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Determining Factors of Cesarean Delivery Trends in Developing Countries: Lessons from Point G National Hospital (Bamako – Mali)

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1. Introduction

Pregnancy and delivery have been and continue to be a high risk endeavour for women [Rivière, 1959]. This assertion explains the continuous efforts of healthcare workers to maintain pregnancy and delivery in a normal course.

One of the obstetric interventions introduced to address this issue is the cesarean – delivery. Cesarean delivery is defined as the birth of a fetus through incisions in the abdominal wall (laparotomy) and the uterine wall (hysterotomy) [Cunningham, 2001]. Historically, cesarean delivery was associated with a high complication rate, sometimes causing maternal death. In the era of modern medicine, however, cesarean section has become safe and is widely endorsed throughout the world as a strategy to improve pregnancy outcomes [Weil & Fernandez, 1999].

In the past decades, cesarean rates in high income countries have increased considerably, leading some experts to question the benefit of these elective procedures on maternal and neonatal outcome [Howell et al, 2009; Malvasi et al, 2009; Ba'aqueel, 2009; Jain, 2009; Karlström et al, 2010; Klemeti et al, 2010; Bogg, 2010]. Critics of the trend toward unindicated cesarean delivery have coined these procedures “unneCesareans” [Althabe et al, 2004; Cohain, 2009]. Policies targeted to reverse this trend have been generally unsuccessful [Choudhury et al, 2009].

This epidemic increase is even encountered in some developing countries [Belizán et al 1999; Khawaja et al., 2009; Naidoo & Moodley, 2009; Betran et al, 2007; Villar et al., 2006; Onsrud & Onsrud, 1996; Barros et al, 1991; Faundes & Cecatti, 1991]. Reasons behind the high cesarean delivery rates in some developing countries are generally unclear [Wylie & Mirza, 2008]. Doing more to gain more mainly in private practice [Naidoo & Moodley, 2009; Wylie & Mirza, 2008]; presumption that CD protects against urinary incontinence, pelvic prolapse, and sexual dissatisfaction; auspicious date of birth; beliefs that babies delivered surgically are smarter.... [Wylie & Mirza, 2008] are some of the unjustified reasons reported.

Most developing countries, however, report cesarean delivery rates well below the acceptable minimum standard of 5% outlined by the WHO. Poor healthcare access, underdeveloped healthcare infrastructure, geographical inaccessibility, cultural mistrust, poverty, and paucity of human health resources are barriers to providing cesarean deliveries to all women who need them [Dumont et al., 2001; De Brouwere et al, 2002; Ronsmans et al, 2002; Kwawukume, 2001]. Large ecological studies in West Africa emphasized this gap by demonstrating increased maternal mortality in settings with a lower percentage of births supervised by a skilled attendant, fewer deliveries performed in-hospital, or a smaller proportion of deliveries performed by cesarean section. Increased access to these services correlated with lower maternal mortality rate [Ronsmans et al, 2003].

Mali is the 3rd poorest nation in the world, with an estimated maternal mortality ratio between 464 and 830 deaths per 100,000 live births [Chou et al, 2010; Samaké et al, 2007]. In 1990, the Mali Ministry of Health developed a healthcare initiative focusing on the maternal and child health. Among the key elements of the Malian healthcare system, is the clear distinction between the three levels of care provision: primary (community health centres), secondary (district referral health centres) and tertiary care (hospitals). Pregnant women are initially supposed to

book at the community health centres (which is the entry point of the healthcare system) with a primary care midwife or obstetric nurse for care provision during pregnancy, birth and the puerperium. These community health centres have the pivotal role of patients selection based on risk assessment. One important innovation of this new policy was the establishment of a referral system for perinatal complications in 1994. To ensure that referral takes place in an optimal fashion, guidelines for consultation and collaboration between community health centres, district referral health centres and hospital have been formulated in the Perinatology Module and in the Standard, Options and Procedures for Reproductive Health Services Manual. In these documents, all professional groups involved in maternity care agreed on the indications for consultation and referral according to the level of care. This program augmented the healthcare system's capacity to manage obstetric emergencies by upgrading referral centres' technical trays including staff training, surgical theatre rehabilitation, creation community health centres in previously inaccessible areas, organisation of transport between the community centres and referral centres, and communities' mobilisation to own the system. The main obstetric emergency encountered was cephalopelvic disproportion and its complications. Cesarean delivery was the main obstetric procedure used to deal with these complications. Lowering of financial barriers to increase access to this major obstetric intervention was one of the strategies of the organisation of the referral system in Mali.

To date, there have not been any in-depth evaluations of cesarean delivery in Mali since the inception of this program. Poor data capture of most population health indicators have called into question the reliability of cesarean delivery reports for other developing countries [Stanton et al, 2005; Holtz and Stanton, 2007]. In this context, large hospital databases of good quality provide a bird's eye view of the national health system and trends in healthcare delivery over time.

This paper aims to assess the trends of cesarean delivery at the Point G national hospital in Bamako, Mali over a period of 2 decades. We explore the impact of sociodemographic,

obstetric, and systemic determinants on cesarean delivery rates. Results are discussed in relation to current medical literature available for developing countries and lessons for improvement of current health systems are highlighted.

2. Study settings and design

2.1 Organisation of delivery care at Point G teaching hospital

Point G National Hospital is a tertiary care referral center in Bamako, Mali affiliated with the Faculty of Medicine, Pharmacy, and Odonto-stomatology at the University of Bamako. This hospital provides emergency obstetric services for women referred from other health centers, as well as prenatal care and delivery services for women from urban and rural areas surrounding Bamako. The catchments population in Bamako grew rapidly from 658,275 in 1987 to 1,016,296 in 1998.

The cesarean delivery rate was 6.5% in Bamako versus 1.6% for the national level [Samaké et al, 2007]. Many patients referred to Point G hospital reside in rural areas surrounding Bamako. Thus, rates of early access to care and facility-based delivery among patients at Point G hospital may be lower than those found among residents of Bamako.

The services available at Point G hospital have changed over time, dividing the hospital's history into distinct periods. Among the major events that influenced obstetric admission at Point G hospital, is the National Perinatal Program implemented in 1994, which included organization of a referral system between primary health structures and district referral centers. Access to cesarean delivery was the cornerstone of this organization which improved transport and designed schemes to lower its cost for women in needs. This referral system has been shown to increase access to emergency obstetric care and decrease maternal mortality in rural Mali [Fournier et al, 2009], though its impact on maternal deaths at an urban tertiary care center is unknown. Between 1998 and 2000, an audit of near-miss events was undertaken to improve delivery services. In 2002 the Government of Mali reorganized the healthcare system, integrating the staff of Point G National Hospital with those at Bamako's Gabriel Touré Teaching Hospital.

The obstetrics and gynecology service of Point G teaching hospital was equipped with 1 labor ward containing 3 delivery tables, 30 beds, and a single operating room for scheduled surgeries as well as emergent surgeries from 1985 to 1994. The hospital has an adult intensive care unit (ICU), but no neonatal ICU, and administers a limited blood transfusion service. At Point G National Hospital the general surgery and urology services also provided care during delivery mainly to those women requiring cesarean delivery.

2.2 Obstetric database

A complete database of all obstetric admissions focusing on characteristics of delivered women, mode of delivery, cesarean indications, and maternal, fetal and immediate neonatal outcome was built to include all deliveries recorded at Point G National Hospital between January 1, 1985 and December 31, 2003 (17 721 patients) [Teguete et al, 2010a]. All data were double-entered in Epi6.fr to insure accuracy. Data were collected from these complete obstetric files, as well as hospital birth registries, registries of on-call midwives, surgical

reports, admissions records for the intensive care service, records from the internal medicine and urology services, and hospital death records.

2.3 Analysis

We report trends in cesarean delivery rates at Point G National Hospital in Bamako, Mali from 1985 to 2003. Annual cesarean deliveries rates were calculated and grouped by historic time intervals to elucidate changes in cesarean utilization over time. These intervals represent 5 distinct periods in the hospital's history: 1985 to 1990 before the department of obstetrics and gynecology was established by the first Malian professor in this field ; 1991 to 1995 encompassing the introduction of the National Perinatal Program; 1996 to 1997 when the service of obstetrics and gynecology functioned at partial capacity due to hospital renovation; 1998 to 2001 immediately after renovation; and 2002 to 2003 when the major obstetric team moved from Point G to Gabriel Touré Teaching Hospital, another teaching hospital in Bamako.

We first computed cesarean delivery rates during the five time periods according to different categories to observe general trends. Cesarean delivery rates were calculated as the percentage of pregnant women delivered after surgical opening of the abdomen. Crude and adjusted odds ratios (OR) were obtained by logistic regression and subsequently transformed into relative risks (because rates of cesarean delivery were more than 10%) by the equation:

$$RR = \frac{OR}{(1 - p_0) + p_0 * OR} \quad [\text{Zhang \& Yu, 1998}]. \quad (1)$$

Characteristics considered to be of relevance for cesarean delivery were: maternal age, marital status, ethnic group, parity, hypertension or diabetes in pregnancy, gestational age, number of fetus (single vs. multiple gestations), cesarean delivery indications and referral status.

We then described the contribution of different indications to overall cesarean delivery rates following the rules of the Baltimore group on cesarean indications reporting for developing countries [Stanton et al, 2008]. Interactions of these indications with maternal characteristics have been reported. The next step looked for our practice concerning specific obstetric group. This step focused on the study of cesarean delivery in ten obstetric groups. The definition of these groups appears in table 3. Based on the review of the relevant literature about this topic [Stavrou et al., 2011; Costa et al, 2010; Brennan et al, 2009; McCarthy et al, 2007; Robson, 2001], we focused on the correlation between trends of overall cesarean delivery rates and that of the cesarean delivery rates in term single cephalic nulliparas (TSCN). The term single cephalic nulliparas gathered groups 1 and 2 during the 19 year period. Pearson's correlation coefficient was used to estimate the relationship between overall CS rates and TSCN cesarean delivery rates. Independent Student *t* test was used to compare mean overall CS rates. The coefficient of variation (CV) was calculated as the standard deviation (SD)/mean x 100. The relevant cesarean indications characterising this specific composite group were identified. Finally, we identified individual factors influencing the cesarean delivery rates in our hospital by multilogistic regression using sequential adjustments.

The final section of the analysis dealt with cesarean morbidity and mortality. We considered maternal as well as fetal and neonatal complications. For maternal complications, we estimated rates of intraoperative complications as well as of post-cesarean complications. We defined intraoperative complications as laceration of the uterus (uterine rupture included), cervix, bladder, vagina or bowel, intraoperative blood loss of ≥ 1000 ml, blood transfusion, and hysterectomy. Post-cesarean complications included post-cesarean infection, hemorrhage, deep venous thrombosis and puerperal psychosis. Regarding post-cesarean infection, we specifically determined surgical infection rate as well as serious infectious morbidity rate. For surgical site infection we adopted the CDC definition as stated by Horan et al. [Horan et al, 1999]. Serious infectious morbidity was defined as bacteremia, septic shock, septic thrombophlebitis, necrotizing fasciitis; peritonitis, or death attributed to infection. Risk factors for intra-operative complications and post-cesarean infection have been studied. We first computed crude odds ratios followed by adjusted odds ratios. We adjusted each factor for potential confounders in a multivariate logistic regression model. The final step in this analysis of maternal complications studied the trends of cesarean related maternal death risk and relationship between cesarean delivery and maternal mortality in a multivariate analysis of primary predictors including antenatal screening, referral status, maternal age, parity and route of delivery. In this analysis adjusted odds ratio have been produced for cesarean delivery. Regarding fetal and neonatal prognosis, we estimated trends of stillbirth rates and neonatal death rates. These indicators were studied by comparing cesarean to vaginal delivery. Stillbirth was defined as Apgar score = 0 immediately after delivery in a live-born-infant. Neonatal deaths are those occurring during the first 28 days following delivery. However, neonatal death rates presented are underestimated since our observation period was limited to the duration of hospitalization at birth; the maximum length of follow up of the neonates was 13 days. Neonates discharged healthy were assumed to have survived to 28 days. Nonetheless, the rates presented give an idea of the size of this important issue.

