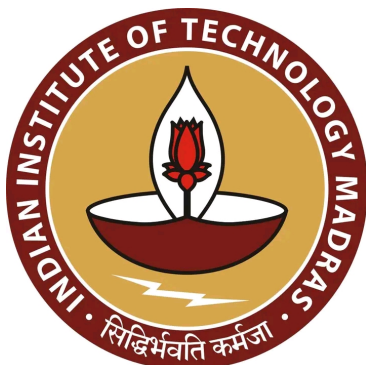# The Revolutionary Government of Zanzibar

Improving Maternal and Neonatal Health in Pemba: Data Driven Analysis of Adverse Pregnancy Outcomes

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Abstract

Pregnancy loss including spontaneous abortion and stillbirth, remains a significant public health concern in Pemba, Zanzibar, with substantial implications for maternal and child health. This report presents a comprehensive data driven analysis of 4,501 pregnancy records from the AMANHI study to identify key determinants of early and late pregnancy loss. The findings reveal that maternal age, education level, parity, gravidity, previous miscarriage or stillbirth, maternal weight and blood pressure are influential factors. Notably, adverse outcomes were more prevalent among women over 30 years, those with low education and those with hypertension or high parity. These insights can guide the Ministry of Health in designing targeted maternal health interventions, strengthening antenatal care services and improving risk screening protocols. By integrating descriptive and statistical analysis, this study supports evidence based strategies to reduce pregnancy loss and enhance maternal health outcomes in Pemba.

Contents

1 Introduction

Pregnancy loss whether through spontaneous abortion (the loss of pregnancy before 20 weeks of gestation) or stillbirth (pregnancy loss after 20 weeks), represents a major maternal and child health challenge, particularly in Pemba, Zanzibar. These outcomes not only affect individual families but also contribute significantly to maternal morbidity, psychological distress and increased healthcare burden.

In Pemba, data indicate that approximately 1.1% of pregnancies end in spontaneous abortion, while 2.38% result in stillbirth. Although these figures appear modest, they reflect persistent gaps in maternal care, health education and timely clinical intervention. Limited access to healthcare services, socioeconomic disparities and undiagnosed risk factors continue to hinder progress toward improved maternal outcomes.

This report presents a comprehensive data-driven analysis of 4,501 pregnancy records collected under the Pemba AMANHI study. By identifying the key maternal, biological and reproductive factors associated with spontaneous abortion and stillbirth, the findings aim to inform evidence based decision making. The ultimate goal is to support the Ministry of Health in designing targeted antenatal interventions, enhancing surveillance systems and strengthening maternal healthcare services across Pemba and the wider Zanzibar region.

2 Methodology

2.1 Data Source and Features Selection

This analysis is based on data from the Pemba AMANHI Study, a large-scale cohort study focused on maternal and reproductive health conducted in Pemba, Zanzibar between 2014 and 2018. The dataset comprises detailed clinical, demographic and obstetric records for 4,501 pregnant women. From an initial pool of 51 variables, relevant features were selected for two primary outcomes of interest (spontaneous abortion and stillbirth).

For the spontaneous abortion analysis, 15 independent variables were selected based on clinical relevance and evidence from existing literature. These included: Maternal age, Maternal education level, Maternal weight, Wealth index, Previous miscarriage, Previous stillbirth, Previous Caesarean section, Systolic and diastolic blood pressure, Antepartum hemorrhage (APH), Parity, Gravidity, Labor hypertension, Type of delivery

For the stillbirth analysis, 26 features were used. In addition to the variables listed above, the stillbirth model incorporated with Serial systolic and diastolic blood pressure measurements: SBP1, DBP1, UDBP1, SBP2, DBP2, UDBP2, SBP3, DBP3, UDBP3, Birth outcome indicators: birth_outcome1,

birth_outcome2, birth_outcome3, Pregnancy type(SINGLE_TWIN).

The dependent variables were: Spontaneous abortion, defined as the loss of pregnancy occurring before 20 weeks of gestation. Stillbirth, defined as fetal death occurring at or after 20 weeks of gestation, including both intrapartum and antepartum losses as recorded under the variable birth outcome.

This careful selection of features ensures a comprehensive assessment of potential risk factors for pregnancy loss and supports the development of targeted maternal health interventions in Pemba, Zanzibar.

2.2 Data Processing

The original dataset comprised 4,501 pregnancy records from the Pemba AMANHI study. The primary outcome variables included gestational age and Birth outcome. Gestational age, originally recorded in days, was converted to weeks by dividing the value by 7. Spontaneous abortion was defined as pregnancy loss occurring before 20 weeks of gestation. Stillbirth was defined as a non-live birth occurring at or after 20 weeks and before 37 weeks of gestation. Preterm birth was defined as a live birth occurring at or before 37 weeks of gestation.

During initial data cleaning, 115 records containing missing or invalid entries, denoted by placeholder codes such as -88 and -77, were identified and removed to ensure analytical accuracy. For the remaining records, missing values in numerical variables were imputed using the mean, while missing values in categorical variables were imputed using the mode both considered standard practices in clinical data management. Following processing, the dataset retained all 4,501 valid records, with the following outcome distribution:

- Spontaneous abortion: 48 cases

- Stillbirth: 66 cases

- Preterm birth: 591 cases

- Live births: 3,796 cases

This cleaned and categorized dataset served as the foundation for the descriptive and statistical analyses presented in this report, aimed at identifying maternal and clinical factors associated with adverse pregnancy outcomes in Pemba.

