Caesarean Sections in a National Referral Hospital in Addis Ababa, Ethiopia: Trends, Predictors and Outcomes

by

Tamara O.M. Kuzma

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University of Alberta

Abstract

Background

Globally, maternal mortality remains a significant public health problem. In order to reduce maternal mortality, emergency obstetric care (EmOC) must be available and accessible to all women. EmOC refers to the services used for the treatment of complications that arise during pregnancy and childbirth. One EmOC indicator, as per the WHO, is that Caesarean sections (CS) as a proportion of all births should be between 5% and 15%; morbidity and mortality rates rise significantly beyond this range in many countries in the world. Worldwide, CS rates have been rising in the last several decades in developed and developing countries. The Ethiopian national CS rate is low at 1.5%, while in Addis Ababa, the capital city, the CS rate is 21.8%.

The difficulty with instituting interventions to modify CS rates is that more information is required concerning both the indications and the appropriateness of surgical delivery. The WHO has concluded that the Robson classification system is the most appropriate classification system of indications for CS for international use. A major limitation of the Robson system is that it does not account for the urgency of the CS. Combining the Robson criteria with urgency criteria provides a more useful tool to analyze and compare CS performed globally.

Objective

The objective of this study was to analyze Caesarean section rate trends and maternal and perinatal outcomes in a specialized hospital in Ethiopia, a low-income country.

Methods

This was a retrospective cohort study of deliveries at an Ethiopian national specialized hospital in the Ethiopian calendar years 2002-2006 (between Meskerem 1, 2002 and Pagume 5, 2006; the equivalent period in the Gregorian calendar is September 11, 2009 to September 10, 2014). Cluster sampling of all deliveries of gestational age ≥ 28 weeks in this period was used (N=4,816). Women were categorized into one of 10 Robson groups. All mothers who delivered by CS were assigned into one of four urgency groups: Emergent, Urgent, Scheduled, Elective. Maternal morbidity rate was used to characterize maternal outcomes. The perinatal mortality and perinatal distress rates were used to characterize perinatal outcomes.

Results

The total CS rate rose from 24.5% in 2002 to 32.8% in 2006 (p= 0.001). An increase in the rate of referral by health care workers and a decrease in hospital instrument deliveries can partially explain the increase in CS rate. Within Robson groups, the only group which had a statistically significant change in CS rate in the 5-year time period was Robson group 1 (Nulliparous women with a single cephalic pregnancy, at greater than or equal to 37 weeks gestation in spontaneous labour) (15.9% in 2002 to 24.1% in 2006; p= 0.02). For nine of ten Robson groups, the largest urgency subgroup was the Scheduled group. The overall maternal morbidity rate increased from 3.5% in 2002 to 4.1% in 2006, with higher morbidity rates in the middle years (p= 0.02). The perinatal mortality and perinatal distress rates did not significantly change over time.

Conclusions

The overall CS rate at SPHMMC significantly increased. Low-risk nulliparous women are the most significant contributors towards the overall CS rate at SPHMMC, followed by women who had a previous CS. The majority of CS performed were done for women requiring an early delivery, and not on an 'emergent' basis. The maternal morbidity rate increased slightly over time, but perinatal outcomes did not significantly change from 2002 to 2006. Despite little evidence of increased complications, increased use of CS without medical indications can result in harm as well as unnecessary drain on limited health care resources. Evidence-informed interventions to reduce both primary and repeat CS need to be studied and implemented at this Ethiopian hospital.

Preface

This thesis is an original work by Tamara Kuzma. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Study ID: Pro00045382, September 3, 2014.

Dedication

To the women of Ethiopia. Your strength, resilience, benevolence and optimism will continually serve as my inspiration.

Acknowledgements

"Amesegnalaw"

I would first like to acknowledge my husband, Chris. Thank you from the bottom of my heart for all of your love and support. Without you, I would not have been able to have the life changing experiences that I did. Next, to my parents, thank you for your unfaltering encouragement, patience and support as I continue along on my educational journey.

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List of Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
CI	Confidence interval
CS	Caesarean section
EC	Ethiopian calendar
EmOC	Emergency obstetric care
EPMM	Ending preventable maternal mortality
ETB	Ethiopian birr
GDP	Gross domestic product
HCW	Health care worker
HDI	Human Development Index
MDG	Millennium Development Goal
MMR	Maternal mortality ratio
OR	Odds ratio
RG	Robson group
SDG	Sustainable Development Goal
SPHMMC	St. Paul's Millennium Medical College
SVD	Spontaneous vaginal delivery
WHO	World Health Organization
WHOGS	WHO Global Survey of Maternal and Perinatal Health
WHOMCS	WHO Multi-Country Survey of Maternal and Newborn Health

Chapter 1- Introduction

Background

The Global Problem of Maternal Mortality

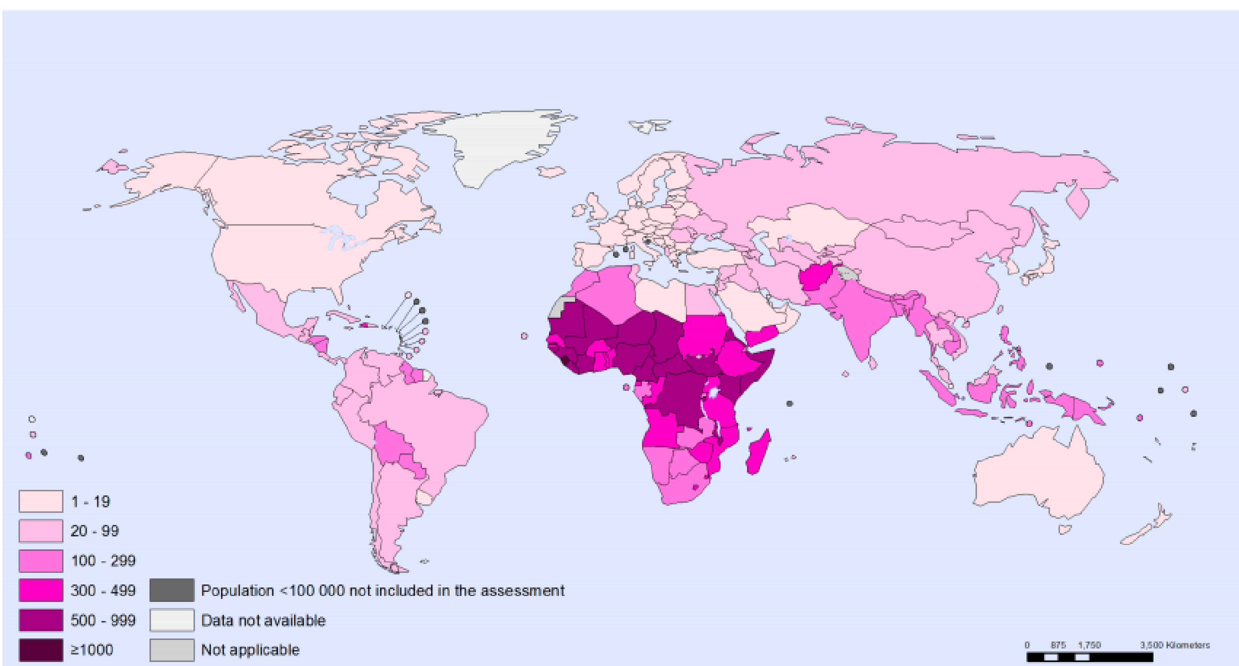
Maternal death is officially defined as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, and from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes" (1). In 2015, approximately 830 women died due to pregnancy or childbirth-related complications every day (2).

Following AIDS, complications of pregnancy and childbirth are the second leading cause of death for women of reproductive age (age 15-49) across the world; in Africa and south Asia, child birthing is the leading cause of death for women of reproductive age (3). The tragedy throughout the world is that the large majority of these deaths are preventable. "An estimated 74 percent of maternal deaths could be averted if all women had access to the interventions for preventing or treating pregnancy and birth complications, in particular emergency obstetric care" (4).

Maternal mortality signifies the continued inequality between men and women in terms of social status as well as access to health services. In this context, maternal mortality is genuinely a human rights issue. Women have both a right to life and a right to health, and both of these rights need to be asserted seriously so that maternal mortality can be reduced. Maternal mortality is also a marker of inequality between the development of wealthy and poor countries. In developing countries, families are highly dependent on women for their economic livelihood; therefore, significantly, maternal morbidity and mortality lead to proportionally greater economic loss in poorer countries, in comparison to the consequence in more developed countries. Such a decrease can be financially crippling in developing countries. For this reason, maternal mortality ratios are closely followed by world organizations as indicators of a country's overall progress and development (5).

In September 2000, world leaders adopted the United Nations Millennium Declaration and translated this global commitment into action by creating the Millennium Development Goals (MDGs) (6). MDG 5 states that by 2015 maternal mortality should be decreased by 75% of 1990 values. At the time of publication of the World Health Organization's report on maternal mortality in 2015, the WHO stated that globally, maternal mortality had decreased by 44%, which although not insignificant, was still short of the MDG 5 target (1). There also remains great regional variation in maternal mortality; the maternal mortality ratio (MMR) in developed countries is 12 (per 100,000 live births), compared to 239 in developing countries (1). Sub-Saharan Africa still has the highest maternal mortality numbers in the world, with an MMR of 546 (Figure 1); this amounts to a lifetime risk of maternal mortality of 1 in 36 (1).

Figure 1 Maternal mortality ratio (maternal deaths per 100,000 live births), 2015 (2)



A new set of goals, the Sustainable Development Goals (SDGs) have now been established post-2015. With regards to maternal mortality, SDG 3 calls for a global MMR of 70 or less by 2030, with no country having an MMR of greater than 140 (7). Globally the MMR will have to decrease by 7.5% each year in order for this goal to be achieved; considering that the global annual rate of decline between 2000 and 2015 was 3.0%, increasingly invigorated efforts will need to be made in order to make the goal a reality (2). The WHO has recently published "Strategies toward ending preventable maternal mortality (EPMM)" to guide program implementation for EPMM; in it, the WHO sets out five strategic objectives: 1. Address inequities in access to and quality of sexual reproductive, maternal and newborn health care services; 2. Ensure universal health coverage for comprehensive sexual, reproductive, maternal and newborn health care; 3. Address all causes of maternal mortality, reproductive and maternal morbidities and related disabilities; 4. Strengthen health systems to respond to the needs and priorities of women and girls; and 5. Ensure accountability to improve quality of care and equity (8). The goal is to combat global maternal mortality in a holistic and comprehensive manner, which is cognizant of context and prioritizes equity.

The Global Problem of Maternal Morbidity

Maternal morbidity has been defined by the WHO as "any health condition attributed to, and/or aggravated by, pregnancy and childbirth that has a negative impact on the woman's wellbeing" (9). For every woman who dies of a pregnancy-related cause, it is estimated that twenty to thirty other women experience a complication, or morbidity (10). The true burden of maternal morbidity is unknown as there is a global lack of accurate data regarding incidence and prevalence.

Maternal morbidity can be a result of a multitude of causes (ex. Uterine prolapse, incontinence, anemia, depression, fistulae), can have short to long-term effects and can range in severity. Maternal morbidity not only affects women, but also affects their families economically and socially via poverty, violence, isolation and divorce (11). In 2010, it was estimated that maternal morbidity had a global cost of $6.8 billion USD (12). As with maternal mortality, the highest incidence and burden of maternal morbidity is seen in low-income countries (10).

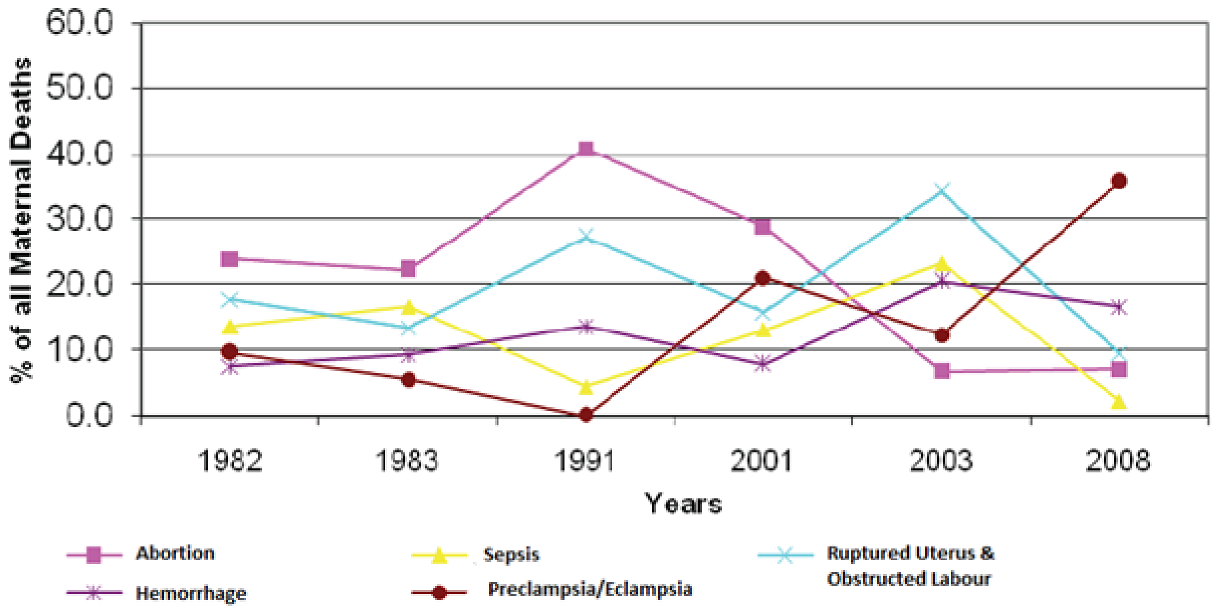
To date, maternal mortality has been primarily examined as the marker of a country's maternal health status. Unfortunately, maternal morbidity has been overlooked. It is important that further research be done and global health policy focus on maternal morbidity as maternal morbidity is associated with long term disability and adverse quality of life.

Maternal Mortality in Ethiopia

In 2008, Ethiopia was part of a group of six countries (including India, Nigeria, Pakistan, Afghanistan and the Democratic Republic of the Congo), which accounted for 50% of the world's maternal deaths (13). In 2015, Ethiopia's estimated MMR was 353, which translates to a lifetime risk of maternal death of 1 in 64 (2).

Seventy percent of maternal mortality in Ethiopian hospitals is attributed to postpartum hemorrhage, infection/sepsis, preeclampsia/eclampsia, abortion complications and obstructed labour (14). While deaths due to hemorrhage, sepsis, abortion and obstructed labour have decreased over time, deaths due to preeclampsia or eclampsia are increasing (Figure 2).

Figure 2 Trends in the causes of maternal death in Ethiopia based on hospital data, 1982-2008 (14)



Ethiopia has made significant strides in decreasing its MMR since 1990, when the MMR was reported at 1250; since 1990, the country has decreased its MMR by an average annual rate of 5.0% (1). However, Ethiopia did not achieve its MDG 3 goal. Significant barriers still exist in the country with regards to access to and provision of antenatal and obstetric health services (15).