All calculations were performed using SPSS version 11.0 (SPSS Inc, Chicago, IL). $P < 0.05$ was considered statistically significant. The database used for this analysis was reviewed and approved by the ethics committee of the Faculty of Medicine, Pharmacy, and Dentistry at the University of Bamako, Mali.

3. Findings

3.1 Characteristics of deliveries in our teaching hospital

During a nineteen year period from 1985-2003, 17,721 women delivered at Point G Teaching Hospital, 20.2% of whom traveled from other regions in southern Mali. The proportion of women residing outside of Bamako increased significantly from 13.3% of deliveries between 1985 and 1990 to 23.6% during the period 1998 – 2003 ($p < 0.001$). Among the women delivering at Point G, 29.9% were referred from outside health institutions. Patients referred for an obstetric emergency represented 18.1% of women delivering while non-emergency referrals constituted 11.8%. Emergency admission rates varied from a minimum of 7.6% of deliveries in 1986 to a maximum of 25.1% of deliveries in 2000. Patients with non-emergent referrals accounted for a minimum of 7.1% of deliveries in 1990 and a maximum of 21% of deliveries in 1998.

Years	Total deliveries	Number of cesarean delivery	Cesarean delivery rates	Odds ratio	Relative risk	P value	% cesarean in TSCN	Contribution Of TSCN to Total deliveries
1985	1056	132	12.5%	Reference			10.3%	19.3%
1986	948	132	13.9%	1.13	1.1	>0,05	14.7%	20.8%
1987	977	173	17.7%	1.51	1.4	<0,001	19.2%	19.8%
1988	1028	172	16.7%	1.41	1.3	<0,05	13.8%	18.3%
1989	1079	220	20.4%	1.79	1.6	<0,001	19.1%	21.7%
1990	982	204	20.8%	1.84	1.7	<0,001	26.3%	20.9%
1991	1066	279	26.2%	2.48	2.1	<0,001	27.5%	23.9%
1992	1114	317	28.5%	2.78	2.3	<0,001	25.9%	19.3%
1993	1169	340	29.1%	2.87	2.3	<0,001	28.6%	21.8%
1994	1041	298	28.6%	2.81	2.3	<0,001	33.7%	19.2%
1995	1098	343	31.2%	3.18	2.5	<0,001	30.4%	21.8%
1996	747	209	28.0%	2.72	2.2	<0,001	28.3%	24.6%
1997	298	110	36.9%	4.10	3.0	<0,001	26.7%	20.0%
1998	944	305	32.3%	3.34	2.6	<0,001	33.0%	24.4%
1999	847	297	35.1%	3.78	2.8	<0,001	40.7%	22.2%
2000	894	262	29.3%	2.90	2.3	<0,001	32.6%	20.6%
2001	1070	352	32.9%	3.43	2.6	<0,001	30.2%	22.7%
2002	660	197	29.8%	2.98	2.4	<0,001	27.5%	21.9%
2003	703	175	24.9%	2.32	2.0	<0,001	22.8%	20.6%
Total	17721	4517	25.5%				Mean= 25.8%	Mean= 21.2%

TSCN : Term Single cephalic nullipara

Table 1. Trends of number of deliveries, rates and risks of cesarean delivery during the study period.

3.2 Cesarean delivery rates

Observed rates of cesarean delivery and relative risk are presented in table 1 above. The coefficient of variation for overall cesarean delivery rates was 27.9, and the ratio of the highest (36.9%) to the lowest (12.5%) was 2.95, indicating significant variability in overall cesarean delivery rates during the 19 years. Using year 1985 as the reference, we noted a striking increase in the cesarean delivery rate through out the study period. Since 1991, the

cesarean delivery rate has been sustained at least 100% above that in 1985. Trends in cesarean delivery rates accounting for sociodemographic characteristics and obstetric history are presented in table 2. Globally, cesarean delivery rates increased ($p<0.05$). Observed cesarean rates were relatively higher in the 35 – 50 years old age group, Bambara ethnic group, grandmultiparas, women residing outside of Bamako, and those referred from other health centers. Cesarean delivery rates for unbooked pregnancies varied between 24.5% and 45.0%. Rates for women who followed antenatal screening varied between 15.6% and 31.0%.

3.3 Indications of cesarean delivery

In practice, the decision to perform a cesarean relies on an array of parameters. There is no general consensus universally accepted way of reporting cesarean delivery indications. Absolute numbers and specific cesarean delivery rates per indication / risk factors for cesarean delivery appeared in table 3. We report here 3 systems of reporting these indications:

3.3.1 Classification of cesareans by mutually exclusive clinical indications

Two independent obstetricians were asked to review our database and to point out what was the major factor leading to the decision of cesarean. They reviewed together cases where they found different factors. The results are presented in table 2 below. Of note, pelvic contraction and suspected fetal distress were the most represented and showed an increasing pattern over time.

Indications	1985 – 1990 N=1033	1991 – 1995 N=1577	1996 – 1997 N=319	1998 – 2001 N=1216	2002 – 2003 N=372
Contracted / deformed pelvis	22.2%	22.1%	19.8%	24.2%	26.6%
Uterine rupture	13.7%	17.8%	9.6%	7.4%	4.4%
Major antepartum hemorrhage	5.8%	5.8%	8.3%	4.2%	4.1%
Transverse lie	11.7%	8.2%	7.7%	6.2%	4.7%
Brow presentation	1.9%	0.9%	1.2%	1.1%	0.8%
Prolonged labor	9.7%	4.8%	7.4%	6.5%	7.4%
Previous cesarean	4.1%	3.5%	4.6%	5.5%	10.4%
Previous obstetric fistula	1.3%	0.6%	1.2%	0.5%	1.9%
Suspected fetal distress	22.8%	28.0%	25.9%	29.9%	26.6%
Maternal diseases	3.6%	5.9%	10.8%	12.2%	8.2%
Breech presentation	3.1%	2.4%	3.4%	3.2%	5.5%

Table 2. Trends in the contribution of eleven mutually exclusive clinical indications.

3.3.2 Classification of Baltimore group on cesarean indications

This classification system separates cesarean indications into absolute, maternal, and non-absolute indications. Absolute maternal indications include obstructed labor (including severe deformed pelvis and failed trial of labor), major antepartum hemorrhage and grade 3 or 4 placenta previa, malpresentation (including transverse, oblique, and brow), and uterine rupture. Non-absolute indications include failure to progress in labor (including prolonged labor); failed induction; previous cesarean delivery; genitourinary fistula or third-degree tear repair; antepartum hemorrhage, (excluding those for absolute indications and including abruptio placentae); maternal medical diseases; severe preeclampsia or eclampsia; psychosocial indications including maternal request, “precious” pregnancy; fetal compromise (including fetal distress, cord prolapse, and severe intrauterine growth retardation); and breech presentation.

Globally 66.3% of cesarean deliveries during the 19 years were performed for absolute maternal indications (2993/4517) vs 33.7% for non-absolute indications (1524/4517). The percentage of absolute maternal indications evolved as follow: 66.8% for 1985 – 1990, 74.6% for 1991 – 1995, 63.6% for 1996 – 1997, 59.5% for 1998 – 2001 and 53.8% for 2002 – 2003 ($p < .001$).

Uterine rupture, an absolute indication for cesarean delivery occurred in 2.6% of all the 17721 deliveries and was the indication of 10.1% of the 4517 cesarean deliveries. The time trends of uterine rupture were as follow: 1.8% of all deliveries recorded in 1985 – 1990, 3.9% for 1991 – 1995, 2.7% for 1996 – 1997, 1.5% for 1998 – 2008 and 0.7% for 2002 – 2003. Of all women with uterine rupture, 94.7% of cases were diagnosed at admission examination in referred patients (92.5% with patients referred emergently).

Uterine rupture occurred in 87.4% (415/475) of cases in an unscarred uterus vs 12.6% (60/475) in a scarred uterus. Observed risk factors for primary uterine rupture included: contracted pelvis, 12.0% (57/475); fetal macrosomia 9.7% (46/475); contracted pelvis associated with macrosomia 3.4% (16/475). Malpresentation was recorded in 12.4% (59/475). Dystocia associated with oxytocin and / or traditional medicines labor augmentation has been observed in 12.6% of cases (60/475). Grandmultiparity (≥ 7 deliveries in obstetric history) accounted for 12.4% (59/475) of all uterine ruptures while short interpregnancy interval has been observed in 12.0% of all uterine ruptures (57/475). Central placenta previa and twin pregnancy accounted for 1.9% (9/475) each while abruptio placentae has been observed in 1.1% (6/4475). Finally, the cause of 8% of uterine ruptures was unknown (38/475). For cases of uterine rupture secondary to a uterine scar, previous cesarean delivery was the most represented, 11.4% (54/475) followed by previous uterine rupture, 1.3% (6/475). No case of uterine rupture secondary to previous myomectomy was reported.

Six conditions representing 86.2% of cesareans for non-absolute indications included: suspected fetal distress (33.7%), previous cesarean delivery (25.6%), breech presentation (10.1%), eclampsia (5.9%) genitourinary fistula (5.9%) and twin pregnancy (5.1%). Percentages of cesarean deliveries for genitourinary fistula, twin pregnancy, and fetal distress did not show a clear trend. The contributions of breech presentation, eclampsia and

previous cesarean delivery, however, increased over time. In 1985 – 1990, 2.90% of cesarean deliveries were performed primarily because of breech presentation; this rate reached 5.64% during 2002 – 2003. These rates were 1.06% and 4.30% respectively for eclampsia and 7.84% and 16.66% for previous cesarean delivery.

Three major indications, when present, gave a 70%-90% likelihood that the woman would receive cesarean. These included cephalopelvic disproportion (CPD), malpresentation, and previous cesarean delivery. 64-85% of women with antepartum hemorrhage were delivered by cesarean section. These four indications accounted for 66.5% of all cesarean deliveries.