2.3 Descriptive Analysis

A comprehensive descriptive statistical analysis was conducted to examine maternal characteristics and their potential associations with adverse pregnancy outcomes, particularly spontaneous abortion and stillbirth. The dataset consisted of 4,501 pregnant women from Pemba, Zanzibar and included variables

such as maternal age, educational attainment, gravidity, parity, maternal weight, blood pressure, gestational age at birth and prior obstetric history (including miscarriage, stillbirth and cesarean section).

To enhance interpretation and facilitate decision making, both visual and tabular summaries were employed. Specifically, box plots were generated to assess differences in **parity** based on **gestational age at birth (GAGEBRTH)** and **birth outcome (BIRTH_OUTCOME)**.
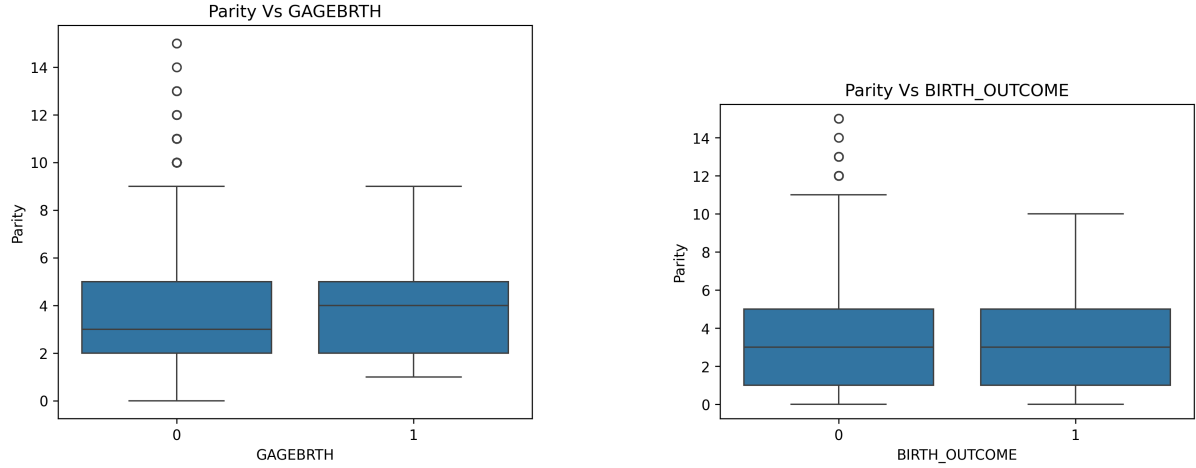

Figure 1: Boxplots showing distribution of Parity by GAGEBRTH (left) and BIRTH_OUTCOME (right)

The left panel in Figure 1 reveals that women who delivered preterm (GAGEBRTH = 0) showed a wider parity distribution and a higher number of outliers, some exceeding parity of 10. Term births (GAGEBRTH = 1) had slightly higher median parity but fewer extreme values.

The right panel compares parity based on birth outcome. Women with adverse outcomes (BIRTH_OUTCOME = 0) showed slightly greater variability and a larger number of high parity cases compared to those with normal outcomes (BIRTH_OUTCOME = 1), suggesting a potential link between high parity and poor birth outcomes.

The table below presents descriptive statistics of key maternal and pregnancy related variables:

Variable	Mean	Std Dev	Min	25%	Median	75%	Max
Maternal Age (PW_AGE)	27.996	6.259	18.0	23.0	27.0	32.0	49.0
Education Level (PW_EDUCATION)	7.377	3.467	0.0	6.0	10.0	10.0	15.0
Maternal Weight (MAT_WEIGHT)	59.799	13.114	35.0	50.6	58.4	65.9	125.0
Systolic BP (SBP1)	114.072	11.092	90.0	107.0	114.0	120.0	205.0
Diastolic BP (DBP1)	71.149	7.597	57.0	65.0	70.0	76.0	119.0
Gestational Age at Birth (GAGEBRTH)	0.011	0.103	0.0	0.0	0.0	0.0	1.0
Previous Miscarriage (PREV_MIS)	0.256	0.651	0.0	0.0	0.0	0.0	7.0
Previous Stillbirth (PREV_SB)	0.080	0.271	0.0	0.0	0.0	0.0	1.0
Previous Cesarean (PREV_CS)	0.026	0.160	0.0	0.0	0.0	0.0	1.0
Gravidity	4.610	2.926	1.0	2.0	4.0	7.0	16.0
Parity	3.614	2.331	0.0	2.0	3.0	5.0	15.0
Birth Outcome (BIRTH_OUTCOME)	1.024	0.152	1.0	1.0	1.0	1.0	2.0

3 Results

This report analyzed data from 4,501 pregnant women in Pemba, Zanzibar, to assess factors associated with pregnancy loss, particularly spontaneous abortion (SA) and stillbirth (SB). Among the participants, 48 women (1.1%) experienced spontaneous abortion and 66 (1.5%) experienced stillbirth and 591 (13.1) experienced preterm birth, while the remaining pregnancies resulted in live births.

