



The Caesarean Section Rate at Mowbray  
Maternity Hospital: Applying Robson's Ten  
Group Classification System

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# Declaration

I, Eben Kruger Venter, hereby declare that this dissertation and all the research, which led up to the drafting of this document, is my own work, unless acknowledged otherwise. I confirm that neither a section nor the whole dissertation has been, is being, or is to be submitted at the University of Cape Town or any other university for purposes of obtaining another degree.

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July 18, 2018

## List of Acronyms

- ACOG American College of Obstetricians and Gynaecologists
- AIDS Acquired Immunodeficiency Syndrome
- ART Antiretroviral Therapy (Mono- or Dual Therapy)
- BMI Body Mass Index
- CI Confidence Interval
- CS Caesarean Section
- CSR Caesarean Section Rate
- CTG Cardiotocograph
- DCDA Dichorionic Diamniotic
- ECV External Cephalic Version
- EFM Electronic Fetal Monitoring
- GSH Groote Schuur Hospital
- HAART Highly Active Antiretroviral Therapy (3 Drug Therapy)
- HIV Human Immunodeficiency Virus
- HREC Human Research Ethics Committee
- IA Intermittent Auscultation
- IOL Induction of Labour
- MCDA Monochorionic Diamniotic
- MDG Millennium Developmental Goals
- MMH Mowbray Maternity Hospital
- MMR Maternal Mortality Ratio
- MOU Midwife Obstetric Unit
- NCCEMD National Committee for Confidential Enquiries into Maternal Deaths
- NICE The National Institute for Health and Care Excellence
- OR Odds Ratio
- PG Prostaglandins
- PNMR Perinatal Mortality Rate
- RCT Randomized Control Trial

- RR Relative Risk
- SES Socio-Economic Status
- TGCS Ten Group Classification System
- USA United States of America
- VBAC Vaginal Birth After Caesarean Section
- VD Vaginal Delivery
- VL HIV Viral Load
- WHO World Health Organization

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# Abstract

## Background

The United Nations (UN) aims to reduce the maternal mortality ratio (MMR) and improve access to reproductive health services. Caesarean sections (CS) are known to be associated with a raised mortality rate by a factor of 2.8 in addition to the raised morbidity rate (OR 3.1; 95% CI 3.0-3.3) compared to vaginal deliveries (VD). Globally, there has been a concerning trend in the caesarean section rate (CSR), rapidly increasing since the 1970's, with some countries reporting CS rates as high as 40.5%. South Africa has a CSR of 25.7%, which is higher than the suggested rate by the World Health Organization (WHO) of 15%; a rate above which the WHO suggests no maternal and fetal benefit exists. Robson introduced a universal classification system for caesarean sections with 10 totally inclusive and mutually exclusive groups. Horak made use of the ten group classification system (TGCS) to calculate the CSR at Mowbray Maternity Hospital (MMH) and its referring midwife obstetric units (MOU) for 2009, and reported it as 20.7%. Since the completion of her study, the referral routes to MMH have changed and the management of HIV-associated illnesses has markedly improved. A period of 7 years has elapsed and it was thought to be an optimal time to repeat a review of the CSR and compare it with the rates from 2009.

## Objectives

The study aims to calculate the CSR for MMH from January 2016 to June 2016. Analyses of the CSR within each Robson group will be done and compared to the rates from 2009. This will allow us to make recommendations, if appropriate, aimed at reducing the CSR.

## Methods

A retrospective, observational study was performed at MMH in Cape Town. Data was collected from birth registers for January 2016 – June 2016. All women who delivered, including all caesarean sections and vaginal births, were entered into the study, provided the newborn was viable with a birth weight >500g. Parameters were recorded onto an electronic and password-protected Microsoft Excel® spreadsheet and were used to classify deliveries according to the Robson Classification system. To allow for

comparison with Horak's study, deliveries at MMH for January 2009 – June 2009 were selected and analyzed. All the data was analyzed with STATA software and presented in various graphical formats. Ethics approval was obtained from University of Cape Town's Human Research Ethics Committee (HREC Ref: 539/2016).

## Results

There were 4727 deliveries from January to June 2016, of which 2472 were vaginal births and 2255 were caesarean sections, giving rise to a CSR of 47.70% (95% CI 46.28-49.13). Of all the caesarean sections performed, 62.7% were primary caesarean sections and 37.3% were repeat caesarean sections. Nulliparous women, compared to multiparous women without a history of a prior CS, were at higher risk for a CS if in spontaneous labour (OR 2.02; 95% CI 1.71-2.38) and if induced (OR 2.75; 95% CI 2.13-3.53). Group 5 (women with a previous CS), with a CSR of 85.34% (95% CI 82.82-87.61) made the greatest contribution to the overall CSR. The overall CSR from January to June 2009 was 44.10% (95% CI 42.63-45.57), calculated from 4379 deliveries.

There was a statistically significant increase in the CSR of 3.60% from 2009 to 2016. A similar significant increase was observed in the respective CS rates of Group 1 (5.59%), Group 2 (11.63%) and Group 10 (8.73%). Group 4 was the only group with a statistically significant decrease of 4.48% in its CSR. An additional 308 labour inductions were performed in 2016, however, women in 2016 were statistically significantly less likely to be successful in a vaginal delivery (OR 0.67; 95% CI 0.55-0.81  $p < 0.001$ ) compared to women in 2009.

## Conclusion

A CSR of 47.70% is acceptable for a secondary level hospital such as MMH. This figure is elevated, but appropriate, as the referral units that perform only low risk vaginal deliveries are excluded. A surge in the number of repeat caesarean sections performed and lower success rates for labour inductions were mostly responsible for the rise. Primary caesarean sections performed on patients directly result in a higher risk patient profile in the future, coupled with more repeat caesarean sections in subsequent pregnancies. This is supported by a 17.5% prevalence of previous CS in women in 2009 as opposed to the 20.79% of women with a prior CS in 2016. This study shows that a CS

in the index pregnancy has sizeable effects on the care of a woman in subsequent pregnancies. This places more strain on the health system and ultimately affects service delivery to all patients. Theoretically it is possible to explore changes in management to curb the ever-increasing CSR, but one has to consider if such changes is acceptable and appropriate to the setting of MMH and the population it serves.

## Introduction

The health of women and children has received a vast amount of attention in recent years, and organizations such as the UN and the WHO have driven projects to improve their well-being. The Millennium Development Goals (MDG), adopted in 2000, set out specific targets addressing issues such as poverty, hunger, education, inequality, environmental protection, as well as maternal and child health. Maternal care efforts were channeled towards reducing the MMR by 75% from the 1990 values, and to provide reproductive health services to all women.<sup>1</sup> In July 2015, the UN published their annual report on the MDG and found that the global MMR has declined by 45% since 1990, with the most profound change being a decline of 64% in Southern Asia, and with sub-Saharan Africa showing a decline of 49%. Additionally, more women received better antenatal services, were assisted by skilled health care providers during childbirth, and contraception services improved.<sup>2</sup>

Caesarean sections are increasingly performed without medical indication, and as a surgical procedure, are associated with higher morbidity and mortality rates when compared to vaginal deliveries.<sup>3-5</sup> Globally, rising CS rates have been an area of concern, and South Africa is no exception to the rule: with a national CSR of 25.7% during the 2014-2016 triennium, higher than the CSR of 23.1% between 2011-2013 and above the rate recommended by the WHO.<sup>3, 6, 7</sup>

Mowbray Maternity Hospital, in the southern suburbs of Cape Town, provides obstetric and neonatal services to a large population group in the greater Cape Town Metropole. Studies performed at the hospital have shown that the CSR is increasing, with the most recent official rate standing at 20.7% for MMH and its referring MOU's for the annum of 2009. Horak et al. made use of Robson's TGCS to analyze the CSR for 2009, proving it to be a simple and clinically relevant classification system.<sup>8</sup> Robson's TGCS has been used by several health institutions globally and is fast becoming the preferred classification system for CSR analysis due to its design and comparative potential.

With the MDG's in the background and the prospect of achieving the new UN Sustainable Development Goal of reducing the MMR to below 70 deaths per 100000 live births, it is important that no effort be spared.<sup>9</sup> One of the measures with which this is achievable is by reducing the number of caesarean sections performed.

# Literature Review

Caesarean sections are performed daily at hospitals worldwide, making it one of the most common surgeries performed on women. It can be a life-saving procedure when indicated and executed well, but equally detrimental if complications arise.<sup>6</sup>

## History of the Caesarean Section

Birth by CS has fascinated the human race since the earliest of days and versions thereof have been immortalized by the passage of time. In Greek mythology, both Aesculapius and Bacchus, gods of medicine and wine, were born with a CS, being cut from their mothers' wombs by their fathers. Buddha, born as Siddhartha, was also removed from the side of his mother, Queen Maha Maya's body. Many other legends exist, from the delivery of King Robert II of Scotland to the theatrical birth of Macduff in Shakespeare's *Macbeth*.<sup>10</sup>

The origin of the term 'Caesarean Section' has been elusive and many believe it took its origin from Julius Caesar (100BC – 44BC) being born via an abdominal incision, but historians disagree.<sup>11</sup> Literature describes that Aurelia Cotta, the mother of Julius Caesar, died in 54BC, 46 years after her son's birth, which makes it unlikely that she had a CS, as the procedure was almost always fatal in these times due to complications of haemorrhage or sepsis.<sup>11-13</sup>

The word Caesar, which started as a byname, became almost synonymous with the emperor and was more frequently observed in the names of Roman Emperors as an indication of rank. Furthermore, The Royal Law (Lex Regia) proclaimed by Emperor Numa Pompilius, instructed that a fetus had to be removed from its mother before she may be buried if she demised whilst pregnant. This law later became known as the Lex Caesarea, and is most likely the origin for the term 'Caesarean Section'.<sup>10-12</sup> A further possibility is from the Latin verb, caedere, which means 'to incise'.<sup>13</sup>

Literature widely adopted the term 'Caesarean Section' after Francois Rousset used the term *Enfantement Caesarien* in 1581, and Jacques Guillemeau's use of the term *La section Caesarienne* in 1598. <sup>10, 12, 13</sup>

Delivery of the fetus by a uterine incision started in the 7<sup>th</sup> century BC as a postmortem procedure, as instructed by the Lex Regia. In 1500, a Swiss pig farmer, Jacob Nufer, performed a CS on his wife and delivered a live infant. Both she and the infant survived and this surgery is therefore widely regarded as the first successful CS. <sup>10</sup>

### Morbidity and Mortality

In the modern era, caesarean sections are regarded as safe surgical procedures. This can be attributed to the medical advances made in blood products and transfusions, antibiotics, safer anaesthesia, anticoagulation therapy, surgical technique and uterotonics. Despite these advancements, complications still occur and maternal morbidity and mortality are raised due the medical condition necessitating the delivery, secondary to the procedure itself or due to anaesthesia-related complications. <sup>12, 13</sup>

Over the 19<sup>th</sup> century, maternal mortality rates were lowered from 65%-75% to 5-10%. <sup>12, 13</sup> The United Kingdom Confidential Enquiry into Maternal Deaths stated towards the end of the 20<sup>th</sup> century that an elective CS compared to a VD carries a 2.84 greater risk of maternal mortality. <sup>5</sup> The National Committee for Confidential Enquiries into Maternal Deaths (NCCEMD) in South Africa also reported in 2015 a similar 2.8 times greater risk of mortality during caesarean delivery compared to a vaginal delivery. <sup>3</sup> Emergency compared to elective caesarean sections have a higher risk of mortality by a factor of 1.5. <sup>14</sup>

Authors of a Canadian study reported in 2007 an adjusted OR of 3.1 (95% CI 3.0-3.3) for planned caesarean birth compared to planned vaginal birth, after reviewing records of more than 2.3 million deliveries between 1991-2005. Women undergoing elective caesarean sections were twice as likely (OR 2.1; 95% CI 1.2-3.8) as women from the planned vaginal birth group to have a hysterectomy secondary to haemorrhage, although the risk of bleeding necessitating a blood transfusion was lower in the planned CS group (OR 0.4; 95% CI 0.2-0.8). The greatest risk of haemorrhage hysterectomy was

observed in the group of women undergoing an emergency CS. <sup>4</sup> In 2015, Iwuh et al. reviewed near-miss cases in the Metro West region of Cape Town Metropole and found that obstetric haemorrhage accounted for 33.9% of all cases. Although vaginal births were also included in this study, the morbidity associated with bleeding is evident as all women had a blood transfusion and 50% required a hysterectomy. <sup>15</sup>

The NCCEDM in South Africa releases statistics about maternal mortality every three years and a consistent finding is that haemorrhage, during a CS or afterwards, is a major contributor to maternal mortality in South Africa. A total of 17.9% of deaths in women who delivered via a CS from 2011-2013 was directly related to bleeding during or soon after the CS. <sup>3</sup> The MMR for obstetric related haemorrhage is increased by a factor of 4.98 in caesarean sections compared to vaginal deliveries. <sup>16</sup>

Future pregnancies are adversely affected by caesarean sections and the extent of morbidity is directly associated with the number of prior caesarean sections.

Uterine scar dehiscence is a concern of increasing importance as the number of prior caesarean sections increase. The risk is dependent on multiple factors, including the type of uterine incision, the presence or absence of sepsis and all the factors that influence tissue healing, from genetics to lifestyle habits such as smoking. In women who had a single previous CS, the risk of uterine rupture prior to the onset of labour is 0.16% but increases to 0.52% with spontaneous labour. Induction of labour carries a higher risk of 0.77% and 2.45% with methods excluding prostaglandins (PG) and methods making use of PG respectively. <sup>17</sup> A review article published in 2014 quotes a risk of uterine rupture of 1.36% in women with 2 or more previous caesarean sections. In a woman with a previous classical uterine incision, the risk of uterine rupture is much higher at 4-9%. <sup>18</sup>

Silver et al. performed an observational trial and in 2006 reported on the risk for a morbidly adherent placenta in women, with a background of a previous CS, delivering via a CS. In this study, the possibility of a morbidly adherent placenta increased significantly with 3 or more previous caesarean sections (2.13%) and up to 6.74% with a history of 5 previous caesarean sections. In the presence of a placenta praevia, this

risk is even higher: already 3.0% in the presence of a single previous CS and 11% with 2 previous caesarean sections. <sup>19</sup>

Damage to intra-abdominal visceral structures during a CS adds to the associated morbidity. Elective compared to emergency caesarean sections are associated with less collateral damage (OR 0.1; 95% CI 0.001-0.4). <sup>20</sup> This risk increases with every subsequent CS. <sup>19</sup>

Puerperal sepsis causes significant morbidity post-delivery, with Iwuh et al. (2015) attributing a figure of 11.6% of all near-miss cases to this cause. <sup>15</sup> The incidence is more common following scheduled caesarean sections compared to scheduled vaginal deliveries (OR 3.0; 95% CI 2.7-3.4) as reported by Liu et al. (2007) in a review. Women who have emergency caesarean sections are at greatest risk for puerperal infection compared to elective caesarean sections and vaginal deliveries. <sup>4, 20</sup> In South Africa, pregnancy-related sepsis is the 5<sup>th</sup> most common cause of maternal mortality. While the risk for sepsis is lower after a vaginal delivery, the NCCEDM reports that mortality rates secondary to postpartum puerperal sepsis is higher in women who delivered vaginally. It accounted for 59.4% of pregnancy related sepsis deaths, whereas post CS sepsis accounted for 29.7% of deaths in this group. This might be attributed to delayed surgical intervention in women who delivered vaginally. <sup>16</sup>

Compared with vaginal births, complications related to caesarean sections further include:

- Anaesthesia-related morbidity: OR 2.3 (95% CI 2.0-2.6)
- Cardiac arrest: OR 5.1 (95% CI 4.1-6.3)
- Venous thromboembolic events: OR 2.2 (95% CI 1.5-3.2)
- Longer hospital admission<sup>4</sup>

Gyhagen et al. (2013) reported that caesarean sections have a protective effect over pelvic organ prolapse when compared to vaginal births: for every 12 caesarean sections, 1 case of symptomatic prolapse would be prevented. A similar protective effect is seen with urinary incontinence, with a case prevented for every 8 caesarean sections. <sup>21</sup>

A consistent neonatal outcome associated with caesarean sections, is an elevated risk of prolonged admission to a neonatal intensive care unit, compared to vaginal deliveries (OR 2.20; 95% CI 1.4-3.18). Data regarding the risk for increased mortality is disputed. Whilst some studies report that caesarean sections are associated with increased fetal and neonatal mortality rates, others report a protective effect over intrauterine demise, but with a raised neonatal mortality rate if a CS was performed in cephalic-presenting baby only. <sup>22-24</sup>

## Caesarean Section Rates

In 1985 and more recently in 2015, the WHO stated that increasing CS rates to 10-15% has been shown to improve maternal and perinatal mortality, however, rates beyond this do not lead to a further decline in mortality. <sup>6, 25</sup> In contrast, there has been a global surge in the number of caesarean sections performed, especially in more developed countries, and much concern exists about the impact it has on the health of patients and their health systems. Despite this general trend, many less developed countries still have CS rates well below the global average, negatively impacting the maternal and perinatal health in these countries. <sup>13, 26, 27</sup>

Betrán et al. (2016) reported an increase in the global CSR from 6.7% to 19.1% between 1990 and 2014. There was a marked difference between respective countries, with lesser-developed countries representing the greatest increase (6.3% to 20.9%), followed by the most developed countries (14.5% to 27.2%). The least developed countries, however, had the smallest increase (1.9% to 6.1%). There was also an appreciable difference in the average CS rates amongst the various continents: Africa had the lowest CSR of 7.4%, whereas South America had the highest of 42.2%. <sup>28</sup>

In 2007 Betrán et al. illustrated the marked variation in the CSR that is observed between different countries of a continent. Egypt and South Africa had the highest CS rates in Africa, while Chad, Niger, Madagascar and Ethiopia all had CS rates below 1%. China had a CSR of 40.5%, which is markedly greater than the observed CSR of 1.0% in Cambodia or Nepal. Similarly, in Europe, the CS rate of Italy stands in stark contrast to the rate in Moldova; 36% versus 6.2% respectively. Haiti averaged a CSR of 1.7%

according to the study, while the highest rate in South & Central America was observed in Mexico, 39.1%.<sup>5</sup>

In 2015, Vogel et al. published an article that evaluated the change in CS rates in 21 developed and developing nations. Apart from Japan, where the CSR decreased by 2.5%, a universal increase in the CSR was seen in both developing and developed nations. The authors also established that nulliparous women and women with a previous CS made the greatest contribution to the CSR. The percentage of women that had an induction of labour (IOL) or CS prior to labour increased between the two periods and was accompanied by a lower percentage of women in spontaneous labour.<sup>29</sup>

South Africa has a national CSR of 25.7% and it increased from 23.1% during the 2011-2013 triennium. In the 2011-2013 report, the CS rate fluctuated amongst the nine provinces with the highest rate observed in Kwazulu-Natal at 28.8% and the lowest rate in Limpopo at 15.4%.<sup>3,7</sup>

Considering the risk-benefit profile of caesarean sections and the discrepancy in international CS rates, finding the optimal CSR for each population in question is essential. According to the WHO, this would represent the lowest rate at which only medically indicated caesarean deliveries are performed.<sup>6</sup> Various other factors will ultimately have an influence on individual CS rates, such as the availability and access to resources, skills, cultural factors and socio-economic status.<sup>30</sup>

Technology and research constantly bring about new expertise and this perpetual renewal of medical knowledge ensures that evidence based medicine is practiced. The 20<sup>th</sup> century has seen a rapid advance in the medical field and this has subsequently been responsible for significant changes in obstetric practice in the past 50 years. These changes may ultimately have affected the CSR.