Characteristics	1985 - 1990 N=6070	1991 – 1995 N = 5488	1996 – 1997 N = 1045	1998 – 2001 N=3755	2002 – 2003 N=1363
Age groups					
13 – 19 yrs	15.9% (1088)	25.2% (1113)	27.2% (180)	31.6% (707)	24.5% (257)
20 – 34 yrs	16.5% (4087)	28.3% (3558)	28.9% (718)	31.6% (2473)	26.8% (890)
35 – 50 yrs	19.2% (895)	33.5% (817)	40.8% (147)	36.4% (575)	31.8% (216)
Ethnic groups					
Bambara	18.2% (2649)	32.5% (2462)	31.3% (460)	35.4% (1572)	32.2% (605)
Peuhl	18.1% (895)	27.4% (828)	30.1% (163)	31.2% (574)	27.8% (194)
Malinke	15.4% (930)	28.3% (736)	32.6% (129)	33.2% (446)	22.9% (123)
Soninke	17.4% (471)	27.4% (402)	28.8% (80)	28.3% (364)	16.7% (131)
Dogon	14.4% (180)	19.6% (214)	20.0% (50)	23.3% (219)	24.4% (90)
Sonrhäi	12.5% (256)	25.1% (183)	43.2% (37)	32.0% (122)	20.0% (41)
Senoufo	15.0% (100)	18.6% (97)	26.9% (26)	27.2% (81)	21.4% (30)
Bobo	13.0% (130)	15.4% (123)	25.0% (24)	29.3% (41)	22.2% (14)
Bozo	24.4% (45)	25.3% (79)	45.5% (11)	23.7% (38)	14.3% (18)
Maure	15.4% (13)	17.3% (52)	40.0% (5)	31.4% (51)	9.5% (21)
Minianka	23.3% (30)	19.3% (57)	0% (6)	43.5% (23)	21.3% (21)
Others	17.0% (371)	25.9% (255)	27.8% (54)	31.3% (224)	27.3% (75)
Region					
Bamako	11.7% (5265)	18.1% (4194)	23.4% (798)	25.3% (2794)	20.5% (1088)
Kayes	54.2% (24)	56.3% (48)	87.5% (8)	50.0% (24)	80.0% (5)
Koulikoro	51.5% (701)	63.3% (1108)	53.1% (213)	53.8% (865)	55.2% (262)
Sikasso	64.8% (54)	74.1% (81)	46.2% (13)	48.3% (29)	00.0% (5)
Segou	35.3% (17)	59.0% (39)	50.0% (10)	45.8% (24)	33.3% (3)
Mopti	40.0% (5)	33.3% (9)	00.0% (1)	37.5% (8)	00.0% (0)
Others	00.0% (4)	55.6% (9)	50.0% (2)	36.4% (11)	-----
Parity					
0	18.3% (1481)	28.9% (1376)	29.2% (295)	33.5% (1089)	25.2% (359)
1 – 6	16.4% (3906)	27.2% (3559)	30.3% (669)	31.5% (2417)	28.3% (918)
≥ 7	16.3% (683)	35.4% (553)	33.8% (81)	35.4% (249)	22.9% (86)
Antenatal booking					
Yes	15.6% (5218)	17.0% (4334)	28.1% (881)	31.0% (3222)	26.3% (1188)
No	25.9% (852)	24.5% (1154)	45.0% (164)	40.5% (533)	33.7% (175)

Characteristics	1985 - 1990 N=6070	1991 - 1995 N = 5488	1996 - 1997 N = 1045	1998 - 2001 N=3755	2002 - 2003 N=1363
Referral status					
Emergency Ref	59.7% (827)	73.6% (1149)	59.8% (241)	60.1% (826)	62.9% (214)
Non emergency ref.	55.4% (496)	45.2% (662)	65.3% (95)	47.8% (695)	69.8% (149)
Self referral	5.6% (4747)	11.9% (3677)	15.9% (709)	17.4% (2234)	13.4% (1000)
Indications					
CPD	87.1% (470)	91.1% (731)	88.4% (129)	90.2% (553)	88.4% (172)
Antepartum hemorrhage	64.7% (150)	75.4% (203)	84.3% (46)	64.8% (128)	75.9% (29)
Malpresentation	72.2% (212)	85.0% (234)	87.8% (234)	86.7% (135)	81.6% (38)
Breech presentation	32.9% (155)	44.2% (206)	48.1% (52)	51.1% (180)	41.0% (78)
Hypertension	23.3% (227)	42.7% (330)	53.5% (86)	42.0% (441)	30.3% (145)
Eclampsia	29.7% (37)	63.9% (36)	59.1% (22)	53.1% (64)	69.2% (26)
Diabetes in pregnancy	25.0% (8)	38.1% (21)	50.0% (2)	55.6% (18)	62.5% (8)
Previous uterine rupture					
Previous cesarean	100% (7)	88.9% (9)	100% (1)	80% (5)	----
Obstetric fistula treated	73.7% (278)	74.9% (458)	82.5% (97)	77.8% (451)	81.6% (179)
Uterine prolapse treated	85.4% (48)	81.0% (42)	90.0% (10)	96.2% (26)	100% (16)
Cord prolapse	78.6% (14)	86.7% (15)	100% (2)	81.8% (11)	0.0% (2)
Cardiac disease	54.8% (42)	67.3% (52)	80.0% (5)	75.0% (32)	25.0% (4)
Post-term (induction)	7.7% (13)	60.0% (15)	50.0% (2)	37.0% (27)	0.0% (8)
Suspected Fetal distress	39.4% (33)	57.8% (45)	57.1% (7)	64.2% (34)	52.6% (19)
Twin pregnancy	36.4% (772)	48.1% (1142)	48.4% (213)	51.2% (732)	51.2% (205)
PROM	24.8% (149)	32.9% (152)	33.3% (33)	41.5% (106)	37.5% (40)
Preterm labor	32.7% (110)	55.3% (170)	64.3% (28)	50.0% (164)	31.4% (86)
	17.0% (570)	24.5% (486)	32.2% (115)	28.9% (419)	23.4% (124)

CPD: cephalopelvic disproportion Antepartum hemorrhage: placenta praevia and placental abruption.
PROM: Premature rupture of membranes
Percentages represents the cesarean delivery rate for each category. Numbers between parentheses correspond to the total number of delivery in each category.

Table 3. Trends in cesarean delivery rates (total number of deliveries in each category) for sociodemographic, pregnancy and delivery characteristics by time period.

3.3.3 Robson’s ten group classification

To further examine trends in cesarean delivery according to patient demographics, we classified our population following Robson’s rules (table 4). Collectively, groups 1, 3 and 5 constituted 78.2% of deliveries. Their cesarean delivery rates are 22.6%, 13.2% and 76.4% while their contributions to total cesarean deliveries were respectively 18.14%, 26.54% and 20.86%. Although group 2 and 4 had high levels of cesarean delivery rates (91.9% and 46.3% respectively), they contributed only 8.95% of total cesarean deliveries.

Trends in cesarean delivery rates for each of the ten groups appear in figure 2. There were no significant changes in abdominal delivery for Robson’s group 2 (Nulliparous, single gestation, cephalic presentation, ≥ 37 weeks gestational age, induced or cesarean delivery before labor) and group 5 (Previous cesarean delivery, single gestation, cephalic presentation, ≥ 37 weeks gestational age). We observed an increasing cesarean delivery rates for groups 4, 8 and 9. Group 9 presented a two pattern aspect with rates shifting from around 75% before 1990 to around 85% thereafter.

To further understand variations in obstetric practice in our hospital, groups 1 (spontaneously laboring term nulliparas) and 2 were combined as a composite variable, the term TSCN (table 1). The annual TSCN cesarean delivery rate and contribution of TSCN to hospital deliveries are documented in Table 1. The mean cesarean delivery rate in TSCN was 25.8% (range, 10.3% –40.7%). The CV for TSCN cesarean delivery rates was 29.5%, again indicating significant variation between different years. The 19 year trends of cesarean delivery rate in TSCN follows a pattern similar to that of overall cesarean delivery rate (Table 1). Figure 1 demonstrates positive correlation between the overall and TSCN cesarean delivery rates over time (Slope = 0.876). Linear regression model suggested that 77% of the variation of the overall cesarean delivery rates can be explained by the variation observed in TSCN cesarean delivery rates ($p<0.001$). Our analyses suggest that the increase in overall cesarean delivery rate was not related to changes in obstetric groups since the proportion of all deliveries that were TSCN did not vary substantially. The average proportion of TSCN in this study was 21.2% (range, 18.3 –24.4%) with a coefficient of variation of only 8.4% (Table 1).

Of note, 57.9% of cesareans in the TSCN group were indicated because of CPD (this represented 31.4% of all cesareans for CPD). One third of all cesarean deliveries indicated for eclampsia occurred in TSCN but this contributes only 3.2% to TSCN cesarean deliveries.

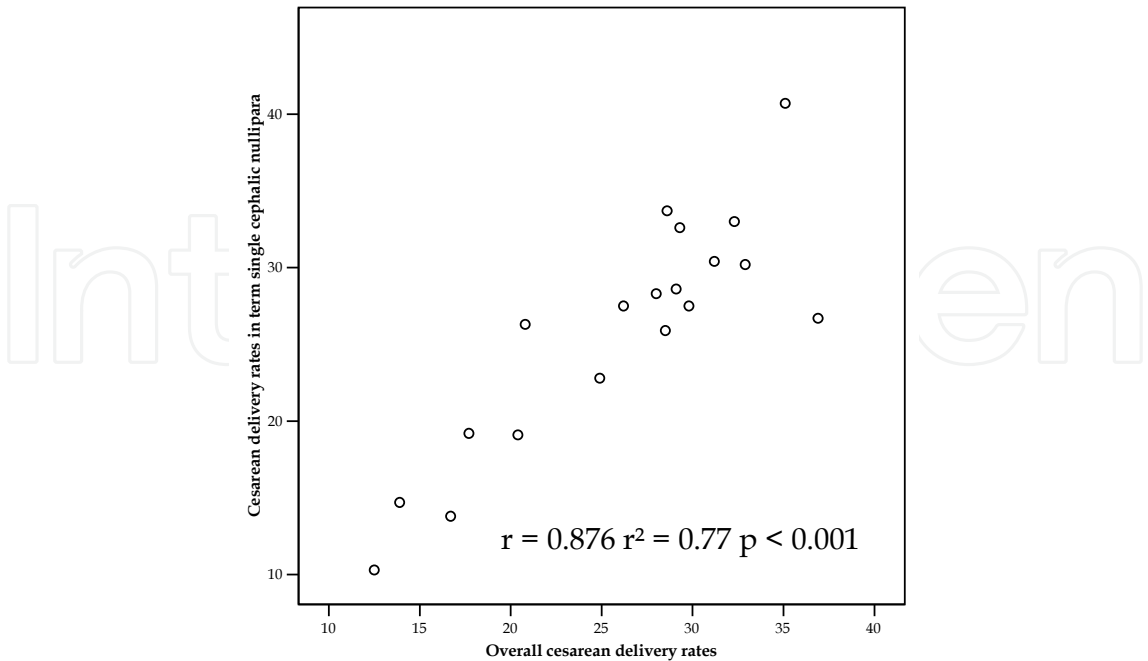


Fig. 1. Correlation between overall cesarean delivery rates and cesarean delivery rates in TSCN.