To guide healthcare professionals and policymakers, a comprehensive summary of the demographic, biological and reproductive characteristics is presented in Table below. This table provides a side-by-side comparison of participants who experienced spontaneous abortion or stillbirth against those with no such outcomes. It includes frequency counts and percentages for each subgroup.

The table facilitates identification of high-risk profiles based on maternal age, education level, wealth index, weight, blood pressure, gravidity, parity and obstetric history. Notably:

- Advanced maternal age (over 30 years) shows increased proportions in both SA and SB cases.

- Low educational levels (0–5 years) is associated with a higher frequency of pregnancy loss.

- Hypertension (systolic and diastolic) appears more commonly in women who experienced SA or SB compared to those who did not.

- High gravidity and high parity are more frequent among those with adverse outcomes.

- Stillbirth is more likely among women with a history of previous stillbirth or complications such as prolonged labor and antepartum hemorrhage.

- Most deliveries across all groups were vaginal, however cesarean sections were more common among stillbirth cases.

This descriptive overview provides critical insight into the epidemiology of pregnancy loss in Pemba and supports future predictive modeling and resource allocation strategies by the Ministry of Health.

Table 1: Socioeconomic, Biological and Reproductive Characteristics by Spontaneous abortion (SPA), Stillbirth (SB) and Pretermbirth (PTB) Status.

Characteristic	SPA (n=48)	SB (n=66)	PTB (n=591)
Socioeconomic Characteristics			
Maternal Age			
Under 20	2	4	41
21–25	7	14	150
26–30	10	13	168
31–35	18	18	118

Over 35	11	17	114
Maternal Education			
Low level (0–6 years)	25	33	303
Middle level (7–10 years)	20	30	274
Higher level (11+ years)	3	3	14
Wealth Index			
Poorest	11	7	130
Poor	11	13	109
Middle	8	14	117
Rich	9	13	103
Richest	9	19	132
Biological Characteristics			
Maternal Weight			
Normal (50–70 kg)	33	35	351
Overweight (71–90 kg)	5	12	142
Underweight (< 50 kg)	5	13	72
Obese (> 90 kg)	5	6	26
Systolic BP1			
Normal (<120 mmHg)	36	43	417
Elevated (120–129 mmHg)	3	8	108
Hypertension Stage 1 (130–139 mmHg)	5	9	43
Hypertension Stage 2 (140–179 mmHg)	4	5	19
Hypertensive Crisis (≥180 mmHg)	0	1	4
Systolic BP2			
Normal (<120 mmHg)	–	38	429
Elevated (120–129 mmHg)	–	7	93
Hypertension Stage 1 (130–139 mmHg)	–	6	41
Hypertension Stage 2 (140–179 mmHg)	–	15	25
Hypertensive Crisis (≥180 mmHg)	–	0	3
Systolic BP3			
Normal (<120 mmHg)	–	39	421
Elevated (120–129 mmHg)	–	10	86
Hypertension Stage 1 (130–139 mmHg)	–	7	38
Hypertension Stage 2 (140–179 mmHg)	–	9	40
Hypertensive Crisis (≥180 mmHg)	–	1	6

Diastolic BP1			
Normal (<80 mmHg)	37	46	505
Elevated (80–89 mmHg)	6	15	53
Hypertension Stage 1 (90–99 mmHg)	5	4	27
Hypertension Stage 2 (100–119 mmHg)	0	1	6
Hypertensive Crisis (≥120 mmHg)	0	0	0
Diastolic BP2			
Normal (<80 mmHg)	–	42	491
Elevated (80–89 mmHg)	–	9	61
Hypertension Stage 1 (90–99 mmHg)	–	12	26
Hypertension Stage 2 (100–119 mmHg)	–	3	12
Hypertensive Crisis (≥120 mmHg)	–	0	1
Diastolic BP3			
Normal (<80 mmHg)	–	42	474
Elevated (80–89 mmHg)	–	18	63
Hypertension Stage 1 (90–99 mmHg)	–	4	33
Hypertension Stage 2 (100–119 mmHg)	–	1	17
Hypertensive Crisis (≥120 mmHg)	–	1	4
Reproductive History			
Gravidity			
Low (1–2)	14	27	168
Moderate (3–5)	12	23	214
High (6+)	22	16	209
Parity			
0 Deliveries	0	1	6
1 Delivery	3	7	82
2–4 Deliveries	25	37	321
5+ Deliveries	20	21	182
Type of Delivery			
Normal Vaginal	48	60	556
Caesarean Section	0	6	35
Assisted (Forceps/Vacuum)	0	0	0
Previous Miscarriage			
0	39	–	–
1	5	–	–

≥2	4	–	–
Previous Stillbirth			
Stillbirth	–	55	–
Livebirth	–	11	–
Previous Preterm Birth			
Preterm Birth	–	–	565
Live Birth	–	–	26

3.1 Socioeconomic Characteristics

Socioeconomic characteristics such as maternal age, education level and household wealth are essential in understanding disparities in pregnancy outcomes, including spontaneous abortion and stillbirth. These factors often reflect underlying social and health system inequities that contribute to maternal vulnerability.