## Breech Presentation

Fetal presentation changes constantly throughout pregnancy, but in most women presentation will be cephalic at term. Breech presentation is the second most common presentation with an incidence of 3% to 4% at term. Several maternal, uterine, fetal and

placental factors predispose to breech presentation at term, but in most women none of these factors will be present.<sup>31,32</sup>

Due to the malpresentation, both mother and the fetus are at higher risk of abnormal labour and associated complications. Management at term has been aimed at minimizing these risks and encompasses external cephalic version (ECV), vaginal breech delivery or a planned CS.<sup>31</sup>

Two Cochrane reviews evaluated the success of ECV conducted in women with a breech presentation at term and before term. ECV at term, compared to no ECV, is associated with a statistically significant decrease in breech presentation with the onset of labour (RR 0.42; 95% CI 0.29-0.61), vaginal breech delivery (RR 0.46; 95% CI 0.33-0.62) and CS (RR 0.57; 95% CI 0.40-0.82).<sup>33</sup> Performing ECV between 34-35 weeks compared to ECV at 37-38 weeks, reduces breech presentation at the onset of labour (RR 0.81; 95% CI 0.74-0.90) and vaginal breech birth (RR 0.44; 95% CI 0.25-0.78). There was no statistically significant reduction in caesarean sections, but preterm labour was more frequent in the early intervention group (RR 1.51; 95% CI 1.03-2.21).<sup>34</sup> The British Human Immunodeficiency Virus Association confirms that ECV can be offered to women infected with the human immunodeficiency virus (HIV), provided the viral load is <50 copies/mL.<sup>35</sup>

Early reports from a retrospective review by Cheng and Hannah (1993) suggested that a planned VD might be associated with a raised perinatal mortality rate (PNMR) (OR 3.86; 95% CI 2.22-6.69) and neonatal mortality rate (OR 3.96; 95% CI 2.76-5.67) when compared to a planned CS in women with a breech presentation.<sup>36</sup> In 2000, Hannah et al. published their findings from a randomized control trial (RCT) of planned VD versus planned CS, conducted in countries with both high and low PNMR's. Overall, planned CS was associated with a statistically lower risk of perinatal and neonatal mortality (RR 0.23; 95% CI 0.07-0.81 p=0.01) as well as serious neonatal morbidity (RR 0.36; 95% CI 0.19-0.65 p<0.001).<sup>32</sup> The reduction in serious neonatal morbidity was only observed in countries with a low PNMR. This observation was thought to be due to poor detection rates or follow up of infants from countries with a high PNMR, but a possibility of a true observation is possible, which would indicate that clinicians in such countries have

more experience with vaginal breech deliveries. No statistically significant difference in maternal morbidity and mortality was observed between the two groups (RR 1.24; 95% CI 0.79-1.95 p=0.35).<sup>32</sup> Critique regarding the conclusions from this RCT was abundant and substantiated by the release of a two-year follow up report of the children born from the trial. The report indicated no significant decrease in risk for delay in neurological development, or the risk of dying in the planned CS group (RR 1.09; 95% CI 0.52-2.30 p=0.85).<sup>37,38</sup>

Goffinet et al. (2006) reported on a prospective cohort study involving 8105 women in France and Belgium, not randomized to planned VD or CS, but selected for a trial of VD or CS based on strict criteria released by the French College of Gynecologists and Obstetricians. Ultimately, 1794 of the 2526 women in the planned VD group and 31 of the 5579 women in the planned CS group delivered vaginally. There was no significant difference between the two groups with regards to fetal and neonatal mortality or serious neonatal morbidity (OR 1.10; 95% CI 0.75-1.61).<sup>39</sup>

In the Netherlands, a retrospective audit of 35453 breech deliveries was performed, reviewing delivery practices prior and subsequent to the publishing of Hannah's RCT. An increase from 50% to 80% was observed in the CSR. In infants with a birth weight <4kg, a significant reduction in the PNMR (OR 0.53; 95% CI 0.33-0.83 p=0.007) and the risk of neonatal injury (OR 0.26; 95% CI 0.14-0.50 p<0.001) were observed. Perinatal mortality and neonatal injury in infants with a birth weight >4kg revealed a lower tendency although not statistically significant.<sup>40</sup> Australia also observed a decrease in the vaginal breech delivery rate, from 27.6% in 1991 to 13.9% in 2008.<sup>37</sup>

A systematic review published in 2014 reviewed seven non-randomized studies from Europe and Asia on the mode of delivery in premature fetuses, ranging from 25 to 36 weeks gestation, with a breech presentation. Caesarean birth was associated with a significant risk reduction in neonatal mortality compared to VD (RR 0.63; 95% CI 0.48-0.81 p<0.001), although it was noted that there were some discrepancies in the definition of the neonatal mortality rate.<sup>41</sup>

## Human Immunodeficiency Virus

The emergence of HIV in the early 1980's has had a major impact on the field of medicine and the modern management of obstetric patients. The initial reports of an unusual pattern of disease were described in the United States of America (USA), first in homosexual men but then later also in intravenous heroin users, haemophilia patients and Haitians. It was not until late 1982 that the name Acquired Immune Deficiency Syndrome (AIDS) was assigned to such individuals.<sup>42-44</sup> The Centre for Disease Control defined AIDS as a condition, suggestive of cell-mediated immunodeficiency, being diagnosed in a patient in the absence of factors placing such a person at risk for the condition. Conditions included an array of opportunistic infections, from bacterial infections to malignancies.<sup>45</sup>

HIV, the causative pathogen of AIDS, was successfully isolated in 1983 by two groups of scientists at the Pasteur Institute in Paris, France and at the University of California in San Francisco, USA. In France it was named the Lymphadenopathy-associated virus and in the USA the Human T-Cell Lymphotropic virus Type III, but was renamed HIV in 1986. The first reports of AIDS amongst women, who were the sexual partners of affected men, were also published in 1983.<sup>44,46</sup>

As paediatric AIDS cases started to appear, vertical transmission patterns gained interest. In the USA, The Women and Infants Transmission Study was initiated in 1988 as a prospective study evaluating perinatal transmission amongst HIV infected women.<sup>46</sup> Conducted at six sites across the USA, they monitored 788 women and their infants post-delivery. Sheon et al. (1996) reported a vertical transmission rate of 17.7%.<sup>47</sup> In 1989, the HIV Infection in Newborns French Collaborative Study Group reported an approximate vertical transmission rate of 33% after reviewing 308 children born to HIV-infected mothers. Furthermore, compared to bottle-fed infants, breastfed infants were statistically more likely to seroconvert.<sup>48</sup> The European Collaborative Study followed 271 newborns up at eight sites across Europe and reported a vertical transmission rate of 24%.<sup>49</sup> A Zambian study published in 1989 displayed an equally high rate of perinatal infection with a vertical transmission rate of 39% and a 44% mortality rate of affected offspring.<sup>50</sup> Kumar et al. managed a study in India and published their finding in 1995 of a vertical transmission rate of 48%.<sup>51</sup>

During these early years of HIV research, the number of enrolled patients into the studies was relatively small, even so, the risk of vertical transmission to an infant ranged from 1 in 2 to 1 in 5.

In the early 1990's therapies were instituted to curb the peripartum vertical transmission, starting with the introduction of Zidovudine antenatally. Connor et al. (1994) published results of a RCT on the efficacy of Zidovudine, started between 14 and 34 weeks of gestation. The vertical transmission rate in the treatment group was 8.3% (95% CI 3.9-12.8) compared to 25.5% (95% CI 18.4-32.5) in the placebo group. This translated into a relative risk reduction of 67.5% (95% CI 40.7-82.1  $p < 0.001$ ).<sup>52</sup>

In Thailand, similar results were obtained from a study evaluating the effect of Zidovudine if initiated after 36 weeks: a 51% (95% CI 15-71) relative risk reduction was observed.<sup>53</sup>

The European Collaborative Study indicated that caesarean sections might decrease HIV vertical transmission by as much as 50%.<sup>54</sup> A prospective South African trial, performed in Durban, evaluated the effect of caesarean delivery on HIV vertical transmission and found that caesarean sections were associated with a lower risk of transmission compared to vaginal deliveries (OR 0.45; 95% CI 0.20-0.99).<sup>55</sup> A meta-analysis of 8533 women confirmed this benefit as an elective CS reduced the odds of HIV transmission by 57% (OR 0.43; 95% CI 0.33-0.56) and when performed in addition to Zidovudine, the odds is reduced by a further 30% (OR 0.13; 95% CI 0.09-0.19).<sup>56</sup>

The European Mode of Delivery Collaboration was the first in 1999 to report results from RCT's evaluating the protective effect of caesarean sections. Outcomes for 370 infants were available from centers in Europe and included mothers receiving antiretroviral therapy and a placebo group. HIV was transmitted in 10.2% (17 out of 167) of vaginal deliveries and 3.5% (7 out of 203) of caesarean sections. Caesarean sections proved to be protective against HIV transmission (OR 0.4; 95% CI 0.2-0.9). This was only true for elective caesarean sections (OR 0.3; 95% CI 0.1-0.8) and not for emergency caesarean sections (OR 1.0; 95% CI 0.3-3.7).<sup>57</sup>

A meta-analysis published in 2001 by The International Perinatal HIV Group indicated that ruptured membranes were associated with a significant increase of 2% in vertical transmission with every passing hour (OR 1.02; 95% CI 1.01-1.04). It also appeared that this effect was augmented in women with AIDS. <sup>58</sup>

In 1996, a steady decline in HIV-related deaths was observed in New York City, which coincided with the introduction of highly active antiretroviral therapy (HAART). <sup>59</sup> This observation was corroborated with results published in 1998 from a RCT, revealing that 3-drug combination therapy is effective in achieving HIV virological suppression in a large percentage of treated patients. <sup>60</sup>

Cooper et al. published figures for the Women and Infants' Transmission Study Group in 2002, indicating that in comparison with a 10.4% vertical transmission rate with Zidovudine monotherapy, HAART was associated with transmission rate of 1.2% (95% CI 0.0-2.5%). Similarly, the vertical transmission rate directly correlated with maternal HIV Viral Load (VL), increasing from a rate of 1% with a VL of <400 copies/mL to 23.4% with a VL of >30000 copies/mL. <sup>61</sup>

Garcia et al. (1999) indicated the relationship between maternal VL (copies/mL) and vertical transmission rate. Vertical transmission nears 0% when the VL is <1000 and combined with ART, whereas this figure increases to 20.6% with a VL >100 000. Vertical transmission is increased further when an HIV-positive woman is not on ART, ranging from 20% with a VL of 1000-10 000 up to 63.3% when the VL is >100 000. <sup>62</sup>

Studies now suggest that in pregnant women achieving HIV virological suppression, an elective CS might not have an additive benefit. <sup>63-65</sup> The AmRo study conducted in Amsterdam and Rotterdam determined that in addition to HAART, 131 caesarean sections have to be performed to prevent one infection in an infant. <sup>66</sup> Evaluation of mother-to-child transmission rates in the United Kingdom has revealed that in women on HAART and with a VL < 50 copies/mL, the risk of vertical transmission is 0.1% (95% CI 0.0-0.4). <sup>67</sup>

There exists no VL at which the risk for vertical transmission is zero. The American College of Obstetricians and Gynaecologists (ACOG) advises an elective CS when the VL is >1000 copies/mL, as the evidence for any additional benefit with a CS with VL <1000 copies/mL is inadequate.<sup>68</sup> Similarly, the British HIV Association advises against an elective CS if the maternal VL is below 50 copies/mL, but recommends considering a CS with levels between 50 and 400 copies/mL and strongly recommend an elective CS if the VL is above 400 copies/mL.<sup>35</sup>

Naude et al. (2015) reported the HIV prevalence in Mitchell's Plain and Gugulethu MOU's as 16.4%, which renders HIV a very common medical illness according to the WHO classification.<sup>69</sup> The current South African Guidelines on the management of HIV-infection in pregnant women does not advocate performing elective caesarean sections for the sole purpose of reducing HIV transmission.<sup>70</sup>

### Higher Order Pregnancies

It is widely reported that higher order pregnancies carry more risk in the antenatal, intrapartum and postpartum periods compared to singleton pregnancies. The background prevalence of twin and higher order pregnancies is about 1.0% in the general population. A steady rise in the incidence of multiple pregnancies has been observed since the 1980's, coinciding with the progressive strides made in reproductive medicine. Another contributing factor is that more career-driven women only start their families at a more advanced age, when multiple pregnancies naturally occur more frequently.<sup>31,71</sup>

At the turn of the century, USA figures already reflected the alarming trend in multiple pregnancies between 1989 and 1997. The number of twin births increased by 13.5%, while the number of triplets more than doubled from 2529 to 6148 sets.<sup>72</sup> USA data from 2008 places the prevalence of multiple pregnancies at 3.4%, coupled with a CSR of 75%.<sup>73</sup> In Norway, an increase in the rate of twins has also been observed: up to 1987 the rate was constant at 1.0%, but subsequently increased steadily to 1.9% in 2004. The rate remained elevated at 1.6% when births from assisted reproduction were not included, with an increasing odds ratio as maternal age increased.<sup>74</sup>

Perinatal outcomes for twins are less favourable when compared to singleton pregnancies. Smith et al. retrospectively evaluated delivery-related outcomes amongst twin pregnancies from a Scottish registry between 1985-2001. Overall, the second twin was more likely to demise than the first twin (OR 5.0; 95% CI 2.0-14.7 p<0.001) and the risk of intrapartum hypoxia being the cause was much higher (OR 21.0; 95% CI 3.4-868.5 p<0.001). Excluding elective caesarean sections, intrapartum hypoxia accounted for 16.67% of deaths in the first twin, but 75.0% of deaths in the second twin during delivery. The CSR was 40% and the number of elective caesarean sections increased with an OR of 1.05 (95% CI 1.04-1.07 p<0.001) per year.<sup>75</sup>

A systematic review on perinatal outcomes published in 2011 indicated lower morbidity (OR 0.53; 95% CI 0.39-0.70) and lower mortality (OR 0.55; 95% CI 0.38-0.81) in the first twin compared to the second twin. Elective caesarean sections were associated with a decrease in morbidity of twin B, however it was not statistically significant.<sup>76</sup> Caesarean sections are also not associated with an improvement in perinatal morbidity (except Apgar score at one minute) or mortality in the second twin when comparing VD to a CS in a non-vertex presentation of the second twin.<sup>77</sup>

Barrett et al. performed a RCT, including 2804 women with twin pregnancies, with the leading twin in a cephalic presentation. Women were randomly assigned to planned VD or planned CS. In 2013, they reported no significant difference in composite perinatal mortality or severe morbidity between the two groups (OR 1.16; 95% CI 0.77-1.74 p=0.49). Perinatal morbidity and mortality were raised in the second twin compared to the first twin (OR 1.90; 95% CI 1.34-2.69 p<0.001), and an elective CS did not alter this risk. Maternal outcomes did not differ between the planned vaginal and planned caesarean delivery groups.<sup>71</sup>

The results from this RCT echoed the conclusions from the systematic review that no significant difference is seen in perinatal outcome of the second twin with an elective CS if the leading twin is in a cephalic presentation.

## Electronic Fetal Monitoring

Fetal monitoring forms an integral part of obstetric practice and has undergone an advancement from basic auscultation of the fetal heart to complex analysis from various electronic sources. It has enabled us to make an array of diagnoses antenatally and alter our management of the fetus in utero.

The earliest report of a fetal monitoring was in the mid 17<sup>th</sup> century when a French physician, Marsac, reportedly heard the fetal heart. It was not until 1818, however, that fetal auscultation was formally documented. A surgeon from Geneva, François-Isaac Mayor, wrote a brief report on the auscultation of the fetal heart near term by means of placing one's ear onto the maternal abdomen. With the pioneering of the stethoscope in 1819, fetal monitoring was easier than before and physicians started to study fetal heart rate and patterns. The modern cardiocograph originated in 1909 when physicians manually produced tracings by causing deflections onto a membrane, which then through several steps were captured as the fetal heart onto a photographic sheet. Augmentation of the heart sounds were first performed in 1921, and in 1930, the fetal heart tracing was recorded by Hyman with the use of a string-galvanometer. This enabled Hyman to observe abnormalities in the recorded tracing.<sup>78</sup>

The use of intermittent auscultation (IA), which was the primary means of fetal assessment in labour, started to decline with the introduction of electronic fetal monitoring (EFM) in the 1970's. This was done in an effort to decrease the inflated PNMR that was quoted to be as high as 33.2 per 1000 live births in 1958 in the United Kingdom, believing oxygen deprivation in labour to be a major contributing factor.<sup>79</sup>

Few reports after its implementation indicated that there has been a decrease in the PNMR but this has since become a very controversial topic.<sup>79, 80</sup> Statistics from Galway, in Ireland, showed that in 15 years subsequent to 1973, the CSR increased with 4.12% from 6.06% to 10.18%, with fetal compromise and a prior CS listed as two major indications.<sup>81</sup> Haverkamp et al. (1976) also reported an elevated CSR of 16.5% in women monitored electronically in labour compared to 6.8% in women monitored with IA from a trial performed in the USA. The perinatal outcomes, including cord blood gas

analysis, Apgar scores, neonatal morbidity and mortality, were comparable between the two groups. <sup>82</sup>

The Dublin Trial was performed to assess whether EFM improves neonatal outcomes. It is the largest randomized controlled trial comparing IA and continuous EFM. The group randomized to continuous monitoring had a slightly higher CSR (2.4% vs 2.2%) and operative vaginal delivery rate (8.2% vs 6.3%), but the incidence of neonatal convulsions was lower. <sup>83</sup> In 1986, Leveno et al. published results from a prospective trial involving 34995 women, evaluating global versus selective electronic monitoring. They found a statistically significant increase in the CSR if EFM is used globally, without a significant variation in neonatal outcomes between the two groups. <sup>84</sup>

A recent systematic review from the Cochrane Library confirmed that continuous EFM compared to IA is associated with an increase in the CSR (RR 1.63; 95% CI 1.29-2.07) as well as an increase in operative vaginal deliveries (RR1.15; 95% CI 1.01-1.33). <sup>85</sup> There is a consensus, supported by various studies, that continuous EFM is associated with an increase in the CSR, without a marked long term neurological benefit.

## Litigation

Litigation in Obstetrics and Gynaecology globally is not a new entity and this is certainly true for South Africa as well. Between 2005 and 2013 there has been an inflation in the cost of medical insurance for practising private Obstetricians, 382% to be exact. This increase was accompanied by a rise in the number and magnitude of medical malpractice claims. This is not limited to private practice, as up to 70% of the pending medical malpractice claims, worth R49 billion, in the South African Government sector in 2017 were obstetric-related. <sup>86,87</sup>

The recourse of many physicians was to practice defensive medicine, a concept that is well reported on worldwide. It encompasses a behavioural change in physicians where excessive investigations are performed, high risk patients avoided and some procedures performed more regularly while riskier procedures are avoided. <sup>88</sup> Already in the 1980's, surveys evaluating this phenomenon were completed: Rosenblatt et al.

reported that Obstetricians with relatively higher claim rates were more likely to discontinue obstetric practice compared to physicians with lower claim rates.<sup>89</sup>

Studdert et al. circulated the results of their investigation in 2005, evaluating defensive behaviour amongst high risk specialities in the USA. Obstetricians & Gynaecologists made up the largest proportion (23%) of the study group, while the remaining 77% comprised of Surgeons, Orthopaedics Surgeons, Radiologists, Emergency Physicians and Neurosurgeons. Ninety-three percent of the 824 physicians reported practicing defensive medicine. Obstetricians & Gynaecologists were more likely to refer high risk patients to their colleagues and to perform more ultrasounds but only 6% indicated that they perform caesarean sections as part of their defensive practice.<sup>90</sup>

The main reasons why patients litigate seems to be universal: hypoxic brain damage remains the leading cause, with fetal injury and maternal morbidity and mortality in second and third place.<sup>86,91,92</sup> Cheng et al. reported in 2014 that Obstetricians, affected by litigation or fearing litigation, are more likely to recommend elective caesarean delivery compared to their unaffected counterparts (17.2% as opposed to 11.3%,  $p=0.008$ ).<sup>93</sup>

The effect of litigation clearly alters the manner in which Obstetricians practice medicine, erring on the side of caution. Although it seems that defensive medicine might have an impact on the CSR, no conclusive evidence exists proving or disproving it. One has to keep in mind that although caesarean sections solely performed as part of a defensive practice might not be reported on as such in the literature. The over investigation of patients and subsequent findings might have a more significant impact on the CSR, and indirectly increase it.