Robson's classification	Prevalence ¹ % of Robson groups	Cesarean delivery ²	Contribution of each group to total cesarean delivery ³ .
Group 1. Nulliparous, single cephalic, ≥ 37 weeks, in spontaneous labor	20.3%	22.6%	18.14%
Group 2. Nulliparous, single cephalic, ≥ 37 weeks, induced or CS before labor	1%	91.9%	3.82%
Group 3. Multiparous (excluding prev. CS), single cephalic, ≥ 37 weeks, in spontaneous labor	51%	13.2%	26.54%
Group 4. Multiparous (excluding prev. CS), single cephalic, ≥ 37 weeks, induced or CS before labor	2.8%	46.3%	5.13%
Group 5. Previous CS, single cephalic, ≥ 37 weeks	6.9%	76.4%	20.86%
Group 6. All nulliparous breeches	0.8%	39.6%	1.27%
Group 7. All multiparous breeches (including prev. CS)	2.3%	45.1%	4.08%
Group 8. All multiple pregnancies (including prev. CS)	2.5%	29.7%	2.94%
Group 9. All abnormal lies (including prev. CS)	2.9%	80%	9.11%
Group 10. All single cephalic, ≤ 36 weeks (including previous CS)	9.5%	21.6%	8.06%
Total	N= 17721	-	N= 4517

¹Calculated by total women in each group by the total number of deliveries

²Calculated by dividing the total number of cesarean in each group by the total number of women in each group

³Calculated by dividing numbers of cesarean per group by the total number of cesarean delivery (N=4517)

Table 4. Prevalence of Robson ten groups ; cesarean delivery rate by group and contribution of each group to cesarean delivery.

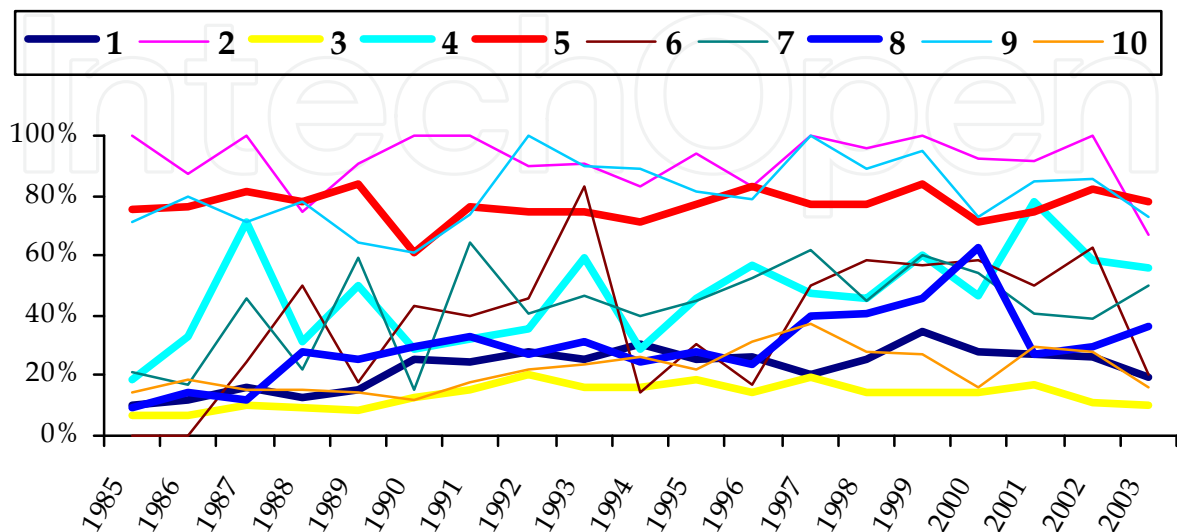


Fig. 2. Nineteen year trends of cesarean delivery rates per Robson’s group.

3.4 Multivariate analysis

Finally, we performed multilogistic regression with sequential adjustment to identify explanatory factors for increased cesarean delivery rates. Unadjusted analysis revealed a 100% increase in the rates of cesarean delivery (2003 vs 1985, RR = 2). The best model identified referral status, cephalopelvic disproportion and history of previous cesarean delivery as 3 factors to account for the observed increases in overall cesarean delivery rates. However, this model explained less than half of the observed increase (Figure 4). Of note, controlling for maternal age, parity and marital status didn’t affect the observed increase. Controlling for cephalopelvic disproportion alone explained 32% of the increase since we found an adjusted relative risk of 1.68. Adjusting simultaneously for cephalopelvic disproportion, referral status and previous cesarean delivery further decrease the adjusted relative risk to 1.58. We couldn’t build another model better than this last one.

As expected, higher levels of abdominal delivery were observed in referred patients (table 2). Since 1986, 60 to 70% of emergency admissions during labor have resulted in cesarean delivery. The cesarean delivery rates for referred patient without emergency fluctuated from 40%-60%. Cesarean delivery rates for direct admissions were ≤ 10% before 1994 and 10-20% thereafter (figure 3).

Cephalopelvic disproportion was a common indication for cesarean delivery, with a mean rate of 39.6% of women delivering abdominally having some degree of CPD. The percentage of CPD in cesarean deliveries ranged from 30.3% in 1985 to 48.8% in 1999. Contracted pelvis constituted 87% of all CPD. Of note, 63.5% of all contracted pelvis were recorded in the referred patients, who generally came from poor rural environments. The high incidence of uterine rupture among this group may correlate with severity of pelvis contraction.

There were 1465 deliveries in which the mother had a history of previous cesarean delivery. An elective cesarean delivery was decided for 858. Common indications for elective cesarean delivery were cephalopelvic disproportion (n=655), abnormal fetal presenting part (112), history of vesico-vaginal fistula (n=36), history of uterine prolapse (n=4), “precious” pregnancy (n=4), post-term pregnancy (n=7), and premature rupture of membranes (n=40). Among the 607 suitable for a trial of scar, 120 were emergency referrals with conditions such as a bleeding placenta praevia, a sudden rise in the blood pressure/eclampsia, or a suspected fetal distress leading to an emergency cesarean delivery. Finally, only 487 trials of scar have been undertaken (one third of all scarred uteri). We recorded 244 vaginal deliveries (50.1%) while 243 were emergency cesarean delivery (49.9%). Two (2) cases of uterine dehiscence occurred (0.4% of the 487 trials of scar) and 1 case of maternal death (0.2%, denominator = 487 trials of scar). There were 25 perinatal deaths (5.1%).

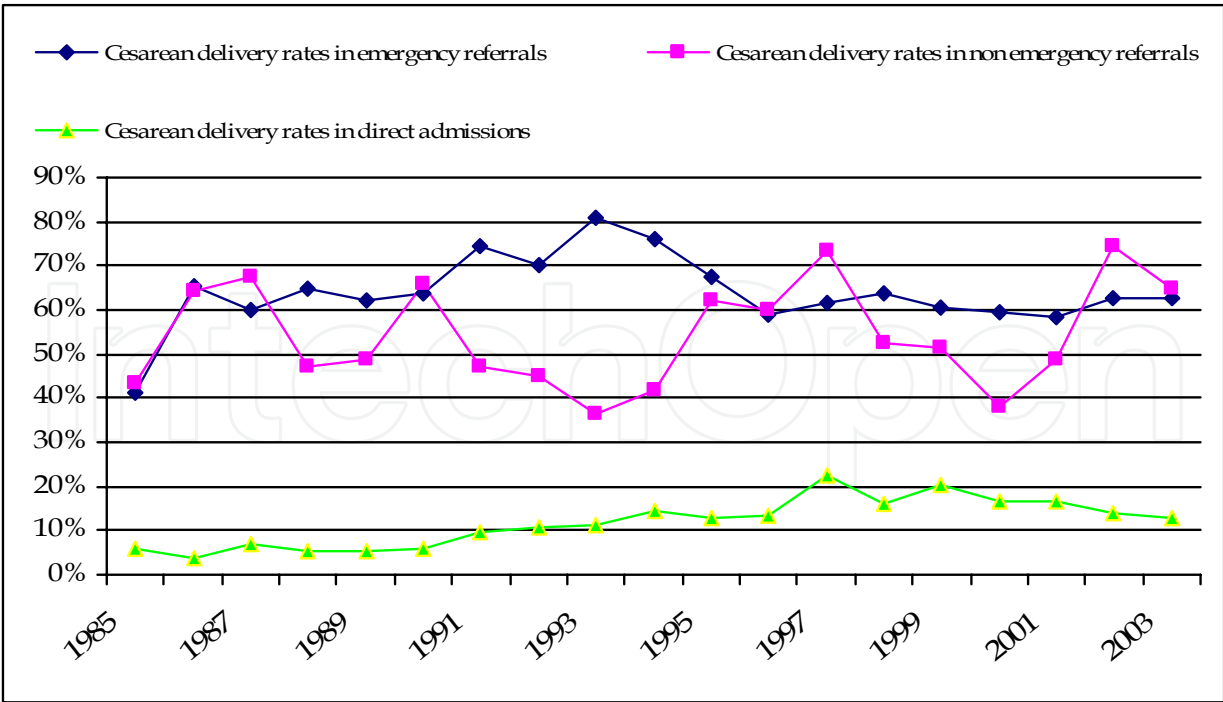


Fig. 3. Trends in cesarean delivery rates by referral status.

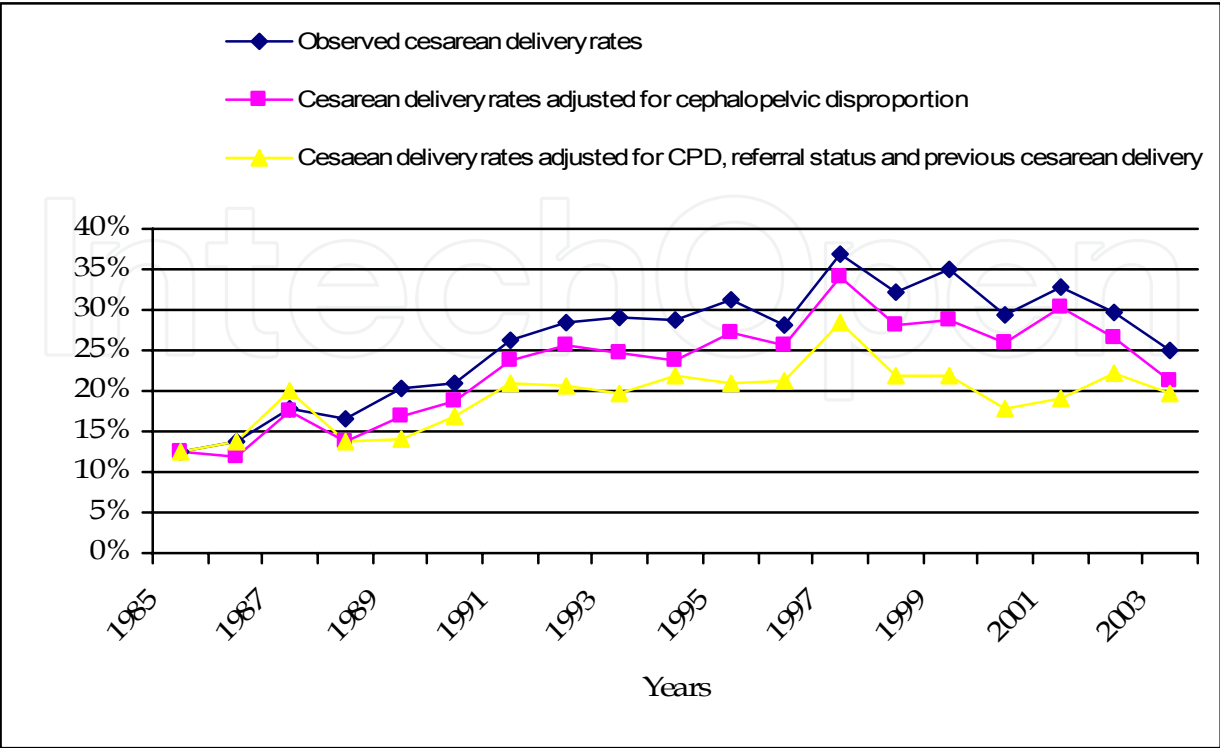


Fig. 4. Observed rates of cesarean delivery and sequentially adjusted rates for changes in cephalopelvic disproportion, mode of admission and history of cesarean delivery.