The Importance & Availability of Emergency Obstetric Care and Caesarean Section

In 2009, the WHO published an updated handbook, *Monitoring emergency obstetric care*, in which it stated that in order to reduce maternal mortality, emergency obstetric care (EmOC) must be available and accessible to all women. Many studies have demonstrated that maternal mortality is effectively reduced when quality EmOC services provided by skilled attendants are available (16). EmOC refers to the services used for the treatment of complications that arise during pregnancy and childbirth (17). The UN estimates that 15% of pregnant women will develop complications that require the use of EmOC (18).

The WHO handbook includes indicators (Table 1.1) for the purpose of assessing, monitoring and evaluating the availability, use and quality of EmOC. A short list of clearly defined 'signal functions' are used to classify the level of care a health care facility is providing, either basic or comprehensive (Table 1.2); an EmOC facility is defined by its performance of each signal function at least once in the previous three months. A 2006 study which examined all the national needs assessments of EmOC services which had been conducted (26 national or near-national studies and 15 smaller scale studies) concluded that comprehensive EmOC facilities are usually available to meet the recommended minimum numbers, even in the least developed countries; that basic EmOC facilities are not available in sufficient numbers; and that the majority of health care facilities offering maternity services do not provide all of the signal function services to qualify as an EmOC facility (19). Another concern with EmOC services is that there may not be equity in the geographical distribution and financial accessibility of these services (14).

Table 1.1 The EmOC Indicators (17)

Indicator	Acceptable Level
1. Availability of emergency obstetric care: basic and comprehensive care facilities	There are at least five emergency obstetric care facilities (including at least one comprehensive facility) for every 500 000 population
2. Geographical distribution of emergency obstetric care facilities	All subnational areas have at least five emergency obstetric care facilities (including at least one comprehensive facility) for every 500 000 population
3. Proportion of all births in emergency obstetric care facilities	(Minimum acceptable level to be set locally)
4. Meeting the need for emergency obstetric care: proportion of women with major direct obstetric complications who are treated in such facilities	100% of women estimated to have major direct obstetric complications are treated in emergency obstetric care facilities
5. Caesarean sections as a proportion of all births	The estimated proportion of births by Caesarean section in the population is not less than 5% or more than 15%
6. Direct obstetric case fatality rate	The case fatality rate among women with direct obstetric complications in emergency obstetric care facilities is less than 1%

Table 1.2 Signal functions used to identify basic and comprehensive EmOC facilities (17)

Basic Services	Comprehensive Services
(1) Administer parenteral antibiotics	Perform signal functions 1 - 7, plus:
(2) Administer uterotonic drugs (i.e. parenteral oxytocin)	(8) Perform surgery (e.g. Caesarean section)
(3) Administer parenteral anticonvulsants for pre-eclampsia and eclampsia (i.e. magnesium sulfate)	(9) Perform blood transfusion)
(4) Manually remove the placenta	
(5) Remove retained products (e.g. manual vacuum extraction, dilation and curettage)	
(6) Perform assisted vaginal delivery (e.g. vacuum extraction, forceps delivery)	
(7) Perform basic neonatal resuscitation (e.g. with bag and mask)	
A basic emergency obstetric care facility is one in which all functions 1 - 7 are performed. A comprehensive emergency obstetric care facility is one in which all functions 1 - 9 are perfomed.	

A caesarean section (CS) is a surgical procedure in which a baby is delivered through incisions made in the mother's abdomen and uterus. Caesarean sections as a proportion of all births is used as an EmOC indicator because it is a measure of use and access to a common obstetric intervention that averts maternal and neonatal deaths as well as preventing complications, such as obstetric fistulae. Since 1985, the World Health Organization has stated that CS as a proportion of all births should be no less than 5% and no more than 15%, in spite of there being a lack of empirical evidence on an optimal range. Very low or very high CS rates are associated with significantly increased morbidity and mortality rates (17).

A 2007 review estimated a global CS rate of 15% (20). There was great regional variation: the lowest CS rates were seen in Africa (3.5%) while the highest were in Latin America (29.2%) (20). While CS rates are increasing globally, even in developing countries (17) rates are increasing in urban centres but remain dangerously low in rural settings. Therefore, the poorest of impoverished women have the least access to potentially life-saving surgery and also the highest maternal mortality rates (21).

The Risks of Caesarean Section and the Need for Caesarean Section Classification Systems

Worldwide, CS rates have been increasing steadily over the last several decades (20); this is true both in developed and in developing countries (22). CS is a major surgical operation and has inherent risks for both the mother and her child. In comparison to vaginal delivery, potential complications for the mother include increased rate of infection, longer healing time, significant bleeding and even death (23). For the infant, potential risks include increased iatrogenic injury, increased breathing difficulties and even death (24, 25). CS also has higher associated direct and indirect economic costs compared to alternate forms of delivery (26). Inappropriate CS delivery can result in a drain on a country's health resources and can have a negative impact on health equity (27). Ideally, CS should occur for all women who medically require the procedure, and as a corollary, should not be performed when it is not medically indicated.

The difficulty with monitoring and comparing CS rates, as well as planning or instituting interventions to modify CS rates, is that more information is required concerning both the indications for CS and the appropriateness of surgical delivery. A major part of the problem is that there is no agreed upon international standard of classification of indications for CS. After conducting several systematic reviews, the WHO concluded that the Robson classification system is most appropriate classification system of indications for CS for international use (28).

The Robson classification system is used to objectively assess the CS rate among different groups of women based on category of pregnancy, previous obstetric record, gestation and course of labour and delivery (29). A description of each of the ten Robson groups (RGs) is given in Figure 3. Since the Robson system is clear and easy to understand, and its categories are mutually exclusive, all women who present to hospital in labour can be immediately classified based on characteristics that are recorded as a part of routine prenatal obstetric care.

Figure 3 The Ten Robson Groups (29)

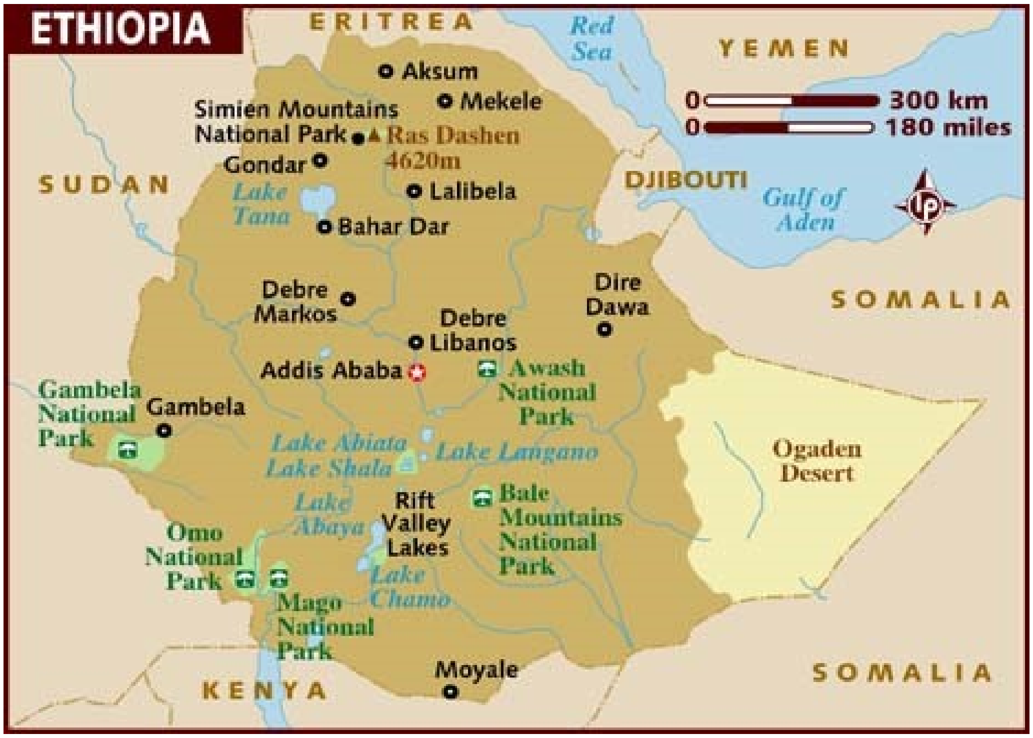
1	Nulliparous women with a single cephalic pregnancy, at greater than or equal to 37 weeks gestation in spontaneous labour
2	Nulliparous women with a single cephalic pregnancy, at greater than or equal to 37 weeks gestation who either had labour induced or were delivered by Caesarean section before labour
3	Multiparous women, without a previous uterine scar, with a single cephalic pregnancy at greater than or equal to 37 weeks in spontaneous labour
4	Multiparous women, without a previous uterine scar, with a single cephalic pregnancy at greater than or equal to 37 weeks gestation who either had labour induced or were delivered by Caesarean section befoure labour
5	All multiparous women, with at least one previous uterine scar and a single cephalic pregnancy at greater than or equal to 37 weeks gestation
6	All nulliparous women with a single breech pregnancy
7	All multiarpous women with a single breech pregnancy including, women with previous uterine scars
8	All women with multiple pregnancies, including women with previous uterine scars
9	All women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars
10	All women with a single cephalic pregnancy at less than or equal to 36 weeks gestation, including women with previous uterine scars

A major limitation of the Robson classification system is that it does not account for the urgency of the CS (30). In contrast, several groups (31-34) have published proposed classification systems based on urgency. In a systematic review of CS classification systems, Torloni et al. (30) concluded that within the urgency classification systems, the system proposed by Lucas et al. (31) was conceptually easy to use and had the added benefit that it previously had been tested on real patients. The Lucas et al. classification system classifies women undergoing CS based on the degree of maternal and/or fetal compromise. Combining the Robson criteria with urgency criteria could provide a useful tool to analyze and compare CS performed globally, as it would provide an additional layer of information with which to compare labouring women. To date, there have been no published studies that have used the Lucas et al. urgency classification to study CS rates or no studies that have incorporated the two types of classification systems.

Study Setting

St. Paul's Millennium Medical College (SPHMMC), the second largest public hospital in Ethiopia, is located in Addis Ababa, the capital city (Figure 4), with an estimated 3.2 million residents (35). Ethiopia is a low-income country and one of the world's most impoverished nations. Ethiopia's fertility rate (5.1 children per woman) is the fourteenth highest in the world (35). Maternal mortality remains high in the country. The WHO estimated the mortality ratio in Ethiopia in 2015 was 353 per 100,000 live births (1).

Figure 4 Map of Ethiopia (36)



The Ethiopian health care system is decentralized, and it is organized into three levels for public delivery. The first level of care is at the woreda level (A woreda is a district that is composed of a number of wards, which are the smallest unit of local government in Ethiopia), and it consists of health posts (1 per 3,000 to 5,000 residents), health centres (1 per 15,000 to 25,000 residents) and a primary hospital (1 per 60,000 to 100,000 residents); the second level of care is a general hospital that serves a population of 1-1.5 million residents; the third level of care is a specialized hospital that serves a population of 3.5-5 million residents (37). People residing in major cities, such as Addis Ababa, can access care at specialized hospitals, such as SPHMMC, directly without first seeking care at the lower levels of the health system.

In 2005, the Ethiopian government enacted a package of free health services including prenatal, delivery and postnatal maternity care and child care. However, patients are still being charged for things such as consultations, supplies and medications (38). Costs also vary significantly among the various institutions, with hospitals charging more than health centers, and private facilities charging more than public ones. At SPHMMC, the cost of admission is 2.50 Ethiopian birr (ETB)/day (1 ETB is approximately equal to $0.05 USD). The cost of supplies for a vaginal delivery is 15 ETB, for an episiotomy 12 ETB, and for a Caesarean section 25 ETB.

Nationally, only 10% of deliveries are attended by a skilled provider, and only 10% of deliveries occur in a health facility; in Addis Ababa, on the other hand, 84% of deliveries are attended by a skilled provider and 82% of deliveries occur in a health facility (39). The 2011 national CS rate was low at 1.5%, while in Addis Ababa, the 2011 CS rate was 21.8% (39). The national CS rate has changed relatively little since 2000 (0.7%-2000, 1.0%-2005), while in Addis Ababa, the CS rate has significantly increased over time (7.9%-2000, 16.0%-2005) (40, 41).

SPHMMC has been designated a national specialized hospital as well as a training centre for obstetrical care by the Federal Ministry of Health. One resident and one obstetrician are on call every day. The obstetrician is usually involved in the CS decision-making process. In 2012, SPHMMC increased the number of maternity ward beds with an associated increase in the number of deliveries.

Study Objective

The objective of this study was to analyze CS rate trends and maternal and perinatal outcomes in a specialized hospital in Ethiopia.

Research Questions

1. What were the annual CS rates at SPHMMC for the period Meskerem 1, 2002 and Pagume 5, 2005 in the Ethiopian calendar (September 11, 2009 to September 10, 2014, Gregorian calendar equivalent)?
2. Which Robson groups accounted for the majority of deliveries and CS at SPHMMC during the study period?
3. What proportion of CS performed at SPHMMC were urgent in nature?
    a. Hypothesis: The proportion of CS that are non-urgent (Scheduled and Elective groups) in nature is increasing over time.
4. What were the indications for operative delivery at SPHMMC?
5. What are the factors that predict having a CS delivery at SPHMMC?
6. What were the morbidities associated with CS at SPHMMC?
    a. Hypothesis: The increasing CS rate at SPHMMC is associated with worsening maternal and perinatal outcomes.
7. What are the factors that predict experiencing maternal and perinatal morbidities at SPHMMC?

Chapter 2- Literature Review

CS Trends in Low-Income Countries

The topic of CS rates has been widely investigated; examining estimates of CS rates worldwide, a divide tends to appear along economic strata (20). High-income countries tend to be well above the WHO recommendation of a CS rate of 5 – 15%, while low-income countries, many of which are in sub-Saharan Africa, tend to have a national CS rate below 5% (17). Even within low-income countries, this same divide seems to appear between wealthy urban and poor rural populations (21); on average, CS rates for women residing in urban settings are three times higher than rates for women residing in rural locations (42).

Generally, when examining CS rates over time in low-income countries, rates are rising (22). Most recently, a 2014 study (43) used data from the Ethiopia Demographic and Health Surveys to investigate changes in both CS rate and the demographic of mothers delivering by CS from 1995 to 2005 in Addis Ababa, Ethiopia. Its findings mirrored those already discussed; the rates increased to well beyond WHO recommendations, and rates in 2011 were 2.6 times higher than those in 2000. Furthermore, it was observed that the rate was higher for "rich" households (28.6%) than in "middle" (19.5%) or "poor" (16.4%) households (p= 0.016), evidence that there was a widening gap in access to care. In a 2013 study (44) conducted in Harar, a city in eastern Ethiopia, the CS rate in private hospitals where patients pay for medical services was 58.7% as compared to 26.6% in government hospitals. Higher monthly family income was significantly associated with CS delivery (adjusted OR= 3.00, 95% CI 1.60 – 5.61).

A 2013 study (45) done for the WHO of CS deliveries in southern Asia and sub-Saharan Africa showed statistically significant increases in the CS rates (between 2 – 19% per year) in 7 of 11 countries studied in west and central Africa, 9 of 11 countries in southern and eastern Africa and 4 of 4 countries in southern Asia. However, in only 12 of the study countries did the CS rate increase among the lowest two wealth quintiles. The study authors stressed that CS rates among the world's poor should be closely monitored and should also used as a key indicator in the progress towards reducing maternal mortality.