## Maternal Choice and Socio-economic Status

The medical field has seen a shift away from paternalistic medicine to patient-centre care, where patients are aware of their rights as health care consumers and are enabled to make autonomous decisions. This has never been more relevant to women as multiple organizations worldwide, including the South African Bill of Rights: Section 9,

strives to promote and empower women, regardless of race, religion, sexual orientation, language and birth country. <sup>9,94</sup>

Many countries report an increased CSR where it is attributed to maternal choice and physician convenience. A prospective study published in 2007 explored some of the reasons women elect to have caesarean sections prior to labour. Compared to women trying for a VD, this group harboured inferiority opinions over their personal health. Secondly, they were more concerned about poor obstetric outcomes and a negative experience during normal labour. Thirdly, they were more inclined to only have a single child. <sup>95</sup>

A global trend in the disparity between the CSR seen in public and private facilities or socio-economic discordant communities exists. Caesarean section rates from a group of Indian women in Chennai varied from 19.8% (95% CI 16.0-24.0) in the public sector and up to 46.7% (95% CI 41.0-52.0) in the private sector, with an overall CSR of 32.6% (95% CI 27.0-38.0). Women delivered in the private sector were also more likely than their counterparts to have their first CS (OR 2.4; 95% CI 1.5-3.8). <sup>96</sup> These are not isolated figures: in China, the CSR in 2008 in metropolitan areas was 64.1% compared to 11.3% in rural areas. <sup>97</sup> Another study from Southeast China reported maternal request as a major factor responsible for the surge in the CSR from 22% to 60% between 1994-2003. <sup>98</sup> In Los Angeles County in the USA, CS rates in the early 1980's were discordant for different racial groups as well as variation in socio-economic status (SES). <sup>99</sup>

Matshidze et al. uncovered the disparity in the CSR between the public and private sectors, as well as different population groups during the final moments of politically-based racial segregation in South Africa. Releasing their results from 1990, CS rates were significantly higher in private facilities compared to public facilities (OR 2.34; 95% CI 1.81-3.02 p<0.001). Caucasian and Brown women were more likely to deliver via a CS compared to African women: OR 1.84 (95% CI 1.40-2.42 p<0.001) and OR 1.38 (95% CI 1.05-1.81 p<0.05) respectively. <sup>100</sup>

Kalafong, a public hospital located on the outskirts of Pretoria, maintained an average CSR of 28-30% in 2002. <sup>101</sup> This rate is much lower than an average CSR of 57.43% between 1998-2000 calculated from 6 private hospitals in Pretoria. <sup>102</sup> A similar precedent was reported from hospitals in the Durban Metropole in 2009, where CS rates of 30% was reported in public hospitals, compared to a private practice, which reported a CSR double that of 60.4%. In this practice, 8.3% of all caesarean sections were performed on maternal request and 37.6% of caesarean sections were performed on women declining a VBAC after one previous CS. <sup>103</sup>

It is undeniable from this data that SES has a major impact on CS rates, benefiting women with a higher SES. The ability to access private healthcare and have a CS on request, regardless of the presence of a uterine scar, is a privilege available to a small percentage of the global population.

The ongoing debate regarding this phenomenon revolves around the ethical justification of the elevated CSR. Investigators argue that a small percentage of the population benefit from a larger proportion of services, while women from a lower SES lack this benefit. This does not align with the principle of distributive justice. On the other hand, patients have the right to autonomy and should make decisions regarding their treatment based on knowledge provided by the medical field. One can argue that, from this viewpoint, there is some justification for the elevated CSR in private institutions. The benefits and disadvantages of caesarean births versus vaginal births have to be discussed with every woman with regards to the fetus as well as the mother.

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Naudé et al. (2015) reported that in a low risk population in Cape Town, South Africa, 82.1% of women prefer a vaginal delivery above a caesarean birth and only 38.5% of participants indicated that women should have a choice to request a caesarean birth. <sup>69</sup>

Respectful maternity care is a holistic approach to women during their pregnancy and labour, which serves to treat women in a dignified and humane manner, educate and empower them, and assist them to make decisions about their pregnancies. This respect extends to woman's autonomy, whether their choices are evidence-based or not.

Secondly, there is an emphasis on unbiased and consensual care, which involves informed consent from the woman.<sup>105</sup>

## Caesarean Section Classification Systems

To enable the medical fraternity to study CS rates and identify which areas to address, a universal system has to be in place, according to which caesarean sections are classified. This is easier said than done, and numerous studies have demonstrated this difficulty. Several models exist for classifying caesarean sections and each has its own advantages and disadvantages. A systematic review by Torloni et al. (2011) evaluated 27 different CS classification systems and divided them into one of four groups:<sup>27, 106</sup>

- Indication-based
- Urgency-based
- Patient characteristics-based
- Other classification systems

The indication-based systems are easy to use, but the groups are not mutually exclusive and the classification is subjective, leading to poorly reproducible results. The urgency-based systems were shown to benefit communication between health care providers, but again are associated with poorly reproducible results secondary to subjective interpretation of the categories. The patient characteristics-based systems were easy to use and had unambiguous, mutually exclusive categories. In addition, women could be identified prospectively and allocated to the different categories.<sup>27, 106</sup> For these reasons, Torloni et al. found the patient characteristics-based system to be superior.

In 2001, Michael Robson proposed that the most suitable classification system would be one that is simple, easy to use and has clinical relevance. The groups have to be clearly defined, prospectively identifiable, mutually exclusive as well as totally inclusive. Robson devised the TGCS, as described in Appendix A, using the following patient and pregnancy parameters:<sup>106</sup>

- Singleton/Multiple pregnancy
- Fetal lie and presentation
- Nulliparous/Multiparous

- Presence or absence of uterine scar
- Spontaneous or induced labour or a CS prior to labour
- Gestational Age: greater than or below 37 completed weeks

At hand of these parameters, the TGCS is as follows:

- Group 1: Nulliparous women with a singleton, cephalic pregnancy, equal to or greater than 37 completed weeks gestation in spontaneous labour.
- Group 2: Nulliparous women with a singleton, cephalic pregnancy, equal to or greater than 37 completed weeks gestation, who had an induction of labour or a caesarean section was performed prior to the onset of labour.
- Group 3: Multiparous women with a singleton, cephalic pregnancy, equal to or greater than 37 completed weeks gestation in spontaneous labour.
- Group 4: Multiparous women with a singleton, cephalic pregnancy, equal to or greater than 37 completed weeks gestation, who had an induction of labour or a caesarean section was performed prior to the onset of labour.
- Group 5: All women with a singleton, cephalic pregnancy, equal to or greater than 37 completed weeks gestation with a previous caesarean section or myomectomy.
- Group 6: Nulliparous women with a singleton, breech pregnancy, of viable gestation with or without previous uterine surgery.
- Group 7: Multiparous women with a singleton, breech pregnancy, of viable gestation with or without a previous caesarean section or uterine surgery.
- Group 8: All women with a multiple pregnancy, of viable gestation with or without a previous uterine surgery.
- Group 9: All women with a pregnancy with an oblique or transverse lie, of viable gestation with or without a previous uterine surgery.
- Group 10: All women with a singleton, cephalic pregnancy, before 37

completed weeks gestation, with or without a previous caesarean section or uterine surgery.

Every delivery, whether a CS or a VD, is categorized into one of the ten groups. Allowing each delivery to be subject to a single group enables the researcher to determine the CSR for each of the specific groups. A more detailed analysis is also possible as the individual contribution of each group to the overall CSR is quantifiable and clear trends can be observed. Since Robson introduced this classification, it has been implemented into the health care systems in many countries globally. This allows for accurate and easy comparisons of the caesarean section rates between different countries. Although the TGCS has several benefits, many authors have made suggestions for it to be modified to include other variables, especially maternal characteristics and indications for delivery.<sup>26, 107</sup>

The Robson classification system has been employed in several studies in South Africa with major success. In 2014, Ayob critically reviewed deliveries over a two-month period at Chris Hani Baragwanath Hospital, a tertiary level hospital in Soweto, Gauteng. She reported a CSR of 39.4%. Groups 5 (23.7%), 1 (16.9%), 3 (15.9%) and 10 (15.8%) contributed the most to the overall CSR. The most frequent indication for a repeat CS in a woman with a single prior CS was maternal request (35.1%).<sup>108</sup>

Inyang-Otu applied the Robson classification system to deliveries at Bertha Gxowa hospital, a district-level hospital in Germiston, Gauteng. He reported an overall CSR for 2011 of 18.4%. Caesarean sections comprised of 65.1% first and 34.9% repeat procedures. Groups 1 (32.6%), 5 (31.8%) and 3 (15.5%) contributed the most to the overall CSR, whereas group 10 only added 2.3% to the total CSR. HIV prevalence in his study group was 24.8%.<sup>109</sup>

In Kwazulu-Natal, Makhanya reviewed birth records for three months at a regional, but rural hospital. He presented a CSR of 42.4%, with groups 1 (27.4%), 10 (23.4%), 5 (17.2%) and 3 (15.2%) contributing the most to the overall CSR. Elective caesarean sections accounted for the most caesarean sections performed at 79.03%. Of the women

from group 5 that were eligible for a VBAC, 53.1% requested a repeat CS. HIV prevalence was calculated at 34.8%.<sup>110</sup>

Horak et al. analyzed the CSR for MMH, including its drainage units, for 2009, and reported it as 20.7%. The study made use of Robson's TGCS to classify women retrospectively and analyze the rates according to each group.<sup>8</sup> This was the first study done at MMH that made use of the TGCS and provides a basis for comparison of CS rates within the groups in the future.

# Objectives

The primary aim of the study is to audit the CSR at MMH making use of Robson's TGCS for the six-month period of January 2016 to June 2016.

Primary objectives are:

1. To calculate the CSR for MMH for January 2016 to June 2016.
2. To analyze the CSR within each of the Robson groups.
3. To compare the results with the findings from the reworked results from Horak et al. (2012) after a secondary analysis in which the MMH data were analysed alone.

Secondary objectives are:

1. To make recommendations for interventions aimed at reducing the CSR where indicated.
2. To assess the feasibility for routine audit of all deliveries, including caesarean sections, using Robson's TGCS.

# Methods

## Study Design

This retrospective, observational study was performed at Mowbray Maternity Hospital for the six-month period of January 1<sup>st</sup> 2016 to June 30<sup>th</sup> 2016. All deliveries, comprising of vaginal deliveries and caesarean sections, that took place during this period, were reviewed.

To allow for a comparison to be made, a secondary analysis was performed from the Horak et al. (2012) data and all the deliveries conducted at MMH between January 1<sup>st</sup> 2009 and June 30<sup>th</sup> 2009 was extracted and used.

## Study Setting

The study was performed at Mowbray Maternity Hospital in Cape Town, South Africa. MMH is a secondary level public hospital, providing obstetric and neonatal services to a population from a large geographical area.

Primary level obstetric care is provided to the residents in the immediate vicinity of the MMH, but the greatest percentage of patients attending MMH are constituted from referrals from the four MOU's that serve the drainage area of MMH. These are Mitchells Plain MOU, Hanover Park MOU, Gugulethu MOU and Retreat MOU. In addition, women are referred from False Bay Hospital, located in Fisk Hoek, should they require secondary level care. Al-Nisa Maternity Home, is a midwife-based, private obstetric facility located in Rondebosch, and also refers women requiring secondary level care. Mitchells Plain District Hospital opened in 2013 and renders primary and some secondary level obstetric care, but refers complicated patients to MMH. In rare circumstances will a woman be referred from one of the private hospitals located in the catchment area of MMH.

The opening of Mitchells Plain District and Khayelitsha District Hospitals and the subsequent change in referral routes this brought about, geographically changed the drainage area to MMH compared to the area investigated by Horak et al. in 2009. In

2009, referral routes to MMH were from Gugulethu MOU, Khayelitsha MOU, and Mitchells Plain MOU. Liesbeck MOU, located at MMH, incorporated a much larger geographical area. False Bay Hospital and Retreat MOU referred all patients to Groote Schuur Hospital, and Hanover Park MOU referred to New Somerset Hospital. The resultant effect has been that MMH now comprises a larger level 2 population than in previous years.

Mowbray Maternity Hospital's theatre complex consists of two fully operational theatres, in which elective caesarean sections are performed every weekday and emergency caesarean sections as necessitated. During daytime hours, both theatres are available until 7pm after which only one theatre remains open. The second theatre can be opened at night should the need arise. Senior doctors, in discussion with patients, make the decision to perform a CS and then confirm this decision with a consultant.

## Study Group

All women who delivered vaginally or by CS at MMH between January 1<sup>st</sup> 2016 and June 30<sup>th</sup> 2016 have been included in the study. A delivery in which the weight of the newborn was recorded as below 500g was regarded as a miscarriage and therefore not eligible for inclusion into the study.

## Data Collection

MMH has two delivery registers per month, one each for labour ward and the theatre complex respectively, that are used to routinely document every delivery that is attended to in the hospital. All the data for January 2016 to June 2016 was collected from 12 registers, six from labour ward and six from theatre, and captured into an electronic password-protected, Microsoft Excel® Spreadsheet.

Information recorded from these registers included:

- Individual folder numbers

Folder numbers were collected to enable the tracking of an individual patient folder in the event that it had to be reviewed.

- Gestational age at the time of delivery  
A term pregnancy is defined as one that has reached a minimum of 37 completed weeks of gestation. Women who delivered before reaching 37 completed weeks gestation were classified as preterm.
- Parity  
Parity refers to the obstetric history of the woman in terms of a previous delivery of a fetus that has achieved viability prior to labour. Viability is the gestational age at which the fetus has a reasonable chance of survival and varies between different centres. Although the international consensus is that prior to 22 completed weeks a fetus is pre-viable, we used 24 completed weeks or 500g as the definition. The delivery may have been a vaginal birth or a CS. Nulliparous women, having never delivered a viable fetus before, might have had a previous miscarriage or ectopic pregnancy and still be classified as being nulliparous. Multiparous women delivered a viable fetus on at least one occasion before.
- HIV status  
The HIV status was captured, either positive or negative and in the case that this information was missing from the birth register, it was coded as unknown.
- Presentation  
This refers to the presenting part, cephalic or breech, and to the lie of the fetus in the case that the fetus is transverse or oblique. In multiple pregnancies, the presenting part or lie was not captured and for purposes of this study, not coded.
- Previous caesarean section / Uterine surgery  
Any previous CS, whether it was a classical CS or a lower uterine segment CS, is included. Previous uterine surgery will include previous myomectomies, corneal ectopic pregnancy resection and metroplasty.
- Singleton or Multiple pregnancy  
Multiple pregnancies comprised of twin pregnancies exclusively as other higher order pregnancies receive antenatal care and subsequently deliver at GSH. In the

event a woman delivered the leading twin vaginally but delivery of the second twin necessitated a CS, classification of the delivery was kept to vaginal birth as this was the intention and to avoid two deliveries for a single patient.

- Course of labour

The process of labour in each woman was either spontaneous, induced or the woman had a CS prior to the onset of labour.

- Mode of Delivery

Mode of delivery was either via a CS or a vaginal birth. Vaginal birth encompassed cephalic and breech presentations and included assisted vaginal deliveries.

One of the difficulties experienced with the data collection during the Horak study was the need to retrieve a large number of folders to complete the deficient information in the delivery registers necessary to classify each woman into one of the 10 groups. The deficient information was mainly limited to the obstetric history and labour course, more specifically the presence or absence of a previous CS and whether the labour was induced or spontaneous. To obviate this potential problem, two additional columns were added to the delivery registers prior to the commencement of the study to aid in documenting these factors at the time of delivery.

Induction of labour can be achieved with various methods. At MMH, the standard procedure is to insert an intracervical catheter as mechanical method of IOL, when a woman is electively admitted for IOL. If labour does not commence, pharmacological induction is performed with either Misoprosol (PG E1) or Dinoprostone (PG E2). Induction by means of artificial rupture of membranes and Syntocinon infusion is also performed in cases where the cervical findings are favourable, however, these cases are in the minimum. An induction document is routinely completed when a woman starts the induction, regardless of the method used. This document is a single page and keeps record of the gestational age, the indication for delivery, labour-altering patient factors, the method of induction used, and the vital signs of the woman during IOL. This document facilitates more efficient the capturing of information into the delivery

registers as performed by the nursing staff. A separate medication register, used to document Misoprostol and Dinoprostone administration as per hospital policy, was reviewed to ensure all pharmacological inductions were captured correctly.

All deliveries, where the fetus has not reached 24 completed weeks gestation or the birth weight of the newborn was below 500g, were excluded from the study. With the use of this information, each delivery was classified according to the Robson's TGCS into a single group. The hospital folder for each entry in the registers, that did not have sufficient information documented, was reviewed individually to allow classification of the delivery according to the TGCS. If the folder was not traceable, then the delivery was not entered into the data sheet, as classification was not possible.

Horak et al. included deliveries from MMH and its referring MOU's in 2009. To allow for a direct comparison between the results from 2016 and 2009, only the entries for January 2009 – June 2009 from MMH were extracted from the dataset of Horak et al.

## Sample Size

The study was conducted over the course of a six-month period and hence the sample size was not set. Based on monthly statistics, we expected 900 deliveries per month, totaling to 5400 deliveries over the study period. We anticipated that at least 40% of the deliveries will be performed by a CS amounting to 2160 deliveries. We foresaw that this projected sample size will provide adequate data, from which conclusions, with statistical significance, can be drawn.

## Prevention of potential data collection errors

Data capturing relied on correct information in the registers as captured by the health care provider making the entry of each delivery. A faulty entry would only have been identified and corrected, if the folder was reviewed for another reason. In an effort to minimize errors in completion of the delivery registers and limit the number of incomplete entries, informative sessions were held with the staff. Nursing staff were encouraged to accurately complete each entry into the delivery register. Unavoidably, some errors occurred, and with some training of the staff, these numbers were kept to a minimum.

## Analysis

Statistical analysis was done making use of Stata software.<sup>111</sup> Standard statistical tests were used to calculate the results, including Pearson Chi<sup>2</sup> test, p-values and Odds Ratios. The p-values were rounded off to the third decimal place and a p-value of <0.05 was selected as being statistically significant. The results are presented in Figures, Tables and Graphic illustrations.

The CSR for January 2016 to June 2016 for Mowbray Maternity Hospital was calculated from the deliveries over this period. Further analysis of each subgroup within the Robson's TGCS was performed; calculating the respective CS rates in each group and comparing it to the results of Horak et al.

## Ethical Considerations

The study protocol was reviewed and approved by the Departmental Research Committee during May 2016 and by the University of Cape Town's HREC (HREC Ref: 539/2016) in July 2016.

All patient information was treated confidentially and in accordance with the Helsinki Declaration.<sup>112</sup> Apart from the folder number, no patient identifiers were collected. Informed consent from individual women was not a requirement, as data was collected retrospectively from the registers and folders. Data entries were stored in a password-protected Microsoft Excel® spreadsheet, to which only the principle investigator had access. There was no direct contact with any patient during the course of this study and the study posed no harm to any patient involved.

## Budget

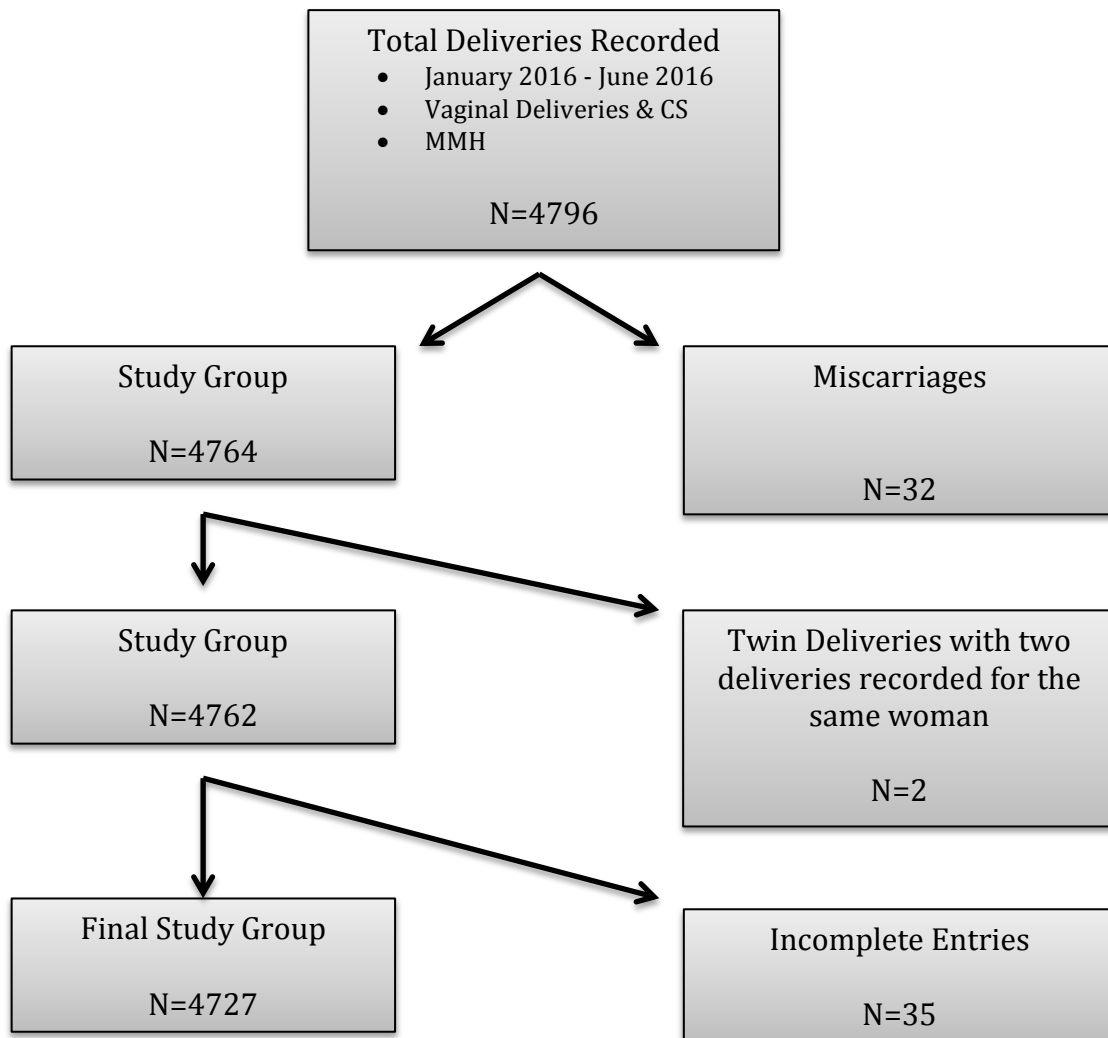
Over the study period, minimal costs were incurred apart from stationery.