3.5 Complications of cesarean delivery

3.5.1 Maternal complications

3.5.1.1 Intraoperative surgical complications

We defined intraoperative complications as laceration of the uterus (uterine rupture included), cervix, bladder, vagina or bowel, intraoperative blood loss of ≥ 1000 ml, blood transfusion, and hysterectomy. Overall, 13.2% (596/4517) of the women undergoing a cesarean delivery had at least one of the above complications. The most common events were uterine rupture (9.2%, 417/4517), hemorrhage (2.4%, 111/4517), hysterectomy (2.1%, 96/4517); urinary tract injury (0.4%, 18/4517), and anesthesia-related complications (0.3%, 15/4517).

Table 5 presents an analysis of factors influencing the occurrence of intraoperative complications. Univariate analyses found four risk factors for intraoperative complications: admission during the active phase of labor (cervical dilatation ≥ 4 cm), transverse lie, total length of labor more than 24 hours, and emergent referrals. However, in multivariate analyses, only emergent referral remained a significant risk factor with a 3.4 folds increase in the odds of intra-operative adverse events. Removing referral status from the multivariate analysis allowed two factors to be linked to intraoperative complications: ruptured membranes at admission (OR=2.1 [1.2 – 3.7], $p<0.01$) and total length of labor (OR=1.9 [1.1 – 3.5], $p<0.05$).

Factors	Crude OR	95% CI OR	P	AOR	95% CIAOR	p
Cervical dilatation at time of intervention						
0 – 3 cm	Reference	---	---	Ref	---	---
4 – 10 cm	2.5	1.9 – 3.1	<0.001	1.6	0.8 – 2.9	>0.05
Fetal presentation						
Cephalic	Reference	---	---	Ref	---	---
Breech	0.8	0.6 – 1.2	>0.05	0.8	0.2 – 2.7	>0.05
Transverse	1.5	1.1 – 1.9	<0.05	0.9	0.4 – 2.1	>0.05
Total length of labor						
<12 hours	Reference	---	---	Ref	---	---
12 – 24 hours	1.4	0.9 – 2.1	>0.05	0.9	0.5 – 1.6	>0.05
>24 hours	3.5	2.3 – 5.3	<0.05	1.5	0.8 – 2.8	>0.05
Membranes status						
Not ruptured	Reference	---	---	Ref	---	--
Ruptured	3.0	2.4 – 3.8	<0.001	1.5	0.8 – 2.8	>0.05
Preterm delivery						
No	Reference	---	---	Ref	---	---
Yes	0.6	0.4-0.9	<0.001	0.3	0.1 – 0.4	>0.05
Referral status						
Self-referred	Reference	---		Ref	---	
Referred with emergency	5.1	3.9 – 6.5	<0.001	3.4	1.7 – 6.8	<0.001
Referred without emerg.	0.7	0.4 – 0.9	<0.01	0.8	0.2 – 2.9	>0.05
Body mass index						
<35.0 kg/m ²	Reference	---	Ref	---	---	--
≥ 35 Kg/m ²	1.3	0.5 – 2.9	>0.05	2.1	0.4 – 10.2	>0.05
Intraoperative adhesions						
No	Reference	---	Ref	---	---	---
Yes	0.8	0.6-1.2	>0.05	1.7	0.8 – 3.9	>0.05

CI: confidence interval OR: odds ratio AOR: adjusted odds ratio CIAOR: confidence interval of the adjusted odds ratio

Table 5. Risk factors for intraoperative surgical complications.

3.5.1.2 Post-cesarean complications

Post-cesarean infection

The incidence of post-partum infection among cesarean deliveries was 20.1% (910/4517) compared to 3.9% (509/13204) for vaginal deliveries (OR= 6.3 [5.6 - 7.1], p<0.001). Of the 4517 cesarean deliveries, 17.5% (790/4517) met the criteria for surgical site infection as defined by CDC. Endometritis, peritonitis, post-partum urinary tract infection and serious infectious morbidity were more linked to abdominal route of delivery (table 6).

Risk factors for post-cesarean infection identified in a univariate analysis were: emergent referral, younger maternal age (13 - 19 years old), nulliparity, ruptured membranes at admission, abnormal amniotic fluid coloration, and prolonged labor (total length ≥ 12 hours). In multivariate analyses, only 3 factors remained significantly associated with postpartum infection: abnormal amniotic fluid coloration, ruptured membranes before admission and duration of labor >24 hours (table 7).

	Cases per Cesarean Delivery (%), n=4517	Cases per Vaginal Delivery (%), n=13204	OR (95% CI)
Endometritis	11.1 (n=500)	3.3 (n=436)	3.6 [3.2 - 4.2]
Wound infection	6.8 (n=305)	---	---
Peritonitis	4.0 (n=18)	0.02 (n=2)	26.4 [6.1 - 113.9]
Urinary tract infection	0.7 (n=35)	0.2 (n=24)	4.3 [2.5 - 7.2]
Serious infectious morbidity [‡]	2.7 (n=123)	0.1 (n=8)	46.2 [22.6 - 94.5]

[‡]Defined as bacteremia, septic shock, septic thrombophlebitis, necrotizing fasciitis; peritonitis, or death attributed to infection

Table 6. Post-Partum Infectious Complications by Delivery Route.

Postpartum hemorrhage: Recorded rates were comparable between cesarean delivery and vaginal delivery, 1.7% vs 1.4% (P>0.05).

Deep venous thrombosis. Only 11 cases have been recorded during the study period; 9 in cesarean deliveries vs 2 in vaginal deliveries (OR = 13.2 [2.8 - 61.0]).

Puerperal psychosis. In 19 years, 6 cases occurred, 5 after cesarean delivery and 1 post-vaginal delivery (OR = 14.6 [1.7 - 125.3]).

Risk factors	Unadjusted Odds ratio	95% CI	P	AOR	95%CI	P
Referral status						
Self admission	1.0	1.3 – 1.9	<0.01	1.0	0.6 – 1.3	>0.05
Referred emergently	1.6	0.4 – 0.7	<0.01	0.9	0.5 – 1.5	>0.05
Referred without	0.5			0.9		
Maternal age						
20 – 34 years	1.0	1.1 – 1.6	>0.01	1.0	0.5 – 1.6	>0.05
13 – 19 years	1.4	0.7 – 1.1	>0.05	0.9	0.9 – 1.8	>0.05
35 – 50 years	0.9			1.1		
Parity						
1 – 6	1.0	1.1 – 1.4	< 0.05	1.0	0.4 – 1.8	>0.05
Nulliparous	1.2	0.8 – 1.3	>0.05	0.8	0.7 – 1.5	>0.05
≥ 7	1.0			1.02		
Body Mass Index (BMI)						
<35 Kg/m²	1.0	0.2 – 0.9	<0.05	1.0	0.2 – 2.1	>0.05
≥35 Kg/m²	0.4			0.6		
Membranes status at admission	1.0	2.8 – 3.9	<0.001	1.0	1.3 – 3.7	<0.01
Non ruptured	3.3			1.9		
Ruptured						
Amniotic fluid color at admission	1.0	2.7 – 3.9	<0.001	1.0	1.5 – 3.2	<0.001
Normal	3.3			2.2		
Abnormal						
Cervical dilatation at admission	1.0	1.2 – 1.7	<0.001	1.0	1.01 – 2.1	<0.05
0 – 3 cm	1.8			1.4		
4 – 10 cm						
Duration of labor						
< 12 hours	1.0	1.1 – 1.9	<0.05	1.0	0.9 – 1.9	>0.05
12 – 23 hours	1.4	1.9 – 3.6	<0.05	1.3	1.4 – 3.4	<0.001
≥ 24 hours	2.7			2.2		
Induction of labor						
No	1.0	0.6 – 1.8	>0.05	1.0	0.3 – 3.6	>0.05
Yes	1.04			1.1		
Antepartum hemorrhage						
No	1.0	0.1 – 0.3	<0.001	1.0	0.01 – 0.4	<0.01
Yes	0.2			0.05		
Per/postpartum hemorrhage	1.0	0.9 – 2.5	>0.05	1.0	0.3 – 4.1	>0.05
No	1.5			1.1		
Yes						

CI = Confidence Interval AOR: Adjusted odds ratio

Table 7. Risk factors for post-partum infection.

3.5.1.3 Maternal mortality and cesarean delivery

During the 19 year period, 417 maternal deaths were recorded. Among these maternal deaths, 348 occurred per or postpartum (83.4%). The majority of these delivery period deaths, 70.1% (244/348), were associated with cesarean delivery. Thus, 5.4% (244/4517) of cesarean deliveries resulted in a maternal death. The corresponding rate for vaginal delivery was 0.9% (104/13204).

Twelve of the 244 maternal deaths associated with cesarean delivery occurred before the intervention was performed (4.9%). A similar proportion occurred during cesarean. The vast majority of maternal deaths were recorded in the post-cesarean period (90.1%).

The absolute number and risk of cesarean-related maternal deaths shows a sharp decrease beginning in 1994 (Figure 5).

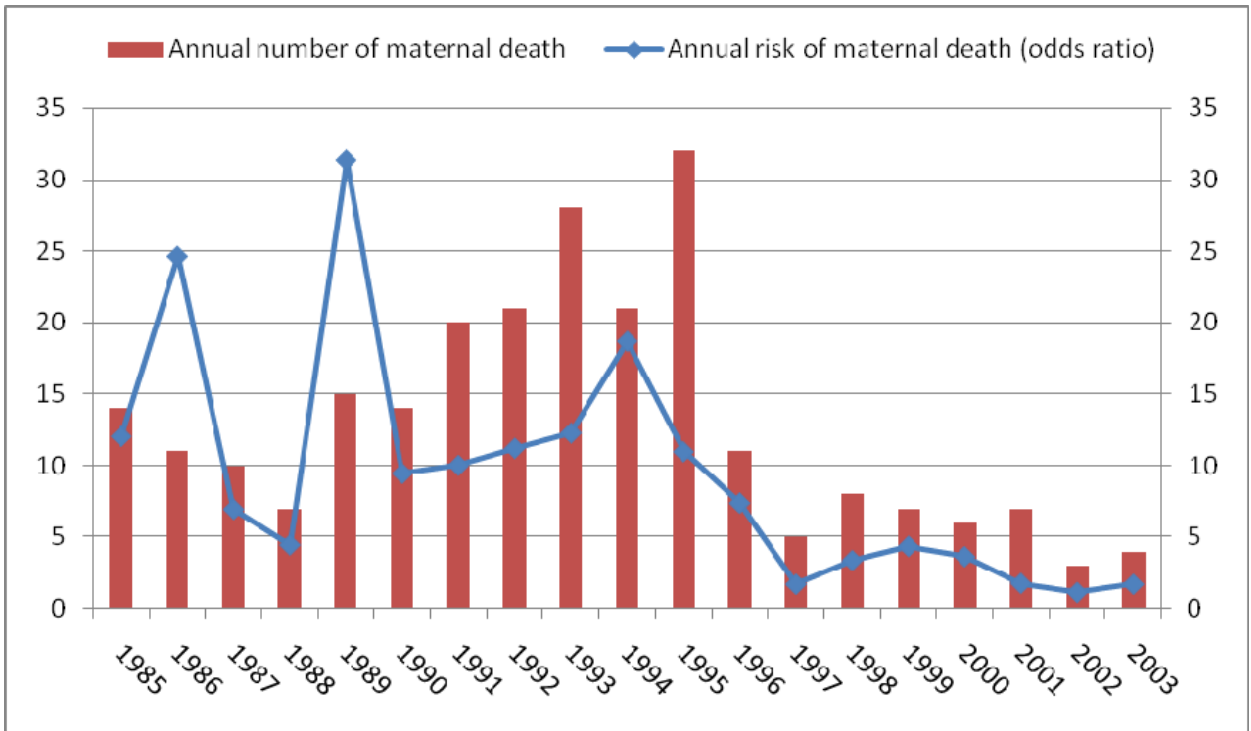


Fig. 5. Trends of annual number and risk of cesarean related maternal deaths.