A 2008 study (46) examined CS rates in six developing countries. The study investigators found that in three countries, namely Bangladesh, Colombia and the Dominican Republic, the probability of having a CS increased with increase in wealth. Overall, women who had better access to medical services and therefore used health care services more frequently, were more likely to have a CS. A 2005 study (47) in eight Latin American countries showed the median CS rate to be 33%. In this study, higher CS rates were associated with greater severe maternal morbidity and mortality and higher neonatal morbidity and mortality, even after adjustment for sociodemographic variables, medical and pregnancy history and institutional factors.

A review of 16 previous studies conducted in sub-Saharan Africa (48) found that access to CS delivery in low-income countries is restricted by the limited number of trained healthcare providers that are able to perform the procedure, and that this is most apparent in rural areas. Even in centres that are able to perform CS, many of them are unable to provide blood transfusions or 24-hour anaesthesia service, which further reduces access to CS for poor women. The authors noted that to correct these deficiencies, a large increase in resources would be required.

The literature has shown the CS rates are rising in developing and low-income countries, just as in their developed country counterparts. Sub-Saharan Africa still has the lowest rates of CS delivery, with many countries having national CS rates below 5%. It is interesting that even within the poorest of the poor countries, there is inequitable distribution of CS delivery, with richer urban residents having better access and more

CS deliveries than their poorer rural neighbors. There is no easy fix to this conundrum as more resources need to be dedicated to maternal health in order to both improve access to CS as well as stem increasingly higher CS rates.

Use of the Robson Classification System in Low-Income Countries

Multiple studies have examined rising CS rates in high and middle income countries using the Robson classification system (e.g. In 2015 alone, 6 studies were conducted for this income bracket (49-54)), but few studies involving low income countries have been conducted (22, 55-58). The indications for CS as well as the relative sizes of Robson groups likely differs between high, middle and low income countries. There are discrepancies in access to care and clinical practice patterns among countries of varying income levels. Additionally, there is wide variance in the availability of resources globally, which results in an excess use of CS in high-income countries and lack of accessibility to CS in lower income countries (59). It is therefore important to study and understand CS rate patterns and Robson group composition in low-income countries; this gave rise to the following literature review and research for this thesis.

A systematic review of the literature was conducted to identify published studies which used the Robson classification system in low-income countries. The databases which were searched were Medline, EMBASE, CINAHL and LILACS. The following search strategy was used in all four databases:

#1 Robson* OR (Robson* classification*) OR (Robson Ten Group classification) OR (TGCS) OR (RTGCS) OR (10-group) OR (Ten Group classification) OR (Robson cesarean classification) OR (Robson caesarean classification)

#2 Caesarean section OR (Cesarean section) OR (C-section) OR (Caesarean delivery) OR (Cesarean delivery) OR (Abdominal delivery)

#3 Developing country OR (Low income country) OR (Low HDI) OR (Africa) OR (South East Asia)

The search in Medline yielded nine articles (22, 53, 54, 56-58, 60-62). Four of the articles did not involve low-income countries, but instead involved middle and high income countries (Belgium (61), Croatia (53), Egypt (62), Singapore (54)). One article (60) did not use the Robson classification system. The four remaining articles (22, 56-58) were included in the literature review.

The search in EMBASE yielded four articles (22, 57, 61, 63). Two of the articles (22, 57) appropriate for inclusion in the literature review were the same ones found in the Medline search. One article (61) was concerning a study conducted in a high-income country (Belgium). One other article (63) discussed the conference proceedings prior to the actual published study (57), which was included in the literature review.

The search in CINHAL yielded two articles (22, 56). Both articles were previously found in Medline, and were included in the literature review. The search in LILACS yielded no articles. A fifth article that was used was found by typing "Robson classification system AND caesarean section" into the University of Alberta main search page; this search yielded 89 articles, one (55) of which was unique and appropriate for inclusion in the literature review. The five articles, which involved the use of the Robson classification in low-income countries are summarized in Table 2.1.

Table 2.1 Studies using the Robson classification system in low-income countries

First Author	Article Year	Institution	Primary Study Objective	Study Period	Study Type	Study Sample Size	CS Rate (%)	Study Findings
Sorbye, I.K. (58)	2011	Kilimanjaro Christian Medical Cenre, Moshi, Tanzania	To compare CS rates among women formally referred for hospital delivery vs. self-referred women	2000 Jan 1-2007 Aug 31	Retrospective analysis of prospectively collected data on a cohort	20,662 deliveries (6765 CS)	28.5 - 35.5	CS rates were higher in the referred group (55%) vs. self-referred group (27%). RGs 5 then 1 contributed most towards the total CS rate in both referral groups. The most common indication for CS was previous CS, followed by obstructed labour.
Litorp, H. (56)	2013	Muhimbili National Hospital, Dar es Salaam, Tanzania	To analyze trends in CS rates and perinatal and maternal outcomes among different RGs	2000 - 2011	Retrospective analysis of prospectively collected data on a cohort	137,094 deliveries (42,201 CS)	19 - 49	RGS 5 and 9 had the highest CS rates. RGS 1, 3 and 5, in descending order, contributed most to the overall CS rate.
Amatya, A. (55)	2013	Tribhuvan University Teaching Hospital, Kathmandu, Nepal	To review institutional 5 year CS rates as well as stratified (by RG) CS rates	2005 - 2010	Retrospective analysis solely of women who delivered via CS	5907 CS	16.6 - 25.4	RGs 1, 3, (5 & 10), in descending order, were the largest groups. The most common indication for CS was fetal distress, followed by previous CS.
Makhanya, V. (57)	2015	Lower Umfolozi War Memorial District Hospital, KwaZulu-Natal Province, South Africa	To use the Robson classification to identify the leading RGs contributing to high institutional CS rates	3 month period, year not specified	Retrospective cohort	2553 deliveries (1082 CS)	42.4	RGs 1, followed by 10, then 5 contributed most to the overall CS rate. The main indications for CS were fetal distress, cephalopelvic disproportion and previous CS.
Vogel, J.P. (22)	2015	287 facilities in 21 countries that were a part of two WHO multicountry surveys (WHOGS & WHOMCS) of deliveries in health-care facilities	To analyze the contribution of specific obstetric populations to changes in CS rates by using the Robson classification	2004- 2008 (WHOGS) & 2010 - 2011 (WHOMCS)	International facility-based, multi-country surveys	466,955 deliveries (134,672 CS) [136,994 deliveries (24,004 CS) in low HDI countries]	26.4 - 31.2 in all included countries (14.4 - 20.3 in low HDI countries)	In low HDI countries, RGs 5 then 2 had the highest CS rates. RGs 5, followed by 1, then 3, contributed most to the overall CS rate. In comparison to higher HDI countries, low HDI countries had a lower proportion of women who had induction, prelabour CS or previous CS, but the proportion is increasing over time.

All five studies were observational in nature. The reported studies were conducted between 2000 – 2011 (Of note, one study (57) did not specify the time period during which it was conducted). Four studies were conducted in single institutions- two occurred in Tanzania (56, 58), one in South Africa (57) and one in Nepal (55). One study (22) was multi-institutional and multi-national in nature; the low-income countries which were included in this study were Kenya, Nigeria, Uganda, Democratic Republic of the Congo, Niger and Nepal.

Sorbye, Vangen, Oneko, Sundby, & Bergsjo (58) examined data from 20,662 deliveries occurring during 2000 - 2007, which was taken from the birth registry of a zonal tertiary hospital in northeastern Tanzania, Kilimanjaro Christian Medical Centre, to compare CS rates among formally referred women versus self-referred women. The hospital had an average CS rate of 33% during the study period, as compared to the CS rate of 7.2% in the Kilimanjaro Region and the Tanzanian national average CS rate of 3%; in the region, 70% of births occur at a health facility. In the study sample, 19% of women were formally referred. Less than 2% of women had an instrumental delivery.

CS rates ranged between 28.5% and 35.5% during the study period. CS rates were higher in the formally referred group of women (55%) versus the self-referred group (27%) ($p<0.001$). Elective CS rates were low, except for RG 5 in both referral groups of women, where the elective rate was >20%. Previous CS and obstructed labour were the most common indications for CS in the study sample.

The three largest Robson groups, in descending order, in the formally referred group were 5, 1 and 3, and in the self-referred group were 3, 1 and 5. While RGs 9, 5 and 6 had the highest CS rates in both referral groups, it was RGs 5 and 1 that contributed most to the overall CS rate, in both referral groups. Neonatal mortality rates were >2% in RGs 6, 7, 8 and 10; neonatal mortality rates were not significantly different between referral groups. Low Apgar score rate was >7% in RGs 6, 7, 9 and 10; low Apgar scores were more common in the formally referred group (OR 1.42, 95% CI 1.09 – 1.86). The absolute number of adverse maternal outcomes (maternal death, hemorrhage, prolonged stay) were low in all RGs, and did not vary significantly between referral groups.

Litorp, Kindanto, Nystrom, Darj, & Essen (56) conducted a retrospective analysis of all deliveries occurring between 2000 – 2011 at Muhimbili National Hospital, the largest public hospital in Tanzania, in Dar es Salaam, Tanzania's largest city. They examined the data from 137,094 deliveries, extracted from the hospital's prospectively collected obstetric data base, in order to analyze trends in CS rates and perinatal and maternal outcomes among different obstetric groups using the Robson classification. The CS rate at the hospital during the entire study period was 31%. In the Dar es Salaam area, 90% of all births are attended by a skilled health provider. 28% of women were referred during the study period. The instrumental delivery rate was low at 0.8%.

The total CS rate at the hospital increased from 19% during the first time period (2000 – 2002) to 49% during the final time period (2009 – 2011). All RGs had a statistically significant increase in their CS rates except for RG 9. The highest CS rates over the entire study period were in RGs 5 and 9 (88% in both). The three largest RGs were 3, 1 and 10, in descending order, but it was RGs 1, then 3, then 5 that contributed most to the overall CS rate (8.5%, 8.1% and 7.8%, respectively).

Robson groups 1, 2, 5, 6 and 8 had decreases in the perinatal mortality ratio and the proportion of neonatal distress. RG 3 had increased perinatal mortality and neonatal distress during the study period. The maternal mortality ratio at the institution increased from 453 per 100,000 live births during the first time period to 650 per 100,000 live births in the last time period (p= 0.031).

In Nepal, Amatya, et. al (55) conducted a retrospective study to review the institutional and stratified (by Robson groups) CS rates over a period of 5 years at Tribhuvan University Teaching Hospital, in Kathmandu, Nepal. The teaching hospital is the largest tertiary hospital in Nepal, and a major referral site. The researchers looked solely at the women who delivered via CS during the study period, 2005 – 2010. Their study sample included 5907 women. The CS rate rose from 16.6% to 25.4% during the 5 years.

The largest RGS were 1, 3, (5 & 10), in descending order. The study investigators did not provide the total number of women in each of the RGs, so that neither the CS rate in each group nor a group's contribution to the overall CS rate could be calculated. The most common indications for undergoing CS, in descending order, were fetal distress and previous CS. The authors did not discuss neonatal or maternal complications.

In a regional, rural hospital in KwaZulu-Natal Province, in South Africa (Lower Umfolozi War Memorial District Hospital), Makhanya, Govender, & Moodley (57) sought to identify groups of women (i.e. RGs) that were contributing to a high institutional CS rate that was increasing over time. The investigators conducted a retrospective review of all women who delivered over a 3-month time period (dates not specified) at the institution. The study sample consisted of 2553 women. The CS rate was 42.4%.

The largest RGs were 1, 10 and 5, in descending order. The authors did not specify the CS rate in each RG. RGs 1, 10, and 5 contributed most to the overall institutional CS rate (27.4%, 23.4%, 17.2%, respectively). The most common indications for CS at this institution were fetal distress, cephalopelvic disproportion and previous CS. In their article, the authors did not discuss neonatal or maternal complications.

The most recent article published concerning the use of the Robson classification system in low-income countries was a multi-institutional, multi-national survey (22). Vogel et. al studied deliveries that occurred in 287 facilities in 21 countries that were a part of two separate WHO surveys- the WHO Global Survey of Maternal and Perinatal Health (WHOGS; 2004 - 2008) and the WHO Multi-Country Survey of Maternal and Newborn Health (WHOMCS; 2010 – 2011). The study investigators divided the participating countries into groups according to the Human Development Index (HDI).

The objective of their study was to explore global CS patterns and possible drivers of these trends by using the Robson classification to assess trends in group-specific CS rates and the contribution of various RGs to overall CS rates. The investigators analyzed 466,955 deliveries, of which 136,994 occurred in low HDI countries. 134,672 CS occurred during the study period, of which 24,004 took place in low HDI countries. Overall, the CS rate increased from 26.4% to 31.2% over the course of the two surveys. In low HDI countries, the CS rate increased from 14.4% to 20.3% in the same time period.

The authors decided to focus reporting results of RGs 1 - 5, since RGs 6 – 10 accounted for only 15% of the obstetric population and 20% of the relative contribution to the overall CS rate. In all HDI groups, nulliparous women (RGs 1 & 2) were the single largest relative contributor to the overall CS rate (approximately one-third), followed by women who had had a previous CS (RG 5) (approximately a quarter of the overall rate). In low HDI countries, RG 3, followed by RG 1 were the largest groups, and RGs 5 and 2 had the highest group CS rates (63.2 – 72.1% and 46.4 – 57.8%, respectively). RGs 5, followed by 1, then 3, contributed most to the overall CS rate in low HDI countries. The proportion of women who had induction or prelabour CS or a history of previous CS was lower in low HDI countries than compared to higher HDI countries, but the proportions are increasing over time. There was no discussion of morbidities or mortalities in this paper.

The five published studies involving the use of the Robson classification in low-income countries all occurred in different settings. In the four studies that occurred over several years, the CS rate increased significantly over time. While the size of the various RGs and the group CS rates differed among the studies, RGs 1 and 5 consistently contributed the most to the overall CS rate. All of the studies commented on the simplicity and ease of use of the Robson classification at their institutions or for research purposes. Also, all studies commented on using the Robson classification to monitor and evaluate CS rates with the ultimate goal of improving the quality of obstetric care that is delivered. It is important that additional studies be completed using the Robson classification to understand relative Robson group size and CS practices in low income countries.

Chapter 3- Methodology

Study Design

Study Type

The study which was conducted was a retrospective cohort study of deliveries which occurred at SPHMMC between Meskerem 1, 2002 and Pagume 5, 2005, inclusive, as per the Ethiopian calendar (this time frame corresponds to September 11, 2009 to September 10, 2014 on the Gregorian calendar). In total, 20,406 deliveries occurred at SPHMMC during this time frame.

Sampling

The study utilized a cluster sampling method, whereby all the deliveries occurring on the first 9 days of the first 12 months of the Ethiopian calendar year, as well as the deliveries occurring on the first day of the 13th month, were identified and used to form the study sample by retrieving the corresponding patient hospital identification numbers. (This was done so that approximately the same proportion of patients (30%) were sampled each month. The first 12 months have 30 days while the 13th month has five days.)