# Results

## A – Caesarean Section Data for 2016

### Study Group

In 2016, there were a total of 4762 women between January and June 2016 that were eligible for enrollment into the study. Figure 1 displays the formation of the study group.



**Figure 1: Study Group 2016**

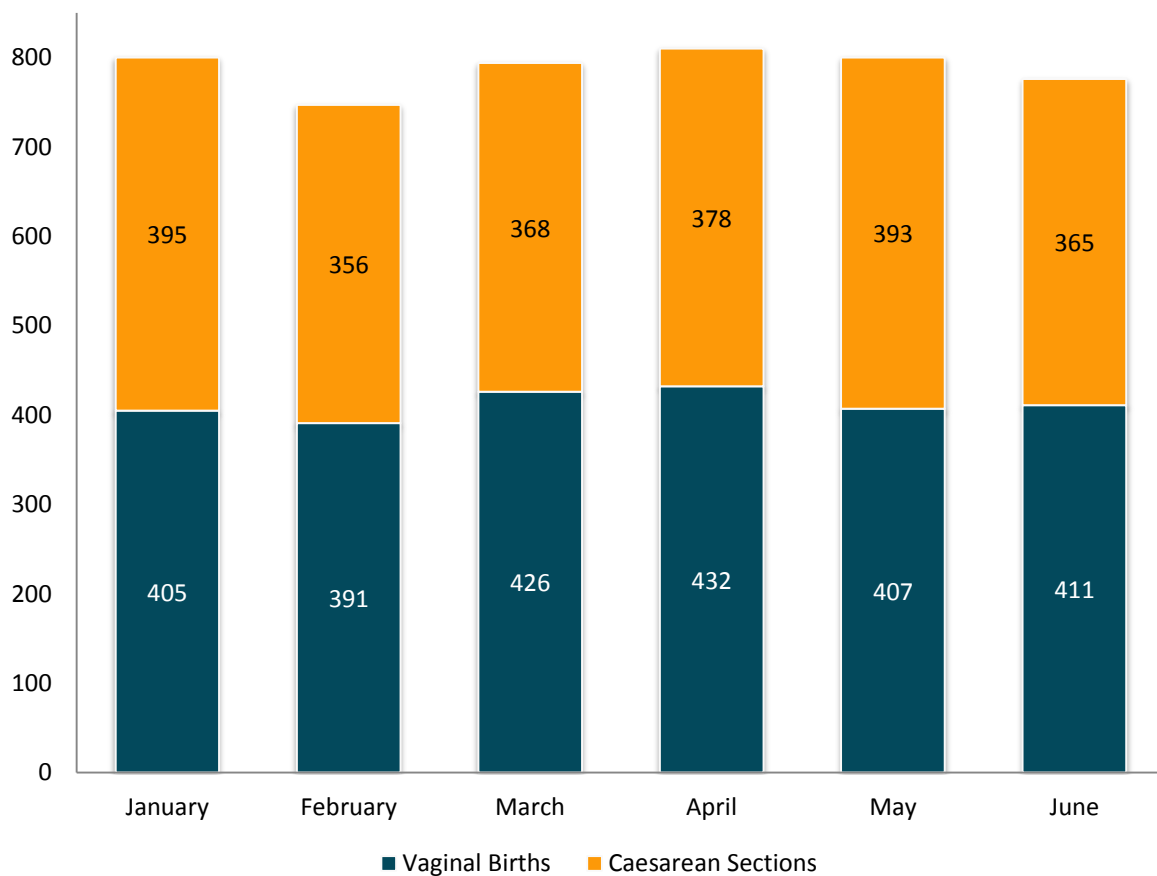
From the eligible women, all the required information could be obtained from the delivery registers, except for 258 folders (5.42%) where the entries were incomplete

and the folders needed to be reviewed to obtain missing information. Of the 258, 35 folders could not be found, giving a final group of 4727 women of the eligible 4762 women, resulting in an enrollment figure of 99.27%.

Two women with twin pregnancies had both a vaginal delivery and a caesarean birth for each individual fetus and in both cases were the deliveries recorded in the labour ward and the theatre registers. To avoid including four instead of two deliveries, the theatre entries were excluded and in both cases were the deliveries classified as vaginal, as this was the planned mode of delivery.

### Details of Total Deliveries

A total of 4727 women delivered 4836 babies over the period of January 1<sup>st</sup> 2016 to June 30<sup>th</sup> 2016. There were 2472 vaginal births and 2255 caesarean sections, resulting in a CSR of 47.70% (95% CI 46.28-49.13).



**Figure 2: Deliveries for January 2016 - June 2016**

Figure 2 illustrates the breakdown of total births into vaginal deliveries and caesarean sections for each month of the 2016 study period. There was an average of 412 vaginal births and an average of 376 caesarean sections per month. The most deliveries were performed in April and the least number of deliveries were in February as it has fewer days than the other months.

The study group was composed of 1778 nulliparous women, 949 of whom had vaginal births and 829 of whom had caesarean deliveries. There were 2949 multiparous women, 1523 of whom had vaginal births and 1426 of whom had caesarean deliveries. Nulliparous women, compared to multiparous women without a history of a prior CS, were at higher risk for a CS if in spontaneous labour (OR 2.02; 95% CI 1.71-2.38).

A total of 218 babies were born from 109 twin pregnancies, accounting for 2.31% of the study group. There were no higher order pregnancies delivered during the study period, as they were identified antenatally and referred for tertiary care.

The fetal presenting part was cephalic in 4473 women, accounting for 94.63% of the study group. Breech presentation was diagnosed in 137 women, resulting in a breech rate of 2.90%, whilst a combined rate of 0.17% was observed for the eight transverse and oblique presentations. The remaining 109 patients fell into group 8, in which the presenting part of the leading twin is not required or captured.

In 2016, there were 978 women whom had a previous CS or myomectomy, representing 20.69% of the study group and 3726 women had no previous uterine surgery. In 23 women this history was not available, but did not hinder the classification of these women because in groups 6-10, the history of previous uterine surgery has no influence on the classification of the delivery in question.

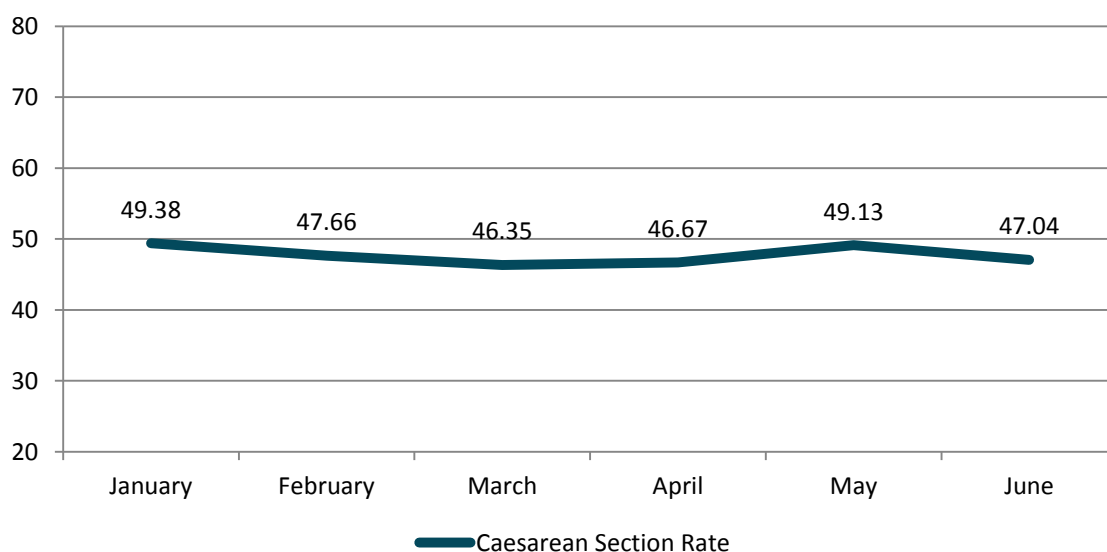
There were 140 of 978 women that had vaginal births after a previous CS. This represents a successful VBAC rate of 14.31% (95% CI 12.26-16.65). Proportionally, women in group 5 made the biggest contribution to the VBAC rate with 123 deliveries, followed by group 10 with 14 deliveries and groups 7 and 8 with 2 and 1 deliveries respectively.

A preterm birth rate of 16.61% (95% CI 15.57-17.69) was recorded, as represented by the 785 deliveries that took place prior to 37 completed weeks. Group 10 consisted of 675 women, with a singleton pregnancy, cephalic presentation that delivered prior to 37 completed weeks of gestation. This group made the largest contribution of 85.99% to the total preterm birth rate. The remaining 14.01% was composed of 16 deliveries from group 6, 44 deliveries from group 7, 49 deliveries from group 8, and a single delivery from group 9.

In 3174 women, labour started spontaneously and 497 women were delivered with a CS prior to the onset of labour. A total of 561 vaginal births resulted from the 1040 inductions of labour that were conducted over the 6 months. This equated to a success rate of 53.94% (95% CI 50.90-56.95) for IOL. Nulliparous women, compared to multiparous women without a history of a prior CS, were at higher risk for a CS if induced (OR 2.75; 95% CI 2.13-3.53). All the deliveries were classified into one of ten totally inclusive and mutually exclusive groups according to the Robson criteria. Each group identifies a specific group of women based on obstetric and patient variables.

### Caesarean Section Rates and Robson’s Classification

The overall CSR for the study period was 47.70% (95% CI 46.28-49.13) and is represented in Graph 1. A statistically non-significant variation in the CSR ( $p=0.759$ ), ranging from 46.35% in March to the 49.38% in January was observed.

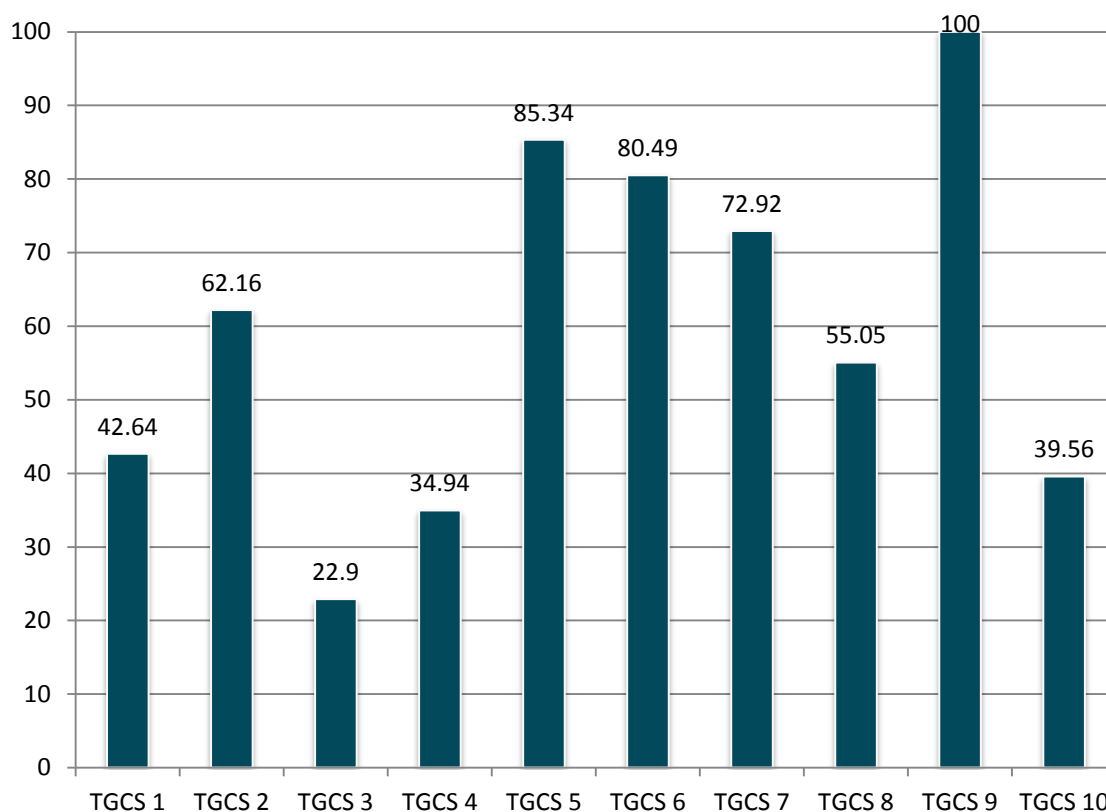


**Graph 1: Caesarean Section Rate 2016**

Primary caesarean sections were performed on 1407 women, which accounts for 62.4% of the caesarean sections, whereas the 838 repeat caesarean sections performed accounted for 37.2% of the caesarean sections. Women who delivered via primary sections comprised of 827 nulliparous women and 580 multiparous women. In ten women who delivered via caesarean sections, the history of a previous CS was not available.

Each of the ten Robson groups represents a specific group and a variation in the CSR between these groups is expected. The results revealed a statistically significant ( $p < 0,001$ ) variation in the CSR between the ten groups. The highest CSR of 100% was observed in Group 9, which includes women with transverse and oblique presentations. Group 3, multiparous women with a singleton cephalic pregnancy in spontaneous labour, had the lowest CSR of 22.90% (95% CI 20.42-25.57).

Figure 3 below illustrates the CSR for each of the individual groups for 2016.



**Figure 3: Caesarean Section Rate 2016: Robson Classification Groups**

Table 1 provides the breakdown of deliveries from each of the ten groups as well as the contribution of each group towards the overall CSR. There were a total of 716 caesarean sections performed on patients from group 5 and although the CSR from this group was not the highest of them all, its contribution of 31.75% towards the overall CSR was the biggest. Nulliparous women in spontaneous labour made the second largest contribution to the CSR. Group 9 had the highest CSR of 100%, but its contribution of 0.35% towards the overall CSR was the smallest.

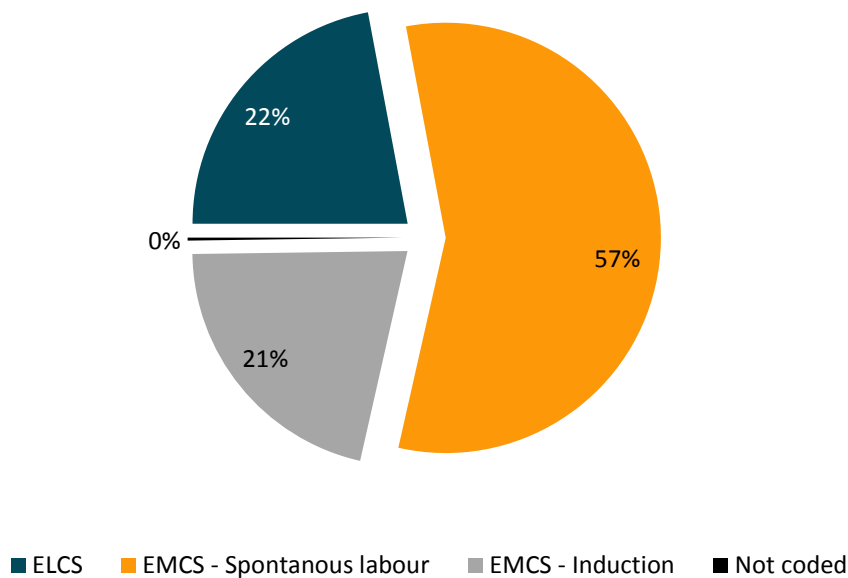
	Vaginal Deliveries (A)	Caesarean Sections (B)	Total Group Deliveries (C)	CS Rate (%) (B/C) x 100	Contribution to overall CSR (%) (B/D) x 100
<b>TGCS 1</b>	592	440	1032	42.64	9.31
<b>TGCS 2</b>	154	253	407	62.16	5.35
<b>TGCS 3</b>	788	234	1022	22.90	4.95
<b>TGCS 4</b>	324	174	498	34.94	3.68
<b>TGCS 5</b>	123	716	839	85.34	15.14
<b>TGCS 6</b>	8	33	41	80.49	0.70
<b>TGCS 7</b>	26	70	96	72.92	1.48
<b>TGCS 8</b>	49	60	109	55.05	1.27
<b>TGCS 9</b>	0	8	8	100.00	0.17
<b>TGCS 10</b>	408	267	675	39.56	5.65
<b>Total</b>	<b>2472</b>	<b>2255</b>	<b>4727 (D)</b>	<b>47.70</b>	<b>47.70</b>

**Table 1: Delivery Figures 2016: Robson Classification Groups**

There were 829 nulliparous and 1426 multiparous women that were delivered by caesarean sections. A nulliparous woman, compared to a multiparous woman without a previous CS, was statistically more likely to have a caesarean birth if in spontaneous labour (OR 2.02; 95% CI 1.71-2.38) or if induced (OR 2.75; 95% CI 2.13-3.53).

Figure 4 visually illustrates the proportionate contributions of elective and emergency caesarean sections. Elective caesarean sections were performed in 497 women,

comprising 28 nulliparous women and 469 multiparous women, and emergency caesarean sections in 1753 women. In 5 women, this information was not obtained, but the lack of this did not affect the classification of the deliveries in question. Emergency caesarean sections were performed on 1274 women in spontaneous labour and 479 women undergoing an IOL.



**Figure 4: Elective and Emergency Caesarean Sections 2016**

- Robson Group 1

Group 1 had the largest number of women over the study period and 592 delivered vaginally, whereas 440 women delivered via caesarean sections. This resulted in a CSR of 42.64% (95% CI 39.64-45.67) for group 1.

- Robson Group 2

Vaginal births accounted for 154 and caesarean sections for 253 of the deliveries in group 2. An overall CSR of 62.16% (95% CI 57.37-66.78) was observed for the study period in group 2.

- Robson Group 3

A total of 788 women delivered vaginally and 234 women had caesarean sections in group 3 over the study period, amounting to a CSR of 22.90% (95% CI 20.40-25.55) for

group 3. Group 3 was the second largest and also had the lowest rate CSR of all the groups over the 6 months.

- Robson Group 4

Collectively, 324 women delivered vaginally and 174 women delivered via caesarean sections, resulting in a CSR of 34.94% (95% CI 30.84-39.21) for group 4.

- Robson Group 5

Group 5 was responsible for the greatest contribution to the overall CSR as it is the group with the highest number of caesarean sections. In contrast to the 716 caesarean sections, only 123 women delivered vaginally. A CSR of 85.34% (95% CI 82.82-87.61) was recorded for the group over the 6 months. Women with any number of previous caesarean sections or other uterine surgery are included into this group. Therefore only a small subset of women, those with a single previous lower uterine segment CS, was eligible for a trial of vaginal delivery.

- Robson Group 6

In total, 33 women in this group delivered via a CS and 8 vaginal breech deliveries were performed. The average caesarean section rate of 80.49% (95% CI 66.29-90.50) varied widely month to month due to the relatively small number of patients in the group.

- Robson Group 7

There were 26 vaginal deliveries and 70 caesarean sections performed in this group over the 6 months, providing a CSR of 72.92% (95% CI 63.38-81.09). The number of vaginal deliveries and caesarean sections per month is visible in Figure 14.

- Robson Group 8

There were 49 sets of twins delivered vaginally and 60 sets delivered via CS. A spike in the number of twin deliveries was observed in March. The CSR for this group was 55.05% (95% CI 45.63-64.19) over the 6 months.

- Robson Group 9

This group has the fewest number of women and made smallest contribution to the overall CSR, despite the CSR being 100%. There were no vaginal deliveries and only 8 caesarean sections performed over the 6 months, one in each month apart from March and June with 2 deliveries each.