Table 8 presents case fatality rates for direct and indirect maternal complications by route of delivery. The vast majority of maternal complications (91.8% for cesarean delivery, 83.9% for vaginal delivery) and maternal deaths (95.5% for cesarean delivery, 87.5% for vaginal delivery) were the consequences of direct maternal complications. The overall case fatality rate was 6.9% (244/3548) for cesarean delivery compared to 2.9% (104/3597)

for vaginal delivery. In the cesarean delivery group among direct maternal complications, uterine rupture had the highest fatality rate (23.2%). There was a consistent decrease in the incidence and case fatality rates of uterine rupture in women delivered abdominally (figure 6). The incidence decreased from 10.5% for the period 1985 – 1990 to 4.5% for the period 2002 – 2003. The case fatality rates decreased from 29.9% to 6.9% in the same time periods.

Causes	CESAREAN DELIVERY			VAGINAL DELIVERY		
	Total number	Death	Case rate fatality	Total number	Death	Case rate fatality
Direct maternal complications						
hemorrhage	377	45	11.9%	491	40	8.1%
Hypertension and complications	374	17	4.5%	1196	24	2.0%
Dystocia	1096	5	0.5%	475	2	0.4%
Uterine rupture	455	101	23.3%	20	0	0.0%
Postpartum infection	910	57	6.2%	480	25	5.2%
Other direct causes	45	8	17.8%	356	0	0.0%
Indirect maternal complications						
HIV	6	0	0.0%	7	0	0.0%
Malaria	135	0	0.0%	170	2	1.2%
Hemoglobinopathy	24	1	4.2%	49	0	0.0%
Anemia	43	1	2.3%	215	0	0.0%
Cardiac disease	25	7	28.0%	59	5	8.5%
Diabetes	17	0	0.0%	23	0	0.0%
Hepatitis	1	0	0.0%	5	0	0.0%
Other indirect causes	40	2	5.0%	51	6	11.8%
Total	3548	244	6.9%	3597	104	2.9%

Table 8. Absolute numbers of cases, number of deaths and case fatality rates of direct and indirect maternal complications for cesarean delivery and vaginal delivery.

We examined the relationship between cesarean delivery and maternal death in the context of other known primary predictors (table 9). Cesarean delivery remained strongly associated with maternal death even after controlling for antenatal screening, referral status, maternal age, parity, abruption, placenta previa, hypertensive disorders, and malpresentation.

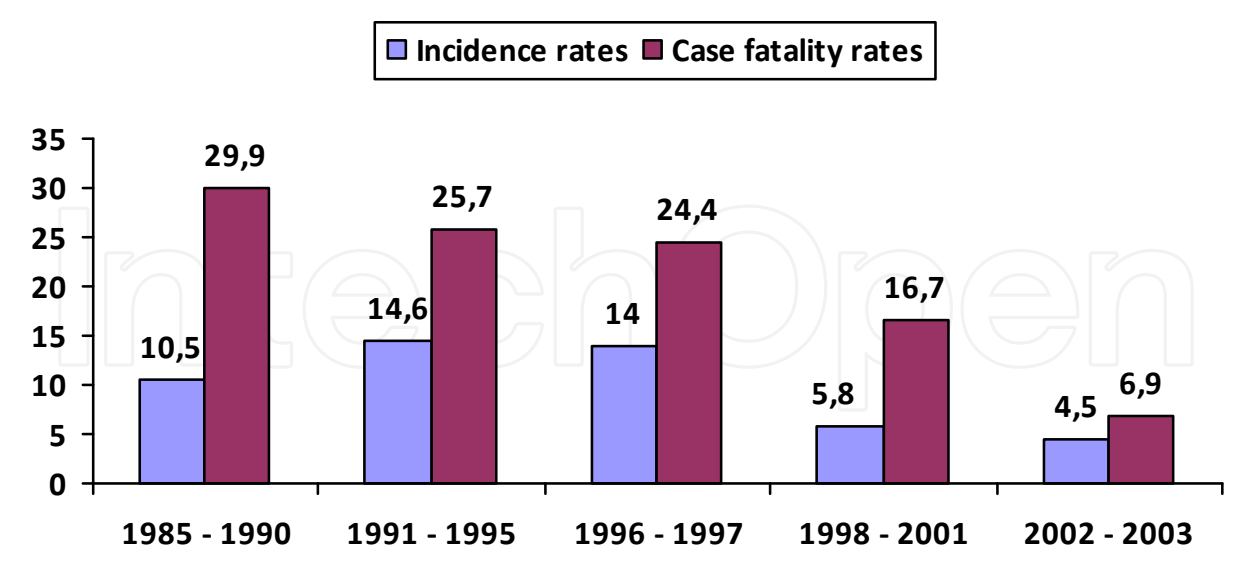


Fig. 6. Time trends of uterine rupture incidence rate and case fatality rates among 4517 cesarean deliveries at Point national hospital, Bamako, Mali, 1985 - 2003.

Variables	Crude OR	95% CI	Adjusted OR	95% CI
Antenatal screening				
No	7.0	5.7 – 8.7		
Yes	1.0			
Referral status				
Referred emergently	25.7	18.7 – 35.4		
Referred without emergency	3.2	1.9 – 5.2		
Self admission	1.0			
Maternal age				
35 – 50 years	0.8	0.6 – 1.2		
13 – 19 years	1.6	1.2 – 2.0		
20 – 34 years	1.0			
Parity				
Nullipara	0.9	0.7 – 1.2		
Grandmultipara	1.2	0.9 – 1.8		
Multipara	1.0			
Route of delivery				
Cesarean delivery	7.2	5.7 – 9.1	2.8*	– 3.8
Vaginal delivery	1.0			

* Controlling for antenatal screening, referral status, maternal age, parity, CPD, placental abnormalities (abruption and previa), hypertensive disorders, and malpresentations.

Table 9. Odds ratios with 95% confidence interval for maternal death for primary predictors.

3.5.2 Perinatal complications

3.5.2.1 Stillbirth rates

Overall, the stillbirth rate for cesarean delivery was 19.3% vs. 7.3% for vaginal delivery ($p<0.001$). Since 2000, the gap between the two curves narrowed significantly (figure 7). Gestational age-specific stillbirth rates are shown in table 10. Preterm stillbirth rates were comparable for the two routes of delivery or higher in the vaginal route. However, there was a statistically significant difference for term stillbirth rates with higher rates observed in the cesarean delivery group. The risk of stillbirth associated with cesarean delivery was high in univariate analysis (2.9 [2.7 - 3.2]). However, after adjusting for maternal age, parity, referral status, CPD, antepartum hemorrhage, hypertension in pregnancy, malpresentation and uterine rupture, the risk disappeared and cesarean delivery ws shown to be protective against stillbirth (aOR = 0.36 [0.30 - 0.42]).

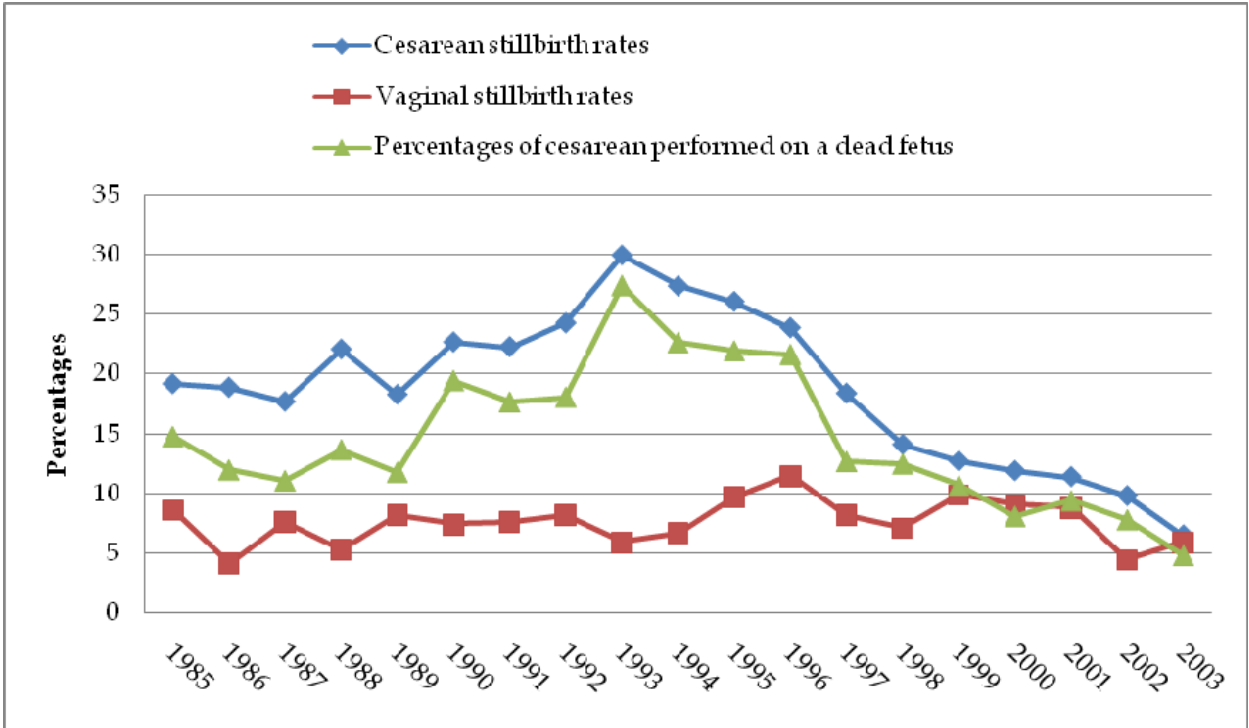


Fig. 7. Time trends of stillbirth rates for cesarean and vaginal delivery, Point G teaching hospital, 1985 - 2003.

