EVALUATING THE EFFECTIVENESS OF THE MOZAMBIQUE-CANADA MATERNAL HEALTH PROJECT NEAR-MISS ABSTRACTION TOOL (MCMH NEAR-MISS TOOL) IN THE IDENTIFICATION OF MATERNAL NEAR-MISS (MNM) EVENTS

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By

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ABSTRACT

Background: Maternal morbidity and mortality has long been of great developmental concern globally. In 2005, the WHO defined Maternal Near-Miss (MNM) as a woman who nearly dies from obstetrical complications during pregnancy or up to 42 days after birth but survives the event. It also developed an abstraction tool that identifies these events. The tool is divided into 3 criteria (Disease, Intervention, and Organ-dysfunction criteria). Earlier studies suggested that the Organ-dysfunction criterion was the best yardstick for identifying MNMs. However, growing research shows that this criterion is not as effective within LMICs due to the lack of necessary laboratory capacity and skilled personnel to diagnose organ system failures. Instead, countries are increasingly relying on the disease-based criterion and have adapted the original WHO tool to suit their local needs. The Mozambique-Canada Maternal Health Project near-miss abstraction tool (MCMH near-miss tool) was tailored for the local resource availability in Mozambique as part of a wider initiative aimed at reducing maternal and neonatal morbidity. The tool contains all three (3) criteria of the WHO tool in addition to two (2) additional clinical criteria, namely, "Expanded Disease" and "Co-morbidities". It also contains important socio-demographic indicators concerning MNM patients. It is important to examine if the added clinical criteria improve the ability of the original disease criterion to identify MNMs.

Purpose: The purpose of this study was to determine how the additional clinical criteria, namely, the "Expanded Disease" and "Co-morbidities" criteria of the MCMH abstraction tool improve the capacity of the Original WHO Disease criterion in the identification of MNM cases in the Inhambane province of Mozambique. It also aimed to examine how specific health system, geographic, and socio-demographic factors influence the identification of MNMs in Inhambane, Mozambique.

Methods: The study utilized data obtained from the MNM 1.0 study, which was conducted across two (2) hospitals in the Inhambane province in Mozambique between August 2021 and February 2022 by researchers in the Mozambique-Canada Maternal Health Project. Approximately 2057 respondent samples were analyzed for this study. To estimate the association between the additional clinical criteria and the original disease criterion, both chi-square test of independence and kappa estimates were performed. Furthermore, multivariable logistic regression was performed to determine the

association between various socio-demographic factors and the identification of MNMs based on all 3 clinical criteria.

Results: Generally, the additional clinical criteria identified more MNMs than the original WHO Disease group. There were stronger associations between the Expanded Disease criterion markers and the WHO disease category. Out of this, hypertension was the most strongly associated and was the only marker with a moderate level of agreement with the original disease group. Contrastingly, the Co-morbidities group showed weak or no associations with the original disease group. Of note, HIV/AIDs had no significant overlap with the original WHO Disease criterion although it contributed the most to the Co-morbidities category. Concerning the socio-demographic indicators, distance from the health facility was consistently associated with MNMs regardless of the clinical criterion. Other factors like education, age, and type of hospital showed varying levels of association with MNMs depending on the clinical criterion. No associations were observed between MNMs and profession or religion.

Conclusion: In conclusion, the Expanded Disease criterion can be a useful category in expanding the ability of the original WHO Disease criterion to identify MNMs. Additionally, the study provides evidence that factors such as distance from the hospital, type of hospital, and age, could be strong predictors for recognizing MNMs especially in rural areas. Overall, this study provides information to help assess the effectiveness of MCMH near-miss tool within the Inhambane province of Mozambique. Further research is however needed to understand its usefulness across different provinces throughout Mozambique.

Key Words: Maternal health, Maternal Near-Miss, Maternal mortality, Mozambique, Severe birth complication, Socio-demographic factors

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DEDICATION

First and foremost, I dedicate this body of work to God Almighty who gave me the needed strength to purse this endeavor. I also dedicate my work to my late father, Mark Muosieyiri, who was instrumental in building my passion for science and research. Furthermore, I dedicate this thesis to my amazing mother, Marian Asaman, and my wonderful siblings, Monique Muosieyiri and Michael Muosieyiri, who continuously provide me with innumerable prayers, encouragement, and support. I love you all.

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LIST OF ABBREVIATIONS

MCMH	Mozambique-Canada Maternal Health Project
CI	Confidence Interval
HPI	Inhambane Provincial Hospital
HRV	Vilankulo Rural Hospital
ICD	International Classification of Disease
IPV	Intimate Partner Violence
LMIC	Low-and-middle-income countries
MDG	Millenium Development Goal
MH	Maternal Health
MMM	Maternal Morbidity Measurement
MNM	Maternal Near-Miss
MWH	Maternity Waiting Home
OBF	Obstetric Fistula
SDG	Sustainable Development Goal
SES	Socio-economic Status
SMI	Safe Motherhood Initiative
SSA	Sub-Saharan Africa
UN	United Nations
WHO	World Health Organization

CHAPTER 1
INTRODUCTION

1.1 Background

Maternal mortality is defined as the death of a woman during pregnancy or within 42 days postpartum due to causes directly or indirectly associated with the pregnancy.(1) Maternal mortality has been a global health and development concern at least since the Nairobi Safe Motherhood Conference, in 1987, where the Safe Motherhood Initiative (SMI) declaration was made with the aim of reducing the prevalence of maternal mortality globally at a time when about 500,000 maternal deaths occurred annually in this period.(1,2) Throughout the 1990s, several expansions to the SMI were made to improve maternal health and reduce maternal mortality especially within developing countries in Africa, Asia, and Latin America, where numerous clinical and structural factors continue to cause significantly higher rates of maternal mortality.(2) To further promote this goal, the United Nations (UN) included maternal health promotion as goal 5 of the Millennium Development Goals (MDGs) in 2000. The aim was to reduce global maternal mortality by 75% between 1990 and 2015. By 2015, the prevalence of maternal mortality ratio had reduced by 44% globally – from 385 to 216 deaths per 100,000 live births.(3) While commendable, this was still less than the annual 5.5% goal needed to achieve the overall 75% MDG goal. As a result, the UN again included maternal health promotion as goal 3 of the 2016 Sustainable Development Goals (SDGs) with the aim of reducing maternal mortality to less than 70 per 100,000 live births by 2030.(4)

Although maternal mortality is still high, about 151 deaths per 100,000 live births globally,(5) its occurrence is rarer than maternal near-miss (MNM) events.(6) This event refers to a woman who nearly died but survived a complication that occurred during pregnancy, childbirth, or within

42 days of termination of pregnancy.(7) This phenomenon has therefore been adopted as a more positive alternative strategy, and indicator, for evaluating and assessing pregnancy complications. Thus, MNMs have been perceived as opportunities to improve the quality of maternal care.(8) After the World Health Organization (WHO) coined this term in 2004, there was a paradigm shift in maternal health research as well with more emphasis placed on using MNM as a yardstick for measuring quality obstetric care.(7) This compelled the WHO to release a global MNM abstraction tool, in 2009, to help clinicians and researchers to effectively identify MNM events.(7)

The original WHO MNM abstraction tool contains severity markers divided into 3 main criteria, namely: Disease-based, Intervention-based –, and Organ-dysfunction criteria. The Disease-based criterion contains 5 "potentially life-threatening" indicators that mark the first stage in the pathological continuum that leads to maternal mortality.(9) Additionally, the Intervention category contains 4 hospital-based parameters that help predict and or mitigate the risk of MNM and maternal death. Finally, the Organ dysfunction criterion consists of 7 "life-threatening" system failure markers that predict the last stage of this pathological continuum that directly causes maternal death.(9,10) Due to infrastructural constraints of using this tool in Low-and-middle-income countries (LMICs), several countries have adapted this tool to suit their local needs and resource availability. An example of this adaptation is the Mozambique- Canada Maternal Health abstraction tool (MCMH tool).[1] This tool has recently been adapted from the Nigerian MNM abstraction tool,[2] which itself was adapted from the original WHO tool, by adding two new clinical categories namely, the Expanded Disease and Co-morbidities criteria. The tool was used in collecting preliminary data in 2 hospitals, the Vilankulo Rural Hospital (HRV) and the Inhambane

[1] The Canada-Mozambique project is also known as the Mozambique-Canada project. The specific title is: "Engaging Communities and Health Workers for Sexual, Reproductive, Maternal and Newborn Health"
[2] The Nigerian tool was used to conduct research and results published by Oladapo et al in 2015

Provincial Hospital (HPI), in the Inhambane province of Mozambique under the MNM sub-project of the Mozambique-Canada Maternal Health. Analysis is yet to be performed to investigate its effectiveness in identifying MNMs in hospital-based clinical population within Mozambique more broadly. Therefore, this thesis set out to investigate the utility of this MCMH tool as applied in two hospitals in the province of Inhambane, Mozambique.

1.2 Statement of Problem

The MNM abstraction tool was created to identify MNM cases within clinical and research settings. For a long time, the Organ dysfunction criterion of this abstraction tool was deemed the most effective for identifying the condition.(11,12,13) However, growing concerns about its efficacy in resource-limited countries have prompted some researchers and practitioners to rely more on the Disease-based criterion for MNM identification.(12,13) Some African countries have further tailored this clinical criterion to suit their local resource availability. For instance, the MCMH abstraction tool was recently adapted from the Nigerian version to make it more applicable to the local Mozambican context. Although it has been used to collect preliminary data, no research has been conducted to investigate how the tool enhances MNM identification. This study therefore attempts to address this gap by comparing the additional clinical criteria to the original WHO Disease criterion. The study also tries to identify specific socio-demographic factors that influence the identification of MNMs in the context of Inhambane province, Mozambique.

1.3 Study Aims

The present quantitative study examines the effectiveness of the MCMH tool in identifying MNM. It also examines specific socio-demographic characteristics that influence the identification of MNMs. The specific objectives are as follows:

1. **Objective One**: To determine how the additional clinical criteria, namely, the Expanded Disease and Co-morbidities criteria of the MCMH abstraction tool improve the capacity of the Original WHO Disease criterion in the identification of MNM cases in the Inhambane province of Mozambique
2. **Objective Two**: To examine how specific health system, geographic, and socio-demographic factors like the type of hospital, distance to health facility, age, education, profession, marital status, and religion, influence the identification of MNMs in Inhambane, Mozambique

1.4 Research Hypothesis

1. **Objective One**: The additional clinical criteria, Expanded Disease and Co-morbidities, enhances the capacity of the original WHO Disease criterion in detecting more MNMs
2. **Objective Two**: At least one of the socio-demographic factors is significantly associated with the identification of MNMs

1.5 Significance of Study

The MCMH abstraction model is the first locally tailored abstraction tool for identifying MNMs in the Mozambican setting. Results from this study will therefore provide relevant information concerning its efficacy that will guide its future utility in MNM research. Particularly, the study results will provide relevant evidence concerning both clinical and socio-demographic indicators that will help detect MNM cases. Furthermore, the MCMH abstraction tool is currently used solely for audit purposes.(14) However, the ultimate goal is to employ it as a standard-of-care matrix in clinical settings to effectively identify and prevent potential MNMs before they occur. Therefore, unveiling a comprehensive profile of an MNM will provide clinicians with essential information

that can be applied to necessary information needed to use this tool safely within standard-of-care settings.

1.6 Organization of Thesis

This thesis is divided into five main chapters. Chapter one introduces the topic of interest, the study rationale, research questions, and the significance of the study. The next chapter explores the current literature and provides the necessary context for understanding the research questions. Additionally, chapter three describes the methodology used for this project. It highlights the study design, research framework, and analysis plan. Finally, chapter four presents the detailed results obtained from data analyses while chapter five discusses the study's main findings as well as its strengths and limitations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The MNM tool is an essential instrument for assessing obstetric care by providing a window into the cascade of events that lead to maternal mortality. (12,15,16,17) Thus, evaluations from this tool help to examine the biological, social, economic, and structural risk factors of maternal morbidities and mortalities.(7,12,17) Findings from this tool often lead to contextually appropriate interventions for the improvement of maternal healthcare.

The WHO standardized a tool for identifying MNMs to help in the comparison, evaluation, and implementation of programs, geared towards the reduction of maternal morbidities, across countries.(13,17) Subsequently, numerous studies, conducted in both High-income and LMICs, have successfully utilized the tool.(7,12,18) For example, it was used to quantify the regional and national morbidity rates in countries like the Netherlands, Tanzania, Ethiopia, Nigeria, Ghana, and Brazil.(7,9, 13,18,19)

Since 2017, there has been a strong push for Sub-Saharan Africa (SSA) countries to adapt the WHO tool to suit local resource availability and that led to the creation of the SSA abstraction tool through a Delphi process.(12) In their seminal systematic review article, Firoz et al noted that there are currently 20 studies across 14 LMICs that have modified the original tool to match their country-specific clinical needs.(18) Although huge variations exist between these adaptations, the common theme is their reliance on the Disease criterion to define MNMs, contrary to the WHO's recommendations of using the Organ-dysfunction criterion.(7) It is important to investigate how well these adaptations capture MNMs based on the clinical markers.

Equally important, these new adaptations include socio-demographic indicators. It is well-established in the literature that socio-demographic factors impact a woman's healthcare-seeking behavior and ultimately, their health outcomes.(20,21,22,23) A pregnant woman's low socio-economic status, low literacy levels, and rural living severely challenge her ability to seek appropriate antenatal care and or access skilled birth attendance for delivery thereby increasing her risk for poor maternal outcomes.(23,24,25) Based on this evidence, more research is needed to understand how different socio-demographic indicators influence MNMs across different geographical regions.

2.2 The Original WHO Abstraction Tool

According to the WHO, the Organ-dysfunction criterion is the most accurate in predicting MNM and maternal death.(9) Thus, Organ-dysfunction criterion is sensitive enough to identify severe life-threatening cases and specific enough to exclude "unnecessary" other severe events to achieve a manageable workload for clinicians.(9) For instance, in the earliest WHO MNM tool pre-validation study, Cecatti and colleagues compared the WHO criteria to the Total Maximum SOFA (TM-SOFA) score – a gold standard scoring system for Organ-dysfunction and failure – among 637 women in Brazil.(11) Their results revealed that from the 194 MNM events identified, 120 cases of organ failure were identified by TM-SOFA score representing 61.9% of the 194 cases.(11) Similarly, Souza et al determined that Organ-dysfunction was the most effective in identifying MNM in 82,388 women in their cross-sectional study across 27 Brazilian hospitals (Sensitivity [95% CI] = 1.0 [0.97-1.0], Specificity [95% CI] = 0.92 [0.91-0.92]).(12) Consequently, researchers like Tuncalp concluded that the Organ-dysfunction criterion remained the most "epidemiologically sound criterion to use in predicting MNM cases".(7)

Despite these initial reports, subsequent studies demonstrated the challenges of relying solely on Organ-dysfunction in LMICs. (9,12) For instance, a study in rural Malawi showed that 88% of the total MNM cases fulfilled Disease-based criterion while less than 22% were categorized as Organ-dysfunction.(14) Also, single-country studies in Tanzania and Brazil revealed that Organ-dysfunction accounted for only approximately 35% of all MNMs.(9) Again, in their 2019 systematic review article, Tura et al stated that 8 of the 15 articles demonstrated significant inaccuracies when depending on Organ-dysfunction markers to identify MNMs in their studies.(12) This discrepancy has been attributed to the lack of sophisticated laboratory and management-based resources in most low-income health facilities.(9,12,26). More importantly, Disease criterion has been theorized to be the better predictor of MNMs in low resource settings.(14,27)

Overwhelming evidence from studies show that disease-based indicators, such as eclampsia, pre-eclampsia, and obstetric hemorrhage, were the leading underlying causes of MNMs in low-income settings.(12,14,26,27). Hemorrhage was the leading cause of MNM and maternal deaths in Africa (33.9%) and Asia (30.8%) while hypertensive disorders proved the highest in Caribbean and Latin American countries (25%). Anemia was an important cause in all these regions but not in developed nations.(6) Furthermore, in their systematic review of 86 articles across 46 countries, Tuncalp and colleagues identified that in most Asian and African countries, Disease-based criterion was a better predictor of MNM than the Organ-dysfunction criterion.(7) Disease markers are especially crucial in these areas because pregnant women usually present a combination of indicators that significantly increase their risk of MNMs due to substantial delays in obtaining obstetric care.(6,12,27) Other researchers have even argued that the WHO Disease criterion is also restrictive resulting in some misses of MNM cases.(12,14,26,27) Tura and colleagues reported that

out of the 1054 women with potentially-life threatening conditions admitted at a referral hospital in Ethiopia, 622 were classified as life-threatening by the Sub-Saharan adapted abstraction model compared to 154 identified by the original WHO tool.(26) These considerable limitations with the original WHO version have inspired different alterations to the MNM tools to suit local needs across SSA. Overall, the most cited challenges associated with the original WHO tool that have prompted changes include the absence of ICUs (Intervention), lack of laboratory testing (Organ-dysfunction), and unavailability of blood products (Intervention). (18)

2.3 Sub-Saharan African Adaptations to MNM Tool and The MCMH A Tool

The WHO tool was initially adapted into the SSA version using a Delphi process in 2017.(16) The finalized SSA tool added 8 more Disease-based indicators and removed 4 Organ-dysfunction laboratory markers as well as 4 management-based parameters.(16) Subsequently, more specific country-adapted versions have been created. For instance, the Haydom Criteria for Tanzania maintained all Disease markers but modified the Intervention criterion by reducing the amount of transfused blood from 5 units to one unit. It also removed 6 out of the 8 markers under the Organ-dysfunction criterion.(12) Similarly, the Ruhengeri Hospital Criteria of Rwanda retained all the disease-based indicators, removed 4 of the 8 Organ-dysfunction markers, and included ICU admissions to the Intervention section.(12) Again, the Nigerian abstraction tool modified the WHO tool mainly by introducing non-obstetric co-morbidities prevalent in Nigeria such as Malaria, HIV/AIDS, and Anemia. This MNM instrument forms the basis of the current MCMH model.

Although all these adaptations are done to reduce the underestimation of MNM cases, they profoundly decrease the capacity for uniform comparisons between studies worldwide. Hence, some scientists still utilize the original WHO version in a few African settings.(12) Other authors, like Tura, also advocate for a universal SSA MNM abstraction model that strikes a balance

between local applicability and maximum comparability power across regions.(12) A possible means of standardizing these adapted versions is by integrating the use of International Classification of Disease (ICD) codes to promote comparability in the collection, processing, classification, and presentation of cases. (18) In their 2019 systematic study, England and colleagues attempted to determine ways to standardize the identification of MNMs globally. Although the adaptations to the MNM abstraction tool, especially within LMICs, prevented direct comparisons of findings, the authors determined that maintaining a standardized definition of MNMs as well as applying the same coding methods to indicators that are universally associated with MNMs, like hemorrhage and hypertension, could improve the ability to compare global MNM findings.(28)

2.4 The Mozambique-Canada Maternal Health Project (MCMH) MNM Abstraction Tool

The present MCMH model is another iteration of the WHO tool that was built from the Nigerian abstraction model. The MCMH tool maintains the indicators of both the Intervention and Organ-dysfunction criteria. However, it substantially expands the Disease criterion markers in alignment with previous recommendations in the literature.(12,14,26,27) Particularly, it creates two new clinical categories called “Expanded Disease” and “Co-morbidities”. The Expanded Disease criterion expands on each marker from the original WHO disease group by including clarifying subsections. For example, “Hemorrhage” contains subsections like ectopic pregnancy, abortive hemorrhage, ruptured uterus, postpartum hemorrhage, among others. In addition, the Co-morbidities category includes the same non-obstetric co-morbidities present in the Nigerian model such as HIV/AIDS, Anemia, Malaria, and Cancers. It also deviates from the original tool by uniquely capturing specific socio-demographic information including age, education, religion, distance from the hospital, profession, and marital status. Thus, the MCMH abstraction tool strives

to include more clinical data than the original WHO Disease criterion with the goal of capturing more "potentially life-threatening" cases.

2.5 Socio-Demographic Factors Influencing Maternal Health

One of the best strategies for minimizing the high rates of MNMs and mortality is to promote access to timely and quality maternal health (MH) services during antenatal, delivery, and postnatal care.(12) However, inadequate access to quality MH services remains a major challenge globally due to the complex integration and overlap of socio-demographical barriers. LMICs still account for about 90% of all pregnancy-related complications annually with the highest incidence occurring within SSA despite continuous governmental improvements and interventions in healthcare.(29) In SSA, gender, education, socio-economic status (SES), religion, geographic factors, age, constitute some of the biggest hindrances to seeking MH care.