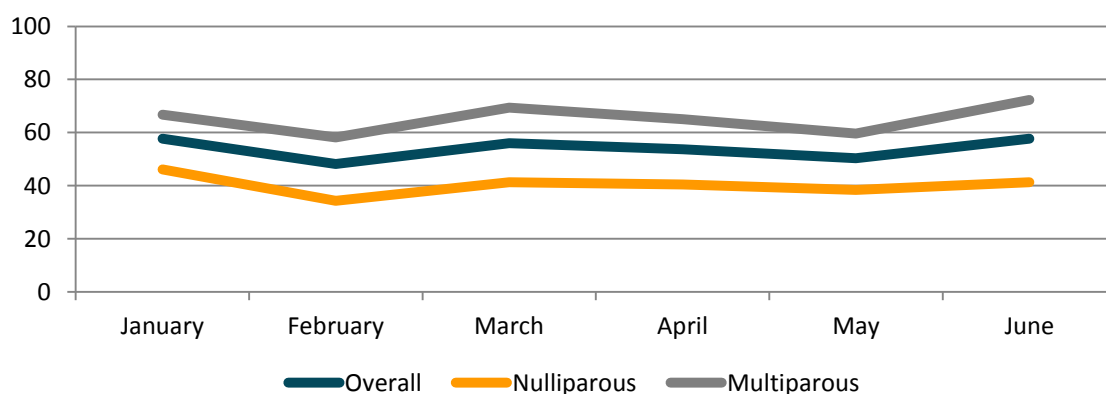
- Robson Group 10

A total of 408 vaginal deliveries and 268 caesarean sections were performed giving rise to a CSR of 39.65% (95% CI 36.01-43.37) in this group. Group 10 was the third largest contributor to the overall CSR after groups 5 and 1.

### Induction of labour

In 2016, there were 561 vaginal deliveries that ensued from the 1040 inductions of labour, resulting in an overall success rate of 53.94% (95% CI 50.90-56.96). Graph 2 illustrates the overall success rate of IOL as well as the success rate specific to nulliparous and multiparous women.

Nulliparous women had a success rate of 40.38% (95% CI 36.00-44.88) in contrast to a success rate of 65.04% (95% CI 61.06-68.86) in multiparous women. Following an IOL, a vaginal birth was more likely to occur in a multiparous woman (OR 2.75; 95% CI 2.13-3.53) compared to a nulliparous woman.

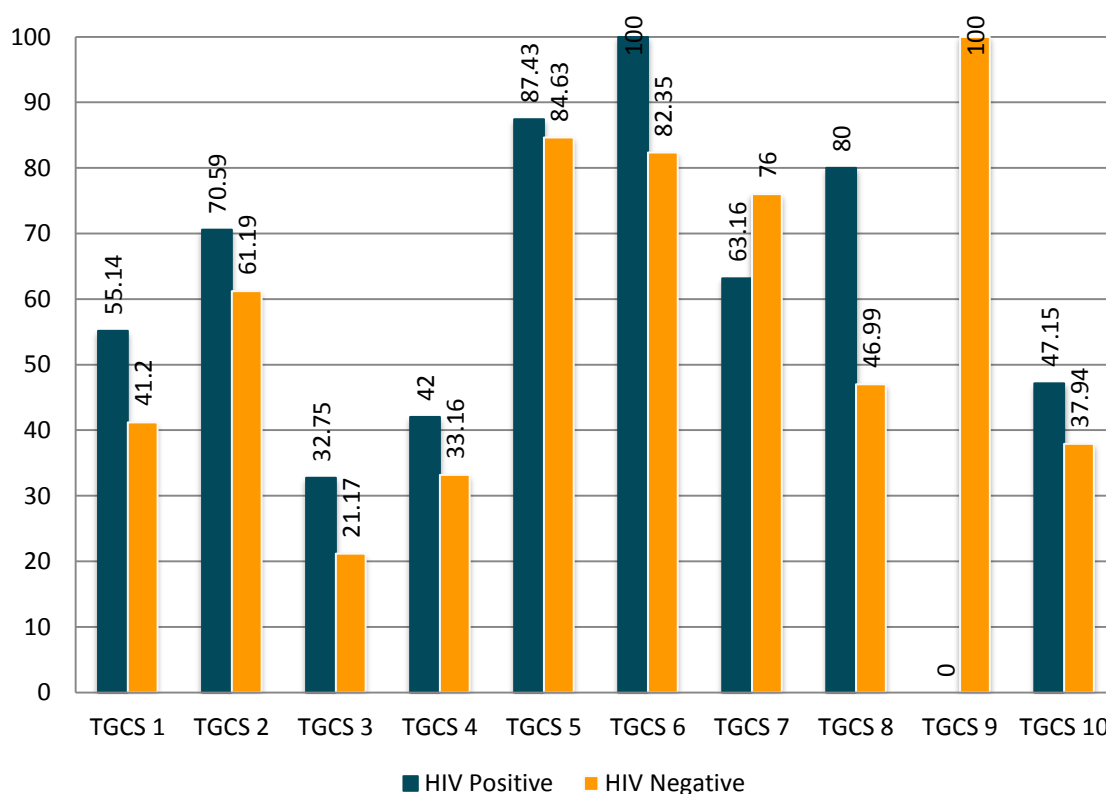


**Graph 2: Induction of labour Success Rate 2016**

## Human Immunodeficiency Virus

In the study population, 759 women were HIV positive, representing a prevalence rate of 16.06% (95% CI 15.03-17.15), whereas 3919 women were HIV negative, which was 82.91% (95% CI 81.80-83.97) of the study group. The HIV status of 49 women was unknown, as it was not recorded in the birth register. The HIV positive group consisted of 175 nulliparous women, representing a figure of 9.84% (95% CI 8.51-11.34) for the total nulliparous group, in comparison with 584 multiparous HIV women accounting for 19.80% (95% CI 18.38-21.29) of the total multiparous group.

Caesarean sections were performed for 429 out the 759 HIV positive women, compared to 1806 caesarean Sections performed in the HIV negative group of 3919 women. This accounted for an overall CSR of 56.52% (95% CI 52.97-60.02) in HIV positive women, which was significantly higher ( $p < 0.001$ ) than the overall CSR of 46.08% (95% CI 44.53-47.65) in HIV negative women. HIV positive women were more likely to have a CS compared to HIV negative women (OR 1.52; 95% CI 1.29-1.78  $p < 0.001$ ).



**Figure 5: TGCS Caesarean Section Rates according to HIV status 2016**

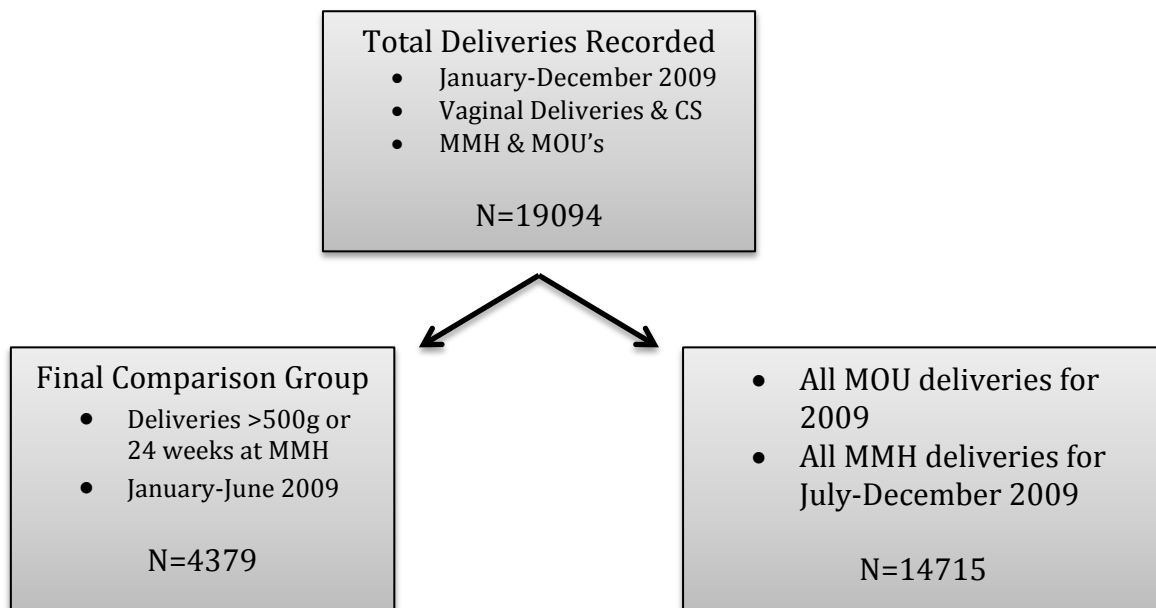
Figure 5 represents the difference in the CSR of HIV positive and negative women for each of the ten groups. Due to the relatively smaller groups seen in groups 6-9, the variation in the CSR between HIV positive and HIV negative women may not be as significant as observed in the groups with larger groups (groups 1-5 and 10).

There were 158 HIV positive women that underwent inductions of labour, with 76 of them having a successful vaginal birth. This represents a success rate of 48.10% (95% CI 40.14-56.15). Reviewing the HIV negative group of women undergoing inductions of labour, 480 women had successful vaginal births out of the 872 that were induced, resulting in a success rate of 55.05% (95% CI 51.68-58.38). HIV positive women were less likely to have a vaginal birth after an IOL (OR 0.76; 95% CI 0.54-1.06 p=0.108) compared to HIV positive women, although this figure did not reach statistical significance.

## B – Caesarean Section Data for 2009

### Study Group

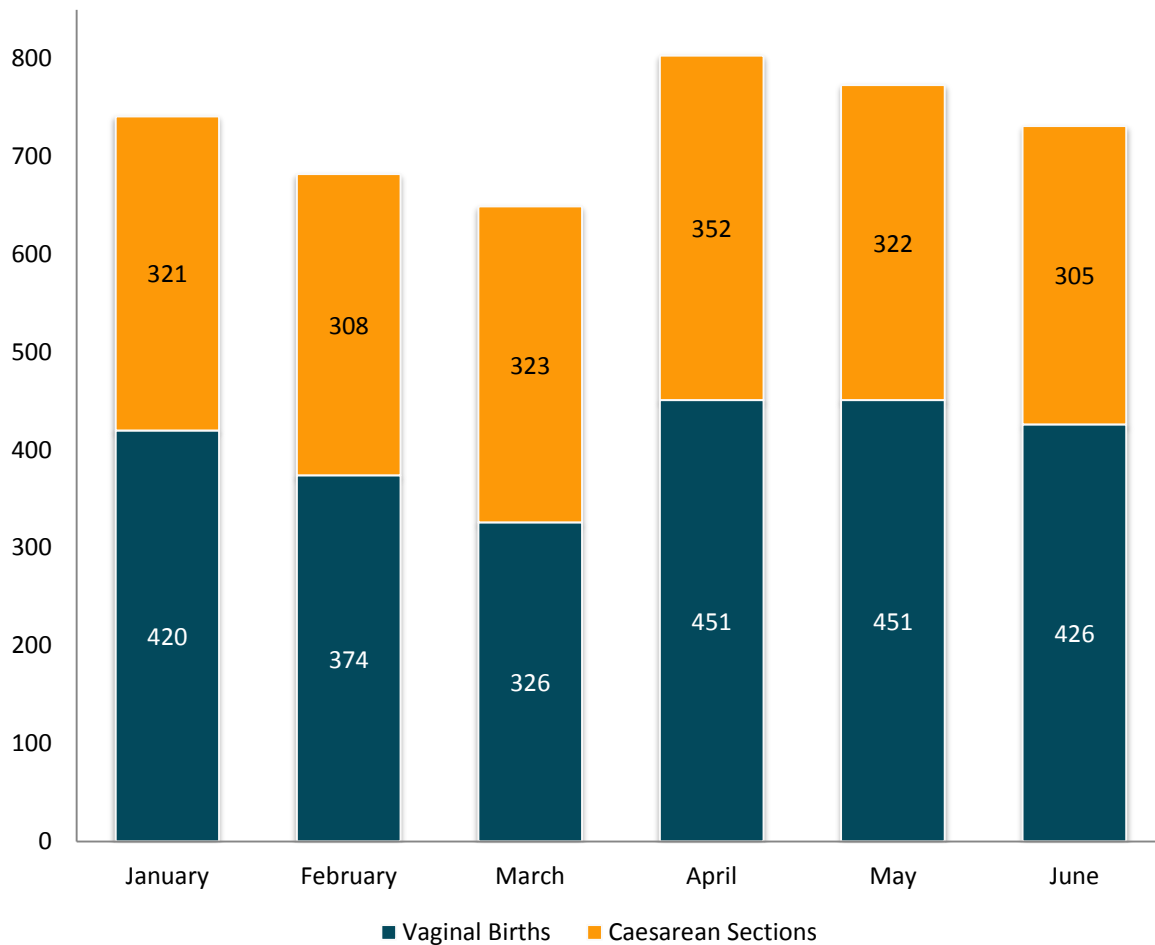
The group from January to June 2009 consisted of 4379 women, after only deliveries, which took place at MMH and not the referring MOU's, were selected. This is indicated in Figure 6.



**Figure 6: Comparison Group 2009**

### Details of Total Deliveries

There were a total of 2448 vaginal births and 1931 caesarean sections performed over this time period, resulting in an overall CSR of 44.10% (95% CI 42.63-45.57). Figure 7 illustrates the relative contribution of vaginal deliveries and caesarean sections to the total deliveries in this group.



**Figure 7: Deliveries for January 2009 - June 2009**

A total of 1788 nulliparous and 2591 multiparous women delivered at MMH over the six-month period. There were 212 babies born from 106 women with multiple pregnancies, accounting for 2.42% of the 2009 study group.

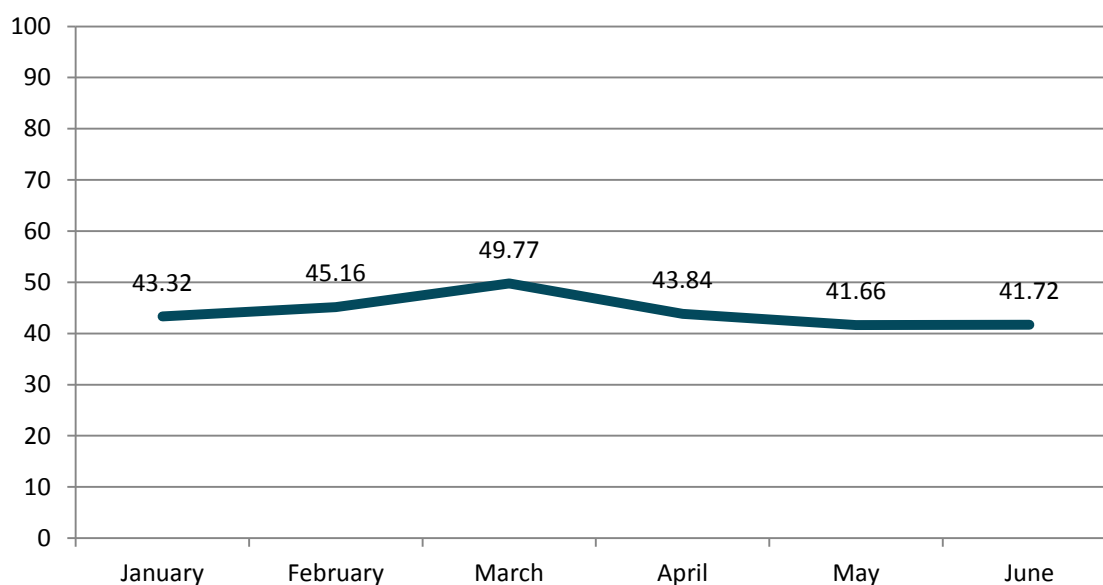
In 684 women, deliveries took place before 37 completed weeks of gestation, representing a preterm delivery rate of 15.62% (95% CI 14.57-16.72). Group 10 made the largest contribution with 587 women, or 85.82%, to this group. Women classified to groups 6-9 constituted the remaining 14.18%.

Of a total of 770 women with a previous CS, 129 women delivered vaginally in the study period, giving rise to a VBAC rate of 16.75% (95% CI 14.24-19.52). The largest contribution was from group 5 with 110 women, followed by group 10 with a further 19 women.

Induction of labour was performed for 732 women from January to June 2009, of which 466 women gave birth vaginally. This represents a success rate for induction of labour of 63.66% (95% CI 60.13-67.09).

### Caesarean Section Rates and Robson's Classification

The CSR for 2009 was 44.10% (95% CI 42.63-45.57) and is depicted in Graph 3.



**Graph 3: Caesarean Section Rate 2009**

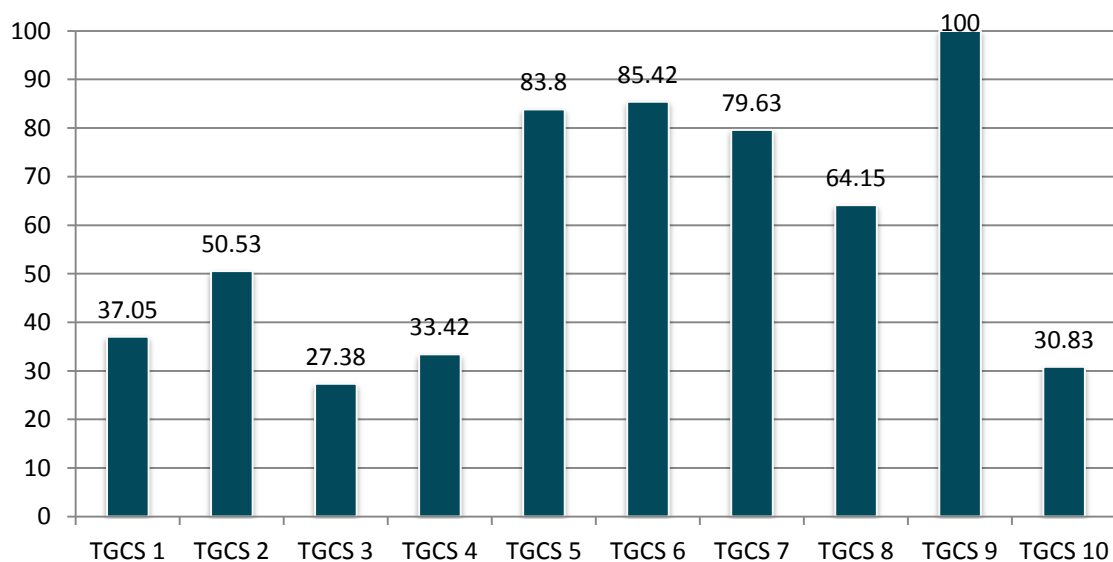
The higher CSR that is observed in March 2009 is brought on by a proportionally lower number of vaginal births that occurred during the month as opposed to an actual increase in the number of caesarean sections. April had the largest number of deliveries, compared to March with the least number of deliveries.

Table 2 provides a breakdown of the deliveries of the respective Robson groups and their respective CS rates for the overall period. The greatest number of caesarean sections was performed for women from group 5, followed by groups 1 and 3.

	Vaginal Deliveries (A)	Caesarean Sections (B)	Total Deliveries (C)	CS Rate (%) (B/C) x 100	Contribution to overall CSR (%) (B/D) x 100
<b>TGCS 1</b>	739	435	1174	37.05	9.94
<b>TGCS 2</b>	139	142	281	50.53	3.24
<b>TGCS 3</b>	732	276	1008	27.38	6.30
<b>TGCS 4</b>	255	128	383	33.42	2.92
<b>TGCS 5</b>	110	569	679	83.80	12.99
<b>TGCS 6</b>	7	41	48	85.42	0.95
<b>TGCS 7</b>	22	86	108	79.63	1.97
<b>TGCS 8</b>	38	68	106	64.15	1.55
<b>TGCS 9</b>	0	5	5	100.00	0.11
<b>TGCS 10</b>	406	181	587	30.83	4.13
<b>Total</b>	<b>2448</b>	<b>1931</b>	<b>4379 (D)</b>	<b>44.10</b>	<b>44.10</b>

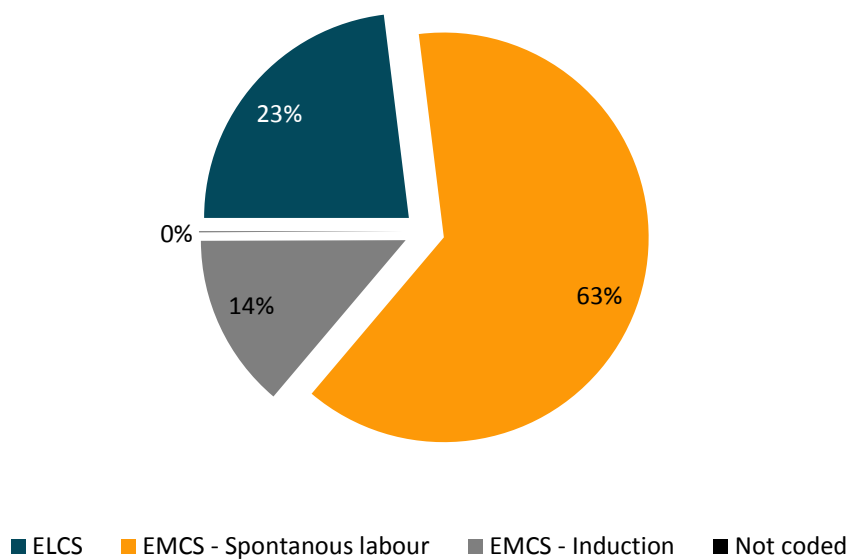
**Table 2: Delivery Figures 2009: Robson Classification Groups**

Figure 8 displays the CS rates from the 10 groups for 2009. The lowest CSR of 27.38% (95% CI 24.72-30.22) was observed in group 3 and the highest CSR of 100% in group 9.