Identification of Participants

Patient medical records are kept in English and in paper chart format. Each patient has a unique medical identification number, which is recorded on the patient's chart. Charts are filed by identification number and stored in the hospital records room. For each delivery that takes place, the date and time of delivery as well as the mother's hospital ID number are recorded in log books, which are stored either in the emergency maternity area or on the labour & delivery ward.

All deliveries of gestational age ≥28 weeks occurring in the specified time period at SPHMMC with complete information concerning the data described below were included in the study. Exclusion criteria consisted of incomplete or missing information on any of the following variables: delivery date, maternal age, gravidity, parity, plurality, mode of delivery, Apgar score at 5 minutes or birth weight.

Ethical Considerations

Ethics approval to conduct the study was applied for and obtained from the Health Research Ethics Board at the University of Alberta (Study ID: Pro00045382) on September 3, 2014 and the Institutional Review Board of St. Paul's Millennium Medical College (Ref.No. PM23/30) on September 23, 2014.

To maintain patient confidentiality, patients were assigned a unique study ID, and their name and hospital ID numbers were stored securely and separately from the data variables collected. No other personal identifying information was collected. Research assistants were provided with confidentiality training.

Measurements

Data Variables

The data that was collected to characterize the study population fell into 6 categories, and were obtained from the patient charts:

1. Maternal Characteristics
    a. Maternal Age (in years)
    b. Gravidity: the number of times a female has been pregnant

c. Parity: the number of times a female has carried a pregnancy to a viable gestation age

d. History of Previous CS (Yes or No)

2. Referral Status (Self-referred or Healthcare worker referred)

3. Pregnancy Characteristics

   a. Gestational Age (in weeks)

   b. Number of Fetuses

   c. Presentation: the anatomical part of the fetus which is closest to the pelvic inlet of the birth canal (Cephalic, Breech or Shoulder)

   d. Onset of Labour (Spontaneous, Induced or CS before labour)

4. Mode of Delivery (Spontaneous vaginal delivery, Instrumental vaginal delivery or Caesarean section)

   a. Indication for CS (if Mode of Delivery was CS)

5. Maternal Outcomes

   a. Maternal Morbidity: any medical complication arising as a result of pregnancy or childbirth occurring within 42 days of the termination of pregnancy (Yes or No)

   b. Maternal Mortality: death of the woman in the first 42 days after giving birth (Yes or No)

6. Perinatal Outcomes

   a. Apgar Score at 5 minutes: composite score of neonatal appearance, pulse rate, irritability, activity and respiratory effort, ranging from 0 – 10

   b. Birth Weight (in grams)

   c. Perinatal Death: fetal death (stillbirth) or death of the neonate in the first 7 days of life (Yes or No)

For some variables, information in the patient's chart needed to be interpreted or modified. For the variable *History of Previous CS*, if there was no mention of previous CS in the patient's history or referral card or if there was no mention of a previous CS scar on physical exam, the woman was considered not to have had a previous CS. For the variable *Presentation*, if the chart did not state the fetus was breech or transverse lie, then the case was considered cephalic. In twin or triplet pregnancies, the variable *Presentation* was recorded for the first twin or triplet only. For the variable *Onset of Labour*, if the chart did not mention induction or CS occurring before labour, then the case was considered spontaneous labour. As few women in our study population had an early prenatal dating ultrasound or could recall the date of their last menstrual period, a birth weight of <2500 grams was used to estimate a gestational age <37 weeks, and a birth weight of ≥2500 grams was used to estimate a gestational age of ≥37 weeks.

The modified Robson criteria was applied to our study sample by reviewing the variables entered for each patient. Each woman was categorized into one of ten Robson groups, by either the lead investigator or the Canadian research assistant (Robson group assignment was according to parity (nulliparous/ parous), plurality (single/ multiple), previous CS (no previous CS/ previous CS), gestational age (<37 weeks/ ≥37 weeks or <2500 grams/ ≥2500 grams), presentation (cephalic/ breech/ shoulder) and labour (spontaneous/ induced/ CS before labour)). The CS rate for each group (number of CS in group/ total number of deliveries in group) was calculated, as was the relative size of the group (number of deliveries within group/ total number of deliveries in a year) and the absolute contribution to the total CS rate (number of CS in group/ total number of deliveries in a year).

All mothers who delivered by CS were assigned into one of four urgency groups (as proposed by Lucas et al. (31)): Emergent, Urgent, Scheduled, Elective (Table 3.1). Two major limitations of the classification of CS based on urgency are 1) the lack of unambiguous definitions for each of the categories, which could result in compromised inter-rater reproducibility, and 2) the necessity of having knowledge of obstetrics in order to judge urgency. To account for this the lead investigator assigned all women with CS deliveries into one of the four urgency groups by reviewing the variables entered for each patient. The urgency rate of CS was calculated for each Robson group (number of CS with particular urgency status/ total number of CS in Robson group).

Table 3.1 Urgency grades and definitions

Urgency Grade	Definition
Emergent	Immediate threat to life of the woman or fetus
Urgent	Maternal or fetal compromise which is not immediately life-threatening
Scheduled	Needing early delivery but no maternal or fetal compromise
Elective	At a time to suit the woman and/or maternity team

The maternal morbidity rate was used to characterize maternal outcomes, and it was defined as the number of mothers who experienced a medical complication arising as a result of pregnancy or childbirth occurring within 42 days of the termination of pregnancy per the total number of mothers. If there was no mention of any complication in the mother's chart during her initial admission, her post-delivery check-up or any other hospital visit, then the mother was considered to have experienced no complication. Instances of maternal mortality (death of a mother within 42 days of delivery) were recorded, but not analyzed, as these events were rare occurrences.

The perinatal mortality and perinatal distress rates were used to characterize perinatal outcomes. The perinatal mortality rate was defined as the number of stillbirths and early infant deaths occurring within seven days of birth per 1000 deliveries. If there was no mention of stillbirth or early infant death in the mother's chart during her initial admission or her post-delivery check-up (one to two weeks post delivery), then her infant was considered to be alive. The perinatal distress rate was defined as the number of deliveries with an Apgar score of <7 at five minutes per the total number of deliveries. Outcomes for twin or triplet deliveries were recorded only for the first infant delivered.

Data Collection

Selected data variables were entered into either an EpiInfo template or Excel template by the lead investigator and two Ethiopian research assistants. At the completion of the data collection period, all records were combined into a master data set in Excel in preparation for data analysis.

Validity Checks

A quality assurance of data entry protocol was put in place, whereby ten patient charts were randomly selected each day in the data collection period by the lead investigator to review the variables entered for these patients to ensure accuracy and completeness. During the assignment of Robson groups, approximately every twentieth entry was inspected to ensure accuracy; similarly, after completion of assignment of urgency status, approximately every tenth entry was re-inspected to ensure accuracy. At the completion of data collection, all entered records were inspected for missing or incorrect values and cleaned as necessary by the lead investigator.

Analyses

Data was exported from Excel into StataIC 14 for statistical analysis.

For Research Question 1, a descriptive analysis of maternal characteristics, as well as the number and type of deliveries was performed. One-way ANOVA analyses were run to assess for temporal changes in mean maternal age, gravidity and parity, previous CS history and referral status, as these variables were considered important in being able to analyze CS rate changes over time. Chi-square test was used to assess for temporal changes in CS rate.

For Research Question 2, Chi-square tests were used to assess for temporal changes in the relative size of Robson groups as well as temporal changes in the contribution of each Robson group to the overall CS rate. For Research Question 3, Chi-square test was used to assess for temporal changes in urgency status of CS performed. For Research Question 4, a descriptive analysis of the indications for operative delivery at SPHMMC was performed.

For Research Question 5, univariate and multivariable logistic regression analyses were conducted to estimate the likelihood of CS during 2006 compared to 2002, adjusting for maternal age and referral status, in each of the ten Robson groups. Only variables that were significant with $p \leq 0.1$ in univariate analysis were included in the multivariable analysis. In the final model using backward elimination, variables were included only if they reached a significance level of $p < 0.05$. Data was presented as odds ratios (OR) with 95% confidence intervals (CI). Maternal age was adjusted for as previous studies have shown increased CS rates with increased maternal age (64, 65). Referral status was adjusted for as being referred to a specialized hospital may indicate higher acuity cases requiring CS. Univariate and multivariable logistic regression analyses were also run to assess independent predictors of having a CS. Only variables that were significant with $p \leq 0.1$ in univariate analysis were included in the multivariable analysis. In the final model using backward elimination, variables were included only if they reached a significance level of $p < 0.05$.

For Research Question 6, Chi-square tests were used to assess for temporal changes in maternal morbidity rate, perinatal mortality rate and perinatal distress rate. A descriptive analysis of cases of maternal mortality was also performed.

For Research Question 7, univariate and multivariable logistic regression analyses were run to assess independent predictors of experiencing maternal morbidity, perinatal mortality and perinatal distress. Only variables that were significant with $p \leq 0.1$ in univariate analysis were included in the multivariable analysis. In the final model using backward elimination, variables were included only if they reached a significance level of $p < 0.05$.

Chapter 4- Study Results

Study Population

During the study period, 20,406 deliveries occurred at SPHMMC (3,254 in 2002, 3,387 in 2003, 3,870 in 2004, 4,026 in 2005 and 5,869 in 2006). In accordance with the sampling protocol, 5,799 delivery events were identified for which charts were requested. Of the 5,799 charts requested, 5,203 charts were located. Of the 5,203 available charts, 226 were incomplete, and 161 were incorrect (i.e. the patient ID had been incorrectly transcribed into the log book) and not included in the study. 4,816 deliveries were included in the study analyses. Table 4.1 summarizes the 983 charts that were not included in the study, by year.

Table 4.1 Charts excluded from analysis by year, 2002 to 2006 (EC).

	2002	2003	2004	2005	2006	2002 - 2006	p-value
Unable to be located	83	142	130	108	133	596	<0.001
Incomplete	45	42	70	23	46	226	<0.001
Incorrect	30	18	35	37	41	161	0.21
Total charts excluded (%)	158 (16.9%)	202 (20.3%)	235 (20.5%)	168 (15.0%)	220 (13.7%)	983 (17.0%)	<0.001

EC: Ethiopian calendar

Table 4.2 summarizes the characteristics of the women in the study sample. Mean maternal age (26.0 years) remained the same over the five-year study period (*p*= 0.62), as did gravidity (2.1) (*p*= 0.96) and parity (0.9) (*p*= 0.84). The previous CS rate (8.0%) did not significantly change over time (*p*= 0.50). The proportion of women who were referred to SPHMMC by a health care worker (HCW) increased from 92.5% to 96.1% (*p*= 0.0004). The instrumental delivery rate decreased from 12.9% to 8.3% (*p*= 0.0003). Among women who had an instrumental delivery, mean gravidity (1.7) did not change over time (*p*= 0.16), and neither did mean parity (0.5) (*p*= 0.32).

Table 4.2 Characteristics of women sampled who delivered at St. Paul's Millennium Medical College, 2002 to 2006 (EC).

		2002	2003	2004	2005	2006	p-value
Maternal age	Mean (SD)	25.9 (5.2)	25.8 (4.8)	25.9 (5.2)	26.0 (4.9)	26.1 (4.9)	0.62
	Range	15-42	16-46	15-45	16-45	16-47	
Gravidity	Mean (SD)	2.1 (1.5)	2.1 (1.4)	2.1 (1.5)	2.1 (1.5)	2.1 (1.5)	0.96
	Range	1-10	1-9	1-12	1-11	1-11	
Parity	Mean (SD)	1.0 (1.4)	0.9 (1.4)	0.9 (1.4)	1.0 (1.4)	1.0 (1.4)	0.84
	Range	0-8	0-8	0-9	0-10	0-10	
Previous CS (%)		59 (7.6%)	61 (7.7%)	66 (7.3%)	86 (9.0%)	122 (8.8%)	0.50
HCW referred (%)		719 (92.5%)	732 (92.2%)	862 (94.7%)	887 (93.2%)	1329 (96.1%)	0.0004
Instrumental deliveries (%)		100 (12.9%)	113 (14.2%)	105 (11.5%)	104 (10.9%)	115 (8.3%)	0.0003
Total deliveries sampled		777	794	910	952	1383	

EC: Ethiopian calendar

Research Question 1: Overall Caesarean Section Rates and Caesarean Section Rates by Robson Group

The total CS rate rose from 24.5% in 2002 to 32.8% in 2006 (p= 0.001) (Table 4.3). Within Robson groups, the only group which had a statistically significant change in CS rate in the 5-year time period was Robson group 1 (15.9% in 2002 to 24.1% in 2006; p= 0.02); this group experienced a 51% relative increase in CS rate. Robson groups 2 and 7 had clinically significant increases in CS rate of 56% and 51% from 2002 to 2006, with borderline statistical significance of 0.08 and 0.07, respectively.

Table 4.3 Caesarean section rate (number of CS in group/total number of deliveries in group) in the ten Robson groups, 2002 to 2006 (EC), and relative change between first and last time period. Chi square for test of trend.

Robson Group	2002	2003	2004	2005	2006	2002-2006	Relative change in %*	p-value
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	15.9%(51/320)	19.7%(59/299)	16.9%(61/361)	22.2%(80/361)	24.1%(127/526)	20.2%(378/1867)	51%	0.02
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	42.9%(9/21)	72.0%(18/25)	78.9%(30/38)	65.4%(17/26)	66.7%(22/33)	67.1%(96/143)	56%	0.08
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	13.9%(31/223)	17.3%(38/220)	12.0%(26/217)	14.9%(40/268)	18.0%(65/361)	15.5%(200/1289)	30%	0.31
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	47.6%(10/21)	55.6%(5/9)	40.6%(13/32)	43.5%(10/23)	58.6%(17/29)	48.2%(55/114)	23%	0.66
5. Previous CS, singleton, cephalic, ≥ 37 weeks	67.4%(31/46)	72.2%(39/54)	61.5%(32/52)	68.9%(51/74)	75.6%(65/86)	69.9%(218/312)	12%	0.50
6. Nulliparous, singleton, breech	47.1%(8/17)	53.3%(16/30)	35.1%(13/37)	59.1%(13/22)	47.9%(23/48)	47.4%(73/154)	2%	0.42
7. Multiparous, singleton, breech (including previous CS)	43.5%(10/23)	46.2%(12/26)	58.3%(21/36)	37.9%(11/29)	65.7%(46/70)	54.3%(100/184)	51%	0.07
8. Multiple pregnancies (including previous CS)	46.7%(14/30)	44.7%(21/47)	51.3%(20/39)	50.0%(25/50)	50.6%(40/79)	49.0%(120/245)	8%	0.96
9. All abnormal lies (including previous CS but excluding breech)	88.9%(8/9)	90.9%(10/11)	91.7%(11/12)	71.4%(5/7)	100.0%(10/10)	90.0%(44/49)	13%	0.44
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)	26.9%(18/67)	30.1%(22/73)	27.9%(24/86)	28.3%(26/92)	27.7%(39/141)	28.1%(129/459)	3%	1.00
Total	24.5%(190/777)	30.2% (240/794)	27.6%(251/910)	29.2%(278/952)	32.8% (454/1383)	29.3% (1413/4816)	34%	0.001

EC: Ethiopian calendar

* Relative change in CS rate = (CS rate 2006 – CS rate 2002)/CS rate 2002

Research Question 2: Trends in Percentage of Deliveries and Caesarean Sections by Robson Group

During the study period, the largest Robson group was Group 1 followed by Group 3 and Group 10 (Table 4.4). The relative size of the groups did not change significantly over the 5-year time period, save for Groups 4 and 7. The relative change in Group 4 likely reached statistical significance because of the tripling in size between 2003 and 2004 (1.1% to 3.5%). Group 7 had the only statistically significant increase (p= 0.05) during the study period from 3.0% to 5.1%, but this is unlikely to have been clinically significant.