2.5.1 Gender, Education, and SES

Gender inequality, rooted in culture and tradition, exists in many parts of Africa and suppresses female autonomy.(30-33) In these regions, gender norms typically limit a woman's educational mobility and access to employment opportunities or resource management, consequently diminishing their self-esteem, while creating an environment of fear and insecurity. Hence, women generally experience more health problems, poorer healthcare accessibility, and low overall health scores than men in these areas.(31-33) Many studies have demonstrated that low education and SES directly impact maternal healthcare-seeking behavior and poor maternal health outcomes (31,33,34-35)

In their study, Adjiwanou and colleagues noted a direct correlation between the autonomy of women and their utilization of skilled birth attendants by measuring gender inequality both at

the individual level by looking into women's household decision-making and at contextual level by analyzing permissive gender norms and their impact on maternal healthcare services across specific SSA countries.(33) They reveal that women's decision-making power in Ghana (46%), Uganda (52%), Kenya (36%) and Tanzania (37%) showed similar patterns in their utilization of skilled birth attendants.(32) Again, a UNFPA survey about Obstetric Fistula (OBF) in Ghana revealed that more than 50% of subjects with a higher level of education were aware of OBF and willing to seek medical attention for the condition compared to less than 50% of those with lower educational levels.(30) It further showed that females with at least a high school education preferred treatment from midwives and doctors while those with lower or no education preferred to utilize traditional birth attendants.(30) Again, Banda et al's study, that examined the role of gender inequality in families across different wealth brackets, showed that, compared with women with more autonomy, those with lower autonomy were 52% more likely to experience higher maternal health risk.(32)

Gender norms permeate marriages as well. Husbands usually monopolize the decision-making power leaving wives with limited control over financial resources and restricted choices.(37) These male partners therefore strongly influence matters like their wives' utilization of obstetric care during pregnancy.(31,38) For example, a woman may utilize antenatal services or maternal waiting homes (MWH) only upon permission from her husband. Intimate Partner Violence (IPV) further diminishes a woman's ability to pursue healthcare during pregnancy which leads to increase in their risk for poor maternal outcomes. (31-33) A study showed that women who experienced IPV were far less likely to use antenatal and delivery care services and had 33% higher odds of being exposed to maternal health risks.(32)

2.5.2 Age

The literature shows a U-shaped relationship between age and maternal morbidities and mortalities.(39-42). Thus, Adolescents (10-19 years) and women older than 35 years have greater risks for poor maternal outcomes as compared to women between 20-24 years.(39-42) Adolescents have about 28% higher odds of maternal mortality than women between 20-24 years. This odds jump to 33% for women above 35 years.(39-40) The risk of death is higher in younger mothers because of the incomplete development of the pelvis which leads to obstructed labor.(41) The prevalence of maternal mortality is amplified amongst adolescent girls within LMICs due to child marriages.(40,42) In 2010, a study looked into child marriages across Africa and Asia. About 18% of child marriages were reported in Middle East/North Africa and 17% across South Asia. These numbers are even higher in SSA. For instance, in the same year, the prevalence of child brides was 59% and 86% in Mozambique and Nigeria respectively.(42) Each year, an estimated 16 million of these child brides give birth.(40) A study observed that the probability of receiving skilled attendants at birth for those who married 14 years or younger as compared to those who married at 18 years or older was significantly reduced by 12%, 13%, and 15% in Bangladesh, Nepal, and Burkina Faso respectively, thereby increasing their risk for morbidities and mortalities.(42)

Unlike in LMICs, the age of first delivery in High-income countries is progressively increasing to an average of 30 years.(39) Older women have a higher risk of obstetric complications because of their higher risk of co-morbidities.(15,36,39) Progression of age increases women's risk for diseases such as cancers and cardiovascular diseases.(39) Blanc and colleagues further noted that older women with HIV/AIDS are especially at a higher risk of maternal death. Although not fully understood, HIV/AIDS has been conjectured to increase the

risk of death by increasing the likelihood of hemorrhages and sepsis.(41) Culturally, older women in LMICs are more likely to refuse antenatal care during pregnancy. Additionally, they are more likely to choose a traditional birth attendant over a skilled one during delivery, further compounding their risk of morbidities and death.(41)

2.5.3 Religion

Religion is another strong social force across SSA, and it influences several aspects of society including health outcomes. Many traditional religions in Africa believe that some or all diseases have spiritual etiologies that require therapeutic spiritual or religious rituals. For example, in Northern Ghana, about 15% of infant deaths are attributed to “chichuru” or “a spirit child” and requires special rituals to be performed on the mother to ward off this spirit.(43) Therefore, traditional religions possess strong influence on predicting acceptable medical interventions.(44) Due to this control, some pregnant women may perceive seeking professional medical care as a sign of lack of faith in their religion.(45)

Like other countries globally, there is tension between religion and western healthcare systems in SSA. Research shows a pattern between religious affiliation and formal MH service utilization in different SSA countries.(46) For example, in their study, Abor and colleagues showed that Christians were most likely to obtain antenatal care, followed by Muslims, and Traditionalists seeking the least care in their study in Ghana.(46) A Zimbabwean study showed a similar trend as affiliation to different religious groups caused variations in the propensity to seek formal medical care among pregnant women.(47) These patterns have again been observed in other parts of the world, such as India, where Sikhs and Christians were more likely than Muslims to attain MH services during pregnancy.(38) Another study in Nigeria reported that Christian women were more likely to attend the recommended 4 or more antenatal visits compared to their Muslim

counterparts.(43). There is evidence that religion intersects with other socio-demographic factors to produce this pattern between Christians, Muslims, and Traditionalists. Specifically, Christian mothers are more likely to be highly educated, live in urbanized areas, and come from wealthier households than those of the other 2 religions in Ghana.(43-44). Gyimah et al revealed that more than half of the Protestant Christians, in their Ghanaian study, had at least a post-secondary degree as compared to only 10% of Muslims and 3.6% Traditionalists.(44) Although the role of religion in maternal health is not as well-studied as other socio-demographic factors, researchers are calling for more in-depth investigations to be conducted especially within SSA, where religion is pervasive.

2.5.4 Geography

Geography equally plays a significant role in determining access to maternal medical care. There is a huge disparity in the distribution of health personnel and infrastructure between urban and rural areas across Africa.(48) Because more people reside in rural places, this disparity causes a massive barrier to medical care for large segments of the African population.(48) For example, a study concluded that about half of rural Ghanaian women lived 2 or more hours from the nearest obstetric emergency care facility.(49) Another study revealed that only 10% of births occurred with women living within 5km of a maternal health facility.(50) According to Tanou et al, the odds of a woman attending antenatal care decreased by 11.3% for women living within 4.4km of a health facility and dropped even further for those who lived further than 4.4km.(51) Long distances therefore either dissuades many women from utilizing a facility or causes them to arrive late with life-threatening obstetric complications.(49,51)

Closely tied to the issue of long distances is the challenges with rural roads and transportation. Research in Mali showed that about 17% of hospital births occurred in areas where the main road

was seasonally impassable due to heavy rains.(50). In such areas, modes of transportation are scarce and or expensive, discouraging many rural women from utilizing them. It also showed the time it takes to get to public transportation influenced the odds of seeking antenatal care. Thus, there was 44% higher odds of going for antenatal care in areas where the time to public transportation was 15 mins or less than in areas where it took more than 15mins.(50) Additionally, emergency transportation systems are minimally- or non-functional in these regions.(50-51) Overall, road and transportation issues have been reported to cause about 47.8% of all maternal barriers and coerce women to seek out traditional community birth agents who do not have professional skills to handle delivery and its associated complications.(29,50)

2.6 Maternal Health in Inhambane Province of Mozambique

Inhambane province is located on the coastal part of southern Mozambique. Like many traditional SSA areas, various health systems and socio-demographic obstacles have historically prevented women from freely accessing obstetric care within this province. Maternal mortality rates in Mozambique remain among the highest in the world, recording about 127 deaths per 100,000 live births annually, making up a significant proportion of all deaths of women of reproductive age.(51-52) Therefore, there is an urgent need to mitigate the high incidence of pregnancy morbidities and mortality through specific evidence-based strategies.

2.6.1 HRV and HPI Hospitals

Both HRV and HPI are secondary referral hospitals within the Inhambane province. While HRV receives referrals from the northern part of the province, HPI receives patients from hospitals across all of Inhambane, including HRV and other secondary hospitals. HPI is also the only hospital in Inhambane with a comprehensive emergency obstetric care (EmONC) unit. HPI has a total bed capacity of 281 beds, 37 of which are dedicated to obstetric use. It also has at least one specialist for departments like Gynecology/Obstetrics, Pediatrics, Psychiatry, Internal Medicine, Urology, and Dermatology. Furthermore, HPI boasts of senior technicians, such as Pharmacists, Laboratory technicians, and Radiology technicians, who provide support within these departments. Finally, it has a functioning laboratory and an on-site Pharmacy. (Appendix D)

On the other hand, HRV has a bed capacity of 223 beds with only 8 dedicated to Obstetrics. Unlike HPI, it has fewer clinical specialists across the different departments. It is important to note that there is no Gynecologist/Obstetrician present at this site. Nevertheless, there are midwives, senior nurses, and senior technicians who perform some of the roles of the specialists. It has a laboratory and Pharmacy on-site. (Appendix D)

Overall, the capacity of HPI is broader than HRV because of its requirement to meet the demands of a secondary referral facility for the whole province. However, there is still opportunities for growth.

2.6.2 Mozambique-Canada Maternal Health Project

Ongoing improvements are being made to MH accessibility within Inhambane . In 2017, a seven-year project to promote sexual, reproductive, maternal, and newborn health began through a collaboration between University of Saskatchewan (USask) and Inhambane Provincial Health Directorate (DPSI), funded by Global Affairs Canada, called Mozambique-Canada Maternal

Health Project, under the leadership of Dr Nazeem Muhajarine.(53) The main objective was to use community engagement, health education, health system strengthening, and research to reduce maternal mortality within this region.(53) So far, several milestones have been achieved to mitigate some of the social barriers to MH accessibility. For instance, the community engagement stream has developed microenterprises for women to promote their financial autonomy and capacity to financially cover medical needs.(53) Furthermore, the health educational stream has developed participatory and engaging discussions on issues, such as gender inequality, that have promoted awareness and empowerment for these women. Additionally, health system strengthening is done through clinical upgrade trainings on topics related to emergency obstetrical and newborn care, construction of new health infrastructure, and provision of hospital equipment such as district and local community ambulances. Again, the research pathway continues to investigate the effects of deficiencies and interventions of maternal health resources for women to better improve obstetric care within this province.

2.7 Summary

Overall, the literature tells us the following:

- The WHO MNM abstraction tool is a useful instrument for investigating the quality of obstetric care especially in LMICs
- Growing concerns about the effectiveness of the WHO abstraction tool has led to the adaptation of this instrument across multiple LMICs
- Many LMICs are increasingly relying on the clinical criterion of the tool to effectively identify MNMs
- The current MCMH tool is an adaptation of the Nigerian tool. It contains two additional clinical criteria namely “Expanded Disease” and “Co-morbidities”

- Geographical indicators and socio-demographic factors like age, education, gender, SES, and religion influence the healthcare-seeking behavior and maternal health outcomes of women
- Maternal health issues in Inhambane province, Mozambique, are currently being mitigated through the efforts of the Mozambique-Canada Maternal Health project.

In conclusion, the study of MNMs provides a unique opportunity to audit and improve maternal healthcare systems, especially within resource-limited areas. It is therefore crucial to find ways of improving the abstraction tool to capture the best contextually appropriate biomedical and socio-demographic indicators associated with this phenomenon.

CHAPTER 3
METHODOLOGY

3.1 Study Setting

The current study is a secondary quantitative analysis of data obtained from the broader MNM study carried out in the Inhambane province entitled MNM 1.0, under the supervision of Dr Nazeem Muhajarine. The MNM 1.0 study was aimed at utilizing the adapted MCMH abstraction tool to collect preliminary biomedical and sociodemographic information from pregnant women in 2 hospitals: HRV and HPI. The present study focuses on understanding how the additional clinical criteria of this instrument ("Expanded Disease" and "Co-morbidities") improve the capacity of the original WHO clinical criterion in identifying MNMs. It also determines the association between sociodemographic factors and MNM identification.

3.2 Study Design and Recruitment

Study data was collected through purposive sampling from all women who presented with in two different hospitals in the Inhambane province of Mozambique during pregnancy, labor and delivery, or up to 42 days post-partum or termination of pregnancy (including abortion and ectopic pregnancy), or those who died on the way to and were brought dead to the hospital during the study period were eligible for this study. A total of 2,057 data samples were retrieved between August 2021 and February 2022: 1255 participants from HRV and 802 participants from HPI.

Four maternal and child health nurses in each health facility were trained under the supervision of a well-qualified team supervisor in each location prior to the data collection phase. These trained personnel positioned themselves in the maternity departments daily and approached newly

admitted women to explain the study through an Informed Consent process. Interested women who met the inclusion/exclusion criteria subsequently signed the Informed Consent Form to provide permission to obtain their information. The data collectors retrieved information from study participant medical records to complete the abstraction tool. Each week during the 6-month period, the study team met to discuss and improve data quality.

3.3 Conceptual Framework

The Maternal Morbidity Measurement (MMM) framework **(Fig. 3.1**) illustrates the broadest facets of maternal morbidity and the different kinds of measurements that capture everything pertaining to women throughout the life cycle, service providers, and policymakers.(54) This framework portrays the interaction between structural factors, like health systems and socio-economic status, and the reproductive health cycle of a woman that influences her risk of maternal morbidities.(54) The MMM differs from previous frameworks in some important ways. Unlike previous versions, this current framework not only shows the connection between distal structural factors and maternal health outcomes, but more importantly, it contextualizes this connection within the life-course approach. Thus, it acknowledges that socio-demographic risk and protective factors throughout a woman's life can contribute to her health outcomes during and beyond reproductive years.(54) Additionally, this framework emphasizes the continuum of maternal morbidity from potentially life-threatening to life-threatening outcomes contrary to other models that focus solely on mortality. The MMM framework serves as a good guide for this current study whose overall aim is to combine both the socio-demographic information and biomedical health indicators in describing the profile of an MNM woman.

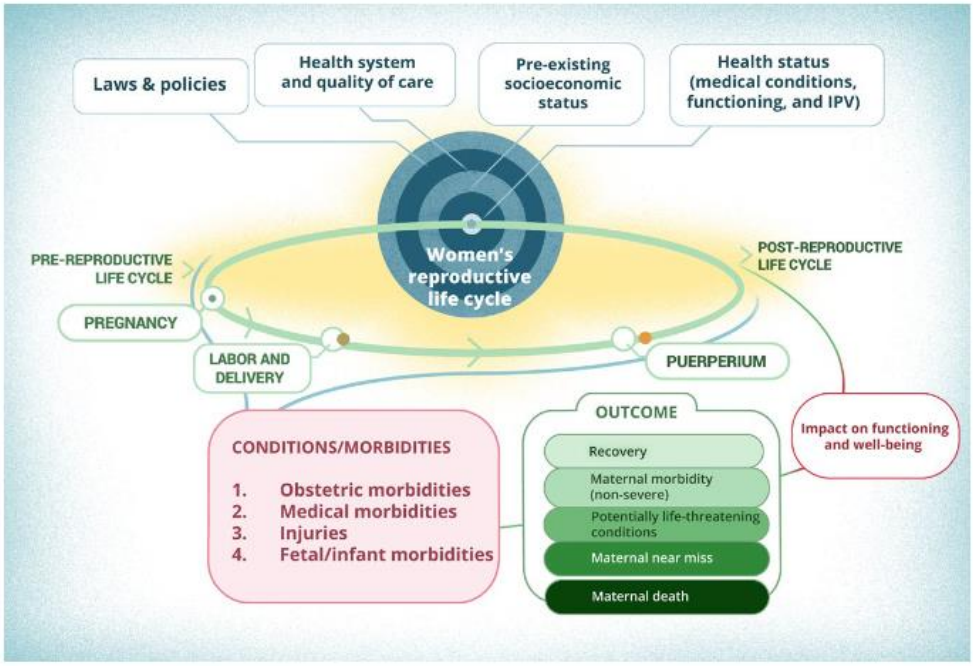


Figure 3.1. Maternal Morbidity Measurement (MMM) Framework (Fillipi et al, 2018)

3.4 Survey Instrument

As previously mentioned, the MCMH model is an iteration of the Nigerian version and serves as the first locally adapted tool for collecting MNM data within Inhambane province. It is divided into the following sections respectively: a) Hospitalization information b) Socio-demographic data c) vitals and pregnancy history d) Organ-dysfunction markers e) Intervention indicators f) Disease-based pointers g) Expanded disease markers h) Co-morbidities indicators i) Fetal/neonatal outcomes. This study focuses on information within sections (b), (d), (e), (f), (g), and (h).

Socio-demographic data was obtained through a combination of patient responses and medical files. These data points include age, distance from health facility, education, profession, marital status, and religious affiliation. Varying response alternatives were provided for these socio-demographic factors. For example, distance had two responses: *within 8 km and more than 8 km*

while education level had four response alternatives: *none, primary school, secondary school, and post-secondary*.

Within sections (d) through (h) each major clinical indicator has multiple sub-markers. The data collector correctly identified the choices corresponding to the participant's condition. For instance, under Expanded Disease criterion, the indicator "Bleeding" has 8 possible options to choose from: *Abortion-related hemorrhage, Ectopic pregnancy, Placenta previa, Abruptio placenta, Accreta/increta/percreta placenta, Ruptured uterus, Postpartum haemorrhage, Other obstetric haemorrhage*.

An MNM case could fulfill definitions from all 5 criteria (sections [d] through [h]). Thus, fulfillment of each criterion was counted as an MNM identified by that criterion. For instance, an HIV-positive woman with severe bleeding and neurological issues who was admitted to the ICU met the Disease-based, Intervention, Organ-dysfunction, and Co-morbidities criteria. All biomedical information obtained for sections (d) through (h) were abstracted solely from medical records. (Appendix B)

3.5 Study Variables

3.5.1 Dependent Variables

There was no clear dependent variable for objective one. The focus of this objective was to understand the relationship between the "Expanded Disease" or "Co-morbidities" criteria with the original "WHO Disease" criterion. Nevertheless, there were 3 explicit dependent variables for objective 2 which looked into how specific sociodemographic and geographical factors influenced the identification of MNMs. These dependent variables were a) MNMs identified by WHO Disease

criterion; b) MNMs identified by Expanded Disease criterion; and c) MNMs identified by Co-morbidities criteria. All dependent variables were dichotomous (yes/no).

3.5.2 Independent Variables

All independent variables were categorical data. They include: type of hospital, distance from hospital, age, education, profession, marital status, and religion.

Type of Hospital: This variable was a dichotomous construct: "HPI" or "HRV". Depending on where participants received care, one of the two was chosen. HPI was used as the reference category.

Distance from Hospital: This construct also had 2 categories: "Within 8km" or "More than 8 km". The reference level was "Within 8km",

Age: The age variable was initially grouped into 6 levels namely "≤ 19", "20-24", "25-29, "30-34", "35-39", and "≤ 40". However, during analysis, some of these levels were re-grouped due to insufficient data within some cells. The first level ("≤ 19") was made the reference category.

Education: Education was subdivided into the following: "Primary school", "Secondary school", Post-secondary school", and "Technical or University training". The reference level was "Primary school"

Marital Status: This variable was sub-categorized into four main levels: "Single", "Married/Lived maritally", "Divorced", and "Widowed". However, due to insufficient data within some categories, these groups were re-grouped into "Partnered" vs "Not Partnered". The Partnered group encompassed the "Married/Lived maritally" group while the "Not Partnered" level included all the others. The referenced category was "Not Partnered".

Religion: Religion had 4 main levels namely, “Islam”, “Christianity”, “Traditional” and “Other”. In some cases, the last 2 categories were combined for analytical reasons. The reference category was “Islam”.

3.6 Data Analysis

All data was initially collected and stored in Microsoft Excel software. After data cleaning, the final data management and analyses were performed using SPSS version 25 statistical software package. Descriptive analysis was conducted on all population-level variables and presented as frequencies. Additionally, chi-square test of independence as well as kappa estimations were performed to fulfill objective 1. To complete the objective 2 aim, multivariate logistic regression was conducted. All alpha levels were set at p-value = 0.05.

3.6.1 Chi-square Test of Independence and Kappa Estimates

To understand how either “Expanded Disease” or “Co-morbidities” criteria related with the “WHO disease” criterion, a chi-square test of independence was conducted. The null hypothesis (H_0) was: “There is no association between MNMs identified by the new criterion and the WHO Disease criterion” and the alternative hypothesis (H_1) was: “There is an association between MNMs identified by the new criterion and the WHO Disease criterion”. The null hypothesis was rejected when p-value < 0.05. To understand hospital-specific variations between the criteria, the data were stratified, and the chi-square test was re-run per facility-specific data.

To further determine the association between these criteria, kappa statistic, and associated confidence intervals, were obtained. Thus, tests were run to obtain the degree of agreement between the original WHO criterion and either the Expanded Disease or Co-morbidities criteria. The level of agreement was interpreted based on the following groupings: 0.01-0.20 = no to slight agreement; 0.21-0.40 = fair agreement; 0.41-0.60 = moderate agreement; 0.61-0.80 = substantial

agreement; and 0.81-1.0 = almost perfect agreement.(55) kappa estimates were also achieved for hospital-specific stratified data.

3.6.2 Logistic Regression Analysis

Multivariate logistic regressions were performed to establish 3 models that revealed the association between specific sociodemographic factors and MNMs identified by the WHO Disease, Expanded Disease, and Co-morbidities criteria. For each model, a bivariate analysis was first performed to establish the relationship between each independent variable with the outcome variable. Alpha level was set at 0.20. Therefore, all variables with p-value < 0.20 was included in the multivariate analysis.