**Figure 8: Caesarean Section Rate 2009: Robson Classification Groups**

Elective caesarean sections were performed in 445 women, comprising of 31 nulliparous and 414 multiparous women, and emergency caesarean sections in 1485 women. In 1 woman, this information was not obtained, but the lack of this did not affect the classification of the delivery in question. Emergency caesarean sections were performed on 1219 women in spontaneous labour and 266 women undergoing an IOL. Primary and repeat caesarean sections accounted for 66.8% and 33.2% respectively of all the caesarean sections performed. Figure 9 provides a visual breakdown.

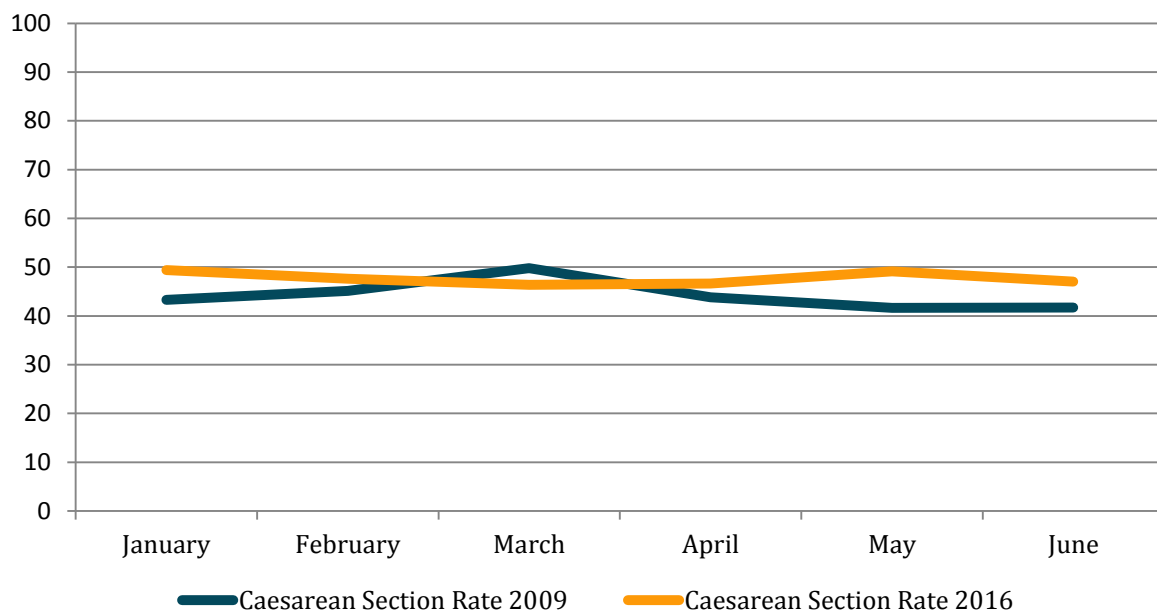


**Figure 9: Elective and Emergency Caesarean Sections 2009**

## C – Comparison of Data from 2009 & 2016

### Detail of overall Caesarean Section Rates

The CSR for MMH from January to June 2016 was 47.70% (95% CI 46.28-49.13), whereas the CSR for the same time period in 2009 was 44.10% (95% CI 42.63-45.57). The increase of 3.6% (p=0.001) was statistically significant. Graph 4 illustrates the respective CS rates.

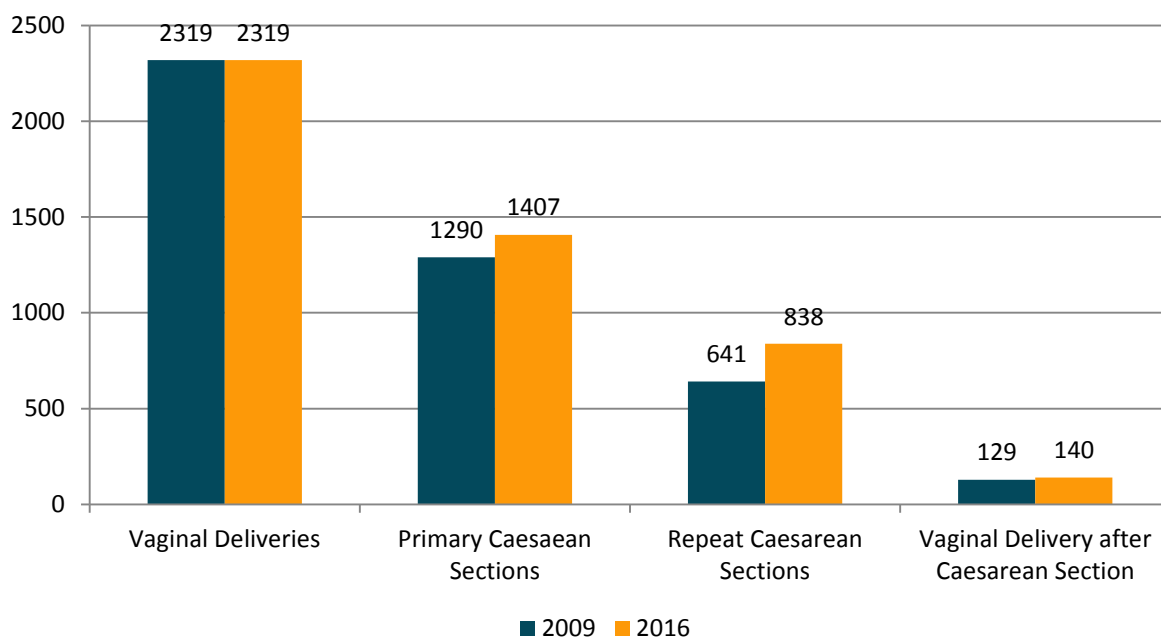


**Graph 4: Comparison of Caesarean Section Rates for 2009 & 2016**

In terms of absolute patient numbers, group 5 had the greatest increase with 160 patients, group 2 with 126, group 4 with 115 and group 10 with 88 patients. The 2016 period had 348 additional women that delivered at MMH, compared to the same period in 2009. On average, the monthly vaginal deliveries increased from 408 in 2009 to 412 in 2016, whereas monthly caesarean sections increased disproportionately from 322 in 2009 to 376 in 2016.

Caesarean sections, both primary and repeat, increased from 2009 to 2016, although repeat caesarean sections increased proportionally more. Primary caesarean sections accounted for 66.84% of all caesarean sections performed in 2009, where this percentage was 62.67% in 2016. In 2016, the information of a possible prior CS was

unavailable for 23 women and they are not included in the figure below. The modes of delivery are depicted in Figure 10.



**Figure 10: Mode of Delivery – 2009 versus 2016**

Table 3 illustrates the change in the CSR of each group as well as the statistical significance thereof.

Robson Groups	CS Rate 2009 (%)	CS Rate 2016 (%)	Change in CSR (%)	p-value
TGCS 1	37.05	42.64	5.59 ↑	<b>0.007</b>
TGCS 2	50.53	62.16	11.63 ↑	<b>0.002</b>
TGCS 3	27.38	22.90	4.48 ↓	<b>0.019</b>
TGCS 4	33.42	34.94	1.52 ↑	0.638
TGCS 5	83.80	85.34	1.54 ↑	0.408
TGCS 6	85.42	80.49	4.93 ↓	0.536
TGCS 7	79.63	72.92	6.71 ↓	0.259
TGCS 8	64.15	55.05	9.10 ↓	0.174
TGCS 9	100.00	100.00	0.00	-
TGCS 10	30.83	39.56	8.73 ↑	<b>0.001</b>
<b>Total</b>	<b>44.10</b>	<b>47.70</b>	<b>3.60 ↑</b>	<b>0.001</b>

**Table 3: Change in Caesarean Section Rates**

Groups 1, 2 and 10 all showed a statistically significant increase in the CSR from 2009 to 2016, whereas only group 3 had a significant decrease in the CSR. Groups 6-8 displayed lower CS rates in 2016 compared to 2009, although none reached statistical significance. Similarly, groups 4 and 5 both had raised CS rates, however, not statistically significant. The most significant increase in the CSR of 11.63% was seen in group 2 followed by an increase of 8.73% in group 10.

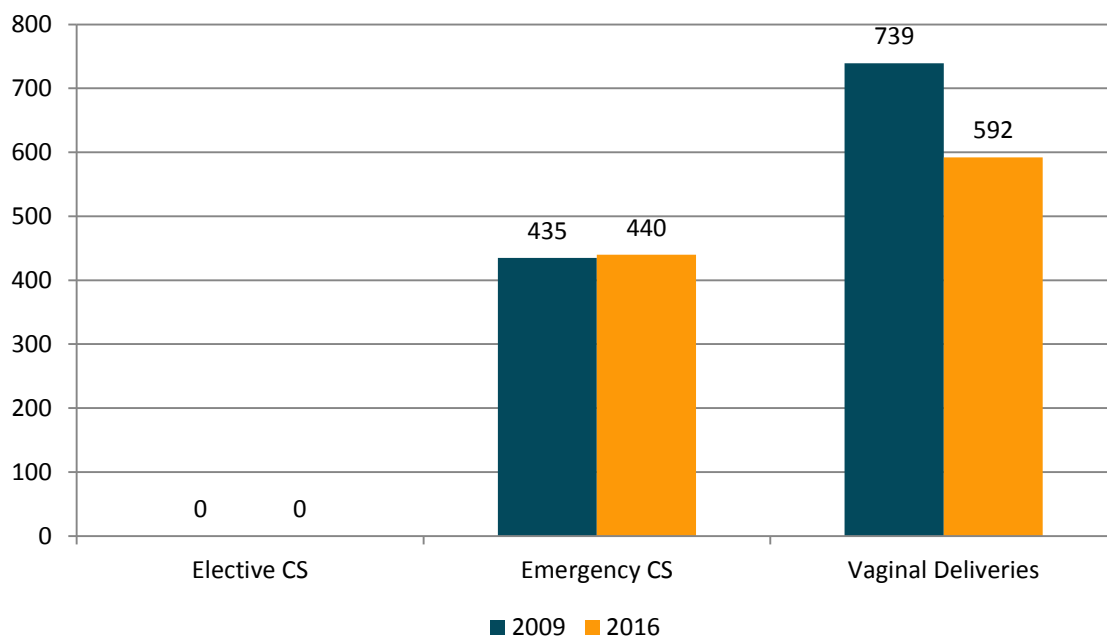
Unlike the respective CS rates of each individual Robson group, in which only the deliveries of each specific group is taken into account, the contribution of each group towards the overall CSR is calculated from the total number of deliveries. The number of deliveries in the other groups, therefore, affects the respective contribution figures. The contribution of each Robson group towards the overall CSR in 2009 and 2016 is depicted in Table 4. Groups 2, 4, 5 and 10 all displayed a significant increase in its respective contribution towards the CSR in 2016, even though the CSR in groups 4 and 5 did not increase significantly. This is due to a proportionally similar increase in the number of vaginal deliveries in groups 4 and 5. Group 3 was the only group with a significant decrease in contribution towards the CSR in 2016, secondary to a decrease in the absolute number of caesarean sections in the group.

Robson Groups	Contribution to CSR 2009 (%)	Contribution to CSR 2016 (%)	p-value
TGCS 1	9.94	9.31	0.312
TGCS 2	3.24	5.35	<b>&lt;0.001</b>
TGCS 3	6.30	4.95	<b>0.005</b>
TGCS 4	2.92	3.68	<b>0.044</b>
TGCS 5	12.99	15.14	<b>0.003</b>
TGCS 6	0.95	0.70	0.206
TGCS 7	1.97	1.48	0.759
TGCS 8	1.55	1.27	0.250
TGCS 9	0.11	0.17	0.487
TGCS 10	4.13	5.65	<b>0.001</b>
<b>Total</b>	<b>44.10</b>	<b>47.70</b>	<b>0.001</b>

Table 4: Contribution towards the Caesarean Sections Rates

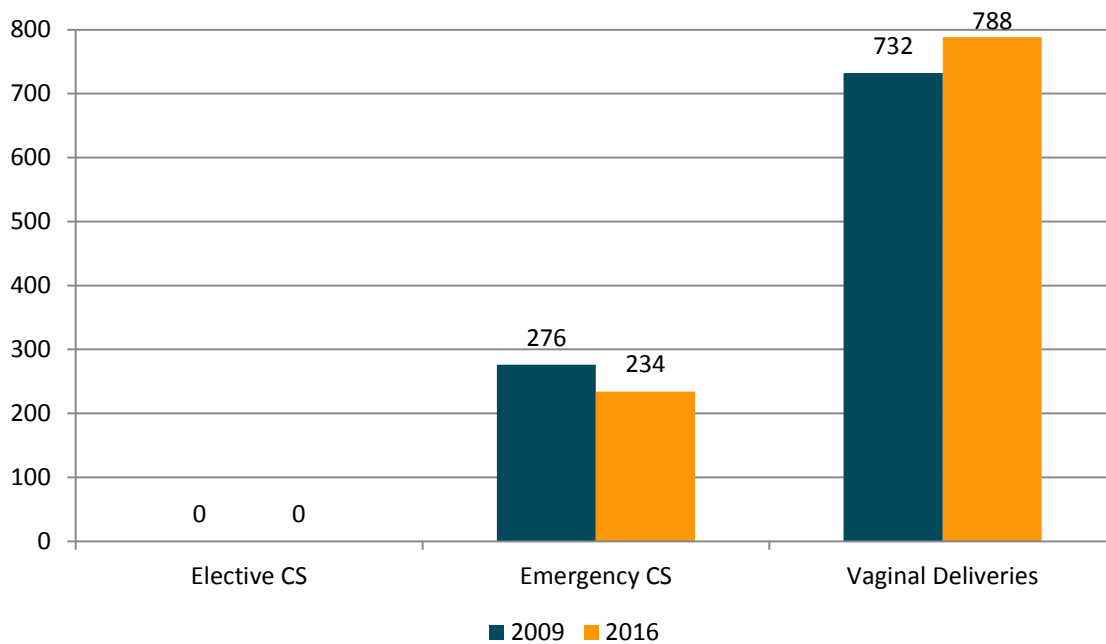
## Individual Robson Groups

Group 1 and 3 represent nulliparous and multiparous women, with a single cephalic pregnancy beyond 37 weeks gestation in spontaneous labour, respectively. Group 1 had the largest number of women in 2016 in the study and the CSR increased by 5.59% since 2009, even though the actual number of deliveries was less. In Figure 11, the raised CSR in group 1 is evident from a significant decrease in the number of successful vaginal deliveries, while emergency caesarean sections remained stable.



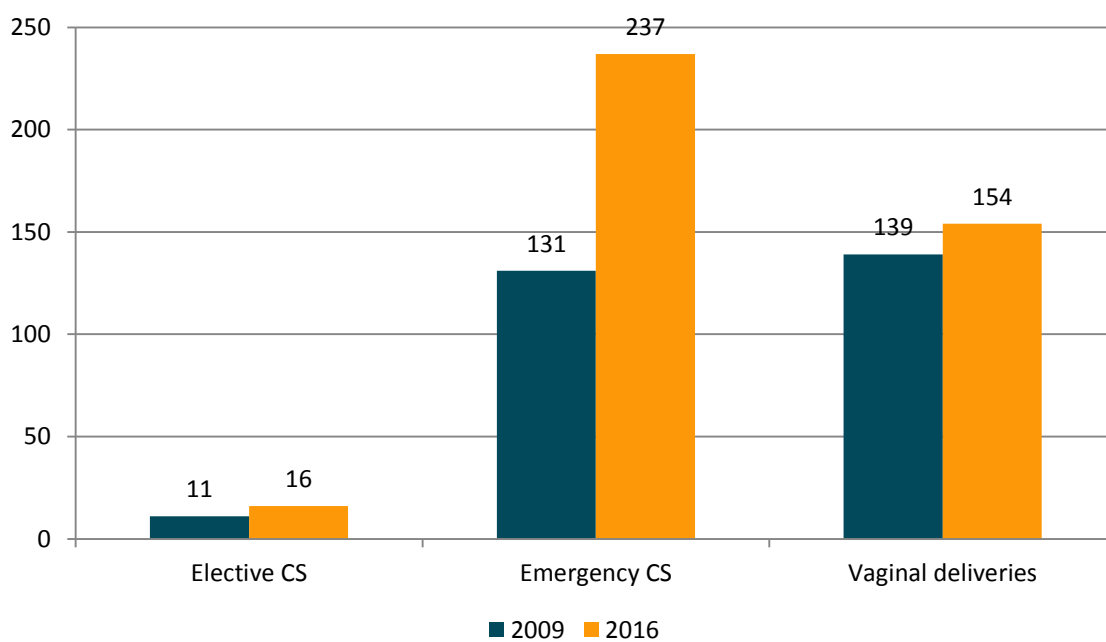
**Figure 11: Comparison of Group 1 – Mode of Delivery**

Group 3 was the second largest group in the study, but had the lowest CSR at 22.9% and was the only group with a statistically significant lower CSR in 2016. Figure 12 provides an overview of the number of deliveries for group 3 for each of the 2 years.



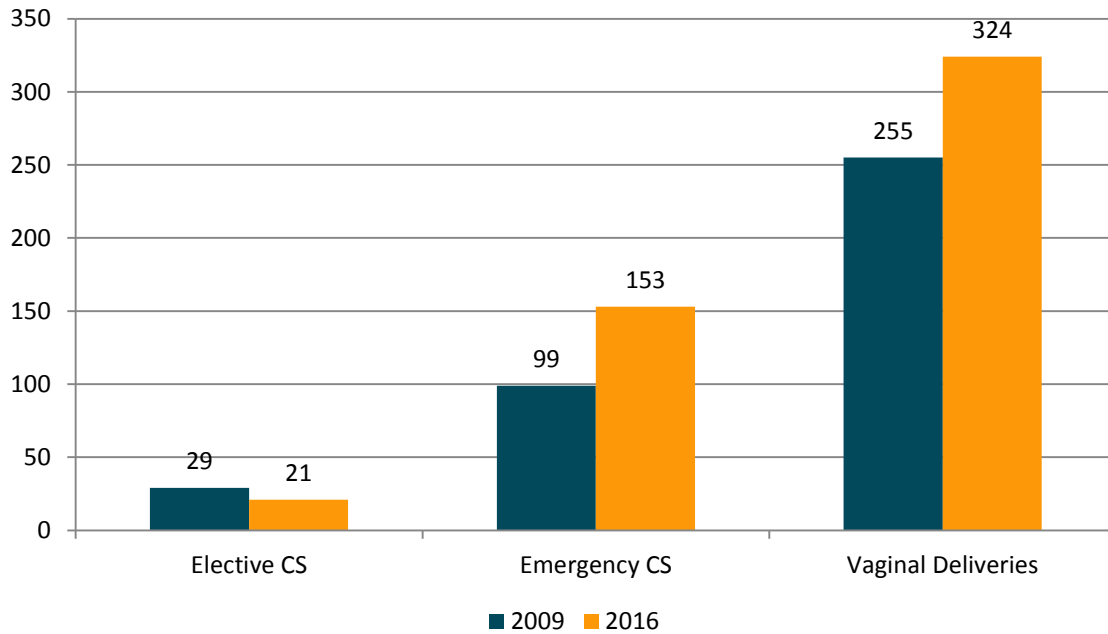
**Figure 12: Comparison of Group 3 - Mode of Delivery**

Groups 2 and 4, represent the same group of women as 1 and 3, except that these women either had an IOL or a CS prior to the onset of labour. Group 2 demonstrated the most dramatic increase in the CSR of 11.63%. Figure 13 below, illustrates the number of deliveries according to each mode of delivery in group 2.