Maternal Age: Age is a well established risk factor for adverse pregnancy outcomes. Among women who experienced spontaneous abortion, the highest proportion (37.5%) were aged 31–35 years, followed by 22.9% in women over 35 years. Younger women under 20 years accounted for only 4.2% of spontaneous abortion cases. Similarly, stillbirths were more prevalent among women aged over 35 (25.5%) and 31–35 (24.5%). This trend aligns with global evidence that advanced maternal age increases the risk of both early and late pregnancy loss due to declining oocyte quality, hypertension and other age-related complications. The distributions are illustrated in Figure below.
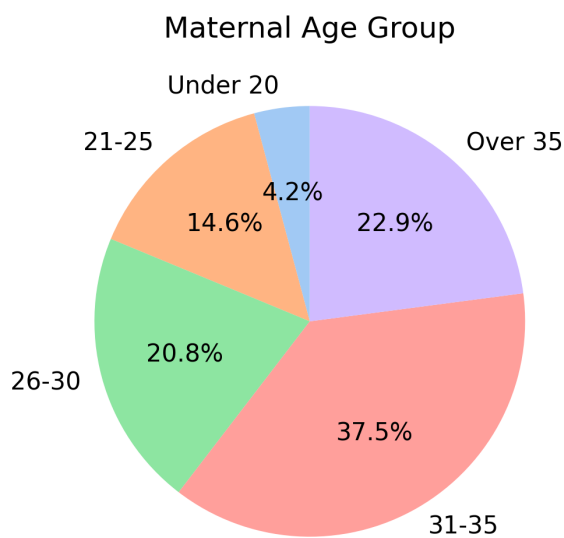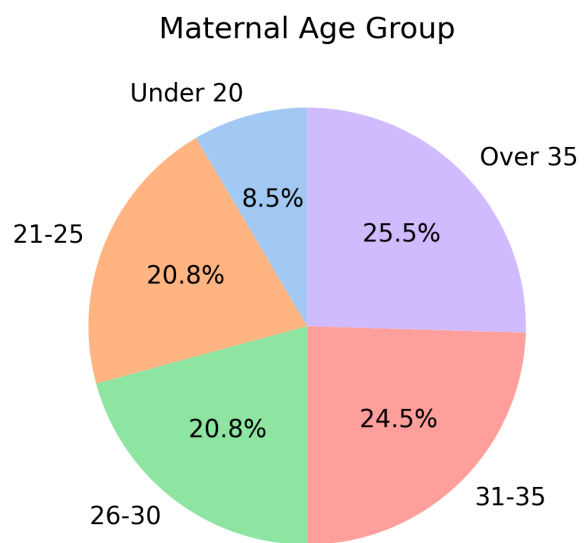

Figure 2: Spontaneous Abortion

Figure 3: Stillbirth

Maternal Education: Educational attainment showed a strong association with both spontaneous abortion and stillbirth. Over half (52.08%) of spontaneous abortion cases were among women with low education levels (0–5 years), followed by 41.7% with middle-level education (6–10 years) and only 6.25% among those with higher education (11+ years). A similar pattern was observed for stillbirths: 49.1% of affected women had low education, 47.2% had middle education and just 3.8% had higher education. These findings suggest that limited access to health information, lower health literacy and reduced utilization of antenatal services may contribute to poor pregnancy outcomes among less educated women. These associations are visualized in Figure below.
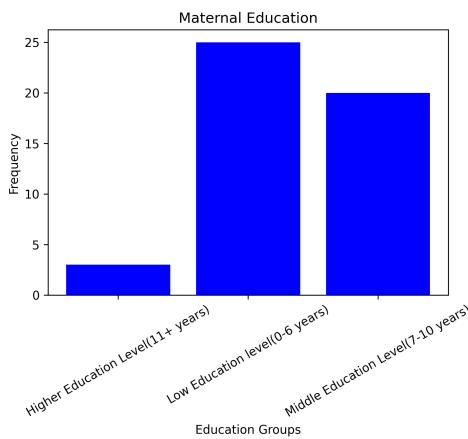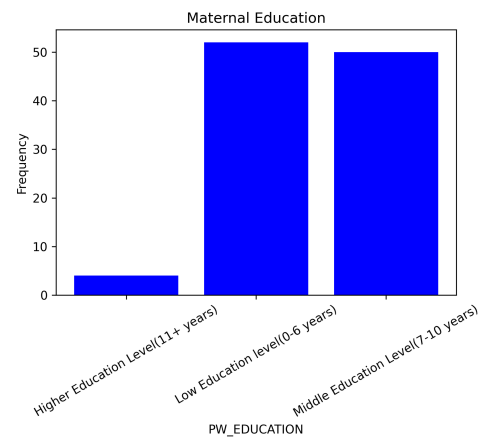