All significant variables were established in the multivariate analysis when p-value < 0.50. Regression models were also tested for Interaction by using the 2-Log-Likelihood method. If the calculated χ^2 > Tabulated χ^2, the interaction term was included in the model. Additionally, each model was assessed for confounding effect. When |Adjusted - Crude ORs| > 10%, the confounder was maintained in the model. Finally, the Goodness-of-Fit statistic was assessed using the Hosmer-Lemeshow estimates.(56) A chi-square value with p-value > 0.05 was regarded a good model. All odds ratio, 95% confidence intervals, and p-values were reported for each model.

To further identify any hospital-specific differences between the models, the data was stratified, and all the above steps were followed to obtain facility-based models. Only statistically meaningful models, per hospital, were reported.

3.7 Ethics Considerations

Application for ethical approval for this secondary use of the MNM 1.0 was sought from the University of Saskatchewan Research Ethics Board. An approval was obtained on December 05, 2022 (Bio 3774 NER). To ensure the confidentiality of patient information, only de-identified patient information was used. All digitized records and Masterfile were also stored in a folder within the secure University of Saskatchewan's OneDrive cloud as well as on the hard drive.

3.8 Knowledge Translation

The aim of this knowledge translation plan is to disseminate the findings of the investigation to relevant stakeholders, to guide future research on MNMs, and to apply evidence-based strategies to future clinical identifications of MNM cases. The findings will be of interest to a wide range of groups including policymakers, like the Inhambane Provincial Directorate of Health and the Mozambique Ministry of Health, health professionals, and researchers. This KT plan entails using both integrated and end-of-study KT approaches to maximize the data dissemination process.

Both the governing body of the Health Directorate and selected health professionals have been engaged in the integrated KT process by providing input in key decision-making such as planning, participant selection, and data collection. Additionally, they are constantly updated on study progress through periodic reports, webinars, and workshops. This also maintains strong relationships between the MNM researchers and health system decision-makers.

To achieve end-of-study knowledge dissemination among the academic audience (healthcare professionals, researchers), traditional platforms such as academic articles, presentations, and data visualizations, will be coupled with actionable messages in graded entry formats that will allow the researcher to access the level of detail required (main message,

executive summary, brief of the project). Equally important, most of the key written knowledge products will be developed in Portuguese to make them readily accessible to the local Mozambican stakeholders. Furthermore, for knowledge application, recommendations will be developed based on the findings of the study and distributed to health professionals through the different provincial physician and nursing associations. Educational meetings, seminars, webinars, and workshops will be utilized to share these recommendations with these clinicians. Likewise, we will look for opportunities to transfer these key findings to the WHO for their consideration.

CHAPTER 4
RESULTS

4.1. Introduction

This chapter begins by characterizing the study population variables. Afterwards, results of Chi-square test of independence and kappa estimates are presented on MNM frequencies identified by the different abstraction criteria (Original WHO Disease, Mozambique Expanded Disease, and Mozambique Co-morbidities criteria). Finally, descriptions of the results from the multiple logistic regression analysis on the association between specific maternal characteristics and MNM identification are shown.

4.2. Descriptive Analysis

4.2.1. Baseline Sociodemographic Characteristics

Distributions of the population characteristics are presented in Table 4.1. According to the data, approximately half (49.8%) of the women were 24 years or younger and nearly one-third of all study participants were either married or lived maritally with their partners. Most women (68%) stayed close to the study health facilities. Less than half of that population (39%) completed a secondary school education and even less than one-tenth completed a technical or university degree. Majority of these women were unemployed (86.7%) and practiced Christianity (93.7%).

4.2.2. MNM Distributions Based on Different Abstraction Criteria

Both Table 4.2 and Figure 4.1 showcase the frequency distributions of MNMs as identified by each criterion. Compared to all other categories, the new Mozambique Expanded disease (28.2%) and co-morbidities criteria (21.1%) identified the highest MNMs while the Organ-dysfunction criterion yielded the least number of MNMs (2.7%)

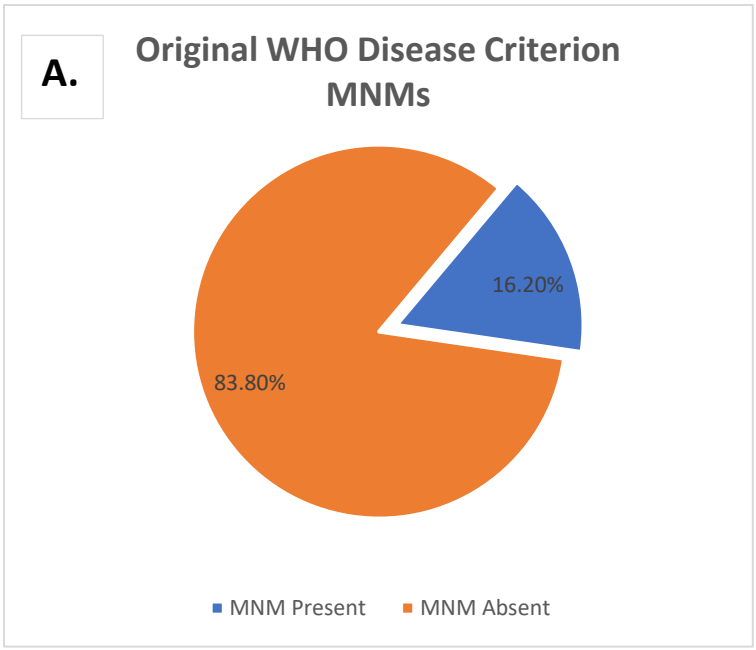
Table 4.1. Characteristics of Study Participants (n=2057)

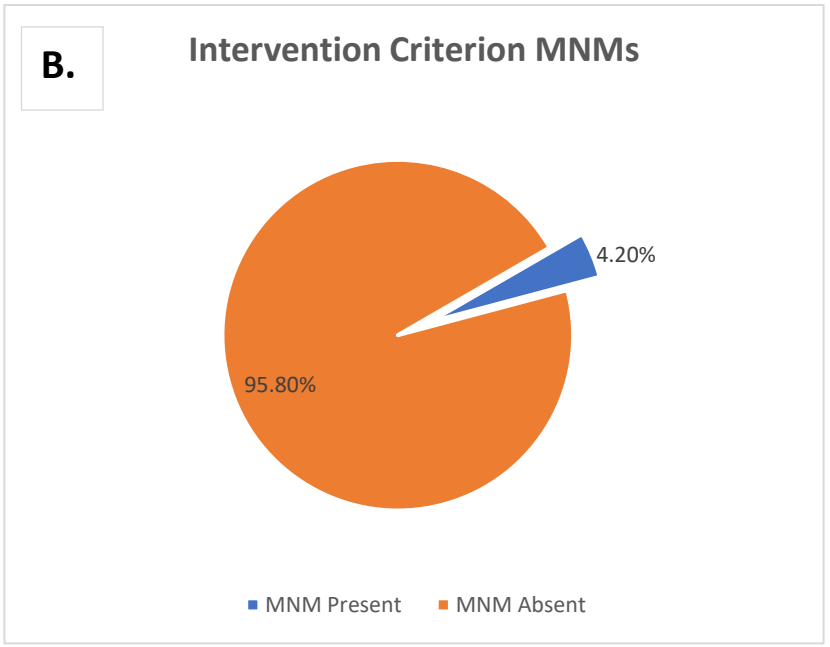
Variable	Frequency (%)
HPI or HRV	
HPI	800 (**38.9**)
HRV	1255 (**61.1**)
Place of Residence	
Within 8km	1397 (**68.0**)
More than 8km	657 (**32.0**)
Educational Level	
None	246 (**12.0**)
Primary Sch 1	255 (**12.4**)
Primary Sch 2	545 (**26.6**)
Secondary School	633 (**30.9**)
Post Secondary	285 (**13.9**)
Technical	77 (**3.7**)
University	10 (**0.5**)
Profession	
Unemployed	1735 (**86.7**)
Unqualified Employment	161 (**8.2**)
Semi-qualified Employment	92 (**4.6**)
Professional	11 (**0.5**)
Religion	
Islam	60 (**3.1**)
Christianity	1867 (**93.7**)
Traditional	63 (**3.1**)
Other	2 (**0.1**)

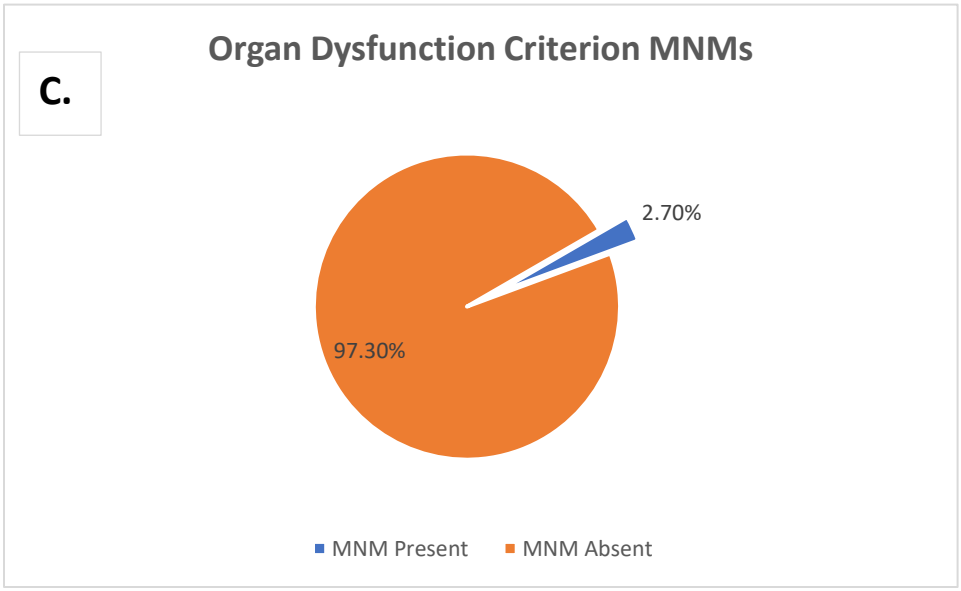
Marital Status	
Single	518 (**25.9**)
Married	96 (**5.0**)
Live Maritally	1374 (**68.6**)
Divorced	9 (**0.4**)
Widow	2 (**0.1**)
Age Categories	
≤19	437 (**21.8**)
20-24	558 (**27.8**)
25-29	433 (**21.6**)
30-34	354 (**17.9**)
35-39	165 (**8.2**)
≥40	55 (**2.7**)

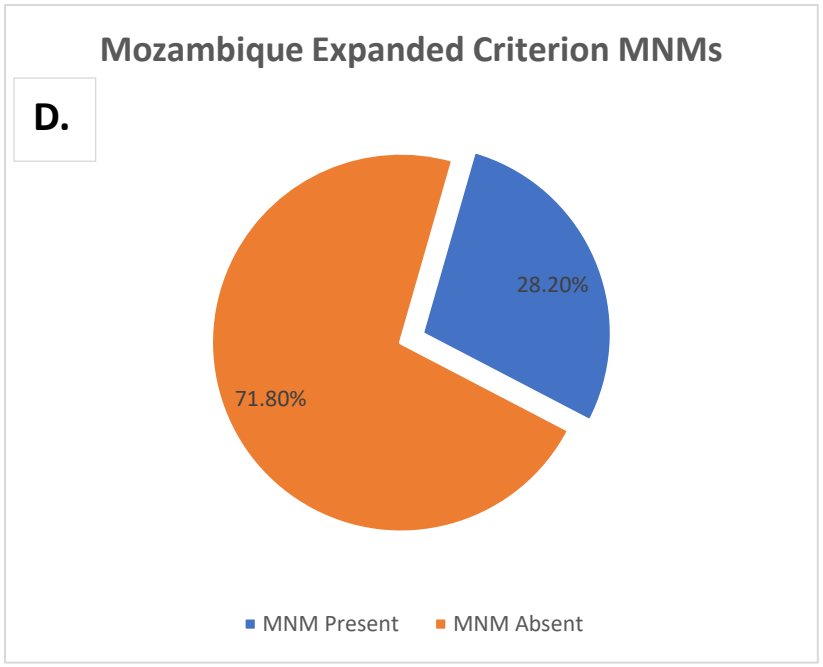
Table 4.2. Frequency Distributions of MNMs as Identified by Different MNM Abstraction Criteria (n=2057)

Criteria	MNM Frequency (%)
Original WHO Disease	332 (**16.2**)
Intervention	87 (**4.2**)
Organ-Dysfunction	55 (**2.7**)
Mozambique Expanded Disease	580 (**28.2**)
Mozambique Co-morbidities	434 (**21.1**)


A.
Original WHO Disease Criterion MNMs
16.20%
83.80%
MNM Present
MNM Absent


B.
Intervention Criterion MNMs
4.20%
95.80%
MNM Present
MNM Absent


C.
Organ Dysfunction Criterion MNMs
2.70%
97.30%
MNM Present
MNM Absent



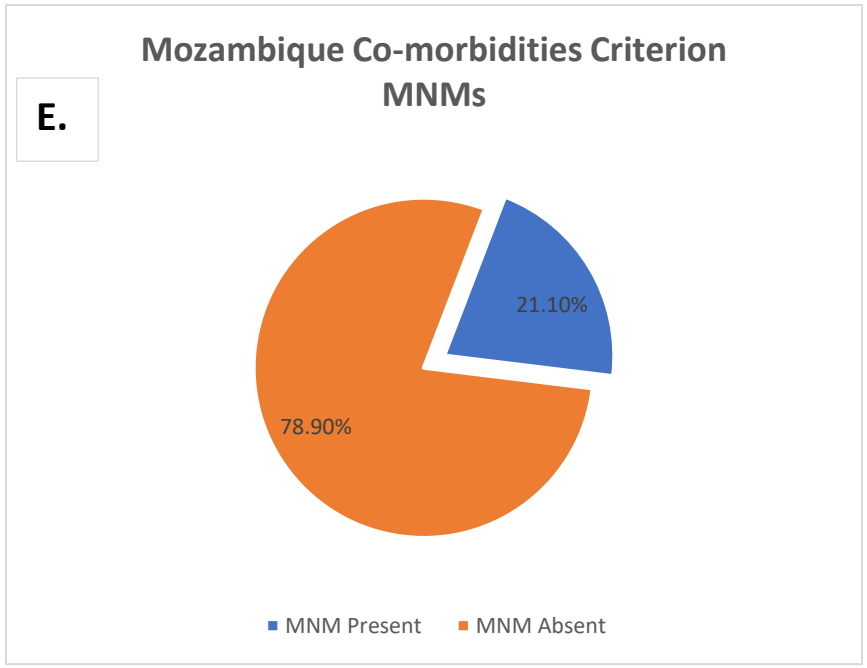


Figure 4.1. MNMs Identified by the Different Criteria (Fig A – E) of the Mozambique-Canada Maternal Health MNM Abstraction Tool

4.2.3 Sub-Criteria Contributions to MNM Identification

Each criterion comprises of markers that helped identify MNMs for that category (**Table 4.3.**). For the original WHO Disease-criterion, Hypertension contributed to the most cases (221; 66.6%) while Infection represented the least (5; 1.5%). While blood transfusion contributed to the most events under Intervention-criterion (62;71.3%), no patient underwent interventional radiology. Under the Organ-dysfunction criterion, 32 (58.18%) cases were attributed to Neurological dysfunction while Liver dysfunction showed the least contribution (1;1.82%). Following similar trends as the original WHO disease category, Hypertension continued to be the highest contributor to the Expanded Disease criterion (322; 36.6%) while infection remained the least contributor (14; 1.6%). For the Co-morbidities criterion, MNMs were mainly attributed to HIV/AIDS (377; 42.9%), Anemia (57; 6.5%), and Malaria (17; 1.9%). Co-morbid conditions like kidney, heart, liver, and lung diseases as well as cancers were not identified for any of the study participants.

4.2.4. Contributions of MNMs By The Criteria Varied Between Hospitals (HPI and HRV)

When stratified by hospitals, more cases per criterion were identified at HRV than HPI (**Table 4.4.**) Nevertheless, a greater percentage of MNMs, identified by the original WHO disease (19.8%), Expanded Disease (35.1%), and Intervention (5%) criteria higher in HPI than at HRV. Only Organ-dysfunction (3%) and Mozambique co-morbidities (26.7%) categories were higher in HRV.

Table 4.3. A Breakdown of Each Sub-Category Contribution to MNM Identification (n=2057)

Category	Sub-category	Frequency (%)
A: Disease (n=332)	Severe Bleeding	11 (**3.3**)
	Hypertensive Disorder	221 (**66.6**)
	Dystocia	69 (**20.8**)
	Infection	5 (**1.5**)
	Anemia	55 (**16.6**)
B: Intervention (n=87)	Admission to ICU	34 (**40.0**)
	Interventional Radiology	0 (**0**)
	Emergency Laparotomy	16 (**18.6**)
	Transfusion of Blood Products	62 (**71.3**)
C: Organ-Dysfunction (n=55)	Cardiac Dysfunction	13 (**23.6**)
	Respiratory Dysfunction	8 (**14.5**)
	Renal Dysfunction	2 (**3.7**)
	Hematological Dysfunction	10 (**18.2**)
	Liver Dysfunction	1 (**1.8**)
	Neurological Dysfunction	32 (**58.2**)
D: Expanded Disease (n=580)	Bleeding	69 (**7.8**)
	Hypertensive Disorder	322 (**36.6**)
	Obstructed Labor	201 (**22.8**)
	Infection	14 (**1.6**)
E: Co-morbidities (n=434)	HIV/AIDS	377 (**42.9**)
	Malaria	17 (**1.9**)
	Embolic Disease	2 (**0.2**)
	Anemia	57 (**6.5**)
	Heart Disease	0 (**0**)
	Kidney	0 (**0**)
	Lung Disease	0 (**0**)
	Liver Disease	0 (**0**)
	Cancer	0 (**0**)
	Concomitant Conditions	2 (**0.2**)

Table 4.5. reveals the results after data from Table 4.3 was stratified by hospitals. Each health facility showed the same patterns of sub-category contribution to MNMs as observed in the overall sub-categorization data (**Table 4.3.**). Thus, hypertension, admission to ICU, neurological dysfunction, and HIV/AIDS remained the highest markers of MNMs for both sites. Out of these, hypertensive disorder (16.2% for WHO disease and 20.6% Mozambique Expanded Disease) and ICU admission (2.9%), remained highest in HPI while Neurological dysfunction (2.1%) and HIV/AIDs (24.2%) contributed the most in HRV.

Table 4.4. MNMs Identified by the Different Criteria Stratified By Hospital (n=2057)

Criteria	**HPI (n = 800)**	**HRV (n = 1255)**
	Frequency (%)	**Frequency (%)**
Original WHO Disease	158 (**19.8**)	174 (**13.9**)
Intervention	40 (**5.0**)	47 (**3.7**)
Organ-Dysfunction	18 (**2.3**)	37 (**3.0**)
Mozambique Expanded Disease	281 (**35.1**)	299 (**23.8**)
Mozambique Co-morbidities	98 (**12.3**)	335 (**26.7**)

Table 4.5. A Breakdown of Each Sub-Category Contribution to MNM Identification Stratified by Hospital (Inhambane Provincial Hospital, HPI and Vilankulo Rural Hospital, HRV)

Category	Sub-category	HPI (n = 800)	HRV (n = 1255)
		Frequency (%)	Frequency (%)
A: Disease	Severe Bleeding	5 (**0.6**)	6 (**0.5**)
	Hypertensive Disorder	129 (**16.2**)	108 (**8.6**)
	Dystocia	27 (**3.4**)	45 (**3.6**)
	Infection	4 (**0.5**)	1 (**0.1**)
	Anemia	13 (**1.6**)	43 (**3.4**)
B: Intervention	Admission to ICU	23 (**2.9**)	12 (**1.0**)
	Interventional Radiology	0 (**0**)	0 (**0**)
	Emergency Laparotomy	5 (**0.6**)	11 (**0.9**)
	Transfusion of Blood Products	24 (**3.0**)	38 (**3.0**)
C: Organ-Dysfunction	Cardiac Dysfunction	6 (**0.8**)	7 (**0.6**)
	Respiratory Dysfunction	4 (**0.5**)	4 (**0.3**)
	Renal Dysfunction	1 (**0.1**)	1 (**0.1**)
	Hematological Dysfunction	4 (**0.5**)	6 (**0.5**)
	Liver Dysfunction	1 (**0.1**)	0 (**0**)
	Neurological Dysfunction	6 (**0.8**)	26 (**2.1**)
D: Expanded Disease	Bleeding	38 (**4.8**)	32 (**2.6**)
	Hypertensive Disorder	164 (**20.6**)	163 (**13.0**)
	Obstructed Labor	87 (**10.9**)	115 (**9.2**)
	Infection	7 (**0.9**)	7 (**0.6**)
E: Co-morbidities	HIV/AIDS	79 (**9.9**)	303 (**24.2**)

	Malaria	7 (**0.9**)	10 (**0.8**)
	Embolic Disease	0 (**0**)	2 (**0.2**)
	Anemia	17 (**2.1**)	40 (**3.2**)
	Heart Disease	0 (**0**)	0 (**0**)
	Kidney	0 (**0**)	0 (**0**)
	Lung Disease	0 (**0**)	0 (**0**)
	Liver Disease	0 (**0**)	0 (**0**)
	Cancer	0 (**0**)	0 (**0**)
	Concomitant Conditions	0 (**0**)	2 (**0.2**)

4.3 Associations and Level of Agreement Between the Different MNM Abstraction Criteria

4.3.1. Associations Between All Criteria of The MCMH Abstraction Tool

Association between all criteria and combination of criteria were tested. Almost all the tests showed a significant association ($p < 0.05$) between groups (Appendix C). The strongest associations were seen among the criteria combinations ($\chi^2 > 1000$, d.f. = 1, p-value < 0.05). Nevertheless, there were a few criteria that were mutually exclusive of each other. This included the lack of association between the Mozambique Expanded Disease and Co-morbidities (p-value > 0.05) criteria. There was also no association between the Intervention/Co-morbidities and Organ-dysfunction/Expanded Disease criteria combinations (p-value > 0.05).