3.5.2.2 Neonatal mortality

Neonatal mortality rates over time are shown in Figure 8. Rates were generally higher for cesarean delivery compared to vaginal delivery. Neonatal death rates didn't vary significantly over time for either route of delivery. As expected, the younger the gestational age, the higher the neonatal death rate (Table 10). Univariate analysis revealed an increased risk of neonatal death when the delivery route was abdominal as compared to vaginal route (Table 11). However, after adjusting for maternal (age, parity, referral status), pregnancy (gestational age at delivery, booking status) and fetal / neonatal (suspected fetal distress during labor characterized by an abnormal heart beat rate and / or an abnormal amnionic

fluid color, birth weight) characteristics, there was no association between cesarean delivery and neonatal death (table 11). Risk factors for neonatal death in the multivariate analysis included suspicion of fetal distress, very low birth weight and emergently referred women in labor.

Weeks of pregnancy	Cesarean delivery						Vaginal delivery					
	Total birth	Live births	Still- births	% Still- births	N.* Deaths	% N.* Deaths	Total birth	Live births	Still- births	% Still- births*	N. * Deaths	% N.* deaths
22 weeks	1	0	1	100	-	-	28	6	22	78.6	5	83.3
23 weeks	2	0	2	100	-	-	5	0	5	100	0	-
24 weeks	2	0	2	100	0	-	42	11	31	73.8	6	54.5
25 weeks	4	3	1	25.0	1	33.3	24	9	15	62.5	2	22.2
26 weeks	4	3	1	25.0	0	0.0	35	19	16	45.7	3	15.8
27 weeks	1	1	0	0.0	0	0.0	29	18	11	37.9	3	16.7
28 weeks	37	17	20	54.1	6	35.3	146	50	96	65.8	8	16.0
29 weeks	16	6	10	62.5	1	16.7	46	28	18	39.1	2	7.1
30 weeks	23	15	8	34.8	2	13.3	76	56	20	26.3	9	16.1
31 weeks	8	7	1	12.5	1	14.3	36	23	13	36.1	2	8.7
32 weeks	34	23	11	32.4	2	8.7	44	30	14	31.8	11	36.7
33 weeks	25	17	8	32.0	1	5.9	87	61	26	29.9	2	3.3
34 weeks	68	53	15	22.1	1	1.9	192	145	47	24.5	7	4.8
35 weeks	67	59	8	11.9	3	5.1	171	138	33	19.3	4	2.9
36 weeks	184	154	30	16.3	10	6.5	470	421	49	10.4	7	1.0
37 weeks	385	332	53	13.8	8	2.4	913	849	64	7.0	10	1.2
38 weeks	1390	1178	212	15.3	36	3.1	4182	3994	188	4.5	32	0.8
39 weeks	1080	866	214	19.8	19	2.2	3581	3433	148	4.1	25	0.7
40 weeks	779	609	170	21.8	24	3.9	2326	2230	96	4.1	21	0.9
41 weeks	177	133	44	24.9	5	3.8	394	380	14	3.6	3	0.8
42 weeks	103	61	42	40.2	4	6.6	122	107	15	12.3	1	0.9
>42 weeks	75	66	9	12.8	1	1.5	63	60	3	4.8	1	1.7

N. death= neonatal death. % N. death = percentage of neonatal death compute by dividing number of neonatal deaths by number of live birth. % stillbirth = percentage of stillbirth computed by dividing numbers of stillbirth by total number of birth

Table 10. Total numbers of births, stillbirth, and stillbirth rates and neonatal death for cesarean and vaginal delivery, Point G teaching hospital, 1985 -2003.

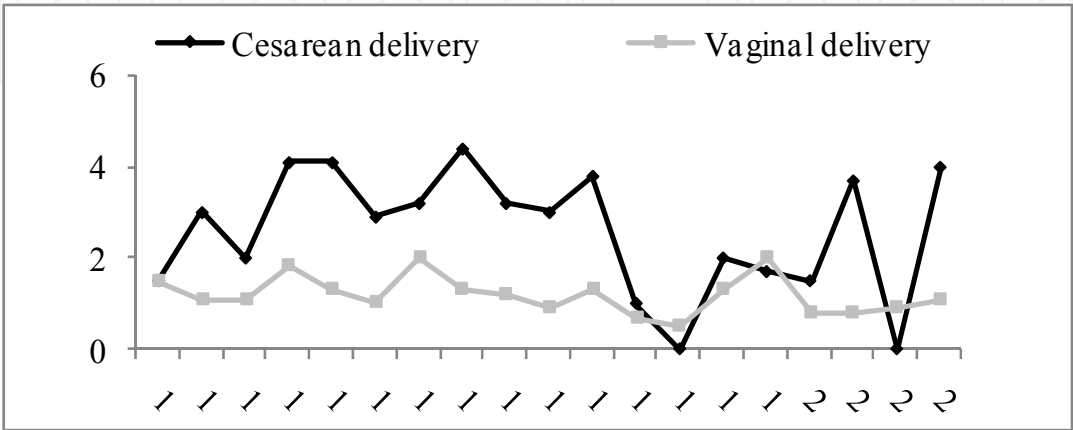


Fig. 8. Neonatal death rates for cesarean and vaginal delivery.

Factors	Unadjusted odds ratio			Adjusted odds ratio		
	OR	95% CI	or P value	AOR	95% CI	aor P value
Route of delivery						
Vaginal delivery	1.0			1.0		
Cesarean delivery	2.6	2.1 – 3.3	<0.001	0.9	0.6 – 1.2	>0.05
Antenatal booking						
Yes	1.0			1.0		
No	3.1	2.3 – 4.1	<0.001	1.5	1.1 – 2.1	<0.01
Maternal age						
20 – 34 years old	1.0			1.0		
13 – 19 years old	2.1	1.6 – 2.7	<0.001	1.3	0.9 – 1.9	>0.05
≥ 35 years old	1.3	0.9 – 1.9	>0.05	1.4	0.9 – 2.2	>0.05
Maternal parity						
1 – 6	1.0			1.0		
0	1.7	1.3 – 2.2	<0.001	1.2	0.9 – 1.7	>0.05
≥ 7	1.2	0.7 – 1.8	>0.05	0.7	0.4 – 1.3	>0.05
Referral status						
Self admission	1.0			1.0		
Referred emergently	7.6	5.9 – 9.9	<0.001	2.6	1.9 – 3.7	<0.001
Referred without emergency	2.5	1.7 – 3.6	<0.001	1.5	0.9 – 2.2	>0.05
Birth weight						
≥ 2500 grs	1.0			1.0		
500 – 999 grs	47.9	28.5 – 80.6	<0.001	8.8	3.2 – 24.3	<0.001
1000 – 1499 grs	16.1	10.6 – 24.6	<0.001	4.3	1.9 – 9.4	<0.001
1500 – 1999 grs	5.3	3.5 – 8.1	<0.001	1.6	0.8 – 3.1	>0.05
2000 – 2499 grs	1.6	1.1 – 2.4	<0.05	0.9	0.5 – 1.5	>0.05
Gestational at delivery						
≥ 37 weeks	1.0			1.0		
22 – 27 weeks	29.9	17.4 – 51.1	<0.001	2.1	0.8 – 5.8	>0.05
28 – 32 weeks	11.6	8.2 – 16.5	<0.001	2.2	1.1 – 4.6	<0.05
33 – 36 weeks	2.6	1.8 – 3.7	<0.001	1.6	0.9 – 2.9	>0.05
Antepartum hemorrhage						
Yes	4.9	3.2 – 7.7	<0.001	1.4	0.8 – 2.3	>0.05
No	1.0			1.0		
Suspect fetal distress						
Yes	20.8	14.3 – 30.3	<0.001	20.6	14.2 – 30.1	<0.001
No	1.0			1.0		

OR : odds ratio CI : confidence interval AOR : adjusted odds ratio

Table 11. Predictors of neonatal mortality, Point G national hospital, Bamako, Mali, 1985 – 2003.

4. Discussion

4.1 Strengths and limitations

We report here an analysis of deliveries during a nineteen year period in a teaching hospital in Mali (West Africa). Our main findings are: (1) a striking increase in cesarean delivery rates throughout the study period; (2) women in labor referred with an emergency condition not only constituted the largest proportion of cesarean deliveries but also this mode of admission seriously jeopardized the maternal as well as the perinatal prognosis; (3) the two most common indications for cesarean delivery were cephalopelvic disproportion and previous cesarean delivery; (4) there were very low rates of planned cesarean delivery as expressed by the small contribution of Robson groups 2 and 4.

While the majority of women delivering at Point G National Hospital originate from Bamako, the substantial proportion of women referred from other regions and the sociodemographic characteristics of the pregnant women in this setting provide a perspective on hospital-based obstetric care in the whole country up to 2003. Since 2003, Mali has instituted important changes in the delivery of obstetric care. In 2004, a nationwide emergency obstetric and neonatal care program was put in place to reinforce the perinatal program. In 2006, the Malian government began to provide medically indicated Cesarean deliveries free of charge in public hospitals and referral district health centers, increasing access and leading to subsequently higher Cesarean delivery rates (Teguete et al, 2010b). Additionally, since 2002, major staffs of the department of obstetrics and gynecology have been appointed to Gabriel Toure teaching hospital, a nearby hospital of the Malian capital city with easier accessibility. These aspects are not covered by the database used here.

Trends in Cesarean delivery rates after 2003 can be examined through an improved and adapted obstetric database installed at Gabriel Touré teaching hospital after the transfer of staff. This database contains more than 400 variables related to patients' demographic, medical and obstetric factors as well as pregnancy outcomes [Teguete et al, 2008; Teguete et al, 2009]. Rates of Cesarean delivery at the Gabriel Touré teaching hospital increased from 21% in 2003 to 32% in 2009 (Teguete I. et al, 2010b). After sequential adjustment for maternal demographic, obstetric, and referral characteristics as described above, 19% of the observed increase remained unexplained (figure 9), compared to 58.5% for the Point G database. CPD, referral status and previous cesarean delivery were the major determinants of cesarean delivery, as at Point G teaching hospital. These findings will be the core of the following comments.

4.2 Cesarean delivery rates in developing countries

The current situation of cesarean delivery rates in developing countries is very complex with large differences between countries, within countries, and between health centers [Fesseha et al, 2011; Cissé et al, 1998]. A large ecological cross-sectional study reported that, in low income countries where cesarean deliveries rates are less than 10%, as section rates increase, neonatal and maternal mortality decrease [Althabe et al, 2006]. Our database revealed a sharp increase in the rates of hospital cesarean delivery, similar to those observed in many teaching hospital maternity wards in Africa [Muganyizi & Kidanto, 2009; Geidam et al, 2009; Kwawukume, 2001]. However, countrywide cesarean delivery rates remain under the minimum level of 5% advised by the WHO for optimal obstetric care (table 12).

Rural populations remain underserved in many developing countries [Leone et al, 2008, Kizonde et al, 2006]. A recent regional meeting for the final evaluation of the “Initiative 2010” aimed at reducing maternal mortality ratios and neonatal mortality rates by 50% by 2010 reported that among 17 West and Central African countries evaluated; only five had national cesarean delivery rates of 5% or more [Ba, 2011]. Thus, in sub-Saharan Africa where coverage in healthcare service is low, initiatives to increase cesarean rates are ongoing in order to meet the millennium development goals [El-Khoury et al, 2011]. At the same time, there are calls for caution [Mbaye et al, 2011; Fesseha et al 2011] to prevent high unnecessary cesarean rates like those observed in many developed countries as well as some developing countries [Khawaja et al, 2004].