Figure 4: Spontaneous Abortion

Figure 5: Stillbirth

Wealth Index: The distribution of pregnancy loss across wealth categories was relatively balanced, though slightly skewed toward poorer households. Among women who experienced spontaneous abortion, 22.9% were from the poorest quintile and 22.9% from the poor group. The richest group accounted for 18.75% of cases. In stillbirth cases, the trend was more noticeable—27.4% of affected women were in the richest quintile, possibly reflecting older maternal age or other comorbidities associated with better-off households. Notably, no cases of spontaneous abortion or stillbirth were recorded among women who reported "Don't Know" for wealth status. These findings highlight the complex and sometimes non-linear relationship between socioeconomic status and pregnancy outcomes, as shown in Figure
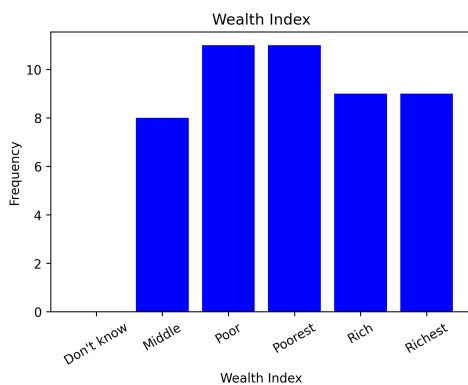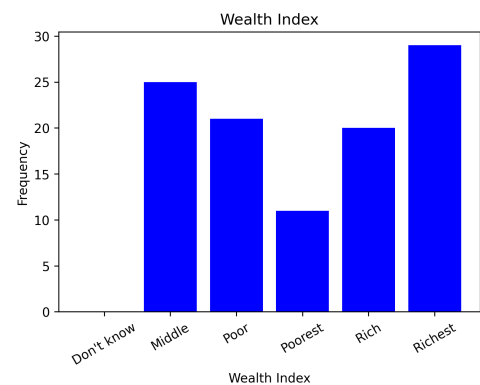

Figure 6: Spontaneous Abortion

Figure 7: Stillbirth

The interpretation of these socioeconomic characteristics provides a valuable foundation for targeted interventions. Priority should be given to women over 30 years of age and those with limited education or living in lower income households, as they represent higher risk groups for pregnancy loss. Community based health education, early risk screening and improved access to antenatal care can help mitigate these disparities.

3.2 Biological Characteristics

Biological characteristics play a critical role in determining the risk of adverse pregnancy outcomes. This section examines the impact of maternal weight, systolic blood pressure (SBP) and diastolic blood pressure (DBP) on both spontaneous abortion (SA) and stillbirth (SB), drawing from multiple timepoint readings (SBP1–3 and DBP1–3).

Maternal Weight: Among women who experienced spontaneous abortion, the majority (68.75%) had normal weight (50–70 kg), suggesting that weight alone may not be a sufficient risk indicator without considering comorbidities. However, underweight (10.42%), overweight (10.41%) and obese (10.41%) women also reported SA, indicating non-negligible risks across the weight spectrum.

Stillbirth cases were more prevalent among overweight (22.6%) and obese (6.6%) mothers compared to their proportion in the overall population, emphasizing the importance of monitoring maternal BMI during antenatal care.

Systolic and Diastolic Blood Pressure (BP): Blood pressure was evaluated at multiple points during pregnancy in both SBP and DBP showed associations with adverse outcomes:

Spontaneous Abortion: Approximately 75% of SA cases had normal SBP1 (<120 mmHg), while 10.41% were classified with Stage 1 hypertension and 8.33% with Stage 2 hypertension. For DBP1, 77.08% were in the normal range (<80 mmHg), while 12.5% had elevated DBP and 10.41% had Stage 1 hypertension.

Stillbirth: At later blood pressure readings (SBP2–3 and DBP2–3), elevated and hypertensive states were more pronounced among stillbirth cases. The trend highlights a possible progressive risk from gestational hypertension that may contribute to fetal loss if left unmanaged.

Key Findings:

- In both SBP2 and SBP3, the proportion of stillbirths was highest among women with Stage 2 hypertension.

- DBP2 and DBP3 confirmed a similar trend stillbirths occurred more frequently in women with elevated diastolic values or Stage 1 hypertension.

- Hypertensive crisis was rare but still observed in isolated stillbirth cases, underscoring the need for emergency care preparedness.

The table below presents a consolidated view of SBP2–3 and DBP2–3 distributions for live birth versus stillbirth outcomes.

SBP2 Category	Live Birth	Stillbirth	Total
Normal (<120 mmHg)	3291	64	3355
Elevated (120–129 mmHg)	783	17	800
Hypertension Stage 1 (130–139 mmHg)	220	8	228
Hypertension Stage 2 (140–179 mmHg)	94	17	111
Hypertensive Crisis ($\geq$180 mmHg)	7	0	7
SBP3 Category			
Normal (<120 mmHg)	3005	62	3067
Elevated (120–129 mmHg)	896	17	913
Hypertension Stage 1 (130–139 mmHg)	297	12	309
Hypertension Stage 2 (140–179 mmHg)	178	14	192
Hypertensive Crisis ($\geq$180 mmHg)	19	1	20
DBP2 Category			
Normal (<80 mmHg)	3884	72	3956
Elevated (80–89 mmHg)	390	18	408
Hypertension Stage 1 (90–99 mmHg)	91	13	104
Hypertension Stage 2 (100–119 mmHg)	27	3	30
Hypertensive Crisis ($\geq$120 mmHg)	3	0	3
DBP3 Category			
Normal (<80 mmHg)	3613	69	3682
Elevated (80–89 mmHg)	565	28	593
Hypertension Stage 1 (90–99 mmHg)	151	6	157
Hypertension Stage 2 (100–119 mmHg)	52	2	54
Hypertensive Crisis ($\geq$120 mmHg)	14	1	15

Table 2: Distribution of Blood Pressure (SBP2–3 and DBP2–3) by Birth Outcome

Implication: These findings underscore the need for routine blood pressure monitoring across pregnancy stages. Women with even mildly elevated readings may benefit from close follow up and timely clinical interventions. This approach can significantly reduce the risk of spontaneous abortion and stillbirth, contributing to better maternal and fetal outcomes in Zanzibar.