4.3.2. Indicators of the Expanded Disease and Co-morbidities Criteria that are Associated With the WHO Disease Criterion

Although the new criteria (Mozambique Expanded Disease and Co-morbidities categories) were generally associated with the other original criteria (Appendix C), further investigations were made to understand their relationship specifically with the Original WHO Disease criterion. Since the WHO Disease criterion, instead of Organ-dysfunction criterion, is used in identifying potential MNMs in LMICs, data from this test could refine the original disease category to capture the most MNMs while maintaining its precision.

As presented in Table 4 .6, all variables in the Mozambique Expanded Disease criterion were statistically associated with the Original WHO Disease group (p-value <0.001). Within this category, Hypertension had the strongest association with the original disease category ($\chi^2 = 678.5$, d.f. = 1, p-value < 0.001) while obstructed labor had the weakest association with the original WHO Disease criterion ($\chi^2 = 24.0$, d.f. = 1, p-value < 0.001). Similarly, most variables in the Mozambique Co-morbidities category were statistically related to the original Disease criterion (p-value < 0.05) except HIV/AIDS (p-value > 0.05). Within the statistically significant group,

anemia was most strongly associated with the Original WHO Disease criterion (χ^2 = 200.1, d.f. = 1, p-value < 0.001) while Malaria maintained the weakest association with this original clinical category (χ^2 = 4.6, d.f. = 1, p-value < 0.005).

The kappa estimates, which corrects or adjusts for chance agreements, between the Original WHO Disease and Mozambique Expanded Disease factors revealed an overall 'weak' agreement between the two categories (**Table 4.6**). Hypertension was the only factor that showed a 'moderate' degree of agreement with original Disease criterion (κ = 0.58, 95% CI: 0.53-0.63). Generally, the kappa estimates for the Co-morbidities group were lower than that of the Expanded Disease criterion. Most of the co-morbidity variables showed no agreement with the original Disease criterion, with embolic disease having the lowest level of agreement (κ = 0.01, 95% CI: -0.00-0.02). Anemia was the only factor to fairly agree with the original WHO Disease criterion (κ = 0.21, 95% CI: 0.16-0.26).

Unlike HPI, all the Mozambique Expanded disease variables remained significantly associated with the original disease group (p-value < 0.001) (**Table 4.8**) in HRV. Hypertension still had the strongest association with the original disease category (χ^2 = 317.1, d.f. = 1, p-value < 0.001) while obstructed labor was not as strongly associated (χ^2 = 26.0, d.f. = 1, p-value < 0.001).

Table 4.6. Overall Results from Chi-Square Test of Independence and Kappa Statistic Between the Original WHO Disease Criterion vs the Mozambique Expanded Disease and Co-morbidities Criteria

Association Variable	Chi-square (χ^2)	d.f.	P-value	kappa Value	Confidence Interval	
					Lower	Upper
Mozambique Expanded Disease Measures with Original WHO Disease Criterion:						
Bleeding and Original Disease Criterion	46.7	1	<0.001	0.11	0.06	0.16
Infection and Original Disease Criterion	35.6	1	<0.001	0.05	0.02	0.08
Hypertension and Original Disease Criterion	678.5	1	<0.001	**0.58****	0.53	0.62
Obstructed Labor and Original Disease Criterion	24.0	1	<0.001	0.10	0.06	0.15
Mozambique Co-morbidities Measures with Original WHO Disease Criterion:						
HIV/AIDS and Original Disease Criterion	0.7	1	**0.409**[b]	0.02	-0.027	0.06
Malaria and Original Disease Criterion	4.7	1	0.032	0.02	-0.00	0.04
Anemia and Original Disease Criterion	200.1	1	<0.001	**0.21****	0.16	0.26
Embolic Disease and Original Disease Criterion	10.4	1	0.001	0.01	-0.00	0.02

** kappa values greater than 0.2 indicating fair or higher reliability

[b] p-value greater than 0.05 suggesting a lack of association between variables

Furthermore, most of the Mozambique Co-morbidities variables were statistically associated with the original Disease criterion except HIV/AIDS which continued to show a lack of association with the WHO disease group (p-value > 0.05). Of the variables that were significantly associated with the original Disease criterion, Anemia had the strongest association (χ^2 = 227.1, d.f. = 1, p-value < 0.001) whereas malaria had the weakest (χ^2 = 11.0, d.f. = 1, p-value <0.05).

Kappa estimates for HPI followed a similar trend as the overall kappa estimates with most variables across the Mozambique Expanded disease and Co-morbidities criteria having only 'slight' agreement with the original WHO disease category (κ = 0.10 - 0.20) as presented in Table 4.7. Of note, the degree of agreement for Hypertension improved from 'moderate' to 'substantial' with the original Disease criterion (κ = 0.65, 95% CI: 0.58-0.72). However, the anemia showed no 'slight' agreement with the WHO disease group (κ = 0.079, 95% CI: 0.0222-0.136).

HRV followed the same kappa estimate trends as HPI with only fair level of agreement between the Mozambique Expanded Disease and Co-morbidities categories with the original WHO Disease criterion (κ = 0.10-0.20) (**Table 4.8**). Unlike HPI, Hypertension had only a 'moderate' agreement with the original disease category (κ = 0.50, 95% CI: 0.43-0.57). Additionally, anemia showed a 'fair' level of agreement with the WHO disease category (κ = 0.32, 95% CI: 0.24-0.40).

4.3.4 Summary

Generally, most variables of the Mozambique Expanded Disease and Co-morbidities were statistically associated with the Original WHO Disease criterion except one disease, HIV/AIDS. Also, both Hypertension and Anemia had the strongest associations to the original Disease criterion. Worth noting is that HRV had more significant associations than HPI across the Expanded disease and Co-morbidities categories. Furthermore, kappa estimates showed only

'slight' agreement between these categories and the WHO disease group. Nevertheless, both Hypertension and Anemia had improved levels of agreement ranging from 'fair' to 'substantial'.

4.4. Hospital, Geographic, and Socio-demographic Factors that are Associated with Identifying MNMs

4.4.1 Model I: Hospital, Geographic, and Sociodemographic Factors Associated with MNMs Identified by the Original WHO Disease Criterion

Factors such as the type of hospital, place of residence, and level of education, were each significantly associated with MNMs defined by the original WHO Disease criterion (p-value < 0.05) (**Table 4.9**). Specifically, patients who went to HRV were less likely to be identified as MNMs in comparison to those who were admitted to HPI (OR = 0.66, 95%CI: 0.52-0.83). Additionally, the odds of MNM identified was two times more among patients who lived greater than 8km from a health facility as compared to those who lived within 8km (OR = 2.54, 95%CI: 2.00-3.23). Furthermore, those who had the highest education had a greater likelihood of being identified as an MNM case (OR = 1.25, 95%CI: 0.70-2.23). Although marital status and age categories were not significantly associated with MNMs (p-value > 0.05), they were included in the multivariable analysis because they had a p-value less than the 0.20 threshold. Religion and professional level were excluded (p-value > 0.20).

Table 4.7. Results From Chi-Square Test of Independence and Kappa Statistic Between the Original WHO Disease Criterion vs the Mozambique Expanded Disease and Co-morbidities Criteria in HPI Hospital

Association Variable	Chi-square (χ^2)	d.f.	P-value	kappa Value	Confidence Interval	
					Lower	Upper
Mozambique Expanded Disease Measures with Original WHO Criterion:						
Bleeding and Original Disease Criterion	3.5	1	**0.061**[b]	0.05	-0.01	0.11
Infection and Original Disease Criterion	6.2	1	0.013	0.03	-0.00	0.07
Hypertension and Original Disease Criterion	336.7	1	<0.001	**0.65****	0.58	0.72
Obstructed Labor and Original Disease Criterion	2.8	1	**0.097**[b]	0.06	-0.02	0.13
Mozambique Co-morbidities Measures with Original WHO Criterion:						
HIV/AIDS and Original Disease Criterion	0.2	1	**0.660**[b]	0.01	-0.05	0.08
Malaria and Original Disease Criterion	0.1	1	**0.714**[b]	-0.00	-0.03	0.019
Anemia and Original Disease Criterion	16.7	1	<0.001	0.08	0.02	0.14

** kappa values greater than 0.2 indicating fair or higher reliability

[b] p-value greater than 0.05 suggesting a lack of association between variables

// Information for Embolic Disease was excluded because sample size was insignificant to obtain accurate data//

Table 4.8. Results from Chi-Square Test of Independence and Kappa Statistic Between the Original WHO Disease Criterion vs the Mozambique Expanded Disease and Co-morbidities Criteria in HRV

Association Variable	Chi-square (χ^2)	d.f.	P-value	kappa Value	Confidence Interval	
					Lower	Upper
Mozambique Expanded Disease Measures with The Original WHO Criterion:						
Bleeding and Original Disease Criterion	64.8	1	<0.001	0.16	-0.53	0.84
Infection and Original Disease Criterion	37.4	1	<0.001	0.06	0.013	0.10
Hypertension and Original Disease Criterion	317.1	1	<0.001	**0.50****	0.43	0.57
Obstructed Labor and Original Disease Criterion	26.0	1	<0.001	0.10	0.071	0.21
Mozambique Co-morbidities Measures with The Original WHO Criterion:						
HIV/AIDS and Original Disease Criterion	2.3	1	**0.129**[b]	0.04	-0.014	0.096
Malaria and Original Disease Criterion	11.0	1	0.001	0.04	-0.00	0.08
Anemia and Original Disease Criterion	227.1	1	<0.001	**0.32****	0.24	0.40
Embolic Disease and Original Disease Criterion	12.4	1	<0.001	0.02	-0.00	0.05

** kappa values greater than 0.2 indicating fair or higher reliability

[b] p-value greater than 0.05 suggesting a lack of association between variables

The results of the multivariable analysis are presented in both Table 4.10 and Figure 4.2. The Hosmer-Lemeshow (goodness of fit) test showed that this model is well-fitted ($\chi^2 = 4.8$ [d.f. = 8, p-value = 0.780 > 0.05]). The results also reveal that about 84% of the time, the model successfully predicted the observed data points. None of the interactions terms tested were statistically significant. Likewise, no confounding effect from covariates was observed. In this multivariable model, only distance from the health facility remained statistically significant. Thus, the odds of MNMs was more than twice among the individuals who lived greater than 8km from the study hospitals than those who lived within 8km (OR = 2.47, 95%CI: 1.92-3.18).

Within the education group, only those who completed a technical or university degree was significantly associated with MNMs. Interestingly, the odds of identifying MNM cases was more than 89% greater among those who had a technical or university degree compared to those who never attended school (OR = 1.89, 95%CI: 1.02-3.52). While age was not statistically significant, Figure 4.3 shows a general graded trend where the odds of identifying MNMs increased as age categories progressed from 20 years to 40 years and older. Again, though not statistically significant, the patients who were admitted at HRV or those who were divorced/widowed were less likely to be identified as MNM cases in comparison to those admitted in HPI or who were married/lived maritally. (**Table 4.10, Figure 4.2**).

Table 4.9. Univariable Analysis on the Association Between Maternal Characteristics and the Original WHO Disease Criterion MNMs

Variables	Unadjusted OR	P-Value
Type of Hospital		**<0.001**
HPI	1 [Ref]	
HRV	0.65 [0.52-0.83]	<0.001
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	2.55 [2.00-3.23]	<0.001
Education Completed		**0.015**
None	1 [Ref]	
Primary School	0.63 [0.43-0.91]	0.013
Secondary School or Post-Secondary	0.75 [0.52-1.07]	0.112
Technical or University	1.25 [0.70- 2.23]	0.456
Profession		0.317
Unemployed	1 [Ref]	

Unqualified employment	1.28 [0.85-1.92]	0.235
Semi-qualified employment	1.36 [0.81-2.28]	0.247
Professional	2.04 [0.54-7.73]	0.295
Religion		0.581
Islam	1 [Ref]	
Christianity	1.32 [0.63-2.81]	0.464
Traditional	1.43 [0.53-3.82]	0.480
Other	6.88 [0.39-121.17]	0.188
Marital Status		**0.141**
Single	1 [Ref]	
Married or Live Maritally	1.31 [0.99-1.74]	0.060
Divorced or Widowed	0.64 [0.80-5.06]	0.670
Age Categories		**0.062**
≤ 19	1 [Ref]	
20-29	0.84 [0.62-1.13]	0.246

30-39	1.10 [0.79-1.53]	0.577
≥ 40	1.70 [0.88-3.27]	0.113

All boldened p-values indicate p-value < 0.20

Table 4.10. Multivariable Analysis on the Association Between Maternal Characteristics and Original WHO Disease Criterion MNMs

Variables	OR	P-Value
Type of Hospital		0.186
HPI	1 [Ref]	
HRV	0.84 [0.65-1.09]	0.186
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	2.47 [1.92-3.18]	<0.001
Education Completed		0.053
None	1 [Ref]	
Primary School	0.88 [0.59-1.33]	0.554

Secondary School or Post-Secondary	1.09 [0.72-1.65]	0.684
Technical or University	1.89 [1.02- 3.52]	**0.043**
Age Categories		0.382
≤ 19	1 [Ref]	
20-29	0.90 [0.66-1.23]	0.511
30-39	1.11 [0.77-1.59]	0.589
≥ 40	1.50 [0.73-3.09]	0.272
Marital Status		0.333
Single	1 [Ref]	
Married or Live Maritally	1.20 [0.89-1.61]	0.229
Divorced or Widowed	0.47 [0.06-3.78]	0.474

All boldened p-values indicate statistically significant values (p-value < 0.05)
Hosmer-Lemeshow Goodness of fit: (χ^2 = 4.790 [d.f. = 8, p-value = 0.780> 0.05])

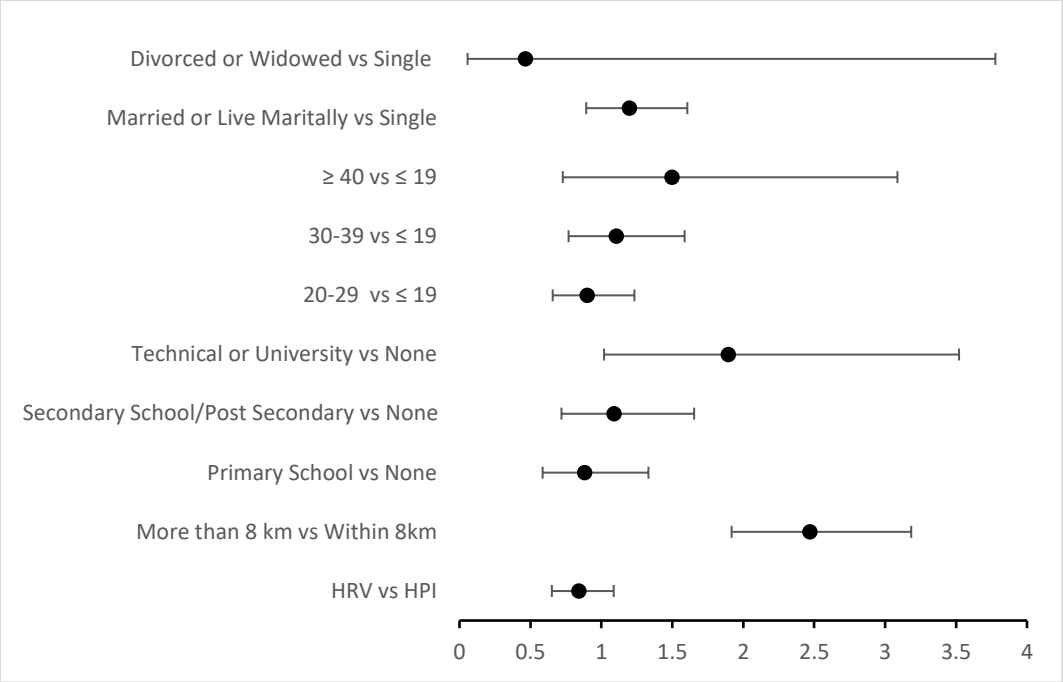


Figure 4.2. Odd Ratios of Sociodemographic Factors on MNMs Defined by The Original WHO Disease Criterion

4.4.2 Model II: Sociodemographic factors Associated with MNMs Identified by the Mozambique Expanded Disease Criterion

As presented in Table 4.11, only the type of hospital and place of residence were statistically associated with MNM defined by the Expanded Disease criterion. Accordingly, the odds of identifying MNMs were greater in participants who lived more than 8km from the hospital (OR = 2.37, 95%CI: 1.94-2.90) than those who lived within 8km. However, these odds were less among the group who attended HRV relative to those who went to HPI (OR = 0.58, 95%CI: 0.48-0.70). Although Education was not significantly associated, it was included in the model because it had a p-value < 0.20. All other covariates namely, marital status, religion, professional level, and age category were excluded from the multivariable model (p-value > 0.20).

Hosmer-Lemeshow (goodness of fit) test showed that the final multivariable model is well-fitted (χ^2 = 4.9 [d.f. = 7, p-value = 0.668 > 0.05]) and has a 71.9% accurate prediction of the observed events. No interaction was determined through statistical testing nor was a confounding effect observed with covariates. Like Model I, distance from health facility remained highly significantly associated with the odds of identifying MNMs with the group who lived greater than 8km having greater than 2 times the odds than those that lived within 8km of the facilities (OR = 2.26, 95%CI:1.83-2.78). Unlike the previous model, the type of hospital remained significant in the multivariate analysis as there was approximately 29% less likelihood of identifying an MNM case in the group who attended HRV than those at HPI (OR = 0.70, 95%CI:0.57-0.87). Even though education was not significantly associated, the same general trend was observed in Model II, where the odds of identifying MNMs increased with the progression of education from primary to technical/university level (**Table 4.12, Figure 4.3**).

4.4.3 Model III: Sociodemographic factors Associated with MNMs Identified by the Mozambique Co-morbidities Criterion

As shown in Table 4.13, the type of hospital, distance from hospital, educational level, and age categories, were each significantly associated with Mozambique Co-morbidities criterion MNMs in the univariable analysis. Living more than 8km from the health facility (OR = 1.34, 95%CI: 1.08-1.68) or patients at HRV (OR = 2.61, 95%CI: 2.04-3.33) increased the odds of being identified as an MNM case (within the Mozambique Co-morbidities criterion). Similarly, participants older than 19 years were more likely to be identified as MNM cases with the odds of MNMs among those 40 years and older almost 5 times that of 19 years or younger (OR = 4.93, 95%CI: 2.70-9.02). Surprisingly, the likelihood of identifying MNMs by this criterion decreased as the level of education increased.