Table 4.4 Number of deliveries and percentage of total deliveries for each Robson group by year, 2002 to 2006 (EC). Chi square for test of trend.

Robson Group	2002	2003	2004	2005	2006	2002-2006	p-value
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	41.2%(320/777)	37.7%(299/794)	39.7%(361/910)	37.9%(361/952)	38.0%(526/1383)	38.8%(1867/4816)	0.52
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	2.7%(21/777)	3.1%(25/794)	4.2%(38/910)	2.7%(26/952)	2.4%(33/1383)	3.0%(143/4816)	0.15
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	28.7%(223/777)	27.7%(220/794)	23.8%(217/910)	28.2%(268/952)	26.1%(361/1383)	26.7%(1289/4816)	0.13
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	2.7%(21/777)	1.1%(9/794)	3.5%(32/910)	2.4%(23/952)	2.1%(29/1383)	2.4%(114/4816)	0.02
5. Previous CS, singleton, cephalic, ≥ 37 weeks	5.9%(46/777)	6.8%(54/794)	5.7%(52/910)	7.8%(74/952)	6.2%(86/1383)	6.5%(312/4816)	0.38
6. Nulliparous, singleton, breech	2.2%(17/777)	3.8%(30/794)	4.1%(37/910)	2.3%(22/952)	3.5%(48/1383)	3.2%(154/4816)	0.08
7. Multiparous, singleton, breech (including previous CS)	3.0%(23/777)	3.3%(26/794)	4.0%(36/910)	3.0%(29/952)	5.1%(70/1383)	3.8%(184/4816)	0.05
8. Multiple pregnancies (including previous CS)	3.9%(30/777)	5.9%(47/794)	4.3%(39/910)	5.3%(50/952)	5.7%(79/1383)	5.1%(245/4816)	0.20
9. All abnormal lies (including previous CS but excluding breech)	1.1%(9/777)	1.4%(11/794)	1.3%(12/910)	0.7%(7/952)	0.7%(10/1383)	1.0%(49/4816)	0.41
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)	8.6%(67/777)	9.2%(73/794)	9.4%(86/910)	9.7%(92/952)	10.2%(141/1383)	9.5%(459/4816)	0.81
Total	100%(777/777)	100%(794/794)	100%(910/910)	100%(952/952)	100%(1383/1383)	100%(4816/4816)	

EC: Ethiopian calendar

The largest Robson group (Group 1) contributed most to the total CS rate over each of the 5 years (Table 4.5); overall, nulliparous women with singleton cephalic term pregnancies in spontaneous labour contributed 7.8% to the overall CS rate. The next two largest contributing groups to the total CS rate were multiparous women with singleton cephalic term pregnancies in spontaneous labour (Group 3) and multiparous women who had a previous CS (Group 5); on average, the two groups contributed 4.2% and 4.5%, respectively. Group 10, the third largest Robson group contributed between 2.3 – 2.8% to the overall CS rate, the fourth largest contribution.

Table 4.5 Number of Caesarean sections and contribution to the CS rate for each Robson group by year, 2002 to 2006 (EC).

Robson Group	2002	2003	2004	2005	2006	2002-2006
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	6.6%(51/777)	7.4%(59/794)	6.7%(61/910)	8.4%(80/952)	9.2%(127/1383)	7.8%(378/4816)
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	1.2%(9/777)	2.3%(18/794)	3.3%(30/910)	1.8%(17/952)	1.6%(22/1383)	2.0%(96/4816)
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	4.0%(31/777)	4.8%(38/794)	2.9%(26/910)	4.2%(40/952)	4.7%(65/1383)	4.2%(200/4816)
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	1.3%(10/777)	0.6%(5/794)	1.4%(13/910)	1.1%(10/952)	1.2%(17/1383)	1.1%(55/4816)
5. Previous CS, singleton, cephalic, ≥ 37 weeks	4.0%(31/777)	4.9%(39/794)	3.5%(32/910)	5.4%(51/952)	4.7%(65/1383)	4.5%(218/4816)
6. Nulliparous, singleton, breech	1.0%(8/777)	2.0%(16/794)	1.4%(13/910)	1.4%(13/952)	1.7%(23/1383)	1.5%(73/4816)
7. Multiparous, singleton, breech (including previous CS)	1.3%(10/777)	1.5%(12/794)	2.3%(21/910)	1.2%(11/952)	3.3%(46/1383)	2.1%(100/4816)
8. Multiple pregnancies (including previous CS)	1.8%(14/777)	2.6%(21/794)	2.2%(20/910)	2.6%(25/952)	2.9%(40/1383)	2.5%(120/4816)
9. All abnormal lies (including previous CS but excluding breech)	1.0%(8/777)	1.3%(10/794)	1.2%(11/910)	0.5%(5/952)	0.7%(10/1383)	0.9%(44/4816)
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)	2.3%(18/777)	2.8%(22/794)	2.6%(24/910)	2.7%(26/952)	2.8%(39/1383)	2.7%(129/4816)
Total	24.5%(190/777)	30.2%(240/794)	27.5%* (251/910)	29.3%* (278/952)	32.8%(454/1383)	29.3%(1413/4816)

EC: Ethiopian calendar

*CS rates differ by 0.1%in Table 4.4 and Table 4.5 due to rounding differences.

Research Question 3: Urgency Status of Caesarean Sections Performed at SPHMMC

There was no statistically significant trend in the urgency status of CS performed during the study period when considering all Robson groups combined (Table 4.6) (p= 0.59). The majority of CS were classified as Scheduled (53.7%), followed by Emergent (24%), Urgent (16.6%), and finally Elective (5.7%).

The largest urgency subgroup, consistently during all 5 years, in the majority of Robson groups, was the Scheduled group. In Robson group 4, the distribution of urgency status changed every year until 2005/2006 when Scheduled CS started to outnumber the other subgroups (Appendix). In Robson group 10, the Emergent subgroup was the largest except for 2003, when Scheduled CS was the largest subgroup (Appendix).

The largest number of Elective CS performed were in women who previously had CS (Group 5) followed by women with multiple pregnancies (Group 8). There were no Elective CS performed in Groups 1, 3 and 6 during the entire study period.

The distribution of CS performed among the urgency subgroups during the study period was only statistically significant in Groups 1, 6 and 8. However, the distribution among the subgroups in these three groups is unlikely to be clinically significant; the slightly different distribution in 2003 for Group 1, and the small numbers of CS in both Groups 6 and 8 causing large variation in percentages, is likely what resulted in statistical significance (Appendix).

Table 4.6 Urgency status of Caesarean sections performed by Robson group, 2002 to 2006 (EC). Chi square for test of trend.

Robson Group		2002-2006	p-value
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour			0.03
	Elective	0.0%(0/378)	
	Scheduled	47.9%(181/378)	
	Urgent	19.8%(75/378)	
	Emergent	32.2%(122/378)	
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour			0.15
	Elective	1.0%(1/96)	
	Scheduled	64.6%(62/96)	
	Urgent	14.6%(14/96)	
	Emergent	19.8%(19/96)	
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour			0.20
	Elective	0.0%(0/200)	
	Scheduled	46.5%(92/200)	
	Urgent	16.5%(33/200)	
	Emergent	37.0%(74/200)	
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour			0.69
	Elective	7.3%(4/55)	
	Scheduled	45.4%(25/55)	
	Urgent	20.0%(11/55)	
	Emergent	27.3%(15/55)	
5. Previous CS, singleton, cephalic, ≥ 37 weeks			0.14
	Elective	21.1%(46/218)	
	Scheduled	64.7%(141/218)	
	Urgent	9.2%(20/218)	
	Emergent	5.0%(11/218)	
6. Nulliparous, singleton, breech			0.02
	Elective	0.0%(0/73)	
	Scheduled	76.7%(56/73)	
	Urgent	13.7%(10/73)	
	Emergent	9.6%(7/73)	
7. Multiparous, singleton, breech (including previous CS)			0.46
	Elective	8.0%(8/100)	
	Scheduled	70.0%(70/100)	
	Urgent	10.0%(10/100)	
	Emergent	12.0%(12/100)	
8. Multiple pregnancies (including previous CS)			0.01
	Elective	14.2%(17/120)	
	Scheduled	60.0%(72/120)	
	Urgent	14.2%(17/120)	
	Emergent	11.6%(14/120)	
9. All abnormal lies (including previous CS but excluding breech)			0.60
	Elective	6.8%(3/44)	
	Scheduled	63.6%(28/44)	
	Urgent	18.2%(8/44)	
	Emergent	11.4%(5/44)	
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)			0.48
	Elective	0.8%(1/129)	
	Scheduled	24.0%(31/129)	
	Urgent	28.7%(37/129)	
	Emergent	46.5%(60/129)	
Total			0.59
	Elective	5.7%(80/1413)	
	Scheduled	53.7%(759/1413)	
	Urgent	16.6%(235/1413)	
	Emergent	24.0%(339/1413)	

EC: Ethiopian calendar

Research Question 4: Indications for Caesarean Sections

The indications for CS performed at SPHMMC in our study sample are presented in Table 4.7. Fetal distress, fetal presentation and cephalopelvic disproportion were consistently in the top 4 most common indications for a CS in each year of the study. Other common causes in most years included a history of previous CS and failure of labour to progress.

Table 4.7 Indications for Caesarean section at SPHMMC, 2002 to 2006 (EC).

Indication for CS	Number of CS performed				
	2002	2003	2004	2005	2006
Fetal distress	31	47	39	63	118
Cord prolapse	2	5	9	5	9
Premature rupture of membranes	3	2	8	9	10
Cephalopelvic disproportion	27	26	28	40	57
Previous CS	30	25	23	41	66
Hypertension related	15	15	15	19	27
Intrauterine growth restriction	1	0	1	3	1
Failure of labour to progress	24	37	28	17	27
Failed induction	5	7	14	6	17
Oligohydramnios	4	14	26	21	31
APH	18	19	18	21	22
Fetal presentation	25	35	38	29	58
Other	5	8	4	4	11
Total	**190**	**240**	**251**	**278**	**454**

EC: Ethiopian calendar

Research Question 5: Factors Predicting Caesarean Section at SPHMMC

The odds ratios of the likelihood of a CS during 2006 in comparison to 2002 are shown in Table 4.8. For the study sample, the OR of CS in 2006 was 1.49 (1.22 – 1.81) after adjustment for maternal age and referral status. All Robson groups (apart from Group 9 for which the OR could not be calculated) had ORs > 1 when comparing the likelihoods of CS in 2006 compared with 2002. However only Group 1 had a statistically significant increase (adjusted OR 1.67, 1.16 – 2.40). These results correlate with our findings as presented in Table 4.5.

Table 4.8 Univariate and multivariable logistic regression analysis of the likelihood of CS during 2006 compared to 2002 (EC) in the ten Robson groups.

Robson Group	2002	2006	
	OR	Univariate Analysis OR (95% CI)	Multivariable Analysis OR (95% CI)
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	1	1.68 (1.17 - 2.41)	1.67 (1.16 - 2.40)[A]
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	1	2.67 (0.86 - 8.23)	2.58 (0.79 - 8.36)[A]
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	1	1.36 (0.85 - 2.16)	1.31 (0.82 - 2.09)[B]
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	1	1.56 (0.50 - 4.83)	1.70 (0.52 - 5.59)[A]
5. Previous CS, singleton, cephalic, ≥ 37 weeks	1	1.50 (0.68 - 3.30)	1.50 (0.68 - 3.30)[C]
6. Nulliparous, singleton, breech	1	1.04 (0.34 - 3.13)	1.23 (0.38 - 3.93)[A]
7. Multiparous, singleton, breech (including previous CS)	1	2.49 (0.95 - 6.51)	2.49 (0.95 - 6.51)[C]
8. Multiple pregnancies (including previous CS)	1	1.17 (0.51 - 2.72)	1.21 (0.51 - 2.88)[A]
9. All abnormal lies (including previous CS but excluding breech)*	1	-	-
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)	1	1.04 (0.54 - 2.00)	1.00 (0.52 - 1.94)[A]
Total	1	1.51 (1.24 - 1.84)	1.49 (1.22 - 1.81)[D]

EC: Ethiopian calendar

* Unable to calculate OR as in 2006, all women in this group delivered via CS.

[A] Adjusted for maternal age.

[B] Adjusted for referral status

[C] No significant change from maternal age or referral status.

[D] Adjusted for both maternal age and referral status.

The results of logistic regression analyses for independent predictors of having a CS during the study period are presented in Table 4.9. Having a fetus with the shoulder as the presenting part was the strongest predictor of having a CS (OR= 36.57 after adjustment, 11.39 – 92.93). The next strongest predictor of having a CS was having had a previous CS (OR= 10.11 after adjustment, 7.86 – 13.01). Other significant predictors were the number of fetuses, year, referral status, maternal age and parity. Birth weight was not a significant predictor of having a CS after statistical adjustment.

Table 4.9 Univariate and multivariable logistic regression analysis of independent predictors of having Caesarean section, 2002 to 2006 (EC).

Variable	Univariate Analysis OR	95% CI	p-value	Multivariable Analysis OR	95% CI	p-value
Year						
2002	-			-		
2003	1.34	1.07 - 1.67	0.01	1.31	1.03 - 1.67	0.03
2004	1.18	0.95 - 1.46	0.15	1.16	0.91 - 1.47	0.23
2005	1.27	1.03 - 1.58	0.03	1.31	1.04 - 1.66	0.02
2006	1.51	1.24 - 1.84	<0.001	1.48	1.20 - 1.84	<0.001
Referral Status						
Self Referred	-			-		
HCW Referred	1.51	1.13 - 2.01	0.005	1.39	1.02 - 1.89	0.03
Maternal Age						
<20	-			-		
20-24	1.04	0.78 - 1.39	0.78	0.97	0.72 - 1.31	0.84
25-29	1.65	1.24 - 2.19	0.001	1.56	1.15 - 2.12	0.004
30-34	1.66	1.22 - 2.25	0.001	1.67	1.19 - 2.34	0.003
35-39	1.82	1.29 - 2.56	0.001	1.88	1.27 - 2.78	0.002
40+	2.05	1.00 - 4.20	0.05	1.99	0.88 - 4.49	0.1
Parity						
0	-			-		
1 - 4	1.25	1.10 - 1.42	0.001	0.57	0.48 - 0.67	<0.001
5+	1.45	1.02 - 2.06	0.04	0.80	0.52 - 1.23	0.31
Previous CS						
No	-			-		
Yes	7.13	5.68 - 8.96	<0.001	10.11	7.86 - 13.01	<0.001
Number of Fetuses						
1	-			-		
2	2.41	1.86 - 3.13	<0.001	2.04	1.53 - 2.72	<0.001
3	5.07	0.93 - 27.74	0.06	5.92	0.97 - 36.02	0.05
Fetal Presentation						
Cephalic	-			-		
Breech	3.43	2.80 - 4.20	<0.001	3.50	2.82 - 4.36	<0.001
Shoulder	28.33	11.27 - 71.22	<0.001	36.57	14.39 - 92.93	<0.001
Birth Weight						
LBW	-					
NBW	0.76	0.64 - 0.89	0.001			
Macrosomia	1.22	0.73 - 2.03	0.45			

EC: Ethiopian calendar

LBW= Low birth weight (<2500 g)
NBW= Normal birth weight (2500 - 4200 g)
Macrosomia= >4200 g

Research Question 6a: Maternal Mortality & Morbidity

In our study sample, there were six maternal deaths (Table 4.10), two in 2003, two in 2004 and one each in 2005 and 2006. Half of the cases were nulliparous women. Two of the women delivered via CS.