3.3 Reproductive Characteristics

This section examines key reproductive characteristics like gravidity, parity, previous pregnancy loss and mode of delivery in relation to both spontaneous abortion and stillbirth. These variables provide important clinical insights into maternal reproductive history and its association with adverse pregnancy outcomes.

Type of Delivery: Among women who experienced a spontaneous abortion, 100% had delivered through normal vaginal delivery. No cases of spontaneous abortion were recorded among women who underwent Caesarean section or assisted delivery (e.g., forceps or vacuum extraction). In contrast, among

stillbirth cases, 85.9% were delivered vaginally, while 12.3% occurred via Caesarean section and 1.9% through assisted delivery. This difference suggests that surgical intervention is more commonly associated with stillbirths, potentially reflecting emergency obstetric care in response to complications.

Gravidity and Parity: For spontaneous abortion, the highest proportion of cases (45.83%) occurred in women with high gravidity (6 or more pregnancies). Low gravidity (1–2 pregnancies) accounted for 29.2% and moderate gravidity (3–5 pregnancies) comprised 25% of cases. Similarly, parity (the number of previous deliveries) showed that women with 5 or more deliveries made up 41.7% of spontaneous abortion cases, followed by those with 2–4 deliveries (27.1%) and those with no prior deliveries (25%).

Among stillbirth cases, 63.2% were found in women with high gravidity ($> or = 6$), indicating a cumulative risk associated with multiple pregnancies. Regarding parity, stillbirth was most common among women with 2–4 deliveries (27.4%) and those with 5 or more (30.2%), while 32.1% of cases occurred among women with only one prior delivery.

Previous Pregnancy Loss: A history of prior pregnancy loss was also assessed. Among women who experienced spontaneous abortion:

- 81.25% had no previous history of miscarriage,

- 10.4% had one prior miscarriage,

- and 8.3% had experienced two (2) or more miscarriages.

With respect to stillbirth, 8.0% of all participants had a recorded history of previous stillbirth. This recurrence underscores the importance of closely monitoring women with a history of pregnancy loss, as prior complications may increase the likelihood of subsequent adverse outcomes. Figure below presents the distribution of previous miscarriage and stillbirth cases among participants.
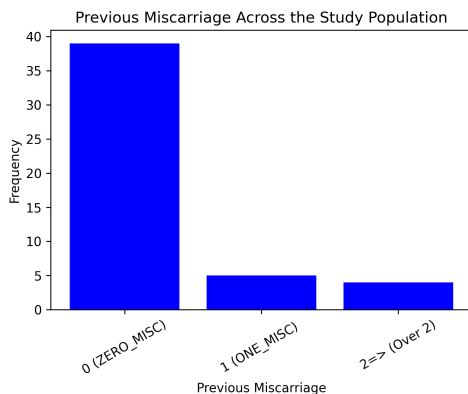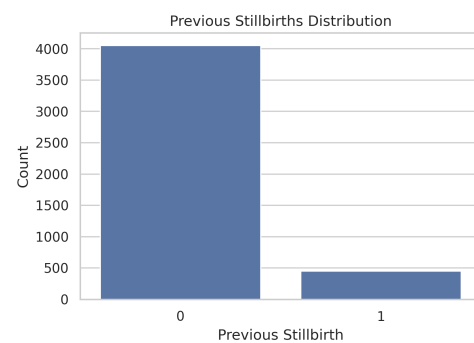

Figure 8: Spontaneous Abortion

Figure 9: Stillbirth

These findings support the need for tailored antenatal care, especially for women with high gravidity or parity, as well as those with prior pregnancy complications. Enhanced screening, regular follow-up,

and targeted clinical interventions may reduce the risk of both spontaneous abortion and stillbirth in this population.

3.4 Statistical Analysis

To better understand the interrelationships between maternal characteristics and the likelihood of pregnancy loss, correlation matrices were computed for both spontaneous abortion and stillbirth datasets. These matrices quantify the strength and direction of linear associations between clinical and demographic variables. Figures 10 and 11 present the correlation heatmaps for spontaneous abortion and stillbirth, respectively.

1. Gravidity and Parity: Across both analyses, a very strong positive correlation was observed between gravidity and parity ($r = 0.92$), indicating that women with more pregnancies are highly likely to have had more deliveries. This association was consistent and robust in both spontaneous abortion and stillbirth data.

2. Maternal Age: Maternal age showed moderate positive correlations with gravidity ($r = 0.59$) and parity ($r = 0.55$) in the spontaneous abortion analysis and similar values ($r = 0.59$ and $r = 0.56$, respectively) in the stillbirth data. This finding reinforces the expected trend that older women tend to have higher reproductive histories.

3. Blood Pressure Patterns: Systolic and diastolic blood pressures (SBP1 and DBP1) were moderately correlated ($r = 0.52$) in both datasets, indicating internal consistency and suggesting potential hemodynamic risk factors. Additional blood pressure readings (SBP2/DBP2 and SBP3/DBP3) in the stillbirth data revealed weaker but consistent inter stage correlations, with SBP2 and DBP2 showing a moderate correlation of $r = 0.61$ and SBP3 and DBP3 sharing a strong correlation of $r = 0.71$.