Table 4.11. Univariable Analysis on the Association Between Maternal Characteristics and the Mozambique Expanded Disease Criterion MNMs

Variables	Unadjusted OR	P-Value
Type of Hospital		**<0.001**
HPI	1 [Ref]	
HRV	0.58 [0.48-0.70]	<0.001
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	2.37 [1.94-2.90]	<0.001
Education Completed		**0.095**
None	1 [Ref]	
Primary School	0.79 [0.57-1.08]	0.139
Secondary School or Post-Secondary	1.00 [0.73-1.35]	0.970
Technical or University	1.19 [0.70- 2.00]	0.525
Profession		0.779

Unemployed	1 [Ref]	
Unqualified employment	1.05 [0.74-1.48]	0.807
Semi-qualified employment	1.21 [0.77-1.88]	0.410
Professional	1.49 [0.44-5.12]	0.524
Religion		0.618
Islam	1 [Ref]	
Christianity	1.37 [0.75-2.51]	0.303
Traditional	1.17 [0.51-2.65]	0.713
Other	3.50 [0.21-59.59]	0.386
Marital Status		0.260
Single	1 [Ref]	
Married or Live Maritally	0.90 [0.72-1.11]	0.320
Divorced or Widowed	0.23 [0.03-1.84]	0.168
Age Categories		0.966
< 19	1 [Ref]	
20-29	1.01 [0.79-1.30]	0.936

30-39	1.06 [0.80-1.41]	0.668
≥ 40	1.07 [0.58-2.00]	0.825

All boldened p-values indicate p-value < 0.20

Table 4.12. Multivariable Analysis on the Association Between Maternal Characteristics and the Mozambique Expanded Disease Criterion MNMs

Variables	OR	P-Value
Type of Hospital		**0.001**
HPI	1 [Ref]	
HRV	0.70 [0.57-0.87]	0.001
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	2.26 [1.83-2.78]	<0.001
Education Completed		0.217
None	1 [Ref]	
Primary School	1.00 [0.71-1.37]	0.946

Secondary School or Post-Secondary	1.19 [0.87-1.64]	0.283
Technical or University	1.47 [0.85- 2.52]	0.167

All boldened p-values indicate statistically significant values (p-value < 0.05)
Hosmer-Lemeshow Goodness of fit: (χ^2 = 4.937 [d.f. = 7, p-value = 0.668> 0.05])

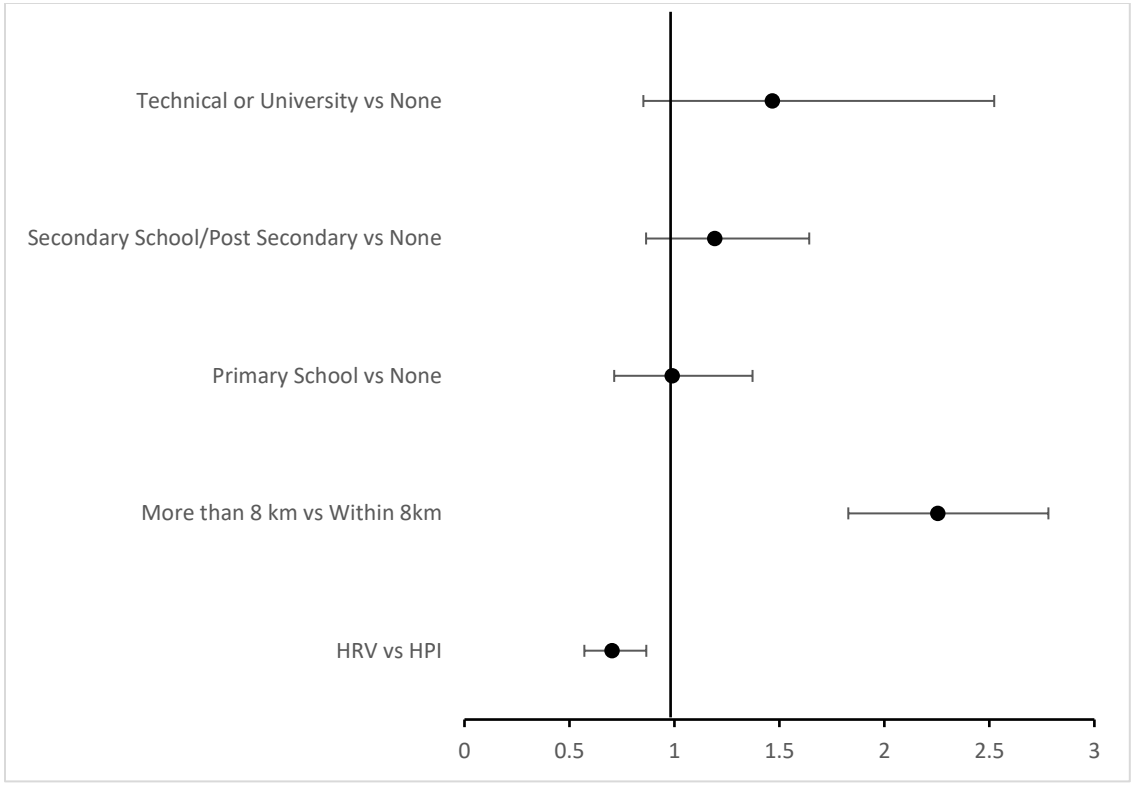


Figure 4.3. Odd Ratios of Sociodemographic Factors on MNMs as Defined By The Mozambique Expanded Disease Criterion

Women with a technical/university degree were about 72% less likely to be identified as MNM than those without any formal education (OR = 0.28, 95%CI: 0.14- 0.55). Profession, marital status, and religion were excluded from the multivariable analysis (p-value > 0.20).

Results from the Hosmer-Lemeshow (goodness of fit) test demonstrated that the final multivariable model is well-fitted (χ^2 = 5.8 [d.f. = 8, p-value = 0.674 > 0.05]) and has a 79.7% accurate prediction of the observed events. No interactions between covariates were observed. However, both educational level and type of hospital produced confounding effects (|Adjusted - Crude ORs| > 10%). In the adjusted model, the group who lived greater than 8km was about 57% more likely to be identified as MNMs than those who lived within that distance (OR = 1.58, 95%CI: 1.24-2.01). Unlike the previous models, being admitted to HRV, rather than HPI, increased the odds of identifying MNM (OR = 3.13, 95%CI: 2.40-4.10). Although educational level was not statistically associated with the outcome variable, it generally showed a trend opposite of that observed in model I. Thus, the odds of identifying MNMs decreased with increasing level of education from primary school to technical/university degree (**Table 4.14, Figure 4.4**)

Table 4.13. Univariable Analysis on the Association Between Maternal Characteristics and the Mozambique Co-morbidities Criterion MNMs

Variables	Unadjusted OR	P-Value
Type of Hospital		**<0.001**
HPI	1 [Ref]	
HRV	2.61 [2.04-3.33]	<0.001
Place of Residence		**0.009**
Within 8 km	1 [Ref]	
More than 8 km	1.34 [1.08-1.68]	0.009
Education Completed		**<0.001**
None	1 [Ref]	
Primary School	0.56 [0.41-0.76]	<0.001
Secondary School or Post-Secondary	0.39 [0.28-0.53]	<0.001
Technical or University	0.28 [0.14- 0.55]	<0.001
Profession		0.482

Unemployed	1 [Ref]	
Unqualified employment	1.00 [0.68-1.47]	0.997
Semi-qualified employment	0.63 [0.36-1.13]	0.122
Professional	0.81 [0.18-3.78]	0.793
Religion		0.540
Islam	1 [Ref]	
Christianity	1.42 [0.72-2.81]	0.317
Traditional	1.92 [0.80-4.60]	0.145
Other	0.000 [0.000]	0.999
Marital Status		0.865
Single	1 [Ref]	
Married or Live Maritally	1.02 [0.80-1.31]	0.856
Divorced or Widowed	1.44 [0.38-5.50]	0.598
Age Categories		**<0.001**
≤ 19	1 [Ref]	
20-29	1.63 [1.19-2.24]	0.003

30-39	2.88 [2.06-4.02]	<0.001
≥ 40	4.93 [2.70-9.02]	<0.001

All boldened p-values indicate p-value < 0.20

Table 4.14. Multivariable Analysis on the Association Between Maternal Characteristics and the Mozambique Co-morbidities Criterion MNMs

Variables	Adjusted OR	P-Value
Type of Hospital		**<0.001**
HPI	1 [Ref]	
HRV	3.13 [2.40-4.08]	<0.001
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	1.58 [1.24-2.01]	<0.001
Education Completed		0.060
None	1 [Ref]	
Primary School	0.70 [0.49-0.98]	**0.040**

Secondary School or Post-Secondary	0.67 [0.47-0.96]	**0.028**
Technical or University	0.45 [0.22- 0.91]	**0.027**
Age Categories		**<0.001**
≤ 19	1 [Ref]	
20-29	1.73 [1.25-2.40]	0.001
30-39	3.06 [2.15-4.36]	<0.001
≥ 40	4.73 [2.43-9.20]	<0.001

All boldened p-values indicate statistical significance of variable (p-value <0.05)
Hosmer-Lemeshow Goodness of fit: (χ^2 = 5.757 [d.f. = 8, p-value = 0.674> 0.05])

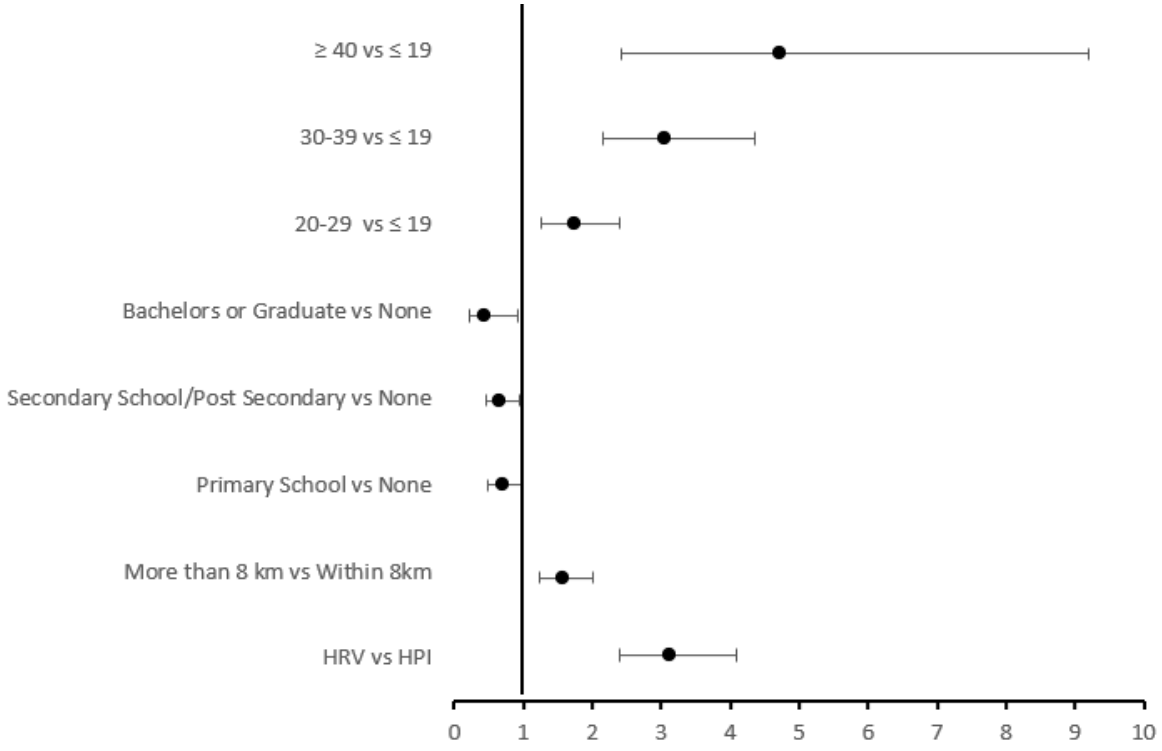


Figure 4.4. Odd Ratios of Sociodemographic Factors on MNMs Defined by The Mozambique Co-morbidities Criterion

4.4.4 Summary

Across all models, distance from health facility was significantly associated with the odds of identifying MNMs. Additionally, the type of hospital (HPI vs HRV) meaningfully contributed to 2 out of the 3 models: while admission to HRV decreased the odds of MNM identification in model containing the identification of MNMs identified by the Expanded Disease criterion, the opposite was true for MNMs identified by the Co-morbidities criterion. Generally, both educational and age categories showed increased odds of identifying MNMs as their levels increased except in the model of MNMs identified by the Co-morbidities group, where the opposite was observed for Educational level. No interaction terms were observed for all 3 models. Confounding effects of Education and Type of hospital were present in the model of MNMs identified by the Co-morbidities category. Profession and religion were not statistically associated with the outcome variable in any of the models. Finally, the Hosmer-Lemeshow goodness of fit test revealed that each final model was well-fitted.

4.5. Geographic and Socio-demographic Factors that are Associated with Identifying MNMs Stratified By Hospitals (HPI and HRV)

Since the type of hospital was significantly associated with MNMs in 2 out of the 3 models (**Sections 4.4.2 – 4.4.3**), logistic regression was performed on hospital-stratified data to determine if there were any hospital-specific variations in the models. When stratified by HPI, the only statistically meaningful model was established between sociodemographic factors and MNMs defined by the Mozambique Co-morbidities criterion. However, under HRV, significant models were established between sociodemographic factors and MNMs identified by the Original WHO Disease, Mozambique Expanded Disease, and Mozambique Co-morbidities criteria.

4.5.1 Geographic and Sociodemographic Factors that are Associated with MNMs Defined by The Mozambique Co-morbidities Criterion in HPI

As demonstrated in Table 4.15, distance from the hospital, education, and age were each statistically associated with MNMs identified by the Mozambique Co-morbidities criterion at HPI. Specifically, living greater than 8km from HPI (OR = 1.48, 95%CI: 1.00-2.26) or being older than 30 years (OR = 3.66, 95%CI: 1.74-7.69) increased the likelihood of MNMs being identified. In Contrast, the odds of identifying MNMs decreased as educational levels increased with approximately 62% less likelihood of identifying MNMs among the technical/university degree group as compared to those with no education. Although Profession was not significantly associated with the outcome variable, unqualified employment was significantly associated. Hence, the likelihood of identifying MNMs was 68% greater within this sub-category than those that were unemployed (OR = 1.68 95%CI: 0.91-3.08). Maternal status was also included in the multivariable model (p-value < 0.20) while Profession and Religion were excluded.

The Hosmer-Lemeshow (goodness of fit) test demonstrated that the final multivariable model is well-fitted ($\chi^2 = 4.1$ [d.f. = 8, p-value = 0.853> 0.05]). No interactions between covariates were observed nor was any confounding effect determined. In the multivariable model, only the age category was statistically associated with MNMs. As age increased, the odds of identifying MNMs also increased with those 30 years or older having more than 3 times the odds of being identified as MNMs than those 19 years or younger (OR = 3.12 95%CI: 1.40-7.00). Overall, education was not statistically significant. However, completing a secondary education significantly reduced the odds of identifying MNMs (OR = 0.53 95%CI: 0.27 -1.05). Surprisingly, distance from the hospital was not statistically associated with MNMs. Nevertheless, it followed the same trend as previous models where the increase in distance increased the odds of identifying MNMs. Although marital

status was also not significant, there was an increased odds of identifying MNMs in women who had partners than those without them (**Table 4.16, Figure 4.5**).

4.5.2 Geographic and Sociodemographic Factors that are Associated with MNMs Defined by The Original WHO Criterion in HRV

Univariable analysis revealed that only distance from HRV was statistically related to MNMs identified by the original WHO Disease criterion (**Table 4.17**). Thus, the odds of identifying MNMs was more than 2 times greater in the group that lived more than 8km than those who lived within this distance (OR = 2.45 95%CI: 1.75 -3.43). Additionally, being 40 years or older increased the likelihood of identifying MNMs by more than 3-fold than those 19 years or younger (OR = 3.00 95%CI: 1.22 -7.40). Both Marital Status and Age were included in the multivariable model because they had p-value < 0.20. Profession, Religion, and Educational level were excluded (p-value > 0.20).

The multivariate model was a good fit according to the Hosmer-Lemeshow statistic ($\chi^2 = 4.2$ [d.f. = 7, p-value = 0.751> 0.05]). No interactions between covariates were observed. No confounding effect was determined. According to both Table 4.18 and Figure 4.6, the odds of identifying MNMs was greater in participants who lived more than 8km than those who lived closer to the HRV (OR = 2.30 95%CI: 1.64 -3.24) or those who were 40 years and above than those 19 years or younger (OR = 2.34 95%CI: 0.93 -5.90). Although not significantly associated with MNMs, having a partner, or increasing in age generally increased the likelihood of identifying MNMs as shown in Figure 4.6.

Table 4.15. Univariable Analysis on the Association Between Socio-demographic Factors and the Mozambique Co-morbidities Criterion MNMs in HPI

Variables	Unadjusted OR	P-Value
Place of Residence		**0.072**
Within 8 km	1 [Ref]	
More than 8 km	1.48 [0.97-2.26]	0.072
Education Completed		**0.003**
None	1 [Ref]	
Primary School	0.54 [0.29-1.00]	0.048
Secondary School or Post-Secondary	0.35 [0.20-0.61]	<0.001
Technical or University	0.38[0.15- 1.01]	0.052
Profession		0.240
Unemployed	1 [Ref]	
Unqualified employment	1.68 [0.91-3.08]	**0.096**
Semi-qualified employment or Professional	1.21 [0.58-2.55]	0.609
Religion		0.816
Islam	1 [Ref]	

Christianity	1.47 [0.34-6.36]	0.608
Traditional or Other	1.85 [0.28-12.39]	0.525
Marital Status		**0.158**
Unpartnered	1 [Ref]	
Partnered	1.56 [0.84-2.88]	0.158
Age Categories		**0.001**
≤ 19	1 [Ref]	
20-29	1.01 [0.68-1.50]	0.046
≥ 30	3.66 [1.74-7.69]	0.001

All boldened p-values indicate p-value < 0.20

Table 4.16. Multivariable Analysis on the Association Between Socio-demographic Factors and the Mozambique Co-morbidities Criterion MNMs in HPI

Variables	OR	P-Value
Place of Residence		0.115
Within 8 km	1 [Ref]	
More than 8 km	1.45 [0.91-2.29]	0.115
Education Completed		0.256
None	1 [Ref]	
Primary School	0.74 [0.38-1.43]	0.372
Secondary School or Post-Secondary	0.53 [0.27-1.05]	**0.067**
Technical or University	0.50 [0.18- 1.37]	0.178
Marital Status		0.228
Unpartnered	1 [Ref]	
Partnered	1.47 [0.79-2.73]	0.228
Age Categories		**0.021**
≤ 19	1 [Ref]	

20-29	2.30 [1.08-4.91]	0.030
≥ 30	3.12 [1.40-6.97]	0.005

All boldened p-values indicate statistical significance of variable (p-value <0.05)
Hosmer-Lemeshow Goodness of fit: (χ^2 = 4.050 [d.f. = 8, p-value = 0.853> 0.05])

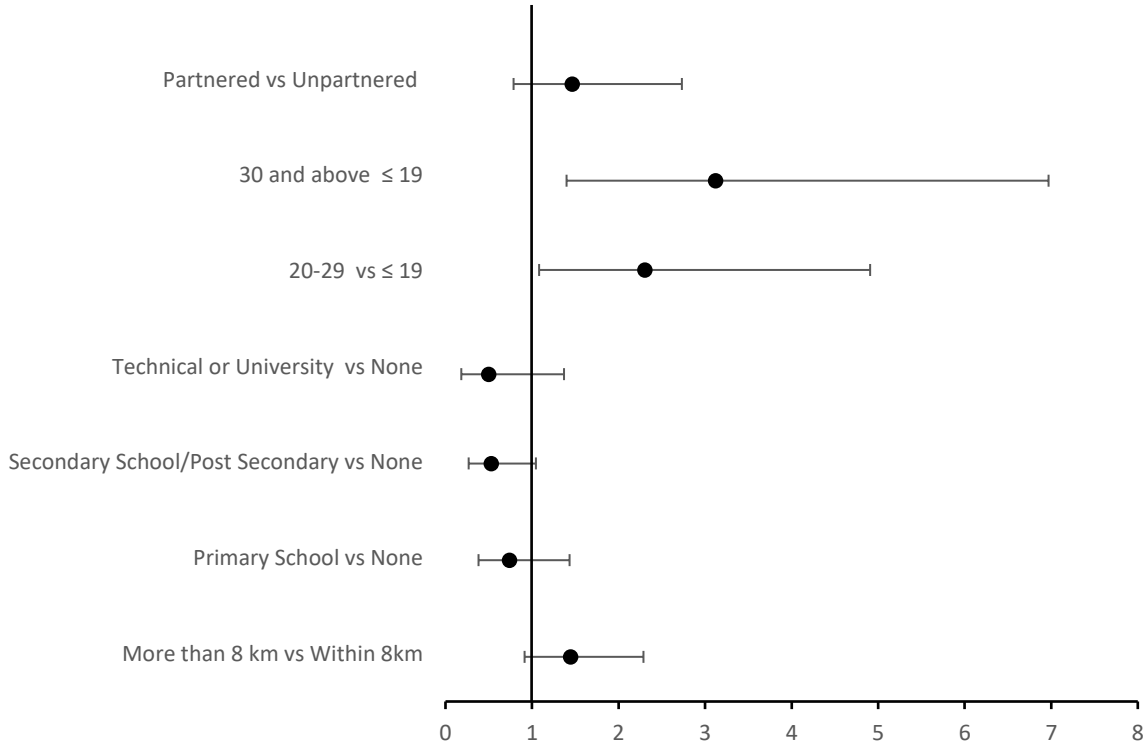


Figure 4.5. Odd Ratios of Sociodemographic factors on MNM Defined by Mozambique Co-morbidities Criterion at HPI

Table 4.17. Univariable Analysis on the Association Between Maternal Characteristics and Original WHO Disease Criterion MNMs in HRV

Variables	Unadjusted OR	P-Value
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	2.45 [1.75-3.43]	<0.001
Education Completed		0.210
None	1 [Ref]	
Primary School	0.74 [0.44-1.23]	0.243
Secondary School or Post-Secondary	0.86 [0.51-1.44]	0.565
Technical or University	1.75 [0.67- 4.60]	0.254
Profession		0.955
Unemployed	1 [Ref]	
Unqualified employment	0.97 [0.50-1.87]	0.921
Semi-qualified employment or Professional	1.14 [0.47-2.75]	0.779

Religion		0.290
Islam	1 [Ref]	
Christianity	3.11 [0.74-13.00]	0.121
Traditional or Other	3.41 [0.67-17.47]	0.141
Marital Status		**0.072**
Unpartnered	1 [Ref]	
Partnered	1.40 [0.97-2.01]	0.072
Age Categories		**0.089**
≤ 19	1 [Ref]	
20-29	1.02 [0.68-1.48]	0.916
30-39	1.19 [0.75-1.91]	0.462
≥ 40	3.00 [1.22-7.40]	**0.017**

All boldened p-values indicate p-value < 0.20

Table 4.18. Multivariable Analysis on the Association Between Maternal Characteristics and the Original WHO Disease Criterion MNMs in HRV