Table 4.10 Cases of maternal deaths, 2002 to 2006 (EC).

Year	Maternal Age (years)	G	P	Gestational Age (weeks)	Robson Group	Labour	Mode of Delivery	CS Indication	Acuity	Cause of Death
2003	30	1	0	41	1	Spontaneous	CS	Eclampsia	Emergent	Intracranial hemorrhage/ Eclampsia
2003	27	1	0	<37	10	Spontaneous	SVD	-	-	Unknown
2004	34	4	3	38	3	Spontaneous	SVD	-	-	Unknown
2004	31	4	3	36	7	Spontaneous	SVD	-	-	HIV/ Cardiac arrest
2005	23	2	1	<37	10	Induced	CS	Failed induction	Scheduled	Multi-organ failure
2006	35	1	0	<37	10	Induced	Instrument	-	-	Intracranial hemorrhage/ Eclampsia

EC: Ethiopian calendar

G: Gravidity

P: Parity

The overall maternal morbidity rate for our study sample increased from 3.5% in 2002 to 4.1% in 2006 (p= 0.02) (Table 4.11). The highest maternal morbidity rate was in Robson group 9 (10.2%), and the rate in this group did not vary significantly over the course of the study (p= 0.72). Robson group 4 had the lowest overall maternal morbidity rate (3.5%), and also statistically significant changes (p= 0.03) in maternal morbidity rate over time. The statistical significant change in rate is due to high morbidity rate in 2003 (22.2%), but otherwise low morbidity rates in the remaining years.

Table 4.11 Maternal morbidity rate (number of mothers with complications post delivery/total number of mothers) in the ten Robson groups, 2002 to 2006 (EC). Chi square for test of trend.

Robson Group	2002	2003	2004	2005	2006	2002-2006	p-value
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	3.1%(10/320)	4.0%(12/299)	6.1%(22/361)	4.2%(15/361)	4.4%(23/526)	4.4%(82/1867)	0.43
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	4.8%(1/21)	4.0%(1/25)	10.5%(4/38)	7.7%(2/26)	6.1%(2/33)	7.0%(10/143)	0.86
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	3.1%(7/223)	4.5%(10/220)	6.0%(13/217)	5.6%(15/268)	2.2%(8/361)	4.1%(53/1289)	0.12
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	0.0%(0/21)	22.2%(2/9)	3.1%(1/32)	4.3%(1/23)	0.0%(0/29)	3.5%(4/114)	0.03
5. Previous CS, singleton, cephalic, ≥ 37 weeks	6.5%(3/46)	9.3%(5/54)	9.6%(5/52)	8.1%(6/74)	3.5%(3/86)	7.1%(22/312)	0.60
6. Nulliparous, singleton, breech	11.8%(2/17)	0.0%(0/30)	2.7%(1/37)	13.6%(3/22)	4.2%(2/48)	5.2%(8/154)	0.14
7. Multiparous, singleton, breech (including previous CS)	4.3%(1/23)	0.0%(0/26)	8.3%(3/36)	10.3%(3/29)	4.3%(3/70)	5.4%(10/184)	0.45
8. Multiple pregnancies (including previous CS)	0.0%(0/30)	4.3%(2/47)	5.1%(2/39)	14.0%(7/50)	7.6%(6/79)	6.9%(17/245)	0.14
9. All abnormal lies (including previous CS but excluding breech)	11.1%(1/9)	18.2%(2/11)	8.3%(1/12)	14.3%(1/7)	0.0%(0/10)	10.2%(5/49)	0.72
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)	3.0%(2/67)	11.0%(8/73)	7.0%(6/86)	5.4%(5/92)	7.1% (10/141)	6.8%(31/459)	0.43
Total	3.5%(27/777)	5.3%(42/794)	6.4%(58/910)	6.1%(58/952)	4.1%(57/1383)	5.0%(242/4816)	0.02

EC: Ethiopian calendar

Research Question 6b: Perinatal Mortality & Morbidity

Perinatal outcomes did not significantly change over time during 2002 to 2006. The overall perinatal mortality rate for all groups was 80 per 1000 deliveries (range from 76 to 84 per 1000 deliveries, *p*= 0.95) (Table 4.12). The overall perinatal distress rate for all groups was 12.7% (range from 12.0 to 13.7%, *p*= 0.82) (Table 4.13).

The highest perinatal mortality rates were in Robson group 9, followed by Robson group 10 (388 per 1000 and 259 per 1000, respectively). Similarly, the highest perinatal distress rates were also in Robson groups 9 and 10 (44.9% and 35.7%, respectively). The rates in these groups did not vary significantly over time. In contrast, the lowest perinatal mortality and distress rates were in Robson group 5 (16 per 1000 deliveries and 2.9%), and these rates did not vary significantly over time.

Multiparous women with singleton breech pregnancies (Robson group 7) had large fluctuations in perinatal mortality ratio during the study period (56 to 345 per 1000 deliveries). During the entire study period, Robson group 7 had a small number of women, and the small changes in the number of mortality events resulted in large changes in the perinatal mortality rate. This resulted in statistical significance (p= 0.002); however, this is unlikely to be clinically significant.

Table 4.12 Perinatal mortality rate (number of stillbirths and early neonatal deaths per 1000 deliveries) in the ten Robson groups, 2002-2006 (EC). P-value for test of trend.

Robson Group	2002	2003	2004	2005	2006	2002-2006	p-value
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	53 (17/320)	50 (15/299)	39 (14/361)	42 (15/361)	57 (30/526)	49 (91/1867)	0.72
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	143 (3/21)	0 (0/25)	79 (3/38)	77 (2/26)	61 (2/33)	70 (10/143)	0.45
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	45 (10/223)	59 (13/220)	46 (10/217)	56 (15/268)	50 (18/361)	51 (66/1289)	0.95
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	95 (2/21)	0 (0/9)	31 (1/32)	87 (2/23)	0 (0/29)	44 (5/114)	0.38
5. Previous CS, singleton, cephalic, ≥ 37 weeks	22 (1/46)	37 (2/54)	19 (1/52)	0 (0/74)	12 (1/86)	16 (5/312)	0.57
6. Nulliparous, singleton, breech	235 (4/17)	67 (2/30)	135 (5/37)	136 (3/22)	125 (6/48)	130 (20/154)	0.60
7. Multiparous, singleton, breech (including previous CS)	87 (2/23)	269 (7/26)	56 (2/36)	345 (10/29)	86 (6/70)	147 (27/184)	0.002
8. Multiple pregnancies (including previous CS)	167 (5/30)	106 (5/47)	128 (5/39)	80 (4/50)	51 (4/79)	94 (23/245)	0.36
9. All abnormal lies (including previous CS but excluding breech)	333 (3/9)	182 (2/11)	500 (6/12)	571 (4/7)	400 (4/10)	388 (19/49)	0.45
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)	269 (18/67)	192 (14/73)	267 (23/86)	272 (25/92)	277 (39/141)	259 (119/459)	0.72
Total	84(65/777)	76 (60/794)	77 (70/910)	84 (80/952)	80 (110/1383)	80 (385/4816)	0.95

EC: Ethiopian calendar

Table 4.13 Perinatal distress rate (number of births with Apgar score <7 at 5 minutes/total number of births) in the ten Robson groups, 2002 to 2006 (EC). P-value for test of trend.

Robson Group	2002	2003	2004	2005	2006	2002-2006	p-value
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	9.4%(30/320)	9.7%(29/299)	9.4%(34/361)	11.4%(41/361)	10.6%(56/526)	10.2%(190/1867)	0.88
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	19.0%(4/21)	4.0%(1/25)	13.2%(5/38)	7.7%(2/26)	12.1%(4/33)	11.2%(16/143)	0.54
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour	7.6%(17/223)	8.6%(19/220)	7.4%(16/217)	8.2%(22/268)	6.9%(25/361)	7.7%(99/1289)	0.95
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour	9.5%(2/21)	0.0%(0/9)	3.1%(1/32)	4.3%(1/23)	6.9%(2/29)	5.3%(6/114)	0.78
5. Previous CS, singleton, cephalic, ≥ 37 weeks	2.2%(1/46)	5.6%(3/54)	7.7%(4/52)	0.0%(0/74)	1.2%(1/86)	2.9%(9/312)	0.07
6. Nulliparous, singleton, breech	29.4%(5/17)	13.3%(4/30)	21.6%(8/37)	27.3%(6/22)	16.7%(8/48)	20.1%(31/154)	0.58
7. Multiparous, singleton, breech (including previous CS)	13.0%(3/23)	26.9%(7/26)	13.9%(5/36)	37.9%(11/29)	18.6%(13/70)	21.2%(39/184)	0.10
8. Multiple pregnancies (including previous CS)	23.3%(7/30)	14.9%(7/47)	17.9%(7/39)	16.0%(8/50)	7.6%(6/79)	14.3%(35/245)	0.24
9. All abnormal lies (including previous CS but excluding breech)	44.4%(4/9)	18.2%(2/11)	58.3%(7/12)	71.4%(5/7)	40.0%(4/10)	44.9%(22/49)	0.19
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)	35.8%(24/67)	31.5%(23/73)	37.2%(32/86)	37.0%(34/92)	36.2%(51/141)	35.7%(164/459)	0.95
Total	12.5%(97/777)	12.0%(95/794)	13.1%(119/910)	13.7%(130/952)	12.3%(170/1383)	12.7%(611/4816)	0.82

EC: Ethiopian calendar

Research Question 7a: Factors Predicting Maternal Morbidity at SPHMMC

The results of logistic regression analyses of independent predictors of maternal morbidity during the study period are presented in Table 4.14. Our analysis did not demonstrate any strong predictors of maternal morbidity. Weaker predictors included the year, the form of delivery and birth weight. Referral status, fetal presentation and the number of fetuses were not significant predictors of morbidity after statistical adjustment.

Table 4.14 Univariate and multivariable logistic regression analysis of independent predictors of maternal morbidity, 2002 to 2006 (EC).

Variable	Univariate Analysis OR	95% CI	p-value	Multivariable Analysis OR	95% CI	p-value
Year						
2002	-			-		
2003	1.55	0.95 - 2.54	0.08	1.46	0.89 - 2.41	0.13
2004	1.89	1.19 - 3.02	0.008	1.81	1.13 - 2.90	0.01
2005	1.80	1.13 - 2.87	0.01	1.69	1.06 - 2.71	0.03
2006	1.19	0.75 - 1.90	0.46	1.07	0.67 - 1.71	0.77
Referral Status						
Self Referred	-					
HCW Referred	1.68	0.85 - 3.30	0.14			
Maternal Age						
<20	-					
20-24	0.90	0.51 - 1.59	0.71			
25-29	1.06	0.60 - 1.85	0.85			
30-34	1.29	0.71 - 2.34	0.41			
35-39	0.89	0.43 - 1.83	0.75			
40+	1.71	0.47 - 6.22	0.41			
Parity						
0	-					
1 - 4	0.97	0.75 - 1.27	0.84			
5+	0.81	0.35 - 1.88	0.63			
Number of Fetuses						
1	-					
2	1.47	0.88 - 2.45	0.14			
3	-	-	-			
Fetal Presentation						
Cephalic	-					
Breech	1.23	0.80 - 1.88	0.35			
Shoulder	1.95	0.77 - 4.93	0.16			
Onset of Labour						
Spontaneous	-					
Induced	1.76	1.06 - 2.90	0.03			
CS before labour	1.48	0.93 - 2.35	0.1			
Form of Delivery						
SVD	-			-		
Instrument	1.00	0.61 - 1.65	0.99	1.05	0.63 - 1.73	0.86
CS	2.59	1.97 - 3.40	<0.001	2.58	1.96 - 3.39	<0.001
Acuity Status						
Elective	-					
Scheduled	0.85	0.37 - 1.92	0.69			
Urgent	1.08	0.44 - 2.63	0.87			
Emergent	1.24	0.53 - 2.90	0.62			
Birth Weight						
NBW	-			-		
LBW	1.73	1.27 - 2.35	<0.001	1.64	1.20 - 2.24	0.002
Macrosomia	0.99	0.31 - 3.17	0.98	0.91	0.28 - 2.94	0.87

EC: Ethiopian calendar

LBW= Low birth weight (<2500 g)
NBW= Normal birth weight (2500 - 4200 g)
Macrosomia= >4200 g

Research Question 7b: Factors Predicting Perinatal Mortality & Morbidity at SPHMMC

The results of logistic regression analyses for independent predictors of perinatal mortality during the study period are presented in Table 4.15. The strongest predictor of perinatal mortality was fetal presentation; a fetus with shoulder presentation had 22.54 times (95% CI 10.54 – 48.19) increased odds of death as compared to a fetus with cephalic presentation. Other weaker predictors of perinatal mortality included acuity status and birth weight. The year of birth, referral status and form of delivery were not significant predictors of perinatal mortality.

Table 4.15 Univariate and multivariable logistic regression analysis of independent predictors of perinatal mortality, 2002 to 2006 (EC).

Variable	Univariate Analysis OR	95% CI	p-value	Multivariable Analysis OR	95% CI	p-value
Year						
2002	-					
2003	0.90	0.62 - 1.29	0.55			
2004	0.91	0.64 - 1.30	0.61			
2005	1.00	0.71 - 1.41	0.98			
2006	0.95	0.69 - 1.30	0.74			
Referral Status						
Self Referred	-					
HCW Referred	1.00	0.64 - 1.55	0.99			
Fetal Presentation						
Cephalic	-			-		
Breech	1.91	1.40 - 2.60	<0.001	1.21	0.57 - 2.56	0.61
Shoulder	8.03	4.60 - 14.00	<0.001	22.54	10.54 - 48.19	<0.001
Onset of Labour +						
Spontaneous	-			-		
Induced	2.57	1.79 - 3.69	<0.001	1.10	0.43 - 2.84	0.84
CS before labour	0.89	0.57 - 1.41	0.57	0.69	0.37 - 1.31	0.26
Form of Delivery ^						
SVD	-					
Instrument	0.30	0.18 - 0.50	<0.001			
CS	0.63	0.49 - 0.81	<0.001			
Acuity Status °						
Elective	-			-		
Scheduled	0.73	0.21 - 2.50	0.62	0.47	0.11 - 1.99	0.31
Urgent	2.00	0.57 - 7.02	0.28	1.52	0.36 - 6.41	0.57
Emergent	4.34	1.32 - 14.29	0.02	4.06	1.00 - 16.39	0.05
Birth Weight						
NBW	-			-		
LBW	6.56	5.27 - 8.17	<0.001	2.61	1.55 - 4.41	<0.001
Macrosomia	0.61	0.15 - 2.50	0.49	1.27	0.16 - 10.14	0.82

EC: Ethiopian calendar

LBW= Low birth weight (<2500 g)
NBW= Normal birth weight (2500 - 4200 g)
Macrosomia= >4200 g

° Acuity Status only recorded for patients who delivered via CS
^ Variable eliminated in multivariable regression due to collinearity
+ Variable kept in the final model as a confounder

The results of logistic regression analyses for independent predictors of perinatal distress during the study period are presented in Table 4.16. The strongest predictor of perinatal distress was acuity status; an infant born via an emergent CS had 8.22 times (95% CI 1.82 – 37.12) increased odds of distress as compared to an infant born via elective CS. Other weaker predictors of neonatal distress included fetal presentation, onset of labour and birth weight. Form of delivery was not a significant predictor after statistical adjustment.