4. Other Relationships: - Maternal weight showed weak correlations with most other variables (ranging from $r = 0.14$ to $r = 0.26$). - Education level had negligible or slightly negative correlations with maternal age, gravidity and parity (e.g., $r = -0.22$ with gravidity). - Previous miscarriage history had only weak associations with age ($r = 0.20$), gravidity ($r = 0.36$), and parity ($r = 0.10$), indicating limited predictive value in isolation. The figures below present the visual correlation matrices that supported these findings:
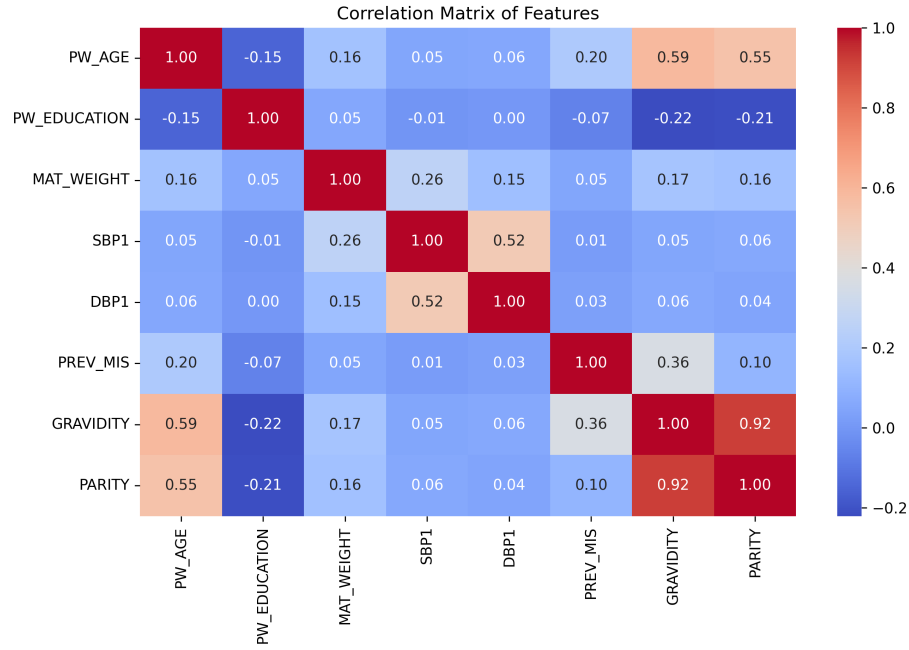
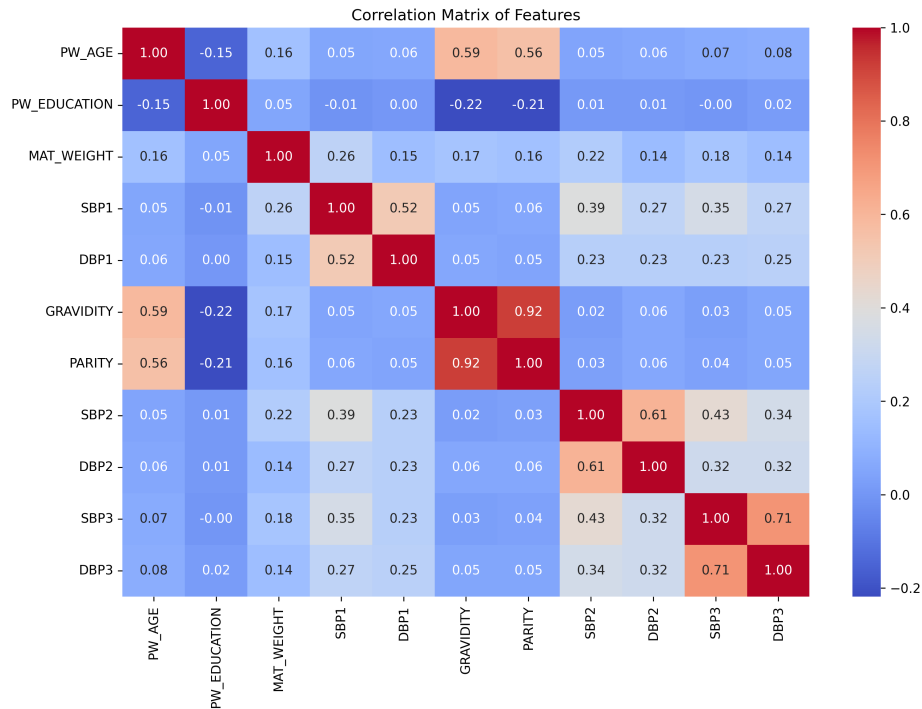Figure 10: Correlation Matrix of Features – Spontaneous Abortion Dataset

Figure 11: Correlation Matrix of Features – Stillbirth Dataset

These analyses highlight that while gravidity, parity and maternal age are interrelated and contribute to increased risk of pregnancy loss, no single variable alone shows strong correlation with spontaneous abortion or stillbirth. This suggests that adverse outcomes are likely multifactorial in nature, requiring a combination of biological, reproductive and socioeconomic indicators for effective risk prediction and intervention.