Variables	OR	P-Value
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	2.30 [1.64-3.24]	<0.001
Marital Status		0.121
Unpartnered	1 [Ref]	
Partnered	1.34 [0.93-1.94]	0.121
Age Categories		0.319
≤ 19	1 [Ref]	
20-29	1.07 [0.70-1.63]	0.751
30-39	1.20 [0.74-1.92]	0.478
≥ 40	2.34 [0.93-5.89]	**0.072**

All boldened p-values indicate statistical significance of variable (p-value <0.05)
Hosmer-Lemeshow Goodness of fit: (χ^2 = 4.249 [d.f. = 7, p-value = 0.751> 0.05])

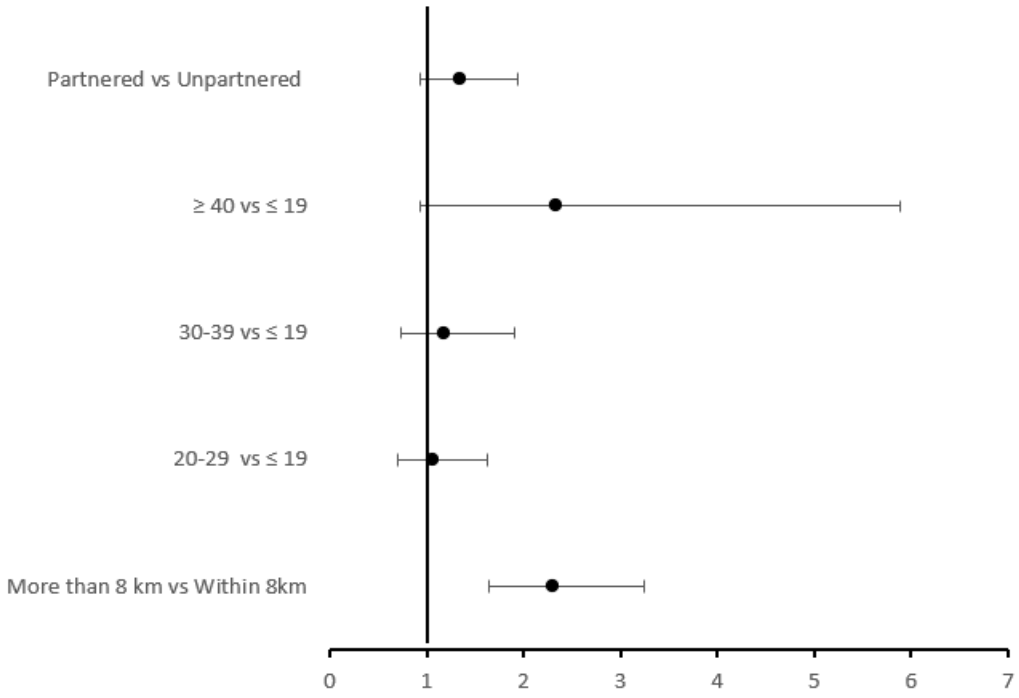


Figure 4.6. Odd Ratios of Sociodemographic factors on MNM Defined by The Original WHO Disease Criterion in HRV

4.5.3 Geographic and Sociodemographic Factors that are Associated with MNMs Defined by the Mozambique Expanded Disease Criterion in HRV

As shown in in Table 4.19, only distance was significantly associated with MNMs identified by the Mozambique Expanded Disease criterion in HRV. Those who lived farther than 8km had more than 2-fold odds of being identified as MNM than those who lived within this distance (OR = 2.33 95%CI: 1.75-3.08). Education, Religion, and Marital status were included in the multivariate model as their p-values < 0.20. Age, and Profession were excluded (p-value > 0.20).

Results from the Hosmer-Lemeshow (goodness of fit) test demonstrated that the final multivariable model is well-fitted ($\chi^2 = 2.0$ [d.f. = 7, p-value = 0.964 > 0.05]). No interaction nor confounding effect was observed between covariates. While there was an increased odds of identifying MNMs for the group who lived greater than 8km from HRV (OR = 2.43 95%CI: 1.82-3.25), there was a decreased odds within those who had partners (OR = 0.75 95%CI: 0.57-1.00). Although Educational level was not statistically significant, there was a general trend of the odds of identifying MNMs increasing with progression in Educational levels from Primary school to technical/university degree. Similarly, there was a general increase in the odds of identifying MNMs among Christians and Traditional worshippers as compared to Muslims, although religion was not statistically associated with MNMs (**Figure 4.7**).

Table 4.19. Univariable Analysis on the Association Between Maternal Characteristics and the Mozambique Expanded Disease Criterion MNMs in HRV

Variables	Unadjusted OR	P-Value
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	2.33 [1.75-3.08]	<0.001
Education Completed		**0.196**
None	1 [Ref]	
Primary School	0.76 [0.50-1.17]	0.210
Secondary School or Post-Secondary	1.01 [0.67-1.55]	0.945
Technical or University	1.16 [0.47- 2.85]	0.751
Profession		0.913
Unemployed	1 [Ref]	
Unqualified employment	1.12 [0.67-1.87]	0.678
Semi-qualified employment or Professional	0.97 [0.46-2.07]	0.941
Religion		**0.200**
Islam	1 [Ref]	

Christianity	2.23 [0.87-5.75]	0.096
Traditional or Other	1.70 [0.52-5.58]	0.379
Marital Status		**0.124**
Unpartnered	1 [Ref]	
Partnered	0.81 [0.61-1.06]	0.124
Age Categories		0.965
≤ 19	1 [Ref]	
20-29	1.03 [0.74-1.42]	0.881
30-39	1.00 [0.66-1.42]	0.861
≥ 40	1.19 [0.48-2.96]	0.705

All boldened p-values indicate p-value < 0.20

Table 4.20. Multivariable Analysis on the Association Between Maternal Characteristics and the Mozambique Expanded Disease Criterion MNMs in HRV

Variables	OR	P-Value
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	2.43 [1.82-3.25]	<0.001
Religion		0.146
Islam	1 [Ref]	
Christianity	2.45 [0.93-6.44]	0.069
Traditional or Other	1.79 [0.52-6.17]	0.356
Marital Status		**0.048**
Unpartnered	1 [Ref]	
Partnered	0.75 [0.57-1.00]	0.048
Education Completed		0.063
None	1 [Ref]	
Primary School	0.86 [0.55-1.32]	0.483
Secondary School or Post-Secondary	1.23 [0.79-1.92]	0.353

Technical or University	1.66 [0.66-4.20]	0.284

All boldened p-values indicate statistical significance of variable (p-value <0.05)
Hosmer-Lemeshow Goodness of fit: (χ^2 = 1.926 [d.f. = 7, p-value = 0.964> 0.05])

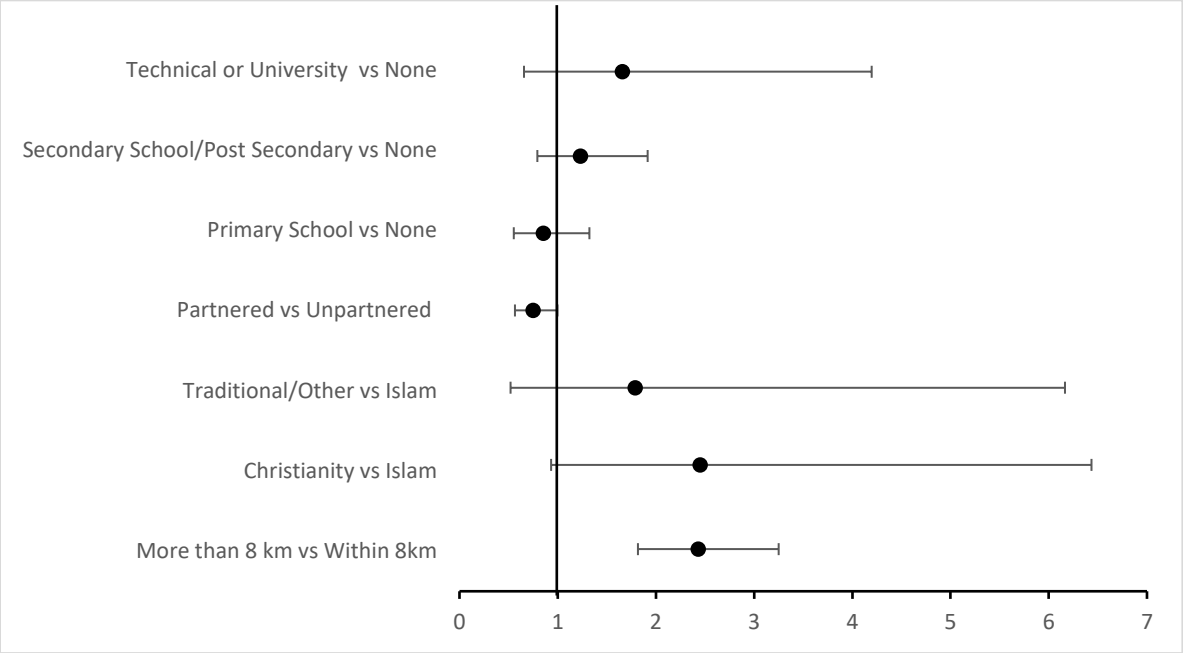


Figure 4.7. Odd Ratios of Sociodemographic Factors on MNM Defined by Maternal Characteristics and Mozambique Expanded Disease Criterion in HRV

4.5.4 Geographic and Sociodemographic Factors that are Associated with MNMs Defined by the Mozambique Co-morbidities Criterion in HRV

According to Table 4.21, distance from HRV, educational level, and age were each statistically associated with MNMs identified by the Mozambique Co-morbidities criterion. Thus, the group who lived farther than 8km were about 78% more likely to be identified as MNMs than those who lived closer (OR = 1.78 95%CI: 1.35-2.36). Again, as age increased, the likelihood of identifying MNMs increased. Women 30 years and above had about 3 times the odds of being identified as MNMs than those 19 years and younger (OR = 3.24 95%CI: 2.20-4.77). In contrast, as educational level increased, there was a decreased odds of identifying MNMs (OR = 0.30 95%CI: 0.11-0.82). All other categories were excluded from the multivariable analysis (p-value > 0.20).

The Hosmer-Lemeshow goodness of fit statistic showed that the model is well-fitted ($\chi^2 = 2.5$ [d.f. = 7, p-value = 0.927> 0.05]). There was no interaction between covariates or confounding effects were seen. Both distance from HRV and age remained statistically significant in the multivariate model (**Table 4.22**). Distance beyond 8km increased the odds of identifying MNMs by almost 62% (OR = 1.62 95%CI: 1.21-2.16). Additionally, the increase in age produced an increase in the odds of identifying MNMs with those 30 years and older showing more than 3 times the odds than those 19 years and younger (OR = 3.06 95%CI: 2.05-4.55). However, those who completed primary school were about 34% less likely to be identified as MNMs in comparison to those without any education (OR = 0.67 95%CI: 0.44-0.99). Although education overall was not statistically associated with MNMs, there was a general trend where the odds of MNM identification decreased as the level of education increased from Primary school to technical/university Degree (**Figure 4.8**).

Table 4.21. Univariable Analysis on the Association Between Maternal Characteristics and the Mozambique Co-morbidities Criterion MNMs in HRV

Variables	Unadjusted OR	P-Value
Place of Residence		**<0.001**
Within 8 km	1 [Ref]	
More than 8 km	1.78 [1.35-2.35]	<0.001
Education Completed		**<0.001**
None	1 [Ref]	
Primary School	0.47 [0.32-0.68]	<0.001
Secondary School or Post-Secondary	0.42[0.29-0.63]	<0.001
Technical or University	0.30 [0.11- 0.82]	0.019
Profession		0.440
Unemployed	1 [Ref]	
Unqualified employment	0.93 [0.55-1.55]	0.766
Semi-qualified employment or Professional	0.59 [0.26-1.35]	0.209
Religion		0.539
Islam	1 [Ref]	

Christianity	1.46 [0.67-3.21]	0.343
Traditional or Other	1.75 [0.65-4.74]	0.271
Marital Status		0.536
Unpartnered	1 [Ref]	
Partnered	1.09 [0.83-1.43]	0.536
Age Categories		**<0.001**
≤ 19	1 [Ref]	
20-29	1.57 [1.10-2.25]	0.041
30-39	3.242 [2.20-4.77]	<0.001
≥ 40	8.000 [3.42-18.69]	<0.001

All boldened p-values indicate p-value < 0.20

Table 4.22. Multivariable Analysis on the Association Maternal Characteristics and the Mozambique Co-morbidities Criterion MNMs in HRV

Variables	Adjusted OR	P-Value
Place of Residence		**0.001**
Within 8 km	1 [Ref]	
More than 8 km	1.62 [1.21-2.16]	0.001
Education Completed		0.103
None	1 [Ref]	
Primary School	0.67 [0.44-0.99]	**0.047**
Secondary School or Post-Secondary	0.68[0.45-1.05]	0.080
Technical or University	0.35 [0.12- 0.99]	**0.047**
Age Categories		**<0.001**
≤ 19	1 [Ref]	
20-29	1.60 [1.11-2.29]	0.011
30-39	3.06 [2.05-4.55]	<0.001
≥ 40	5.90 [2.43-14.29]	<0.001

All boldened p-values indicate statistical significance of variable (p-value <0.05)
Hosmer-Lemeshow Goodness of fit: (χ^2 = 2.505 [d.f. = 7, p-value = 0.927> 0.05])

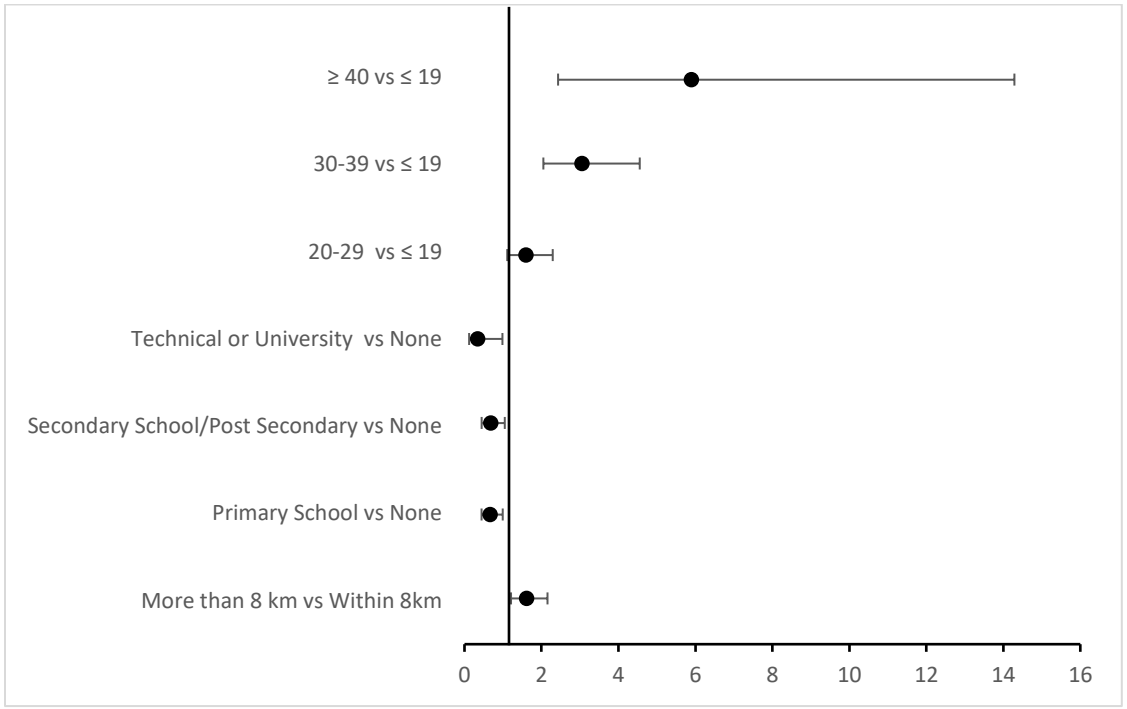


Figure 4.8. Odd Ratios of Sociodemographic Factors on MNM Defined by Maternal Characteristics and Mozambique Co-morbidities Criterion in HRV

4.5.5 Summary

At HPI, no significant models were obtained for associations between sociodemographic factors and MNMs identified by both the Original WHO Disease and Mozambique Expanded Disease criteria. Nevertheless, one was obtained for the relationship between these factors and the Mozambique Co-morbidities criterion. This model was similar to the model containing MNMs identified by the Co-morbidities criterion of the unstratified data (**Section 4.4.3; Figure 4.4**). Yet, one observed difference was that distance was not significantly associated with MNMs in the current model. Another difference was that marital status contributed to this new model. In HRV, meaningful models were obtained for associations between sociodemographic factors and MNMs identified by all three clinical criteria. Each of the 3 models followed similar trends as their counterpart models in the unstratified data. Of note, marital status contributed to 2 of the 3 models under HRV, namely MNMs identified by WHO disease and Expanded Disease criteria. Interestingly, this variable was absent from the model containing MNMs identified by the Expanded Disease criterion of the unstratified data (**Section 4.4.2)**.

CHAPTER 5

DISCUSSION

5.1. Summary of Findings

The aim of the current study was to determine how two additional categories namely, Expanded Disease and Co-morbidities, of the MCMH Abstraction tool, improved the capacity of the original WHO Disease criterion to identify MNMs in the Inhambane province of Mozambique. It also strived to examine the relationships between specific health facility, geographic, or socio-demographic factors and the identification of MNMs. Therefore, a secondary analysis was performed on data collected for the MNM 1.0 study. MNM 1.0 was a cross-sectional study carried out in both a secondary (HRV) and a secondary referral (HPI) hospital in Inhambane Province. Approximately 2057 respondents were assessed across both hospitals, between August 2021 and February 2022.

5.1.1 Association Between Expanded Disease or Co-morbidities Criteria and Original WHO Disease Criterion

In examining the relationship between Expanded Disease or Co-morbidities criteria with the Original Disease criterion, all markers under the Expanded Disease criterion were statistically associated with the original WHO disease category. Hypertensive disease was the most strongly associated and showed a moderate level of agreement with the original disease group. Likewise, some markers within the Co-morbidities category were significantly associated with the WHO clinical group except HIV/AIDS. Anemia was the most strongly associated and had a fair level of agreement with the WHO criterion. All other indicators had only a slight level of agreement with the original clinical category.

The data was further stratified to identify potential hospital-specific variations. Results from HRV generally mirrored the trends observed in the unstratified data. Anemia and Hypertensive

disorders continued to maintain a fair and moderate level of agreement with the original clinical group, respectively, while HIV/AIDS still showed a lack of association with the original Disease criterion. Unlike HRV, data from HPI revealed that only infection and Hypertensive disorders remained significantly associated with the original disease group under the Expanded Disease criterion and Hypertensive disorders still maintained a moderate level of agreement with the original disease group. Only Anemia was statistically associated with the WHO clinical group under the Co-morbidities criterion. Interestingly, Anemia showed no level of agreement with the Disease criterion at HPI.

5.1.2 Association Between Hospital, Geographical, or Socio-demographic Factors and MNMs Identified By Original WHO Disease, Expanded Disease, and Co-morbidities Criteria

Three models were obtained that demonstrated the association between hospital, geographic, and socio-demographic factors with the various MNM categories. Overall, Distance from the hospital showed a strong association with MNMs identified by all 3 clinical definitions. Specifically, distances greater than 8km more than doubled the odds of identifying MNMs in comparison with living within that distance to the facility. Also, the type of hospital was significantly associated with MNMs identified by the two newest categories, i.e., Expanded Disease and Co-morbidities criteria. The odds of identifying MNM cases was less in HRV than HPI under the Expanded Disease criterion. In contrast, the likelihood of identifying MNMs increased for HRV compared to HPI under the Co-morbidities criterion. Furthermore, Age was statistically associated only with MNMs identified by the Co-morbidities criterion. Thus, the odds of identifying MNMs in this category increased with the advancing of age. Although Education was not statistically associated with identifying the condition, it showed interesting trends within the models by showing patterns that are mostly contrary to the dominant literature. For instance,

the odds of identifying MNMs increased as the educational levels progressed from Primary to Technical/University degree for MNMs identified by both the Original WHO Disease and Expanded Disease criteria. The opposite effect was observed for the MNMs defined by Co-morbidities criterion, where these odds reduced with progression in educational level. Factors like Profession and Religion were absent from these models.

The data was stratified again by the Type of hospital to determine hospital-specific differences. At HRV, associations generally reflected the same trends as the unstratified data for Distance from the hospital, Age, and Education. Unexpectedly, marital status was also statistically associated with MNMs identified by the Expanded Disease criterion. Namely, women with partners had about 25% less likelihood of being identified as an MNM as compared to those without partners. Regarding HPI, only one meaningful model was obtained which demonstrated the relationship between factors and MNMs defined by the Co-morbidities criterion. Similar to the other Co-morbidities models, age was statistically associated with MNMs. Nevertheless, this was the only model where Distance from the hospital lacked an association with MNMs.

5.2. Interpretation of Results

Generally, the Organ-dysfunction criterion of the WHO abstraction tool is the most conservative for identifying MNMs. This category identifies even fewer cases in LMICs due to the lack of laboratory capacity and skilled personnel necessary to assess organ failure markers. (14,26,57) Consequently, the growing consensus is to rely on the disease-based criterion which identifies a greater number of MNMs. (14) For example, in a Malawian district hospital, while 88% of patients were defined as MNM by the Disease criterion, only 22% were identified by the Organ-dysfunction category.(14) Also, Tura and colleagues observed, in their study, that the adapted SSA clinical criterion recognized 56% of MNM cases while the Organ-dysfunction

criterion of the original WHO tool identified only 12% of them.(26) Similarly, the disease-based criterion in our study identified 13.5% more MNMs than the Organ-dysfunction group.