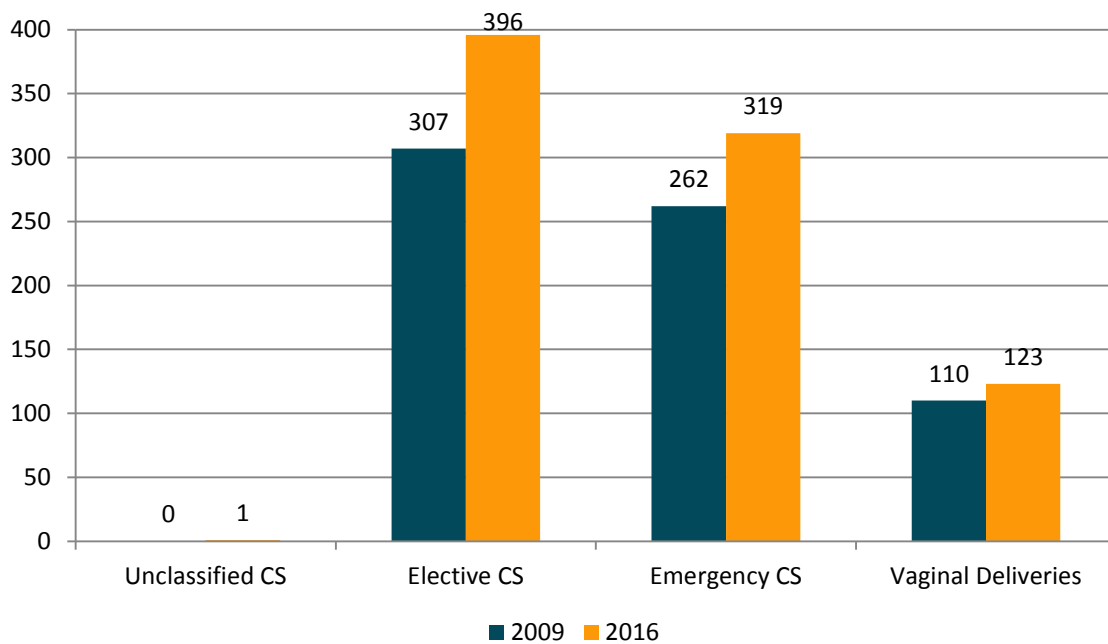
**Figure 13: Comparison of Group 2 - Mode of Delivery**

The CSR in group 4 increased by 1.52% but this was not statistically significant. Figure 14 provides a breakdown of the deliveries and confirms a proportional increase in vaginal deliveries and caesarean sections consistent with a stable CSR.



**Figure 14: Comparison of Group 4 - Mode of Delivery**

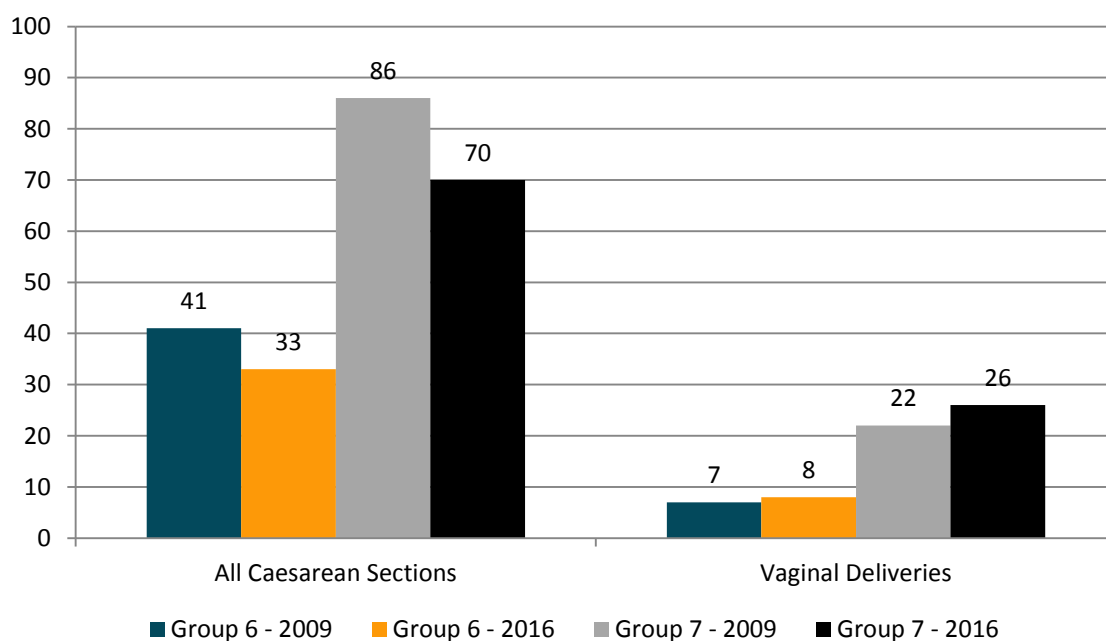
The number of deliveries for each delivery mode for group 5 is indicated in Figure 15.



**Figure 15: Comparison of Group 5 - Mode of Delivery**

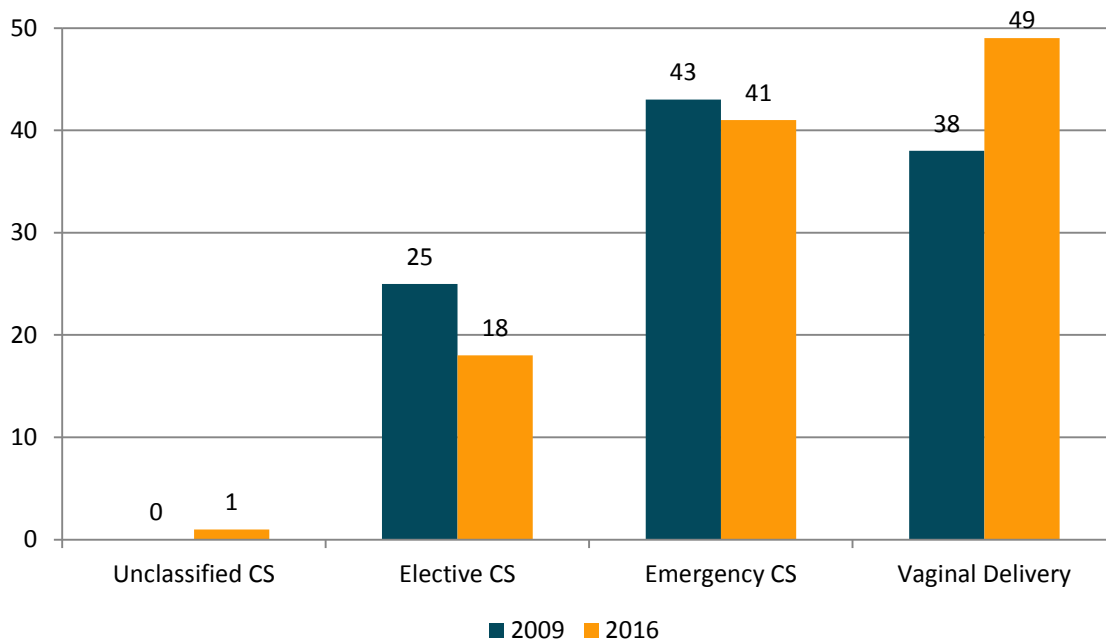
Group 5 had the greatest increase in the absolute number of deliveries, in addition to contributing the most to the overall CSR, however, the change in the CSR was not statistically significant. Elective caesarean sections increased more than emergency caesarean sections as well as vaginal deliveries. Women attempting a vaginal delivery had a success rate of 27.8% in 2016 compared to 29.6% in 2009. A single CS was not classified as whether it was an emergency or elective CS.

Groups 6 and 7 account for women in whom the fetus lies in a breech presentation in nulliparous and multiparous women respectively. The absolute numbers as well as the CSR in both groups revealed a slight decrease, although not statistically significant. Figure 16 illustrates this.



**Figure 16: Comparison of Groups 6 & 7 – Mode of Delivery**

All multiple pregnancies are accounted for in group 8 and Figure 17 indicates the distribution of deliveries between caesarean sections and vaginal deliveries. There has been a decrease in the number of elective caesarean sections together with a paradoxical increase in the number of vaginal deliveries, while emergency caesarean sections remained comparable. There was one CS from 2016 from this group, which was not coded as elective or emergency and is indicated as such.

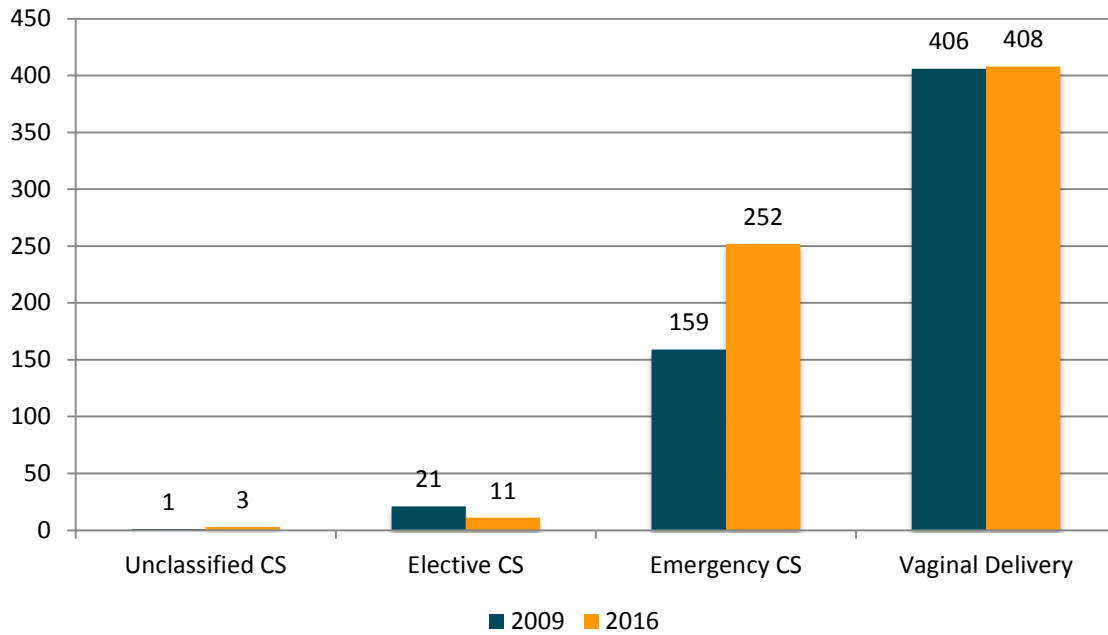


**Figure 17: Comparison of Group 8 - Mode of Delivery**

In the first 6 months of 2009, only 8 women within this group were induced, with 6 of them successfully delivering vaginally. In contrast, 18 women in the first 6 months in 2016 were induced, with successful vaginal deliveries in 10 of them.

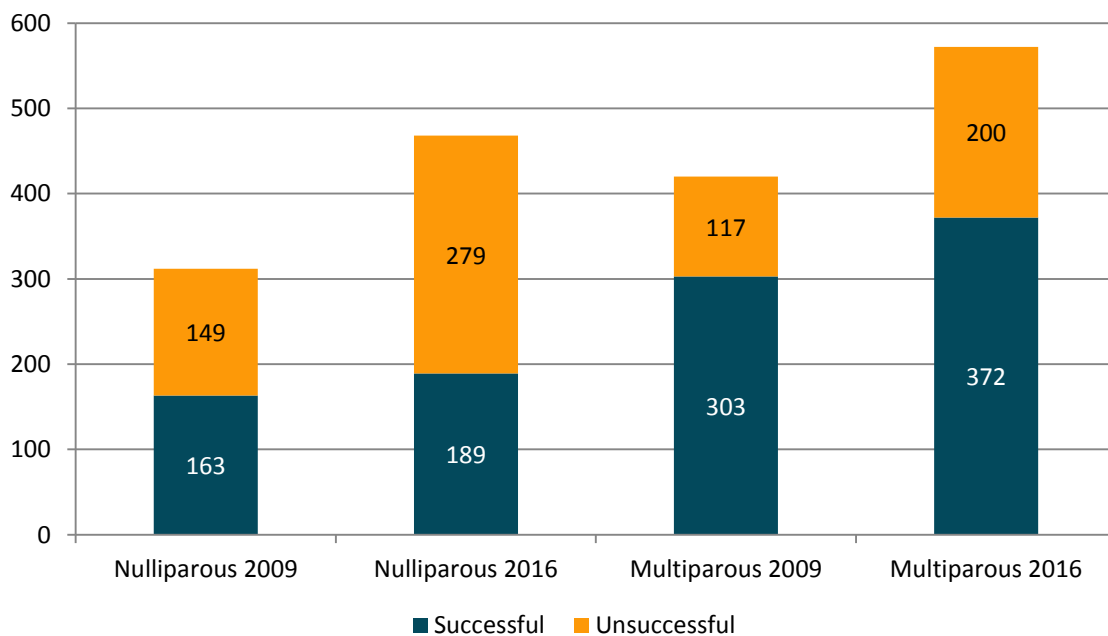
All women, nulliparous and multiparous, delivering prematurely before 37 weeks gestation permitted the fetus lies in a cephalic presentation were included in group 10, which made the third largest contribution to the overall CSR in 2016. In 2009, 94 women were induced in group 10 and 32.98% ended up delivering with a CS, in contrast to 52.98% of the 151 women induced in 2016 had a CS.

Figure 18 represents the distribution of deliveries in this group for 2009 and 2016. It is appreciable that both the actual number of deliveries as well as the CSR in this group increased and the increase in the CSR being statistically significant. Further analysis reveals an increase in the number of emergency caesarean sections that were performed during 2016, whereas the number of elective CS halved and the vaginal deliveries remained constant.



**Figure 18: Comparison of Group 10 - Mode of Delivery**

Total inductions performed increased from 732 in 2009 to 1040 in 2016 and Figure 19 provides a graphical distribution amongst nulliparous and multiparous women.



**Figure 19: Comparison of Inductions of Labour**

## Inductions of Labour

Inductions of labour increased by 49.7% in nulliparous women from 2009 to 2016 and by 36.2% in multiparous women for the same period. The rate of successful vaginal deliveries from inductions of labour in nulliparous women decreased from 52.24% in 2009 to 40.38% in 2016 and this observation was similar in multiparous women: 72.14% in 2009 vs. 65.03% in 2016. Women, including nulliparous and multiparous, in 2016 were statistically significant less likely to be successful in a vaginal delivery (OR 0.67; 95% CI 0.55-0.81  $p < 0.001$ ) compared to women in 2009.

## Discussion

The CSR for MMH increased with 3.60% from 2009 to 47.70% in 2016, with groups 1, 2 and 10 all showing a statistically significant increase in the CSR. Horak et al. reported the CSR as 20.7% in 2009, which included MMH and the MOU's in its drainage area. This is a better representative CSR as it includes the lower levels, but not tertiary level of care. The rate was mostly unchanged from 19.5% in 2003. <sup>8</sup>

The levels of obstetric care in South Africa are divided into primary, secondary and tertiary and together they serve the community as one body, but different smaller units. Due to this unique distribution, CS rates will be different at each level of care. MOU's have a 0% CSR even though they account for approximately 50% of all the deliveries. <sup>8</sup> Having an institutional CSR at MMH that is higher than the global CSR is therefore expected.

### Robson Group 1

There was a statistically significant increase in the CSR from 37.05% to 42.64%. This was due to a decrease in the number of successful vaginal deliveries as opposed to an actual increase in the number of emergency caesarean sections. Even though an insignificant decrease in the contribution of group 1 towards the overall CSR was observed, the raised CSR is still of importance: compared to 2009, there were fewer women in this group in 2016 and fewer had successful vaginal deliveries. The women in this group hold a higher risk profile as they are often younger, are at higher risk of diseases such as preeclampsia, and have not had a successful vaginal delivery. The raised CSR is secondary to disease processes necessitating delivery, but also labour related factors such as labour dystocia. Multiple studies, including one conducted at MMH, reported that the most common indications for caesarean sections in this group are fetal distress and labour dystocia.<sup>108, 110, 113</sup>

At MMH, the diagnosis of fetal compromise is made based on the interpretation of the cardiotocograph (CTG) at hand of the NICE guidelines. Fetal scalp blood sampling should be performed to confirm the fetal compromise, as CTG's have a notoriously high

false positive rate.<sup>79</sup> Due to the vast number of patients labouring at MMH and the HIV epidemic, fetal blood sampling is not performed. Even if fetal scalp sampling was introduced for the HIV negative group, one has to consider the sepsis risk to the fetus as well as the labour intensiveness of this procedure in a busy labour ward, as repeated sampling is continuously required. Clinical and radiological pelvimetry have been used to attempt and foretell a successful vaginal delivery or labour dystocia, however, there is no clear benefit of pelvimetry and it may even increase the CSR.<sup>114</sup>

## Robson Group 2

This group had the highest statistically significant increase in the CSR of 11.63% as well as a significant increase in its contribution to the overall CSR. Labour is always induced in these women and therefore every delivery, apart from the elective caesarean sections, is directly related to an IOL. The appreciable increase in the CSR of 2016 is due to a rise in the number of inductions undertaken, and a less successful induction rate: 51.5% in 2009 vs. 39.4% in 2016. MMH employs various methods to induce labour. The first line method used is that of mechanical traction via an intracervical catheter. This catheter is inserted in the antenatal clinic when the patient is admitted for an elective induction. In a small percentage of patients this is sufficient to effect labour, but the majority of women still require pharmacological induction. The Robson classification does not include the indication for the expedited delivery or the subsequent CS, which is one of the weaker characteristics of this classification. Most likely, fetal distress and labour arrest accounted for the majority of the indications for caesarean sections, as for group 1.

## Robson Group 3

These women are obstetrically speaking at the lowest risk, as all of them had a background of at least had 1 successful VD and no previous CS. In the original 2009 group, group 3 (MMH & MOU's) was the biggest group by more than 2700 deliveries and had the lowest CSR of 6.9%.<sup>8</sup> Between 2009 (adjusted group) and 2016, the CSR decreased by statistically significant 4.48%, represented by an absolute decrease in the number of caesarean sections and an absolute increase in the number of successful vaginal deliveries, even though the total number of deliveries remained relatively

stable. In 2016, compared to 2009, the contribution of this group towards the overall CSR was the only group to be statistically decreased.

#### Robson Group 4

Resembling women in group 2, the number of multiparous women subjected to an induced labour increased. There was a slight decrease in the number of elective caesarean sections, whereas emergency caesarean sections and vaginal deliveries increased proportionally, resulting in a slight, but not statistically significant, increase in the CSR. The minimal increase in the CSR might just represent a natural fluctuation of a stable CSR and future research will be able to confirm or refute this. There were more women in 2016 in this group indicative of an increase in the number of inductions undertaken in multiparous women.

#### Robson Group 5

At MMH, patients are advised to have a repeat CS at 39 weeks gestation if they have had 2 or more prior caesarean sections. In contrast, women with only a single previous CS are encouraged to undertake a trial of labour, if they fulfill the criteria for attempting a VBAC. Such women are counseled on the benefits and risks involved for themselves and their unborn babies for each respective mode of delivery, but the final decision remains that of the individual patient. Women opting for a VD are followed up regularly in the antenatal clinic and are offered an elective CS between 40-41 weeks gestation if labour does not ensue.

In 2016 compared to 2009, elective caesareans increased proportionally more than emergency caesarean sections and vaginal births. This finding was unexpected as women are encouraged to opt for a trial of VBAC, however, the group of women undertaking an elective CS might be the group whom have had 2 or more previous caesarean sections. The implication of women failing a trial of VBAC is that none of them will be eligible for a VD in the next pregnancy, which will significantly add to the CSR and the associated morbidity.

The sole reason for the observed increase of patients in group 5 is an increase in the number of primary caesarean sections performed prior to the index pregnancy. The

statistically significant increase in the contribution of this group towards the overall CSR is due to the increase in absolute number of women in this group, as the CSR for group 5 did not change significantly from 2009 to 2016. Kelly et al. (2013) reported findings on CS rates, classified according to Robson's TGCS, in Canada over a four year period. Group 5 was consistently the greatest contributor to the CSR due to its high CSR, even though it was not the largest group in terms of the number of women.<sup>115</sup> This is reflected in the results of our study too.

This group includes women with either one or multiple previous caesarean sections, so calculating a true VBAC rate from these figures is not possible as not all women are eligible for a VD. In addition, a number of women in group 10 are also eligible for a trial of vaginal delivery after a CS. The chance of a successful VD rapidly decreases in patients with a previous CS compared to women without a previous CS. In all women from 2016 without a previous CS that attempted a vaginal delivery when in spontaneous labour with a cephalic-presenting fetus, 67.5% were successful. This rate, however, decreased to 25.5% in the presence of at least one previous CS.