Table 4.16 Univariate and multivariable logistic regression analysis of independent predictors of perinatal distress, 2002 to 2006 (EC).

Variable	Univariate Analysis OR	95% CI	p-value	Multivariable Analysis OR	95% CI	p-value
Year						
2002	-					
2003	0.95	0.70 - 1.29	0.75			
2004	1.05	0.79 - 1.41	0.72			
2005	1.11	0.84 - 1.47	0.47			
2006	0.98	0.75 - 1.28	0.9			
Referral Status						
Self Referred	-					
HCW Referred	1.17	0.80 - 1.70	0.42			
Fetal Presentation						
Cephalic	-			-		
Breech	1.80	1.39 - 2.33	<0.001	0.85	0.50 - 1.43	0.53
Shoulder	5.86	3.41 - 10.07	<0.001	6.68	3.46 - 12.92	<0.001
Onset of Labour						
Spontaneous	-			-		
Induced	1.62	1.15 - 2.29	0.006	0.41	0.18 - 0.97	0.04
CS before labour	0.90	0.63 - 1.30	0.59	0.60	0.38 - 0.96	0.04
Form of Delivery ^						
SVD	-					
Instrument	0.52	0.37 - 0.73	<0.001			
CS	0.91	0.75 - 1.10	0.33			
Acuity Status º						
Elective	-			-		
Scheduled	3.29	0.79 - 13.72	0.10	2.21	0.49 - 10.04	0.31
Urgent	7.29	1.72 - 30.97	0.007	4.63	1.01 - 21.19	0.05
Emergent	12.05	2.90 - 50.13	0.001	8.22	1.82 - 37.12	0.006
Birth Weight						
NBW	-			-		
LBW	5.65	4.69 - 6.80	<0.001	3.50	2.38 - 5.16	<0.001
Macrosomia	0.68	0.24 - 1.87	0.45	1.04	0.23 - 4.62	0.96

EC: Ethiopian calendar

LBW= Low birth weight (<2500 g)
NBW= Normal birth weight (2500 - 4200 g)
Macrosomia= >4200 g

º Acuity Status only recorded for patients who delivered via CS
^ Variable eliminated in multivariable regression due to collinearity

Chapter 5- Discussion

Summary of Results

Increasing Caesarean Section Rate at SPHMMC

During the study period, 2002 to 2006, the overall CS rate at SPHMMC significantly increased from 24.5% to 32.8% (p= 0.001). This is not surprising when examining the global trend of increased CS rates in the last three decades; this has shown to be the case in studies of CS rates in either developed or developing countries. The CS rate at SPHMMC is much higher than the last published Ethiopian national CS rate of 1.5%, and even higher than the Addis Ababa CS rate of 21.8% (These rates were published in 2011, which corresponds to 2003 on the Ethiopian calendar) (39). The higher rate at SPHMMC can be accounted for by the fact that SPHMMC serves as a national specialized hospital and therefore receives high acuity and ill patients from all over the country.

The results found in this study showed a slight but statistically significant increase in the rate of referral by HCWs from 92.5% in 2002 to 96.1% in 2006 (p= 0.0004). This increase in the number of patients referred may have contributed to some of the rise in the CS rate at SPHMMC as more acutely ill patients may have required delivery via CS. On the other hand, the referral pattern may not have contributed to the rising CS rate as analysis of the urgency subgroups at SPHMMC did not reveal a significant change in the proportion of women requiring Urgent or Emergent CS. Additional research specifically examining the effects of changes in referral patterns is required.

The distribution of indications for CS did not change throughout the study with fetal distress and fetal presentation being the two most common indications for CS every single year of the study. Thus, a change in CS indications cannot account for the rise in CS rate at SPHMMC. On the other hand, a statistically significant decrease in the number of instrument deliveries was found at SPHMMC. In 2002, 12.9% of deliveries were instrumental, which decreased to 8.3% in 2006 (p= 0.0003). It is likely that the decrease in instrument deliveries partially contributed to the increasing number of CS. Globally, instrumental delivery rates have been decreasing in high and low-income countries; possible explanations for this trend include decreased health care provider training in instrumental delivery, fear of causing harm to the newborn and lack of professional and financial support (66). Additional research examining the factors for decreased instrument use at SPHMMC is required.

Low Risk Women are Contributing Most to the Overall CS Rate at SPHMMC

The largest Robson group in all 5 years of the study, was RG 1, which contained approximately 40% of the patients in our study sample. RG 1 also had the only statistically significant increase in group CS rate, with a 51% relative increase from 15.9% in 2002 to 24.1% in 2006. Furthermore, RG 1 contributed most to the total CS rate over the 5-year study period; overall, the nulliparous population (RGs 1 and 2) contributed between 8 – 11% to the overall CS rate at SPHMMC.

These findings correspond to those found in the single institution studies conducted in Tanzania (56), Nepal (55) and South Africa (57). In the multi-institutional multi-national study conducted by Vogel et al. (22), the nulliparous population was the largest contributor to the overall CS rate in high, moderate and low HDI countries. This suggests that the threshold for performing a CS has become lower over time, and that this is not just a phenomenon in developed countries, but also becoming an important issue in developing countries as well.

Performing a CS without definite medical need can result in harm. Performing excessive CSs is also a drain on health care resources, a problem which is only exacerbated in low income countries. Additionally, a woman who is delivered via CS in her first pregnancy is at increased risk of requiring a CS in subsequent pregnancies, which consequently places more strain on the health care system. Thus, a very concerning domino effect of performing excessive CS can result.

Women Who Had a Previous CS are at High Risk of Repeat CS at SPHMMC

At SPHMMC, the strongest predictor of having a CS was a previous history of CS (OR= 10.11). In examining predictive factors of having a CS, studies conducted in both high and low-income countries (67-69), demonstrated that a previous history of CS was the strongest predictor of CS in the current pregnancy. Globally there is a lower threshold for performing a CS after a previous CS, and this fact has contributed to the global rise in CS rates.

Women who had a previous CS (RG 5), although one of the smaller RGs at SPHMMC, contributed second most (4.2%) to the overall hospital CS rate, after RG 1. Although the CS rate in RG 5 did not change significantly (p=0.50) over the course of the study, the group CS rate was high, with a range of 61.5 – 75.6%.

The finding that RG 5 is a top contributor to SPHMMC's overall CS rate is similar to the findings of the studies done in Tanzania (56, 58) and South Africa (57). In the study done by Vogel et al. (22), the CS rate in RG 5 in low-income countries in 2010 – 2011 was not far behind the CS rate in RG 5 in high-income countries in the same time period (72.1% and 79.4%, respectively). This data suggests that the problem of repeat CS (as discussed below) is a worldwide problem, and not just a phenomenon observed in developed countries.

These global rising repeat CS rates can partially be attributed to a seminal 2001 article (70) and subsequent editorial (71) which described the increased risk of uterine rupture in women undergoing vaginal birth following a previous CS as compared to women who were delivered by repeat CS. The relative risk of uterine rupture was 3.3 in women who experienced spontaneous labour, and the risk was even higher in women who were induced with or without prostaglandins (RR= 4.9 and 15.6, respectively). As a result, in developed countries, and especially in the US, there was a resultant increased fear of litigation and increased malpractice insurance rates as well as a move to increased patient autonomy regarding the choice to deliver via CS (72).

The major concerns with having a repeat CS are financial strain as well as the risk of increased morbidity, and in particular, experiencing postpartum hemorrhage (73) or developing placenta praevia or placenta accreta (74). The risk of complications is significantly higher with the more CS a woman undergoes; a 2013 UK study (75) that studied women who had 5 or more CS showed that these women were at significantly increased risk of hemorrhage, ICU admission and iatrogenic abdominal organ injury as compared to women who had had 2 – 4 previous CS.

Fetal Distress and Fetal Presentation are Common Indications for CS at SPHMMC

The most common indication for CS at SPHMMC during each year of the study period was fetal distress. Fetal distress was also the most common indication for CS in the studies using the Robson classification system in Nepal (55) and South Africa (57). Two other of the most common indications for CS were fetal presentation (other than cephalic) and cephalopelvic disproportion.

In the category of fetal presentation as a CS indication, singleton breech was the most common diagnosis. Compared to a fetus with cephalic presentation, a fetus with breech presentation is at increased risk of traumatic injury during delivery as well as asphyxia secondary to cord compression (76). Worldwide, the management of breech cases typically involves delivery via CS despite the lack of evidence.

The Society of Obstetricians & Gynaecologists of Canada has stated that selected women with a term, singleton, breech fetus can undergo a vaginal delivery, but an ultrasound must be available to conduct a pre- or early labour assessment of type of breech, fetal growth and weight (76). The availability of ultrasound is an obstacle to obstetrical care in Ethiopia. Many women do not live near a facility capable of conducting an ultrasound and others are unable to afford it. This lack of access to ultrasound results in breech presentation being one of the most common indications for CS performed at SPHMMC.

The Majority of CS Performed at SPHMMC are "Scheduled"

During the study period, there was no clinically significant variation in the distribution of women among the urgency subgroups. In the majority of Robson groups and in most years, the Scheduled subgroup (Needing early delivery but no maternal or fetal compromise) was the largest. The notable exception was in RG 10, where the Emergent subgroup (Immediate threat to life of the women or fetus) was the largest.

Traditionally, only a binary distinction, elective versus emergency, of performed CS was made. However, there is great variation in urgency between patients in the non-elective group; therefore, the binary distinction is inadequate when assessing CS rates. The Lucas et al. (31) group in the UK proposed a four grade urgency classification system that acknowledges the differences among the traditional emergency CS group; van Dillen et al. (34) studied the use of this classification system in different hospitals in the Netherlands and Belgium, and they concluded that there was substantial agreement among obstetricians using the proposed system (κ=0.70).

There have been no published studies to date that have used the urgency classification system as proposed by Lucas et al. to study CS rates. In this study, the Lucas et al. urgency classification was relatively simple to apply; some difficulty did arise in choosing urgency grades for some patients as some information was not available due to the retrospective nature of the study. There were no discrepancies in urgency grade between researchers, as the lead investigator assigned the urgency grade. If more than one clinician or researcher with obstetric knowledge was available, it would have been useful to compare the assigned urgency grades and agree on the final grade assignment.

The Lucas et al. urgency classification system provided useful insight into what has been traditionally termed the emergency CS group. Although it was hypothesized that the proportion of non-urgent (Scheduled and Elective groups) CS was increasing over time (which in this study was not the case), it was concurrently suspected that the urgent (Urgent and Emergent groups) CS compromised the majority of CS performed at SPHMMC. It was thought this might be the case because limited health care resources would affect what CS could be performed and as a result, CS would be reserved for the most severely ill patients. It was noteworthy that this was not in actuality the situation at SPHMMC, save for women delivering preterm infants (RG 10). It would be most informative if more studies at different centres, which used the Lucas et al. classification were conducted, so as to compare urgency grades between centres and possible associations with differences in morbidity and mortality rates.

Maternal Morbidity Increased Slightly Over Time at SPHMMC

From 2002 to 2006, the maternal morbidity rate in our study sample increased slightly from 3.5% to 4.1%; the morbidity rate was higher in the in-between years (5.3 – 6.1%). No Robson group had a statistically significant change in morbidity rate, except for RG 4; RG 4 had great fluctuations in morbidity rate, likely due to the small number of women in this group.

RG 9 had the highest maternal morbidity rate throughout the study. Just as transverse lie is known to be associated with increased rates of perinatal morbidity, transverse lie is also associated with an increased risk of maternal morbidity. In the previously mentioned study, from Ghana (77), the vast majority (93.4%) of women carrying fetuses lying transversely required CS during delivery (in comparison to 90.0% in our study) and preoperatively, 17.7% of women had chorioamnionitis, 9.9% had antepartum hemorrhage and 3.2% experienced uterine rupture.

There were no strong predictors of maternal morbidity during the study period. Of the weak predictors, the strongest predictor was form of delivery in that OR of morbidity for a woman delivered by CS compared to a woman delivering vaginally was 2.58 (95% CI 1.96 – 3.39). It is well known that there is increased risk of morbidity following CS as compared to vaginal delivery. In a large study done in the US (78), women who delivered via CS were 10 – 20 times more likely to develop endometritis and four times as likely to require a post-operative transfusion than women who delivered vaginally. Therefore, a proportion of maternal morbidities could be avoided if the CS rate could be reduced. Strategies to reduce the CS rate will be discussed in Chapter 6.

Neonatal Morbidity & Mortality Did Not Change Over Time at SPHMMC

The increasing CS rate at SPHMMC was not associated with worsening neonatal outcomes (*p*= 0.95 for perinatal mortality; *p*= 0.82 for neonatal distress). Overall, the perinatal mortality rate over the 5-year study period was 80 per 1000 deliveries. In comparison to the similar study conducted in Tanzania by Litorp et al. (56), the perinatal mortality rate in this study was lower, but did not decrease over time like in the Tanzanian study. (In the Tanzanian study, the perinatal mortality rate decreased over time from 112 per 1000 deliveries to 101 per 1000 deliveries, *p*= 0.001). In our study the overall neonatal distress rate was 12.7%, which was higher than the distress rate in the Tanzanian study (8.0%). The neonatal distress rate in our study did not decrease significantly over time (12.5% in 2002 and 12.3% in 2006) unlike in the Tanzanian study, in which the neonatal distress rate decreased from 8.5% to 7.7% (*p*= 0.001).

Between Robson groups, RG 9 and 10 had some of the worst perinatal mortality and perinatal distress rates throughout the entire study period. In the Tanzanian study, their RG 10 also had the worst perinatal mortality and distress rates throughout their study period of 2000 to 2011. On the other hand, RG 5 had the lowest rates of perinatal mortality and morbidity in our study as well as in the Tanzanian study.

The strongest predictor of perinatal mortality was fetal presentation. Fetal presentation was also a weaker predictor of perinatal distress. Transverse lie (i.e. shoulder presentation) is known to be associated with increased risk of perinatal morbidity and mortality as compared to fetuses in either cephalic or breech presentation. In a study of women labouring with fetuses in the transverse lie done in Ghana (77), there was a high rate of stillbirths (16.4%) as well as a high rate of neonates requiring NICU admission (24.3%). To modify this risk factor, external cephalic version may be attempted prelabour or in early labour in order to reposition the fetus into a cephalic presentation; however, a necessary prerequisite of external cephalic version is ultrasound examination, which as previously mentioned, is of limited availability in our study setting.