4 Discussion

This study investigated the factors associated with pregnancy loss including spontaneous abortion (1.1%) and stillbirth (2.4%) among 4,501 women in Pemba, Zanzibar. The findings underscore the multifactorial nature of pregnancy loss with biological, reproductive and socioeconomic characteristics contributing to adverse outcomes.

A key observation is the elevated risk of pregnancy loss among women of advanced maternal age, particularly those aged 31–35 and above 35 years. This aligns with global literature, including studies from China and sub Saharan Africa, which consistently report increased rates of spontaneous abortion and stillbirth in older women due to declining oocyte quality, increased chromosomal abnormalities, and age-related medical conditions.

Low maternal education was another significant predictor, with most adverse outcomes occurring among women with 0–5 years of schooling. This supports findings from the World Health Organization and various maternal health studies indicating that low education limits health literacy and reduces utilization of antenatal care services, ultimately increasing pregnancy related risks.

Hypertension both systolic and diastolic was more prevalent among women who experienced spontaneous abortion or stillbirth, especially those classified under Stage 1 or Stage 2 hypertension. These findings reinforce existing clinical literature that recognizes maternal hypertension as a leading cause of fetal growth restriction, placental insufficiency and early pregnancy loss.

While most cases of spontaneous abortion occurred in women with normal weight, underweight and obese women also showed elevated risk, suggesting a U-shaped risk pattern consistent with global maternal health research.

High gravidity and parity were positively correlated with adverse outcomes. Women with six or more pregnancies or five or more previous deliveries experienced higher rates of both spontaneous abortion and stillbirth. These associations reflect the cumulative reproductive burden on maternal physiology, especially when compounded by limited access to healthcare and family planning services.

Although wealth status did not show a strong correlation with spontaneous abortion, a slight trend was observed for increased stillbirths among women in the lowest wealth quintiles. This suggests socioeconomic inequality may still indirectly influence maternal health outcomes through reduced access to quality care, nutrition or emergency obstetric services.

Overall, the results are consistent with prior literature indicating that spontaneous abortion and stillbirth are complex outcomes shaped by age, education, blood pressure, weight, reproductive history and systemic barriers to care.

5 Recommendations

Based on the findings of this study, the following recommendations are proposed to the Ministry of Health Zanzibar and associated stakeholders to reduce the incidence of pregnancy loss and improve maternal health outcomes:

- **Enhance Antenatal Care Services:** Prioritize early and routine antenatal visits, especially for women over the age of 30, those with high blood pressure or a history of multiple pregnancies.

- **Strengthen Health Education and Community Outreach:** Develop targeted health promotion campaigns focused on reproductive health, blood pressure monitoring and nutrition. These should be delivered through both health facilities and community health workers.

- **Improve Access to Emergency Obstetric Care:** Expand availability of skilled birth attendants and emergency obstetric services, especially in remote areas, to manage complications that may lead to stillbirth or miscarriage.

- **Integrate Routine Hypertension Screening:** Ensure that blood pressure is checked and managed during every antenatal care visit and provide appropriate treatment or referral for hypertensive patients.

- **Support Reproductive Life Planning:** Encourage family planning programs and counseling services to help women and families make informed decisions regarding birth spacing and pregnancy timing.

- **Implement Data Driven Monitoring:** Use maternal health data to identify high risk women early and target interventions appropriately. Digital tools and predictive modeling can support decision making.

- **Expand Coverage of Maternal Education:** Promote schooling and adult literacy programs for women as a long term strategy to improve maternal and child health outcomes.

6 Conclusion

This study highlights the key predictors of pregnancy loss specifically spontaneous abortion and stillbirth among women in Pemba, Zanzibar. Risk factors include advanced maternal age, low education level, high blood pressure, extremes of maternal weight, high gravidity and parity and previous adverse pregnancy outcomes.

These findings underscore the urgent need for targeted maternal health interventions that address both medical and social determinants of health. Strengthening antenatal care services, promoting ed-

ucation and awareness and ensuring timely access to emergency care are critical steps toward reducing maternal and perinatal mortality.

Future research should explore environmental, nutritional, and genetic influences on pregnancy loss and assess the impact of intervention programs. Expanding the dataset to include Unguja and other parts of Zanzibar and incorporating predictive analytics, will further support evidence based planning and improved maternal health policy development across the region.

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A Appendix

To promote transparency, reproducibility, and further exploration by public health professionals, the complete data analysis workflows used in this report are accessible via interactive Google Colaboratory notebooks. These notebooks include all data cleaning procedures, descriptive statistics, correlation analysis and visualizations supporting the findings presented in this report.

1. **Spontaneous Abortion Analysis Notebook:** Retrieved from: `https://colab.research.google.com/drive/1EQzfwlz7OEU6JL5dlXn6DMkEpY11ItzT?usp=sharing`

2. **Stillbirth Analysis Notebook:** Retrieved from: `https://colab.research.google.com/drive/1yyKUhVRRG_2LuxaTnxoGN6SkwQchwbAh?usp=sharing`

These resources are intended for use by Ministry of Health analysts, clinical researchers and academic partners interested in validating the results or building upon the methods used. Users can run, modify, or extend the code directly in the browser using a Google account.