Across the SSA literature, the biggest clinical markers of MNMs are Hemorrhage and Hypertensive disorders. (13,14,17,26,57-61) Most studies report post-partum hemorrhage as the highest cause of MNMs in SSA ranging from 20% to 57% of all the cases. (59-60) This is closely followed by Hypertensive disorders that range between 20% and 53% of MNMs. (19,58-60) Other studies also include Anemia and Dystocia as top causes of maternal morbidity. (7,14,62-62) Regarding this current study, Hypertensive disorders, and Anemia were the biggest contributors to MNMs. In contrast, Hemorrhage contributed only to 3.3% of all cases. This may be partly explained by an effective hospital management protocol for hemorrhages such as the rapid administration of blood transfusion. (64) This is further evidenced by the fact that about 72% of all MNMs identified by the Intervention criterion received blood transfusion. Alternatively, the low hemorrhage cases could be attributed to a renewed focus on clinical upgrade training on managing obstetrical complications, hemorrhage in particular, partly as a result of the training provided by the Mozambique-Canada Maternal Health project to health personnel within this province.

The Expanded Disease criterion of the MCMH model also showed Hypertensive disorders and Dystocia as the main contributors to all MNMs. However, it captured more cases than the original WHO Disease criterion. Because there was a strong association between these 2 categories, it suggests that they both target similar populations even though the former includes more MNMs. The moderate level of agreement between Hypertensive diseases of the Expanded criterion and the original clinical category further buttresses the point that the biggest contributor of the Expanded group, while including more MNMs, still relates to the original Disease criterion. Notably, this

overlap between the 2 criteria was more pronounced in HRV than HPI where only 2 markers, Hypertensive disorders and Infection, were associated with the original clinical criterion. Collectively, the results suggest that the Expanded Disease criterion could potentially replace or be used alongside the original WHO criterion to identify more MNMs from the same general target population especially in HRV.

Although HIV/AIDS was the highest indicator for MNMs identified by the Co-morbidities criterion, it consistently lacked an association with the original disease category across both hospitals. Other Co-morbidities markers, like Malaria and Embolic disease, showed weak associations with the original clinical group as well. Anemia was the only marker that showed a consistently strong association with the WHO criterion and demonstrated a fair level of agreement with this original clinical category. Researchers assert that Co-morbid/pre-existing non-obstetric indicators only account for a small subset of all MNMs. For instance, a study showed that only 2.5% of cases were associated with HIV/AIDS and 4.1% with Malaria.(65) Again, Oladapo and colleagues noted that these Co-morbid diseases contributed only marginally to the overall MNM cases in their study. Nonetheless, they also observed that these diseases disproportionately contributed more to maternal deaths. Thus, in their study, while only 6.8% of all MNMs were attributed to Co-morbid diseases, about 19.6% of maternal deaths were associated with these underlying non-obstetric markers. (19) Overall, the results indicate that the Co-morbidities criterion, except Anemia, does not help improve the capacity of the original disease group in identifying MNMs across both hospitals.

To further understand the profile of a potential MNM, it is necessary to understand the structural factors underpinning the condition. (54) Distance from the hospital was consistently associated with MNMs, regardless of the clinical definition. Thaddeus and Maine stipulated, in

their 3-delay framework, that Distance from a health facility was an essential determinant of the 2nd type of delay that increases the risk of maternal near-miss and/or death. (66) In many rural areas within SSA, the paucity of public transportation, high transport cost, and/or poor road infrastructure exacerbates the delays in reaching these facilities during an obstetric complication. (16,63,67-68). The unavailability of suitable transportation consequently forces some women to walk the distance during their crises. (15,22,67) A study showed that walking for more than 1 hour to a health facility was associated with about 4 times higher odds of MNMs (15). Another study revealed that delays caused by the lack of vehicles increased the odds of MNMs by 8 times. (34) Furthermore, Hadush observed that delays in reaching a health facility contributed to about 40% of the maternal morbidities in their study. (69) Since our results reveal similar trends, it suggests that significant delays potentially occur for patients who live greater than 8km from a health facility due to transport-related issues which subsequently increases their odds of MNMs. It is important to highlight that the study does not capture the role of secondary markers related to distance, such as road infrastructure and transportation, in delays within rural areas. For instance, a woman who lives 8km from an obstetric care center but has readily available transportation and good roads to the health facility will be less impacted by delays than one who lives at the same distance but lacks transportation and good roads to the hospital. Consequently, future studies are needed to fully characterize a more comprehensive understanding of the role of these secondary factors in the risk of MNMs in rural parts of Inhambane.

The type of hospital was also significantly associated with the identification of MNMs by the additional clinical categories. As compared to HPI, it was less likely for patients to be identified as MNMs in HRV under the Expanded Disease criterion. One potential reason is that, as a provincial secondary referral hospital, HPI receives patients in more critical clinical conditions

than those seen by HRV. Conversely, the odds of identifying MNMs using the Co-morbidities criterion was higher in HRV than HPI because HRV screens more for co-morbid conditions, like HIV/AIDS and Malaria, than HPI. It is interesting to note that the Type of hospital did not influence the identification of MNMs under the original WHO Disease criterion. Again, this suggests that the WHO abstraction tool is more conservative in MNM identification.(26) Therefore, incorporating these additional clinical categories possibly expands the range of structural factors to consider, like the type of health facility, when creating a potential MNM profile.

As expected, advancement in Age increased the odds of identifying MNMs in the Co-morbidities criterion. (15,21,70-72) It is well-established that the risk of maternal morbidities is higher at two periods in a woman's reproductive life cycle (54,71) The first is during adolescence (10 years -19 years) and the second is at the end of a woman's -reproductive life (35 years and above). (71,73) One study shows that for women 10 to 15 years, their risk of maternal mortality is about five-fold higher than women between 20 to 24 years. (73) Another study presented that women older than 35 years were 74% more likely to develop a maternal near-miss than women between 25 and 34 years. (21) Women above 35 years especially run a higher risk of developing co-morbid diseases such as hypertension, heart and thyroid disease, and diabetes that complicate their pregnancies and make them more susceptible to MNMs. (21) This may also explain why the odds of identifying MNMs in women over 35 years was almost 5-fold within the Co-morbidities group in our study as well. Although this socio-demographic factor did not show a significant association with MNMs identified by the other clinical criteria, it is important to realize that a similar trend was seen with the odds of identifying MNMs defined by the original WHO Disease criterion. In summary, Age may be an important factor to consider when building the MNM profile

especially when relying on the Co-morbidities definition within secondary hospitals across Inhambane.

Most studies have also documented Education as an important socio-demographic factor associated with MNMs. (15,21-22,72,74) Generally, women with no formal education have greater odds of MNMs than those with advanced degrees. (15,21-22,74) For instance, Dessalegn and colleagues report that a lack of formal education increased the odds of MNMs by more than twice that of women with a Bachelors degree in their study conducted within public hospitals across Oromia state in Ethiopia. (22) Possibly, women without formal education lack access to relevant information that augments their awareness of pregnancy complications and the need to seek better healthcare. (22,64) Surprisingly, there was no statistically significant associations between education and MNMs defined by all 3 clinical groups in our study. Yet, for the WHO disease and Expanded Disease models, education showed an opposing trend to the dominant literature. Thus, an increase in educational level increased the odds of identifying MNMs. In a society where a person's higher social standing typically attracts preferential treatment, it is likely that more attention is given to women with higher educational status who present with obstetric complication and thereby improves the rapid identification of MNMs within this group compared to those of lower educational status. One study in Iran observed the same trend as this current study. However, it attributed the phenomenon to the tendency of highly educated women to choose cesarean sections that further increases the risk for MNMs. (72) On the other hand, the Co-morbidities model showed a trend that was parallel to the dominant evidence. This could be as a result of the ability of higher educated women to gain access to better care for the management of their co-morbid diseases. Overall, although there were no statistical associations between Education and MNM identifications, future studies should be performed to explore these intriguing patterns.

In SSA, marital status also serves as another prominent marker of MNMs. (35,66,68) This socio-demographic factor was statistically associated only with MNMs identified by the Expanded model in the HRV-stratified data. Women who were married or live maritally were less likely to be experience a MNM than those without partners. This finding is consistent with the current literature. According to Adeoye et al, unmarried women had more than 3 times the odds of MNMs compared to their married counterpart. (68) Assarag also noted that a lack of male family authority causes significant delays that increase the risk of maternal morbidities. (35,66) Since husbands typically hold the decision-making power, financial resources, and social capital to form social networks with people who can assist with transportation, their decisions to allow their wives to seek prompt medical care is crucial to avoiding MNMs or the worsening of the condition. (35,66,68,75) Hence, several interventions to improve the healthcare-seeking behavior of women in rural areas usually involve their husbands. (76) In situations where husbands lack the necessary obstetric awareness, the odds of MNMs increase by more than 5-fold. (21) This may also explain why this phenomenon was not observed in HPI since the decision-making power to refer the pregnant woman to HPI mainly lies with the clinicians from where she is transferred. In summation, the evidence indicates that marital status should be considered when describing MNM profiles, especially within rural health facilities, like HRV.

Our study did not find any statistically meaningful associations between Profession or Religion and MNMs in all 3 models. This is potentially because of the homogeneity of the study population as majority of women were unemployed and Christian. Different groups of women with varying professional and religious background should therefore be included in future studies.

5.3. Strengths and Limitations of Study

This study has several strengths. To the best of our knowledge, it is one of the first studies that attempt to evaluate the Mozambique-Canada Maternal Health Abstraction tool and to refine the WHO clinical definition of MNMs based on local Mozambican clinical contexts. It also sheds more light on specific socio-demographic factors that help influence MNM identification in Inhambane. Moreover, the design of the MCMH abstraction tool – to include both the additional and original MNM clinical criteria – helps to better compare data and improve internal validity. This sharply contrasts with other studies where the WHO tool is completely separate and different in design from the adapted versions, potentially causing inconsistencies in the data collection and comparison processes. (13,19,21,58) Again, this study worked directly with local clinicians who provided relevant clinical and cultural information to help contextualize the investigation. Another major strength was our considerable study sample that was comparable to the sample sizes present in the literature. Furthermore, since all pregnant women, who visited both HPI and HRV, were eligible and were approached to participate over a 6-month period, the resultant sample was appropriately representative of the patient populations at both health facilities. Consequently, the findings are sufficiently generalizable to those patients admitted to both institutions.

Nevertheless, some limitations must be acknowledged. For instance, we observed some data quality issues, such as participants receiving the same unique identifiers on separate hospital admissions. However, these errors were corrected during the data cleaning phase. Also, the rigor of the study could have been further strengthened by introducing external control. Specifically, a clinician could have performed their own clinical diagnoses of potential MNMs, independent of any abstraction criterion, as another source of comparison with both the WHO disease and additional abstraction criteria. Another limitation is the homogeneity of the study population that

potentially narrows the ability to broadly generalize the findings beyond this circumscribed population. Additionally, the lack of ICD-coded medical abstractions diminishes its capacity for comparability with other findings. Finally, the cross-sectional design of this study produces limitations such as non-response bias, recall bias, difficulty in making causal inferences, and social desirability bias.

Despite these limitations, our study unveiled important findings concerning MNM identification in rural settings. We hope that these findings can be applied to the current maternal health practices to improve obstetric care especially within health facilities across Inhambane.

5.4. Recommendations and Future Research

The current study provides important practical implications for MNM mitigation within rural settings, particularly, to improve the capacity of the WHO Disease criterion in identifying potential MNMs. The findings from this study are important to health practitioners as well as to policy- and decision-makers.

The study revealed that the MCMH tool provides more comprehensive and detailed locally-relevant clinical information to health personnel, that may not typically be captured by routine clinical assessments of obstetric complications. Specifically, it showed that Hypertension and Anemia were the leading contributors of MNMs within the Inhambane area. Armed with this information, clinicians can incorporate these indicators into their standard of care matrix to better identify potential MNM cases. Additionally, health practitioners can combine these clinical indicators with the socio-demographic factors, like distance to hospital and age, to predict potentially high risk pregnant women and provide adequate care to prevent the occurrence and or worsening of MNMs. Thus, health personnel will be able to equitably distribute their attention and

resources in a manner where vulnerable patients are provided fair opportunities to improve their health outcomes.

Policymakers can also utilize the study findings to implement policies that address and improve determinants of maternal healthcare. For instance, policymakers can rely on findings of anemia and hypertension to initiate community-based programs geared towards improving nutrition and heart health for women within Inhambane. In addition, findings about the impact of distance and type of hospitals on MNMs could motivate decision-makers to provide adequate road and obstetric care infrastructure to augment the overall maternal healthcare provision within the province.

To further advance the identification of MNMs using the MCMH model, future research is needed. For example, more investigation is required to determine if the MCMH tool produces similar results within different levels of care, such as primary and tertiary-level facilities. Although Profession and Religion were not statistically associated to MNMs in our study, further research should be done to test these associations within more diverse study populations. Furthermore, other socio-demographic factors that were not originally captured should also be tested based on the available literature. Although interrogating the quality of obstetric care by healthcare providers and the Mozambican health system were out of scope for this current study, it should be researched in the future. Finally, qualitative studies should be conducted to provide more insight that complement the findings of this present study.

5.5. Conclusion

This study focused on understanding the impact of the additional MCMH clinical criteria on the original WHO disease identification of MNMs within two secondary facilities in Inhambane

province. It also explored the association between different socio-demographic factors with the identification of the condition.

It is evident that the additional clinical categories identified more potential MNMs than the WHO disease group. The clinical markers of the Expanded Disease criterion showed a strong association with the original disease group, suggesting an overlap between their target patient populations. This was even more evident in HRV than in HPI. On the contrary, markers, like HIV/AIDS, within the Co-morbidities criterion, consistently did not show any statistical associations with the original clinical group, thereby indicating less overlap between their populations.

The study also showed that geographical and socio-demographic factors such as longer distance to a health facility, increased the odds of identifying MNMs while being admitted to HRV reduced the odds of identifying MNMs. The results further demonstrated that the additional clinical categories included more significant associations between these factors and MNMs than the original WHO Disease criterion, thereby broadening the capacity of the MCMH tool to include more potential cases. Again, there was more consistency between the patterns of associations between sociodemographic factors and both the WHO disease and Expanded disease criteria than between these factors and the Co-morbidities group, consequently suggesting closer relatedness among the former groups than among the latter. Finally, no significant associations were observed between Profession or Religion and MNMs defined by all 3 clinical criteria.

In summation, the study provides evidence to support the use of the Expanded Disease criterion in conjunction with the original WHO disease category to identify a broader range of MNMs. It also suggests that specific socio-demographic factors should be assessed to guide the

identification of these cases. Based on the results, health practitioners and policy makers can tailor necessary changes that will improve the overall obstetric healthcare in Inhambane province.

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APPENDIX A: ETHICAL APPROVAL

UNIVERSITY OF SASKATCHEWAN

Biomedical Research Ethics Board (Bio-REB) 07-Dec-2022

Certificate of Approval

Application ID: 3774

Principal Investigator: Nazeem Muhajarine

Department: Department of Community Health and Epidemiology

Locations Where Research Activities are Conducted: Vilankulo Rural Hospital, Inhambane Province, Mozambique Inhambane Provincial Inhambane Province, Mozambique, Mozambique

Student(s): Maud Zinayele Muosieyiri

Funder(s): College of Medicine

Sponsor: University of Saskatchewan

Title: Evaluating The Effectiveness Of The Canada-Mozambique Project Abstraction Tool (CM Tool) In The Identification Of Maternal Near Miss (MNM) Events

Protocol Number:

Approved On: 05-Dec-2022

Expiry Date: 05-Dec-2023

Approval Of:

* Bio 3774 NER_Ethics Applicant Responses
* Behavioural Applicatio Form_Ethics Application_Revised_Track-Change version

Acknowledgment Of:

* TCPS 2: CORE Tutorial Certificate of Completion for Maud Muosieyiri
* National Ethics Approval letter_Mozambique
* Muhajarine N 2022 Nov CV Form 1 v2

Review Type: Delegated Review

IRB Registration Number: Not Applicable

CERTIFICATION

The University of Saskatchewan Biomedical Research Ethics Board (Bio-REB) has reviewed the above-named project. The project was found to be acceptable on scientific and ethical grounds. The principal investigator is responsible for obtaining any other administrative or regulatory approvals that may pertain to this project, and for ensuring that the authorized project is carried out according to governing law. This approval is valid for the specified period, provided there is no change to the approved project.

FIRST TIME REVIEW AND CONTINUING APPROVAL

The University of Saskatchewan Research Ethics Boards review above minimal risk projects at full-board meetings. If a project is reviewed at a full board meeting, any subsequent projects being added with the same protocol may be reviewed through the delegated review process. Research classified as minimal risk is reviewed through the delegated review process. The initial Certificate of Approval indicates the approval period the REB has assigned to a study.

To remain in compliance, the REB must receive a status report form (renewal or closure) prior to the assigned expiry date each year. Any specific requirements of the sponsoring organizations deemed necessary for continuing ethics review (e.g., requirement for full-board review and approval) should be indicated by the researcher to the REB. Any change to the approved project must be reported to the Chair of the Bio-REB for consideration in advance of its implementation through the amendment process.

REB ATTESTATION

In respect to clinical trials, the University of Saskatchewan Bio-REB complies with the membership requirements for Research Ethics Boards defined in Part 4 of the Natural Health Products Regulations and Part C Division 5 of the Food and Drug Regulations, and carries out its functions in a manner consistent with Good Clinical Practices. The University of Saskatchewan is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans - TCPS 2 (2018). If a member of the REB is named as an investigator on a project under review, the member is absent from REB deliberations and decisions regarding the project. This approval and the views of the Bio-REB have been documented in writing.

Digitally Approved by Dr. Gordon McKay, Ph.D.
Vice-Chair, Biomedical Research Ethics Board
University of Saskatchewan

APPENDIX B: SURVEY QUESTIONNAIRES

Annex 2. Sample data collection form

World Health Organization

Maternal Near-Miss Tool

Individual data collection form

WHO MNMA 1.1

IDENTIFICATION

Facility code (1-20): ☐☐ Individual identification code: ☐☐☐☐

SCREENING QUESTIONS

In the questions 1 to 4, please specify:

0= The condition was not present during the hospital stay
1= The condition was present at arrival or within 12 hours of hospital arrival
2= The condition developed after 12 hours of hospital arrival
3= Information not available / unknown or not applicable

1. Severe complications / potentially life-threatening conditions

☐ A0 Severe postpartum haemorrhage
☐ A1 Severe preeclampsia
☐ A2 Eclampsia
☐ A3 Sepsis or severe systemic infection
☐ A4 Ruptured uterus

2. Critical interventions or intensive care unit admission

☐ B0 Use of blood products (includes any blood transfusion)
☐ B1 Interventional radiology (uterine artery embolization)
☐ B2 Laparotomy
☐ B3 Admission to Intensive Care Unit

3. Organ dysfunction / life-threatening conditions

☐ C0 **Cardiovascular dysfunction**
[shock, use of continuous vasoactive drugs, cardiac arrest, cardio-pulmonary resuscitation, severe hypoperfusion (lactate >5 mmol/L or >45mg/dL) or severe acidosis (pH<7.1)]

☐ C1 **Respiratory dysfunction**
[acute cyanosis, gasping, severe tachypnea (respiratory rate>40 bpm), severe bradypnea (respiratory rate<6 bpm), severe hypoxemia (PAO2/FiO2<200 O2 saturation <90% for ≥60min) or intubation and ventilation not related to anaesthesia]

☐ C2 **Renal dysfunction**
[oliguria non responsive to fluids or diuretics, dialysis for acute renal failure or severe acute azotemia (creatinine ≥300umol/ml or ≥3.5mg/dL)]

☐ C3 **Coagulation/hematologic dysfunction**
[failure to form clots, massive transfusion of blood or red cells (≥ 5 units) or severe acute thrombocytopenia (<50,000 platelets/ml)]

☐ C4 **Hepatic dysfunction**
[jaundice in the presence of pre-eclampsia, severe acute hyperbilirubinemia (bilirubin>100umol/L or >6.0mg/dL)]

☐ C5 **Neurologic dysfunction**
[prolonged unconsciousness / coma (lasting >12 hours), stroke, status epilepticus / uncontrollable fits, total paralysis]

☐ C6 **Uterine dysfunction / Hysterectomy**
[haemorrhage or infection leading to hysterectomy]

4. Maternal deaths

☐ D0 Death during pregnancy or within 42 days of termination of pregnancy
☐ D1 Death after 42 days of termination of pregnancy

Please note:
i. If you answered "1" or "2" to any of the questions 1 to 4, go to question 5
ii. If you answered "0" to all of the questions 1 to 4, the woman is not eligible for this assessment. Do not answer the questions 5 to 14
iii. In case of doubt on questions 1 to 4, consult the attending physician
iv. In the questions 5 to 14, if information is not available, unknown or not applicable, fill with "9"(s)

