001$)
   Interpretation: Smoking, alcohol consumption, and physical activity, established lifestyle risks, were confirmed to be related to miscarriage risk. This implies that risks associated with elevated lifestyle increase the chances of miscarriage as presented by the positive coefficient above. This accords with existing studies associating miscarriages with specific lifestyle factors such as smoking and drinking alcohol (Maas et al., 2021). But it is important to remember, in the real world, lifestyle choices do not exist in isolation and may combine with others such as genetic predisposition or coexisting diseases.
4. Antenatal Care Visits (ANC):
   The antenatal care visit frequency had a negative relationship with miscarriage risk (Coefficient $= -0.022, p < 0.001$). Hence, poor compliance with recommended antenatal care visit is a significant problem when it comes to the management of complicated pregnancies and identification of maternal complications. These visits portray hotel access to, and maternal involvement in pregnancy, a very important factor in the prevention of pregnancy complications.

**Indirect Effects**

The indirect effect of lifestyle risks on miscarriage through the number of antenatal care visits was also modeled. We also found lifestyle risks were independent of the number of antenatal care visits, as indicated by the insignificant value for the path coefficient between the two variables ($\text{Coefficient} = 0.045, p\ 0.709$). Therefore, the above analysis of total and direct mediation of antenatal care visits showed that the impact of lifestyle risks on miscarriage was actually direct rather than to do with the number of antenatal care visits.

**Discussion**

This paper therefore presents antenatal and lifestyle factors contiguity results suggesting the possibility of risks in miscarriage occurrences. SEM analysis showed direct impacts of the lifestyle risks especially smoking and alcohol intake on miscarriage risk with empirical evidence supporting that observation (Wang et al., 2021; Maas et al., 2021). On the other hand, the findings revealed significant associations of maternal age, education level and ANC visits in miscarriage risk.

The nature of the relationships that have been observed might be accounted for by several reasons. Higher maternal age was associated with increased miscarriage risk as has been postulated, pointing to raised risks arising from chromosomal issues and declining oocyte reserve (Charles, A., & Khong, T. Y., 2022; Kanmaz et al.,2019; Rafael et al., 2022). On the protective factors, the educational level suggests improved health literacy and socio-economic status of the participants, affirming the study done by Maher et al. (2023). As with the finding revealing that fewer ANC visits were linked to an increased risk of miscarriage, Mina et al. (2023) pointed out that firm and frequent prenatal care is relevant.

However, some limitations with implications for practice are inherent in the study due to the use of simulation data. Interactions were described with parameters assumed to be uncomplicated even though they could not have been so in actuality. For instance, effect of maternal age on miscarriage might have curvilinear associations and either education, operationalised as a continuous variable, might not reflect diverse socio-economic effects Raghupathi, V., & Raghupathi, W. (2020). However, ANC timing and quality were not considered, even though they are important predictors of pregnancy outcomes (Mandiwa, C., & Namondwe, B., 2024).

The observed direct, positive link between several lifestyle risks and miscarriage has profound public health implications. These primary risk factors include smoking and alcohol intake which are have been shown to be associated with contralateral outcomes (Wang et al., 2021). Programs that would reduce these risks include smoking cessation and alcohol control could enhance the mother fetus prognosis. Standardized population approaches, complementary with brief interventions targeting women during ANC visits, are essential in lowering the identified lifestyle risks.

**Limitation**

The main limitations of this study are as follows: First, because this was an experimental simulation, results might be generalized cautiously in that the observed relationships among variables of interest may not necessarily capture the relationships in actual population(s). Some assumptions made in the simulation may not hold in real data for instance the assumption that maternal age is Normally distributed and the fact that education level is categorized simply as low middle and high. Further, some possible confounding factors are not included in the model, these are diseases that pregnant women could have had in the past any genetic disorder that runs in families, or a woman's social status. In addition, the simulation also had no interaction terms whereby main effects can be conditioned of each other making it difficult for researchers to determine the effect of one on the other between the maternal characteristics and the lifestyle factors on the risk of miscarriage. For example, the relationship between maternal age and miscarázev weighting may be moderated by lifestyle or by the number of antenatal visits. Finally, only a few factors were studied in the present study; thus, it may be possible that there are other factors, not captured within the above model, for example, environmental conditions, stress levels, or, perhaps the use of fertility treatments. The following additional factors can come into research works with real-world data to help enhance the understanding of the risk of miscarriage;

## Conclusion and Recommendation

Therefore, the author of this study stresses the importance of lifestyle risks in miscarriage and their need to develop measures designed for the modification of lifestyle factors for the enhancement of pregnancy results. Future work will have to extend the presented model and will have to use it to validate these results with actual data. Future research should come up and test the findings from this simulation study to see whether the results hold up when actual data is used to compare the interrelation between maternal characteristics and lifestyle and miscarriage risk. This would include wider sampling, and using finer measures of maternal characteristics, lifestyle behaviors, and antenatal care to test the model. Thus, it may be also interesting to analyze the mechanisms of interactions between lifestyle factors and other individual characteristics, for example, health status, and miscarriage risk.

## Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.



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