Study Strengths

This study had several strengths that are worthy of mention. First, this study is part of a small group of other studies which have examined the use of the Robson classification system in low-income countries. It adds to the limited knowledge that is available on this topic. Additionally, this is the only known study to date that has used urgency criteria to study CS rates. The urgency criteria proved simple to use, and added an additional level of understanding to CS practice patterns; however, it is important to mention and to recognize that knowledge in the field of obstetrics is necessary in assigning urgency status. Additional strengths of this study included the analysis of CS rates over a period of 5 years and the analysis of CS rate changes over time combined with concomitant analyses of maternal and neonatal morbidity and mortality rates.

Study Limitations

Although the goals of this research were achieved and research questions answered, there were some unavoidable limitations. First, because of the time limit on data collection, a cluster sampling method had to be used. This may have resulted in sampling error. However, it is unlikely that the deliveries that occurred on the first 9 days of the first 12 months and the first day of the 13th month differed significantly from the deliveries that occurred on the remaining days for the sample to be very biased.

A second limitation is that some of the Robson groups had a small number of patients. The small number of events of interest in these smaller groups drastically changed rates from year to year. It is difficult to be confident that the true picture of CS rates and morbidity and mortality rates in these groups were captured. The findings in these groups therefore have to be interpreted with caution. The only way to have overcome this limitation would have been to study all the patients that fell within these smaller Robson groups.

Another limitation is that 10% of the charts requested for deliveries occurring on the days that were part of our sampling protocol were unable to be located in the hospital records, and 4% of located charts were excluded because of missing information. This may have resulted in some selection bias being introduced into the study. However, since the missing and incomplete charts were for varying days, months and years, it is unlikely that this factor introduced bias.

Fourthly, due to the retrospective nature of this study, there was no access to a patient's sociodemographic data, as this information was not included in the chart. Such data would have added additional value to the study, and possibly deeper understanding of the study results. As discussed in the literature review, even within developing countries, "richer" urban women tend to have more access to CS and deliver via CS more frequently than "poorer" rural women. We were unable to study whether this was the case at SPHMMC, but if future prospective studies were to be conducted, it would be advisable to study this economic divide phenomenon.

The final major limitation of this research is that the complete picture of maternal and perinatal morbidity and mortality was unable to be obtained. This is due to the fact that women do not always return to the hospital at which they delivered if a complication arises (women are typically discharged from hospital 6 to 12 hours after vaginal delivery and 1 to 2 days after CS). These complications and deaths that occur outside of the hospital are important to understand the complete picture of CS that are being performed at SPHMMC, but until there is a way of obtaining this data (i.e. electronic record management that is shared between health facilities), our knowledge will not be complete.

Chapter 6- Conclusions & Recommendations

This study sought to understand the increasing CS rate at a national public referral hospital in a low-income country. As discussed, low-risk nulliparous women are the most significant contributors towards the overall CS rate at SPHMMC. Women who had a previous CS are the next largest contributing group to the CS rate at SPHMMC. The majority of CS performed were done for women requiring an early delivery, and not an 'emergent' basis where there were signs of maternal or fetal compromise. The rising CS rate at SPHMMC was not associated with worsening neonatal outcomes and only slightly worsening maternal outcomes.

The results of this study provided valuable insight into the CS rate at SPHMMC. It is important that the results of this study be reviewed with key administrators and health care providers at SPHMMC. The discussion of study results and health implications is an important step in knowledge translation in order to reap the benefits of research. It is also important that the results of this study be published in the literature in order to expand the small body of knowledge on CS in low-income countries that is currently available.

This study can hopefully serve as a baseline for further research regarding caesarean section at SPHMMC which is discussed in the following section. Finally, the results of this study suggest that evidence-based interventions to reduce primary and repeat CS rates would be beneficial at SPHMMC, and these are discussed in the final section.

Future Research

Firstly, to aid in future research in obstetrics at SPHMMC, it would be invaluable to create a simple electronic database, in which information can be collected prospectively on patient characteristics, sociodemographic variables, antenatal care, labour and maternal and neonatal outcomes of delivery.

With regards to future research at SPHMMC, repeating this study over a longer period of time and including all eligible deliveries in the study sample would give better insight into the CS rate over time at the hospital. Furthermore, with a larger sample size, a more complete understanding could be gained of the smaller Robson groups. Additionally, if CS-reducing interventions are implemented, a longer study period would capture the effects of such interventions.

Outside of SPHMMC, it is recommended that any research undertaken to examine CS rates should make use of urgency criteria as proposed by Lucas et al. (31). As demonstrated in our study, the urgency criteria provided a deeper understanding of the CS rate at SPHMMC. There is significant variation between patients in the group traditionally classified as 'emergency' CS, and it is important to capture as well as to examine these differences.

Strategies to Reduce the Primary & Repeat CS Rate at SPHMMC are Needed

The increasing CS rate in low-risk women (i.e. nulliparous women in RG 1) suggests that the threshold for medically indicated CS in these women is becoming lower over time at SPHMMC. If the primary CS rate continues to rise, there will likely be a domino effect of CS use in that more women will require repeat CS, and as a result, the CS rate in RG 5 will continue to rise. Therefore, evidence-informed interventions to reduce the primary and repeat caesarean section rates are needed. The following discussion of non-clinical interventions have shown to be effective in other settings: 1) Clinical interventions, such as external cephalic version and vaginal birth following previous CS, were mentioned in the Discussion.

2) Clinical audits have been shown to be effective in several settings. In a study conducted in Karachi, Pakistan (79), at a university hospital, two rounds of clinical audits with an in between implementation of standardized protocols, the primary CS rate was decreased from 17% to 12% in a one-year period. Similarly, in a study done in Tehran, Iran (80), after a clinical audit at a general hospital, the overall CS rate decreased from 40% to 33%, and there was also a 27% reduction in the primary CS rate, from 29% to 21%.

3) Another intervention that has been studied in both high and low-income countries is mandatory second opinion. Studies that showed the success of mandatory second opinion have been done in the US (81) and in Ecuador (82), although both studies were non-randomized. Another recently conducted study done in four countries in Latin America (83), which was a cluster randomized trial, showed a small reduction in CS rates (relative reduction of 7.3%), but the study authors noted that the intervention was well received by both patients and physicians.

4) Other interventions that have been directly targeted towards pregnant women have also shown to be effective. In a randomized controlled trial in Iran (84), investigators showed that relaxation education in order to reduce anxiety surrounding labour could also reduce the CS rate; in this particular study, the CS rate in the experimental group was 40.4% as compared to 78.8% in the control group. In another randomized controlled trial, also done in Iran (85), the use of birth preparation courses resulted in a decreased rate of CS in the experimental group (3%) compared to the control group (10%) (p= 0.044).

There are a variety of evidence-based interventions and programs that could be attempted at SPHMMC for the purpose of lowering the CS rate. However, due to the broad scope of the possible interventions mentioned above, as well as the varying settings in which they were applied, it is difficult to predict the effectiveness and magnitude of effect at SPHMMC. On the other hand, it would be well advised to attempt some interventions at SPHMMC so that the trend of rising CS rates be halted.

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Appendix

Urgency status of Caesarean sections performed by Robson group, 2002 to 2006 (Ethiopian calendar). Chi square for test of trend.

Robson Group	2002	2003	2004	2005	2006	2002-2006	p-value
1. Nulliparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour							0.03
Elective	0.0%(0/51)	0.0%(0/59)	0.0%(0/61)	0.0%(0/80)	0.0%(0/127)	0.0%(0/378)	
Scheduled	58.8%(30/51)	40.7%(24/59)	55.7%(34/61)	36.2%(29/80)	50.4%(64/127)	47.9%(181/378)	
Urgent	19.6%(10/51)	16.9%(10/59)	18.0%(11/61)	31.3%(25/80)	15.0%(19/127)	19.8%(75/378)	
Emergent	21.6%(11/51)	42.4%(25/59)	26.2%(16/61)	32.5%(26/80)	34.6%(44/127)	32.2%(122/378)	
2. Nulliparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour							0.15
Elective	0.0%(0/9)	0.0%(0/18)	3.3%(1/30)	0.0%(0/17)	0.0%(0/22)	1.0%(1/96)	
Scheduled	44.4%(4/9)	66.7%(12/18)	66.7%(20/30)	76.4%(13/17)	59.1%(13/22)	64.6%(62/96)	
Urgent	22.2%(2/9)	33.3%(6/18)	3.3%(1/30)	11.8%(2/17)	13.6%(3/22)	14.6%(14/96)	
Emergent	33.3%(3/9)	0.0%(0/18)	26.7%(8/30)	11.8%(2/17)	27.3%(6/22)	19.8%(19/96)	
3. Multiparous, singleton, cephalic, ≥ 37 weeks, spontaneous labour							0.20
Elective	0.0%(0/31)	0.0%(0/38)	0.0%(0/26)	0.0%(0/40)	0.0%(0/65)	0.0%(0/200)	
Scheduled	32.3%(10/31)	44.7%(17/38)	46.2%(12/26)	55.0%(22/40)	49.2%(32/65)	46.5%(92/200)	
Urgent	12.9%(4/31)	28.9%(11/38)	11.5%(3/26)	12.5%(5/40)	15.4%(10/65)	16.5%(33/200)	
Emergent	54.8%(17/31)	26.3%(10/38)	42.3%(11/26)	32.5%(13/40)	35.4%(23/65)	37.0%(74/200)	
4. Multiparous, singleton, cephalic, ≥ 37 weeks, induced labour or CS before labour							0.69
Elective	10.0%(1/10)	20.0%(1/5)	0.0%(0/13)	10.0%(1/10)	5.9%(1/17)	7.3%(4/55)	
Scheduled	30.0%(3/10)	40.0%(2/5)	38.5%(5/13)	60.0%(6/10)	52.9%(9/17)	45.4%(25/55)	
Urgent	30.0%(3/10)	0.0%(0/5)	38.5%(5/13)	10.0%(1/10)	11.8%(2/17)	20.0%(11/55)	
Emergent	30.0%(3/10)	40.0%(2/5)	23.0%(3/13)	20.0%(2/10)	29.4%(5/17)	27.3%(15/55)	
5. Previous CS, singleton, cephalic, ≥ 37 weeks							0.14
Elective	29.0%(9/31)	12.8%(5/39)	21.9%(7/32)	27.5%(14/51)	16.9%(11/65)	21.1%(46/218)	
Scheduled	64.5%(20/31)	71.8%(28/39)	59.4%(19/32)	54.9%(28/51)	70.8%(46/65)	64.7%(141/218)	
Urgent	6.5%(2/31)	10.3%(4/39)	3.1%(1/32)	13.7%(7/51)	9.2%(6/65)	9.2%(20/218)	
Emergent	0.0%(0/31)	5.1%(2/39)	15.6%(5/32)	3.9%(2/51)	3.1%(2/65)	5.0%(11/218)	
6. Nulliparous, singleton, breech							0.02
Elective	0.0%(0/8)	0.0%(0/16)	0.0%(0/13)	0.0%(0/13)	0.0%(0/23)	0.0%(0/73)	
Scheduled	62.5%(5/8)	100.0%(16/16)	61.5%(8/13)	76.9%(10/13)	73.9%(17/23)	76.7%(56/73)	
Urgent	25.0%(2/8)	0.0%(0/16)	7.7%(1/13)	7.7%(1/13)	26.1%(6/23)	13.7%(10/73)	
Emergent	12.5%(1/8)	0.0%(0/16)	30.8%(4/13)	15.4%(2/13)	0.0%(0/23)	9.6%(7/73)	
7. Multiparous, singleton, breech (including previous CS)							0.46
Elective	0.0%(0/10)	8.3%(1/12)	4.8%(1/21)	18.2%(2/11)	8.7%(4/46)	8.0%(8/100)	
Scheduled	90.0%(9/10)	50.0%(6/12)	61.9%(13/21)	81.8%(9/11)	71.7%(33/46)	70.0%(70/100)	
Urgent	0.0%(0/10)	16.7%(2/12)	19.0%(4/21)	0.0%(0/11)	8.7%(4/46)	10.0%(10/100)	
Emergent	10.0%(1/10)	25.0%(3/12)	14.3%(3/21)	0.0%(0/11)	10.9%(5/46)	12.0%(12/100)	
8. Multiple pregnancies (including previous CS)							0.01
Elective	21.4%(3/14)	0.0%(0/21)	10.0%(2/20)	4.0%(1/25)	27.5%(11/40)	14.2%(17/120)	
Scheduled	71.4%(10/14)	71.4%(15/21)	45.0%(9/20)	76.0%(19/25)	47.5%(19/40)	60.0%(72/120)	
Urgent	7.1%(1/14)	23.8%(5/21)	15.0%(3/20)	8.0%(2/25)	15.0%(6/40)	14.2%(17/120)	
Emergent	0.0%(0/14)	4.8%(1/21)	30.0%(6/20)	12.0%(3/25)	10.0%(4/40)	11.6%(14/120)	
9. All abnormal lies (including previous CS but excluding breech)							0.60
Elective	0.0%(0/8)	0.0%(0/10)	18.2%(2/11)	0.0%(0/5)	10.0%(1/10)	6.8%(3/44)	
Scheduled	50.0%(4/8)	80.0%(8/10)	45.4%(5/11)	60.0%(3/5)	80.0%(8/10)	63.6%(28/44)	
Urgent	37.5%(3/8)	10.0%(1/10)	27.3%(3/11)	20.0%(1/5)	0.0%(0/10)	18.2%(8/44)	
Emergent	12.5%(1/8)	10.0%(1/10)	9.1%(1/11)	20.0%(1/5)	10.0%(1/10)	11.4%(5/44)	
10. Singleton, cephalic, ≤ 36 weeks (including previous CS)							0.48
Elective	0.0%(0/18)	4.5%(1/22)	0.0%(0/24)	0.0%(0/26)	0.0%(0/39)	0.8%(1/129)	
Scheduled	22.2%(4/18)	40.9%(9/2)	16.7%(4/24)	19.2%(5/26)	23.1%(9/39)	24.0%(31/129)	
Urgent	27.8%(5/18)	27.3%(6/22)	33.3%(8/24)	34.6%(9/26)	23.1%(9/39)	28.7%(37/129)	
Emergent	50.0%(9/18)	27.3%(6/22)	50.0%(12/24)	46.2%(12/26)	53.8%(21/39)	46.5%(60/129)	
Total							0.59
Elective	6.8%(13/190)	3.3%(8/240)	5.2%(13/251)	6.5%(18/278)	6.2%(28/454)	5.7%(80/1413)	
Scheduled	52.1%(99/190)	57.1%(137/240)	51.4%(129/251)	51.8%(143/278)	55.1%(250/454)	53.7%(759/1413)	
Urgent	16.8%(32/190)	18.8%(45/240)	15.9%(40/251)	19.0%(53/278)	14.3%(65/454)	16.6%(235/1413)	
Emergent	24.2%(46/190)	20.8%(50/240)	27.5%(69/251)	22.7%(63/278)	24.4%(111/454)	24.0%(339/1413)	