MATERNAL AND PERINATAL INFORMATION

5. Date of hospital admission d d m m y y y y ☐ E0

6. Date of delivery or uterine evacuation d d m m y y y y ☐ E1

7. Date of hospital discharge or death d d m m y y y y ☐

8. Final mode of delivery / end of pregnancy. Please specify: ☐ E3

1= Vaginal Delivery
2= Caesarean section
3= Complete abortion
4= Curettage / vacuum aspiration
5= Medical methods for uterine evacuation
6= Laparotomy for ectopic pregnancy
7= Laparotomy for ruptured uterus
8= Women discharged or died still pregnant
9= Unknown / other

9. Best estimate of gestational age in completed weeks (obstetric/neonatal) at:

Delivery or abortion (not applicable if Q8="8") ☐☐ E4

Maternal death or hospital discharge (applicable if Q8="8") ☐☐ E5

10. Regarding the vital status of the infant, please specify: 0=Alive 1=Dead

At birth ☐ E6
At hospital discharge or on the 7th day of life if still in the hospital ☐ E7

PROCESS INDICATORS

11. About conditions at arrival in the facility and the referral process, specify: (0=No 1=Yes)

☐ F0 Delivery or abortion occurred before arrival at any health facility
☐ F1 Delivery within 3 hours of arrival in the health facility
☐ F2 Laparotomy within 3 hours of hospital arrival or in other hospital
☐ F3 Woman referred from other health facility
☐ F4 Woman referred to any higher complexity hospital

12. About the use of interventions, please specify whether the woman received any of the following : (0=No 1=Yes)

Prevention of postpartum haemorrhage
☐ G0 Oxytocin ☐ G1 Other uterotonic

Treatment of postpartum haemorrhage
☐ H0 Oxytocin ☐ H5 Removal of retained products
☐ H1 Ergometrine ☐ H6 Balloon or condom tamponade
☐ H2 Misoprostol ☐ H7 Artery ligation (uterine/hypogastric)
☐ H3 Other uterotonics ☐ H8 Hysterectomy
☐ H4 Tranexamic acid ☐ H9 Abdominal packing

Anticonvulsant
☐ I0 Magnesium sulfate ☐ I1 Other anticonvulsant

Antibiotics
☐ J0 Prophylactic antibiotic during caesarean section
☐ J1 Parenteral, therapeutic antibiotics

Fetal lung maturation
☐ K0 Corticosteroids (betamethasone or dexamethasone)

UNDERLYING CAUSES OF DEATH / NEAR MISS

13. Please specify: (0=No 1=Yes)

☐ L0 Pregnancy with abortive outcome (abortion/ectopic pregnancy)
☐ L1 Obstetric haemorrhage
☐ L2 Hypertensive disorders
☐ L3 Pregnancy-related infection
☐ L4 Other obstetric disease or complication
☐ L5 Medical/surgical/mental disease or complication
☐ L6 Unanticipated complications of management
☐ L7 Coincidental conditions
☐ L8 Unknown

CONTRIBUTORY / ASSOCIATED CONDITIONS

14. Please specify: (0=No 1=Yes)

☐ M0 Anaemia
☐ M1 HIV infection
☐ M2 Previous caesarean section
☐ M3 Prolonged/obstructed labour
☐ M4 Other condition specified in the local manual of operations
☐ M5 Other condition specified in the local manual of operations
☐ M6 Other condition specified in the local manual of operations
☐

Date

MATERNAL NEAR-MISS: INHAMBANE

INDIVIDUAL FORM

Instructions

This form consists of 9 main sections. All sections must be completed. If there is no information, the information is not available, or is not applicable, fill in 9. **Questions 29 to 32 are crucial to this study. If in doubt, CONSULT the hospital's research supervisor.**

In case of incorrect insertion, scratch without blurring, and write the correct information out of the

Study population - eligibility criteria All Women admitted during pregnancy, childbirth or within 42 days after delivery or termination of pregnancy (including abortion and ectopic pregnancy) or pregnant women, women in

PILOT STUDY, MOZAMBIQUE

No._____

square and then place your initials.

postpartum who died on the way to the hospital or brought dead to the hospital during the study period.

A. IDENTIFICATION

1. Identification: a) Health Facility code 01 = HPI 02 = HRV

b) Participant's No.

2. Date of hospitalization: d d m m a a a a

3. Date of hospital discharge or d d m m a a a a death:

4. Admission mode: 1 = Emergency 2 = Regular

5. Admission time: 1 = 7h00 to 16h59 2 = 17h00 to 6h59

6. Referral status: 1 = Not referred 2 = Referred to before labor 3 = Referred to during labor 4 = Referred to after delivery
Referred from: _____

7. Emergency contact and phone number _____

B. MATERNAL CHARACTERISTICS

8. Age (in years):

9. Place of residence to hospital: 1 = Within 8 km 2 = More than 8 km

10. Educational level completed:1 = None 2 = Primary School1 3 = Primary School 2. 4= Secondary School 5 = post-secondary

11. Profession: 1 = Unemployed 2 = Unqualified employment 3 = Semi-qualified employment 4 = Professional

12. Religion: 1 = Islam 2 = Christianity 3=Traditional 4 = Other_____

13. Marital status: 1 = Single 2 = Married 3 = Live maritally 4 = Divorced 5 = Widow

14. Stayed in the maternity waiting home: 1 = Yes 2 = No

C OBSTETRIC HISTORY

15. Total number of pregnancies:

16. Number of living children:

17. Number of previous stillborn (≥28 weeks):

18. Number of previous miscarriages (<28 weeks):

19. Number of induced abortions (<28 weeks):

20. Number of previous caesarean sections:

21. Result of the last pregnancy:
1 = Live birth, still alive2= Live birth, deceased 3 = Stillbirth 4 = Miscarriage 5 = Induced abortion

22. Interval between the end of the last pregnancy (delivery or discontinuation) and the current delivery (months)

23. State of prenatal care:
1 = None 2 = < 4 PNC 3 = ≥ 4 PNC

24. Number of prenatal consultations at the study site:

25. Trimester of pregnancy at the time of consultation at the study site: 1 = 1st 2 = 2rd 3rd = 3rd

26. Patient height (cm):

27. Weight on admission (kg):

28. Most recent hematocrit (HCT) (%):

D1 NEAR-MISS CRITERIA: ORGAN DYSFUNCTION

29. Final maternal result: 1 = Normal delivery 2 = Maternal *near miss* 3 = Maternal death

30. Specify any of the following identified life-threatening conditions:

(See Definitions described in the POP)

Cardiac dysfunction 1 = No = Yes

a) Shock
b) Cardiac arrest or cardiopulmonary resuscitation
c) Severe hypoperfusion (lactate> 5mmol/L or> 45mg/dL)
d) Acidose grave (pH<7,1)
e) Use of vasoactive drugs
f) Peripartum cardiomyopathy

Respiratory dysfunction

g) Acute cyanosis
h) Difficulty breathing
i) Severe aquipnea (respiratory rate >40 bpm)
j) Severe bradypnea (respiratory rate <6bpm)
k) Severe hypoxemia (PAO2/FIO2<200, O2 saturation <90% per ≥60 min)
l) Intubation or ventilation not related to anesthesia **Renal dysfunction**
m) Oliguria not responsive to fluids or diuretics
n) Severe acute azotemia (Creatinine ≥300umol/ml or ≥35 mg/dL)
o) o) Dialysis for severe acute renal failure

Coagulation/haematological dysfunction

p) Blood does not clot
q) Severe acute thrombocytopenia (<50,000 platelets/ml)
r) Massive transfusion of blood or red cells

Liver dysfunction

s) Ichthyics in the presence of preeclampsia
t) severe acute hyperbilirubinemia (bilirubin>100umol/L or>6.0mg/dL)

Neurological dysfunction

u) Prolonged unconsciousness/coma (duration>12 hours) v)Stroke w) Status of epileptic disease x) Total paralysis

Uterine dysfunction/ Hysterectomy y) Bleeding or infection leading to hysterectomy

CRITICAL

D2 NEAR-MISS CRITERIA:

31. During the current hospital stay, specify whether some **2** of the following conditions were observed: (1 = No 2 = Yes)

a) **Severe bleeding** (which resulted in shock, emergency hysterectomy, clotting defects and/or blood transfusion of ≥ 2L)

b) **Hypertensive disorders in pregnancy** (severe preeclampsia or eclampsia with clinical/laboratory indications for termination of pregnancy tosave thewoman's life)

c) **Dystocia** (uterine rupture and impending rupture e.g. prolonged obstructed delivery with anterior cesarean section)

d) **Infection** (hyperthermia or hypothermia or a clear source of infection and clinical signs of septic shock or systemic infection)

e) Anaemia (<6 g/dL or clinical signs of severe anaemia in women without severe bleeding)

D3 INTERVENTIONSORUSEOFINTENSIE CARE

32. During the current hospital stay specify whether any of the following interventions were performed: (1 = No2 = Yes)

a) **Admission to intensive care (any** medical reason) Length of stay in intensive care (number of days)

b) **Interventional radiology** (uterine artery embolization)

c) **Emergency** laparotomy (in a pregnant or recently pregnant woman to perform life-saving procedures such as hysterectomy, inter-na iliac arterial ligation, B-Lynch sutures)

d) **Transfusion of blood products** (other than whole blood, e.g. fresh frozen plasma or platelets to save a woman's life)

EPRIMARY DETERMINING FACTOR FOR **NEAR-MISS OR DEATH**

33. Which of the following conditions was the PRIMARY cause of events leading to *near miss* or death?

Bleeding (1 = No2 = Yes)

a) Abortion-related haemorrhage
b) Ectopic pregnancy
c) Placenta previa
d) Abruptio placenta
e) Acrylic placenta / acreta / percreta
f) Ruptured uterus
g) Postpartum haemorrhage
h) Other obstetric haemorrhage

Infection

i) Abortion-related infection
j) Sepsis genital puerperal
k) Corioamnionite
l) Pyelonephritis
m) Other systemic infections / sepsis

Hypertensive disorders

n) Chronic hypertension
o) Severe preeclampsia
p) Eclampsia

Obstructed labor

q) Prolonged labour
r) Obstructed labor **Other conditions**
s) HIV/AIDS
t) Malaria
u) Anemia
v) Embolic disease (blood clot / amniotic / air embolism)
w) Heart disease
x) Lung disease
y) Kidney disease
z) Liver disease
a1)Cancer

F CONTRIBUTING EVENTS:

b1) Coincident conditions

(includes violence, accident, poisoning, self-mutilation)

G FETAL OUTCOME IN WOMEN WITH CHILDBIRTH

39. Total number of neonates

40. Birth order (1, 2, 3 etc.) *corresponding to the sequence of >1*

41. Beginning of labor (1 = Spontaneous 2 = Induced 3 = Cesarean Section)

42. Fetal presentation at delivery (1 = Cephalic 2 = Breech birth 3 = Other)

43. Gestational age at birth (full weeks)

44. Birth weight (g)

45. Baby sex 1 = Male 2 = Female

SERVICES

34. Time between diagnosis of primary determinant factor *near miss or* maternal death and definitive treatment (minutes)

35. Skill Birth Attendant level:
1 = Trainee 2 = Midwife 3 = Middle Skilled Birth Attendant 4 = Advanced Maternal and Child Health Nurse 5 = General Practitioner
6 = OBGYN

36. Time between diagnosis of primary determinant factor and care by higher education medical personnel (minutes)

37. Any deviation from the standard management protocol?
1 = No 2 = Yes

38. Reason(s) of the deviation of the management protocol
1 = No 2 = Yes **Administrative problems** a) Lack of power source
b) Lack of /inefficient transportation or communication

c) Lack of life-saving drugs in the hospital pharmacy
d) No availability of blood/blood products required for transfusion
e) Absence / lack of equipment / competent personnel required for the necessary interventions f) Other

Patient-oriented problems

g) Delay presenting to/or reaching the hospital
h) Refusal of help, advice or medical treatment
i) Language barrier
j) Inability to pay (or lack of health insurance) for the necessary intervention

k) Other

Medical-oriented problems

l) Delay in correct diagnosis
m) Delay in medical procedures after diagnosis
n) No evaluation by senior physician or OBGYN
o) Poor patient monitoring, resulting in *near-miss* or death
p) Other

46. Neonatal conditions at birth
a) Vital status (1 = Alive 2 = Stillborn 3 = Macerated stillbirth
b)Apgar score at 5 minutes

47. Has any neonatal complications been identified? (1 = No 2 = Yes)

48. Admission of newborn to intensive care (1 = No 2 = Yes)

49. Status on hospital discharge or the 7th day of life (1 = Alive 2 = Death)

50. Date of hospital discharge, transfer or death of the newborn | d | d | | a | a | a | a |

DATA COLLECTION: INFORMATION

Data collection date **Data Collector Name** **Signature**

d	d	m m	a	a	a	a

Legend:

CPN – Stands for prenatal consultation and the second CPN listed – postnatal consultation

POP translated into English stands for standard operating plan *(SOP)*

APPENDIX C: SUPPLEMENTAL RESULTS

Association Between all Criteria and Criteria Combination of the Mozambique-Canada Maternal Health Abstraction Tool

Association Variable	Chi-square (χ^2)	d.f.	p-value
Disease and Intervention Criteria (A*B)	258.6	1	<0.001
Disease and Expanded Disease Criteria (A*D)	643.3	1	<0.001
Intervention and Organ-Dysfunction Criteria (B*C)	196.6	1	<0.001
Intervention and Expanded Disease Criteria (B*D)	123.2	1	<0.001
Expanded Disease and Co-morbidities Criteria (D*E)	**2.7**[b]	1	**0.691****
Disease/Intervention and Disease/Organ Dysfunction (AB*AC)	**1756.5**[a]	1	<0.001
Disease/Intervention and Disease/Expand Disease (AB*AD)	940.4	1	<0.001
Disease/Intervention and Disease/Co-morbidities (AB*AE)	804.7	1	<0.001
Disease/Intervention and Intervention/Organ Dysfunction (AB*BC)	324.2	1	<0.001
Disease/Intervention and Intervention/Expand Disease (AB*BD)	772.4	1	<0.001
Disease/Intervention and Organ Dysfunction/Expand Disease (AB*CD)	654.9	1	<0.001
Disease/Intervention and Expand Disease/Co-morbidities (AB*DE)	421.0	1	<0.001
Disease/Organ Dysfunction and Disease/Expand Disease (AC*AD)	807.7	1	<0.001
Disease/Organ Dysfunction and Disease/Co-morbidities (AC*AE)	730.2	1	<0.001

Disease/Organ Dysfunction and Intervention/Organ Dysfunction (AC*BC)	405.8	1	<0.001
Disease/Organ Dysfunction and Intervention/Expand Disease (AC*BD)	634.3	1	<0.001
Disease/Organ Dysfunction and Organ Dysfunction/Expand Disease (AC*CD)	706.8	1	<0.001
Disease/Organ Dysfunction and Expand Disease/Co-morbidities (AC*DE)	346.1	1	<0.001
Disease/Expand Disease and Disease/Co-morbidities (AD*AE)	324.6	1	<0.001
Disease/Expand Disease and Intervention/Organ Dysfunction (AD*BC)	126.3	1	<0.001
Disease/Expand Disease and Intervention/Expand Disease (AD*BD)	**1882.1**[a]	1	<0.001
Disease/Expand Disease and Organ Dysfunction/ Expand Disease (AD*CD)	**1733.0**[a]	1	<0.001
Disease/Expand Disease and Organ Dysfunction/Co-morbidities (AD*CE)	**5.7**[b]	1	0.017
Disease/Expand Disease and Expand Disease/Co-morbidities (AD*DE)	**1037.4**[a]	1	<0.001
Disease/Co-morbidities and Intervention/Expand Disease (AE*BD)	248.9	1	<0.001
Disease/Co-morbidities and Intervention/Co-morbidities (AE*BE)	**1176.8**[a]	1	<0.001
Disease/Co-morbidities and Organ Dysfunction/Expand Disease (AE*CD)	206.8	1	<0.001
Disease/Co-morbidities and Organ Dysfunction/Co-morbidities (AE*CE)	**1079.8**[a]	1	<0.001
Disease/Co-morbidities and Expand Disease/Co-morbidities (AE*DE)	**1128.6**[a]	1	<0.001

Intervention/Organ Dysfunction and Intervention/Expand Disease (BC*BD)	148.7	1	<0.001
Intervention/Organ Dysfunction and Intervention/Co-morbidities (BC*BE)	202.2	1	<0.001
Intervention/Organ Dysfunction and Organ Dysfunction/Expand Disease (BC*CD)	203.8	1	<0.001
Intervention/Organ Dysfunction and Organ Dysfunction/Co-morbidities (BC*CE)	231.8	1	<0.001
Intervention/Expand Disease and Organ Dysfunction/Expand Disease (BD*CD)	**1858.8**[a]	1	<0.001
Intervention/Expand Disease and Organ Dysfunction/Co-morbidities (BD*CE)	**3.4**[b]	1	**0.065****
Intervention/Expand Disease and Expand Disease/Co-morbidities (BD*DE)	**1077.2**[a]	1	<0.001
Intervention/Co-morbidities and Organ Dysfunction/Expand Disease (BE*CD)	**5.8**[b]	1	0.016
Intervention/Co-morbidities and Organ Dysfunction/Co-morbidities (BE*CE)	**1761.9**[a]	1	<0.001
Intervention/Co-morbidities and Expand Disease/Co-morbidities (BE*DE)	769.6	1	<0.001
Organ Dysfunction/Expand Disease and Expand Disease/Co-morbidities (CD*DE)	985.1	1	<0.001
Organ Dysfunction/Co-morbidities and Expand Disease/Co-morbidities (CE*DE)	671.5	1	<0.001

Values reported indicate the strongest ($\chi^2 > 100$) and weakest ($\chi^2 < 10$) associations between criteria

** $p > 0.05$. Thus, showing a lack of association between those groups

[a] Chi-square value less than 10 indication a weak association between valuables

[b] Chi-square value less than 1000 indication a very association between valuables

APPENDIX D: HOSPITAL CAPACITY INFORMATION (HPI AND HRV)

1. HOSPITAL PROVINCIAL DE INHAMBANE (HPI) CAPACITY

Inpatient beds:	223
Total beds including SUR and extra beds	281
Healthcare Professionals	
Obstetricians and Gynecologists	1
Surgeons	2
Pediatricians	3
Internists	1
Dermatologists	1
Physiatrists	1
Urologist Physicians	1
Ophthalmologists	2
Dentists	2
Maxillofacial Doctors - Anesthesiologists	1
General Practitioners	26
Senior technicians	
Pharmacist A	5
Nutritionist A	3
Clinical Psychologist A	6
Medicine F. Rehabilitation	4
Anesthesiologist A:	2
Tecn. Sup. Surgery	1
Laboratory Technician A	6
Nurse A	6
Nurse of S. Materna A	4
Pediatrics Nurse A	4
Instrumentalist A	2
Technician S. Public Health	3
Health technicians:	
Anesthesiology Technicians	4
Preventive Measurement Technicians	4
Ophthalmology Technicians	1

Statistics Technicians	2
Instrumentation technicians	5
Pharmacy Technicians	14
Laboratory Technicians	20
Radiology technicians	5
Technicians of Med. Fis. Reab.	7
General Medicine	4
Basic Technicians	
Nurses	3
Pharmacy agents	2

Infirmary	Nr.de beds
Medicine	44
Surgery	35
Paediatrics	48
Obstetrics	37
Motherhood	44
Other	13
Total	223

2. RURAL HOSPITAL OF VILANCULOS (HRV) CAPACITY

HRV Healthcare Professionals by Category	2023 Real
Health Specialist	01
Urology Specialist	00
Medical surgeons	01
Orthopedic Physicians	01
Ophthalmologists	00
Gyneco-obstetricians	00
Dentists	01
Otorhinolaryngologist	01
General Practitioners placed in the Hospital	07
GC Doctors q. Participate in the scale of emergencies	09
Superior Nurses of Maternal Health with surgical component	02
Superior Nurses of Maternal Health without surgical component	01
Senior Nurses	02
Pediatric Senior Nurses	02

Superior Surgical Technicians	02
Superior Nutrition Technicians	03
Superior Instrumentation Technicians	01
Superior Technicians of Clinical Psychology	03
HRV Healthcare Professionals by Category	2023
	Real
Senior Statistics Technicians	00
Senior Laboratory Technicians	04
Senior Pharmacy Technicians	02
Senior Technicians of Hospital Administration	01
Superior Optometry Technicians	01
Superior Physiotherapy Technicians	01
Other Senior Technicians	21
Media, basic and administrative technician	
Dental Technicians – stomatologists	02
Health Statistics Technician	01
Pharmacists (Agents, Technicians)	12
General Medicine Technicians	07
Average Nurses	40
Basic nurses	01
Maternal and Child Health (SMI) Nurses	14
Other Nursing	00
Psychiatry Technicians	02
Anesthesia Technicians	02
Instrumentation Technicians	01
Laboratory Technicians	04
Nutrition Technicians	00
Laboratory Agents	00
Physical Therapy Technicians	01
X-rays (Medium and Basic)	03
Ophthalmology Technicians	01
Otorhinolaryngology Technicians	01
Orthoprosthesis (Medium, Basic and Auxiliary)	06
Preventive Medicine Technicians	01
Maintenance Technicians	01
Administrative Staff	32
Servants	49
Drivers	03

Infirmary	Nr. Of beds
Medicine	30
Surgery	42
Paediatrics	18
Obstetrics	08
Total	244
Motherhood	28
Other	06
Total	132