### Robson Groups 6 & 7

In both of these groups, a decrease in the CSR was observed, although neither reached statistical significance. In addition, neither group altered the overall CSR significantly due to the relative small sizes of these two groups in comparison to groups 1-5 and 10. Since the publishing of the Term Breech Trial by Hannah et al., the benefit of an elective CS for breech presentation was confirmed in their RCT. MMH offers women in our service an elective CS or ECV, provided the woman meets all the qualifying criteria. Overall, we have seen an increase in vaginal breech deliveries and a decrease in the total number of caesarean sections in these groups, in 2016. This is promising as some academics feel that an essential obstetric skill is lost through avoiding vaginal delivery by performing an elective CS. Additionally, this trend towards a higher success rate for vaginal deliveries might be representative of selectively allowing some women to attempt a trial of vaginal delivery, as the success of carefully selecting patients has been shown by Goffinet et al. (2006).<sup>39</sup>

Membe et al. (2014) reported on the use of ECV in women, whom had a CS for a breech-presenting fetus, from MMH and New Somerset Hospital. She found that out of 165 women, 52 had ECV offered as an alternative to a CS, and of those women, only 21 had a trial of ECV performed. ECV was only successful in a single woman. She concluded that opportunities were not adequately used to encourage the use of ECV as an alternative to an elective CS. <sup>116</sup> The decrease in patients with a breech presentation at the time of delivery at MMH from 2009 to 2016 might be reflective of an increase in the number of ECV procedures being undertaken antenatally. A repeat of the analysis done by Membe et al. (2014) will be invaluable to explain this trend.

### Robson Group 8

Overall, the total number of twin deliveries remained constant between the two periods, even though the CSR decreased with 9.10%. As a result of the relative small size of group 8, the observed decrease in the CSR did not alter the overall CSR between 2009 and 2016 significantly. MMH renders care to uncomplicated dichorionic, diamniotic (DCDA) twins and monochorionic, diamniotic (MCDA) twins, whilst complicated DCDA and MCDA and monochorionic monoamniotic twins are referred to GSH for further management. It is known that higher order pregnancies carry a significantly higher risk for adverse outcomes, in some cases exponentially more than a singleton pregnancy, necessitating earlier delivery. Expedited delivery is indicated at 37-38 weeks for uncomplicated DCDA twins and 36-37 weeks for uncomplicated MCDA twins in an attempt to mitigate the increasing risk late in pregnancy. The current MMH protocol is to offer an induction of labour, provided that the leading twin lies in a cephalic presentation and there are no conditions precluding a VD.

The decrease in the number of elective caesarean sections might be due to the increased number of inductions performed in 2009. A second possibility would be that in 2009, more elective caesarean sections were performed if women were HIV positive and had a twin pregnancy to ameliorate the risk of vertical transmission.

Studies have proven that in selective twin pregnancies, vaginal delivery is still safer. The increased perinatal risk for the second twin is not reduced by performing an elective CS. In addition, if a CS has to be performed for the second twin after the first twin was

delivered vaginally, the perinatal outcomes of the second twin are substantially bleaker. In 2016 there were 2 patients whom delivered the leading twin vaginally and then a CS was performed for the following twin. To allow for classification in the Robson groups, both women were classified to the planned mode of delivery group i.e. vaginal delivery.

### Robson Group 9

Group 9 consists of women with a transverse or oblique presenting fetus. These women are the minority and due to the fetal lie VD is not possible, resulting in a CSR of 100%, which is expected and justified. In the absence of contraindications, it is reasonable to offer these women ECV as an alternative to an elective or emergency caesarean section.

### Robson Group 10

Women from group 10 had a significantly higher CSR in 2016 compared to 2009 and also contributed significantly more towards the overall CSR in 2016. These observations are almost completely attributed to the increase in the absolute number of caesarean sections.

The disadvantage of group 10 lies in the diverse group of women included: nulliparous and multiparous women, spontaneous and induced labour and women with previous caesarean sections. It is the equivalent to merging groups 1-5, but only for pregnancies below 37 weeks gestation. To evaluate whether similar trends exist in group 10, it will be very informative to sub-analyze the group according to the criteria for groups 1-5.

The increased number of women in group 10 can be secondary to many causes. MMH had a larger geographical drainage area in 2016 and in addition, the referral criteria to MMH were altered and more patients with conditions such as Chronic Hypertension and Impaired Glucose Tolerance were referred to receive antenatal care at MMH. The increase in the number of inductions of labour and subsequent emergency caesarean sections might be reflective of a lower threshold for delivery of more premature fetuses. Expedited delivery due to various disease processes, such as early-onset and late-onset Preeclampsia, macrosomia, Chorioamnionitis and Prolonged Preterm Rupture of Membranes will naturally occur more frequently in women with medical conditions.

## Inductions of Labour

The observed increase, in the number of inductions of labour undertaken, is alarming as it translates into more caesarean sections being undertaken to deliver women in labour and as seen from group 5, these women will more likely have a repeat CS in the subsequent pregnancy. MMH had more women attending during the 2016 period and therefore the number of inductions of labour would have naturally increased, however the increase in inductions was disproportionately more than the increase in the number of women. The risk profile of the women labouring at MMH changed from 2009 to 2016: MMH attended to more secondary level patients with chronic medical and obstetric related illnesses and in addition, with the opening of Mitchell's Plain District Hospital, a proportion of MMH's level 1 patients were now delivering there. In addition to this change in risk profile, a variation in the inter-observer interpretation of CTG's and labour progress may be responsible for the change in the CSR. This interpretation is influenced by a host of factors, ranging from the level of experience and confidence of the medical staff as well circumstantial factors, such as staffing and available facilities at the time of delivery.

## HIV

One of the questions that remained unanswered in the publication by Horak was the impact that HIV has on the CS rate. The prevalence of HIV at MMH in 2016 was 16.06%, which is below the 2016 National South African prevalence of 21.29% of women in their reproductive years.<sup>117</sup> The HIV prevalence in 2016 at MMH correlated with the prevalence of 16.4% in 2014 at primary level MOU's as reported by Naudé (2015).<sup>69</sup> National protocol currently advocates for all HIV-positive pregnant women to be started on ARV's, regardless of clinical stage or CD4 count. The response to treatment is then monitored by analyzing blood for the HIV viral load. According to the South African guidelines, a viral load RNA <1000 copies/mL is regarded as successful viral suppression. MMH only renders care to women with HIV viral loads below this level. In the event that the viral load is not suppressed, the woman is referred to a specialized clinic at GSH. HIV-positive women were independently more likely than HIV-negative women to have a CS (OR 1.52; 95% CI 1.29-1.78 p<0.001) in 2016.

In 2016, Tooke et al. published the results of a prospective study of extremely low birth weight infants and found that 24% of extremely low birth weight babies had HIV mothers, in contrast to the 17% of HIV mothers in babies with bigger birth weights. More than half of these cases were related to pre-eclampsia. The study further found that women were more likely to develop pre-eclampsia if they were on HAART/ART for four weeks or longer, but HIV was not independently associated with pre-eclampsia.<sup>118</sup> A systematic review from 2016 also describes that in the case where HAART was commenced prior to conception, then a woman from a low or middle income country was at increased risk for preterm birth (OR 1.41; 95% CI 1.22-1.63) and to deliver a neonate with a low birth weight (OR 1.30; 95% CI 1.04-1.62).<sup>119</sup> The prevalence of HIV in our study was higher in preterm births (18.24%) compared to births greater than 37 weeks gestation (15.83%) and this association is thus in line with results from the two quoted studies.

Suy et al. published results in 2006 that are in line with that of Tooke. It was found that prenatal initiation of antiretrovirals significantly increases a woman's risk for pre-eclampsia (OR 5.6; 95% CI 1.7-18.1 p=0.004).<sup>120</sup> A third study from Botswana indicated that a HIV RNA level >100 000 copies/mL prior to the commencement of HAART significantly increase the risk to develop pre-eclampsia (OR 5.8; 95% CI 1.8-19.4 p=0.004).<sup>121</sup>

The pharmacological management of HIV in pregnant women has been subject to various changes in the past decade. In 2009, only women with an AIDS defining illness or a CD4 count below 350 cells/mcL were eligible for HAART. The remaining women received dual therapy from 14 weeks gestation. Since 2010, all women that are pregnant, breastfeeding or within one year of a pregnancy, should be started on HAART, irrespective of clinical or biochemical staging and irrespective of the outcome of the pregnancy. A fixed dose combination drug containing Tenofovir, Emtricitabine and Efavirenz is the first line therapy started on all pregnant women in South Africa. Due to this change, the majority of women in the 2016 was receiving HAART and achieved viral suppression, whereas in 2009, only a select few qualified for HAART. In addition, many women in 2016 were already taking HAART prior to conception. Unfortunately the HIV statistics for the 2009 group were not available, thereby thwarting a direct comparison

between the two groups. In 2016, however, it is clearly observed that the CSR is meaningfully higher in HIV positive women compared to their HIV negative counterparts. As mentioned earlier, HIV positive status alone is not an indication for a caesarean delivery at MMH, as all women who do not reach viral suppression are referred to GSH for further management. The conclusion is therefore reached that the increased number of caesarean sections has to be due to labour related factors or complications, such as pre-eclampsia, necessitating the operative delivery of the fetus.

### MMH Caesarean Section Rate

The CSR is subject to various factors and fluctuates between different groups of women. Dividing these factors into various groups will aid in finding solutions to curb the persistent rise.

The major factors that facilitated the increase in the CSR from 2009 to 2016 were:

1. An increase in the number of inductions performed in both nulliparous and multiparous women, coupled with lower success rates, especially in nulliparous women.
2. An increase in the number of women with previous caesarean sections, tied to a disproportionate increase in the number of repeat caesarean sections compared to successful vaginal births after a CS.
3. Nulliparous women in spontaneous labour had significantly less vaginal deliveries.
4. An increase in the number of inductions and caesarean sections in women with premature fetuses.

Factor that limited the increase in the CSR was:

1. Fewer caesarean sections and more vaginal deliveries in multiparous patients in spontaneous labour.

Factors that had no influence on the CSR were:

1. The decrease in the total number of breech deliveries, accompanied by an increase in the number of successful vaginal breech deliveries.

2. More successful vaginal births in twin pregnancies, together with less emergent and elective caesarean sections.
3. Any delivery of a fetus in a transverse lie.

Factors possibly affecting the CSR were:

1. An increase in the total number of patients attending MMH for antenatal care and delivery, most likely due to the change in the geographical drainage and change in referral criteria.
2. National escalation of HAART initiation in HIV positive pregnant women, possibly indirectly influencing the CSR by altering the risk of obstetric complications.

The management of pregnancy and labour at MMH are carefully guided by standard protocols in place. These protocols have been developed to best assist the need of the women attending the facility and to achieve this with the available facilities, staff and equipment at hand.

I strongly suspect that further research aimed at the inductions performed at MMH, including the indication for delivery, will be of much benefit. There has been a tremendous increase in the number of inductions performed and the procedure was not as successful as in 2009. The lower success rate of performed inductions might be explained by the higher risk profile of the women attending MMH for antenatal care and delivery.

Fetal compromise and labour dystocia are two major indications for emergency caesarean sections. The current situation in which we deliver women do not allow for confirmation of fetal compromise detected on a CTG, and most decisions are based on the interpretation of CTG's. Reviewing the criteria from the NICE guidelines on a regular basis might assist in preventing caesarean sections for tracings not associated with fetal compromise. The management of labour dystocia differs depending on the stage of labour. Operative vaginal deliveries form an integral part of the management of the second stage of labour. The Robson classification does not address or collect information regarding this valuable skill, which is another area of future research. Fear

of litigation and poor obstetric outcome may be a deterrent to performing an operative vaginal delivery. This invaluable skill, however, can prevent some caesarean sections if indicated and acceptable to the woman.

In recent years, there has been an international focus on the prevalence of obesity and the subsequent associated morbidity. In a systematic review by Poobalan et al. (2009), a Body Mass Index (BMI) greater than 25 kg/m<sup>2</sup> was independently associated with greater odds of a CS (OR 1.53; 95% CI 1.48-1.58) compared to a BMI of 20-25 kg/m<sup>2</sup>. This risk increased further in obese (OR 2.26; 95% CI 2.04-2.51) and morbidly obese women (OR 3.38; 95% CI 2.49-4.57).<sup>122</sup> A large percentage of women attending MMH are overweight or obese, as one of the referral criteria to MMH is any woman with a BMI greater than 40 kg/m<sup>2</sup>. There is, unfortunately, not current data on the association of BMI and mode of delivery at MMH and this leaves an area for future research.

In 2014, the ACOG in collaboration with the Society for Maternal-Fetal Medicine released a document in reaction to the rising CSR. They included numerous recommendations in an effort to curb the rising CSR and it includes amongst other: Tolerating a slower latent phase of labour with 6cm cervical dilatation as the onset for active labour.

- Increasing acceptable limits for time periods for latent phase.
- Ensuring that women had a trial of labour with adequate contractions accompanied by ruptured membranes, prior to the diagnosis of labour dystocia.
- Allow longer time periods with second stage of labour and active bearing down effort.
- Considering an operative vaginal delivery as a sensible alternative to a CS.
- Introducing an amnioinfusion for variable decelerations.
- As an alternative to fetal scalp sampling, stimulation of the fetal scalp can be employed to assess fetal wellbeing.
- IOL for prolonged pregnancies only to be performed after 41 weeks gestation.
- Actively perform more ECVs in women eligible for the procedure.
- Increasing the cut off weight for macrosomia to 5kg in non-diabetic women and 4.5kg in diabetic women.
- Avoid excessive maternal weight gain.

- Encourage vaginal delivery in twins if all criteria are met. <sup>123</sup>

Prevention of the primary CS is of utmost importance as there is a snowball effect on the CSR in a woman with a prior history of a CS. The environment of the labour ward at MMH is dynamic and the management of women in labour might be directly affected by it. Triaging of patients to specific care is also dependent on the availability of staff, equipment, skill and possible complications in the immediate future. As part of ensuring an optimal standard of care at MMH, a second opinion from a consultant is obtained prior to the commencement of an IOL or CS.

The standard operating procedures at MMH already include numerous of the recommendations from the document by the ACOG. In our setting, women are only induced once they reach 41 weeks and 3 days and labour has not started. Amnioinfusions in the setting of MMH is controversial. Although it might be helpful in curbing the rising CSR, one might be exposing the fetus to a higher risk of sepsis as well as HIV transmission in the 16.06% HIV positive women. There might be real value in prolonging the time limits of latent phase of labour as well as inductions of labour. MMH, however, has a high turnover of patients and possibly do not have the capacity to accommodate more women in the hospital.

The Robson Classification system was an easy and practical system to classify the deliveries at MMH. The precise description of each group allowed for accurate comparison of the respective groups between the two study periods as well as with other units. A consistent shortcoming of the system is the lack of information with regards to the indication for the delivery. An inclusion of subgroups for different fetal or maternal indications or factors within each group might be useful for further intra group analysis.

## Study Strengths & Limitations

The strength of this study lies in the novelty of being able to compare data from the same study setting, providing us with an accurate representation of current trends in the various Robson groups. Comparison with other units will not be as informative due to various administrative, logistical and medical factors.

A large percentage of the results were statistically significant and this was due to the large number of entries into the database. This made the results accurate and reliable.

Data collection was done from the birth registers, which are completed by the nursing staff after each delivery. The accuracy of the data is therefore highly dependent on the diligence with which the registers are completed. The addition of extra columns to the birth register was extremely beneficial and limited the number of folders that had to be reviewed in the end. During the study period, intermittent education and reminders had to be used to encourage the nursing staff to correctly complete the registers. Any inaccuracy in the registers would not have been identified unless the folder had to be reviewed for additional information. In some entries, not all the information was completed, but this did not affect the classification of such patients. These patients were in the minority. Elective caesarean sections are based on the coding in the delivery register. The delivery register does not indicate which women had an emergency CS prior to labour; this might have a small influence by increasing the CSR in groups 2 and 4.

Only a small percentage of folders were not accessible and >99% of the women were included into the study.

## Conclusion

The management of a pregnant woman is a complex and dynamic process as the needs of two individuals are addressed and changes as the gestation progresses. There are multiple factors influencing this process, from social, societal and medical factors up to inter-physician variation of training, skill and conviction.

In 2016 it was demonstrated that the CSR at Mowbray Maternity Hospital from January to June was 47.70%, 3.6% higher than the rate for the same period in 2009. This increase was statistically significant. The increase was related to more inductions of labour being undertaken, coupled with a lower success rate, as well as due to an increase in the number of women with a prior CS, of whom a large percentage subsequently deliver via a repeat CS. The increase in the CSR in women with premature fetuses also contributed to the overall increased CSR. The treatment of HIV with HAART possibly indirectly affects the caesarean section rate by exposing women to a higher risk of preterm delivery and pre-eclampsia.

The Robson Classification System proved to be a useful tool to analyze and observe trends among the different groups of women that attend Mowbray Maternity Hospital. The addition of the two extra columns to the delivery registers allowed all the necessary information for the classification of all deliveries into the ten Robson groups to be done routinely. This addition is suggested for other maternity units embarking on Robson's ten group classification of deliveries. The classification system enabled the investigators to identify women at greater risk for caesarean sections. Detailed intra-group analysis of indications for delivery, inductions of labour and caesarean sections will be invaluable to the medical fraternity.

The increase in the CSR should not be viewed as unnecessarily exposing women to the increased risks associated with the procedure, as MMH is a large referral centre. Every woman attending our facility receives individualized care and numerous factors are considered to provide the optimal management. The aim is to ensure a positive birthing

experience for the family as well as the best chance of a positive maternal and neonatal outcome.

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## Appendix A

### Robson's Ten Group Classification System

- 1** Nulliparous women with a single cephalic pregnancy, at greater than or equal to 37 completed weeks gestation in spontaneous labour.
- 2** Nulliparous women with a single cephalic pregnancy, at greater than or equal to 37 completed weeks gestation, who either has an induction of labour or is delivered by caesarean section before the onset of labour.
- 3** Multiparous women, without a previous uterine scar, with a single cephalic pregnancy at greater than or equal to 37 completed weeks gestation in spontaneous labour.
- 4** Multiparous women, without a previous uterine scar, with a single cephalic pregnancy at greater than or equal to 37 completed weeks gestation, who either has an induction of labour or is delivered by caesarean section before the onset of labour.
- 5** Multiparous women, with at least one previous uterine scar, with a single cephalic pregnancy at greater than or equal to 37 completed weeks gestation.
- 6** Nulliparous women with a single breech pregnancy.
- 7** Multiparous women with a single breech pregnancy, including women with a previous uterine scar.
- 8** All women with multiple pregnancies, including women with a previous uterine scar.
- 9** All women with a single pregnancy with a transverse or oblique lie, including women with a previous uterine scar.
- 10** All women with a single cephalic pregnancy at less than or equal to 36 weeks gestation, including women with a previous uterine scar.



# Appendix C



UNIVERSITY OF CAPE TOWN  
Faculty of Health Sciences  
Human Research Ethics Committee



Room E53-46 Old Main Building  
Groote Schuur Hospital  
Observatory 7925  
Telephone [021] 406 6492  
Email: [sumayah.riefdien@uct.ac.za](mailto:sumayah.riefdien@uct.ac.za)

Website: [www.health.uct.ac.za/fhs/research/humanethics/forms](http://www.health.uct.ac.za/fhs/research/humanethics/forms)

27 July 2016

**HREC REF: 539/2016**

**Dr T Horak**  
Department of Obstetrics & Gynaecology  
H-Floor  
OMB

Dear Dr Horak

**PROJECT TITLE: THE CAESAREAN SECTION RATE AT MOWBRAY MATERNITY HOSPITAL:  
APPLYING ROBSON'S TEN GROUP CLASSIFICATION SYSTEM (MMeD-candidate-Dr E Venter)**

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

**Approval is granted for one year until the 30 July 2017.**

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.  
(Forms can be found on our website: [www.health.uct.ac.za/fhs/research/humanethics/forms](http://www.health.uct.ac.za/fhs/research/humanethics/forms))

**Please quote the HREC REF in all your correspondence.**

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate Institutional approval before the research may occur.

Yours sincerely

*T. Burgess*  
PP **PROFESSOR M BLOCKMAN**  
**CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE**

Federal Wide Assurance Number: FWA00001637.  
Institutional Review Board (IRB) number: IRB00001938  
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines.  
The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.