Countries	Teaching hospital	District hospital /Rural area	Country level
Tanzania	Muganyizi & Kidanto, 2009 1999: 15.1% 2005: 25.6%	Stein, 2008 1986 – 1994: 9.4% 1995 – 1999: 20.3%	Wenjuan et al, 2011 1992 – 1993: 2.9% 2004 – 2005: 4.0%
Nigeria	Ijaiya & Aboyeji 2001 1990: 3.8% 1999: 20.7% Geidam et al, 2009 2000: 7.2% 2003: 13.3% 2005: 13.9%	Ikeako, 2009 2005 – 2009 : 10.4%	Wenjuan et al, 2011 1990: 2.5% 2003: 1.9% 2008: 2.1%
Ghana	Kwawukume, 2001 1988: 25.2% 1995: 17.7% 1999: 23.8%	Buekens et al, 1998 1998 = 2.8%	Wenjuan et al, 2011 1993: 4.8% 2003: 4.4% 2008: 7.2%
Mali	Our study, 2011 1985: 12.5% 1988: 16.7% 1990: 20.8% 1999: 35.1% 2003: 24.9%	Maïga et al, 1999 1993 – 1995: 1%	El-Khoury et al, 2011 2005: 0.9% 2006: 1.6% 2007: 2.1% 2008: 2.2% 2009: 2.3%
Burkina Faso	Bambara et al, 2007 2000 : 11.3%	Buekens et al, 2003 1999 = 1.0%	Wenjuan et al, 2001 1993: 1.6% 2003: 0.7
Senegal	Cissé et al 2004 1992 : 12% 1996: 17.5% Ngom et al, 2001 2001: 25.1%	Cissé, 1998 1996 : 0.1% - 0.7%	Wenjuan et al, 2011 1992 – 1993: 2.5% 2005: 3.9%
Madagascar	Andriamady et al, 2001 1998 : 6.8%	Robitail et al, 2004 1997 : 0.7% 1999: 0.58% 2000: 0.67% 2001: 0.71%	1997: 0.6% Wenjuan et al, 2011 1993: 1.1% 2008 – 2009: 1.7%
Kenya	Wanyonyi et al, 2007 1996: 20.4% 2001: 25.9% 2004: 38.1%	Buekens et al, 2003 1993: 4.1% 1998: 5.7%	Wenjuan et al, 2011 1993: 6.0% 2003: 4.9% 2008: 7.2%
Namibia		van Dillen J, 2007 2001 – 2002 : 7.9%	Wenjuan et al, 2011 1992: 7.2% 2006 – 2007: 13.6%

Table 12. Cesarean delivery rates in different settings of selected sub-saharan african countries.

4.3 Referral system and cesarean delivery

Like in many developing countries, access to healthcare for the poor and underserved remains insufficient in Mali.

After the publication of the now famous article “Where is the M in MCH?” [Rosenfield & Maine, 1985], and the introduction of the Safe Motherhood Initiative in Nairobi in 1987, maternal mortality reduction in sub-Saharan Africa garnered increased attention and commitment [UN. Report, 1994]. In this context, maternal and child protection have become major targets in the implementation of the healthcare system by the Malian government.

Many developing countries paid special attention to the organisation of the referral system to improve maternal and child health [Rudge et al, 2011]. Likewise, the National Perinatology Program of Mali was conceived in 1994 and organised the referral system to improve the environment of perinatal care. Reported interventions at the community level focused on (1) educational activities to raise awareness of danger signs and encourage the use of obstetric services; (2) reducing geographical and financial barriers through emergency loan schemes / subvention and (3) improving transport and communication [Kandeh et al, 1997; Nwakoby et al 1997]. This policy led to an increase in cesarean delivery rates in rural district hospitals [De Brouwere, 1997], but it was very difficult to implement in large cities like Bamako. The high incidence at Point G of uterine rupture, a preventable end stage obstetric morbidity, demonstrates the unmet needs of cesarean delivery.

Thus, like in many developing countries [Sørbye et al, 2011], access to emergency obstetric care is unsatisfactory in Mali and unequal. Despite a national obstetric referral system, many birthing women (often without complications or known risk factors) bypass referring facilities to get access directly to the higher level of obstetric care. On the other hand, many women without access to care have to travel long distances to access care during labor and delivery. Difficulties related to referral health systems are frequently reported in sub-Saharan Africa [Cissé et al; 1998] and were common features in our hospital before 1994. Large population based studies emphasize the need to ensure that the women least likely to seek care are not marginalized [Jacqueline et al., 2003], requiring a functional referral system.

In Mali, access to cesarean delivery was a priority of referral system organisation from its inception. This system may be partially responsible for the decreased risk of caesarean-related maternal death after 1994 as well as the downward trend in post-caesarean stillbirth rates. However, the risk of maternal death when caesarean delivery is needed is still high despite adjustment for other factors. The unsatisfactory initial impact of cesarean delivery on maternal and fetal / neonatal health led the Malian government to make it free of charge. Many other countries engaged in such political commitment to eliminate financial barriers. However some authors reported that, although removing user fees has the potential to improve access to health services especially for the poor, it is not appropriate in all contexts [James et al, 2006]. Similarly, simulations have found that decreasing the price of Cesarean delivery has minor effects, suggesting that greater increases in access to care would come from investment in the improvement of healthcare structures and care processes [Mariko, 2003]. Developing countries face serious issues in this respect, due to the lack of and inequitable distribution of human resources. For example, in 2002 in Mali, 265 midwives were posted in Bamako or in regional hospitals, while only 164 were working at the

peripheral level. As a result, only 24% of deliveries were attended by a skilled professional. Similar figures have been reported from Tanzania [Olsen et al., 2005]. Many basic health facilities do not even have a midwife, so, many patients have to come directly to the tertiary hospital or go nowhere at all [Gerein N et al, 2006]. Many strategies have been or are being tested to solve this problem. Unfortunately, there is no one single-bullet solution [Dayrit et al, 2010]. These gaps contribute to the poor performance of the health system [Lawn J E., 2009]. Thus, a holistic approach has to be considered for better strengthening of the health system in order to meet the performance goals of the WHO schematic framework [WHO, 2007]

4.4 Cephalopelvic disproportion

The expression cephalopelvic disproportion (CPD) came into use prior to the 20th century to describe obstructed labor due to disparity between the dimensions of the fetal head and maternal pelvis that preclude vaginal delivery. This term, however, originated at a time when the main indication for cesarean delivery was overt pelvic contracture due to rickets (Olah & Neilson, 1994). CPD can be due to a contracted pelvis or a disproportionately large fetal head and is thus not limited to primary cesarean delivery only [Carbone B., 2000].

In a systematic review of cesarean delivery for maternal indication, Dumont A. et al [Dumont al, 2001] found that cephalopelvic disproportion was the commonest indication, and 1.4% to 8.5% of all deliveries resulted in cesarean birth for this indication. Similarly, a large population based study in West Africa reported that 1% of all deliveries were complicated by CPD [Ould El Jouda D et al, 2001]. The proportion of all cesarean deliveries due to contracted pelvis (a sub-entity of CPD) has been reported to be between 20% in Senegal [Bouillin et al, 1994] and 37.3% in Bobo Dioulasso, Burkina Faso [Bambara et al, 2007]. Comparable trends have been reported in Senegal with mean rates of 31.3% for CPD ranging from 26% to 34.9% between 1992 and 2001 [Cissé et al, 2004; N'Gom PM et al, 2004], as well as Ethiopia (34% [Fesseha et al, 2011]). Similar high incidence rates of CPD have been reported in non sub-Saharan developing countries [Festin et al, 2009]. Our data pointed out the importance of contracted pelvis in CPD. Cephalopelvic disproportion was a major indication of cesarean delivery in our hospital from 1985 to 2003. A mean rate of 39.6% of women who delivered abdominally had some degree of CPD, ranging from 30.3% to 43.4% between 1985 and 2003. In addition, in our study contracted pelvis constituted the vast majority of all CPD (87%). 63.5% of all contracted pelvis cases were found in patients referred most commonly from poor rural settings. The high incidence rates of uterine rupture (an end stage of obstructed labor) recorded in this group may correlate with severity of pelvis contraction and confirmed the close link between referred patients during labor / delivery and need of cesarean reported elsewhere [Amelink – Verburg et al, 2009].

The cause of high rates of contracted pelvis in rural areas may be due to several factors such as genetics, increasing recognition, or the impact of resource scarcity on the female bony pelvis [Cissé et al, 2004; Kurki, 2011]. Special attention must be devoted to malnutrition in sub-Saharan Africa. Malnutrition prevalence remains unfortunately high; the proportion of the population with low daily caloric intake exceed 30% in many countries, and this trend is mirrored by the prevalence of low weight in children under five years old [USAID / West Africa professional paper series, 2008]. Consequently, prevention of obstructed labor can be achieved only through a multidisciplinary approach aimed in the short term at identifying

high-risk cases and in the long term at improving nutrition. Early motherhood should be discouraged, and efforts are needed to improve nutrition during infancy, childhood, early adulthood, and pregnancy. Improving the access to and promoting the use of reproductive and contraceptive services will also help reduce the prevalence of this complication [Konje & Ladipo, 2000].

4.5 Previous cesarean delivery

One third of our patients with a history of previous cesarean delivery were allowed a trial of labor (TOL), and the probability of successful vaginal delivery in this group was 50.1%. In our guidelines for trial of labor after cesarean birth (TOLAC), neither labor induction nor labor augmentation were permitted. No TOLAC was attempted when the number of previous cesarean delivery was >1 or in the case of a previous history of uterine rupture. These strict criteria explained our relative low rate of TOLAC.

In a meta-analysis of 963 papers, the range for TOLAC and VBAC rates was large (28-82 percent and 49-87 percent, respectively). Predictors of women having a TOL were having a prior vaginal delivery and settings of higher-level care, namely tertiary care centers [Guise et al, 2010]. Similar findings have been reported in sub-Saharan [Boulvain et al, 1997]; the percentage of TOL ranged from 37% to 97% across reports, with probability of successful vaginal delivery of 69% (95% CI 63-75%). Maternal mortality among all women with a previous cesarean section was 1.9/1000 (95% CI 0-4.3). Uterine rupture and scar dehiscence occurred in 2.1% (95% CI 1.0-3.2). With our restrictions on VBAC, we recorded fewer vaginal deliveries, but also less uterine rupture / dehiscence, as was found in rural Zimbabwe [Spaans et al, 1997]. In settings where such cautions were not applied, higher morbidity levels were observed [Olagbuji et al., 2010, Adanu & McCarthy, 2007; Olusanya & Solanke, 2009; Sepou et al, 2003; Nwokoro et al 2003; Oboro et al, 2010; Wanyonyi & Karuga, 2010]. A large multicenter prospective study in a western country with a uniform and well organised delivery care system emphasized the greater perinatal risk associated with a trial of labor [Landon et al, 2004]. Although these findings can be a subject of debate [Greene, 2004]; they must be considered and women deserve to be well informed of the risks and benefits of TOL and VBAC [Kraemer et al, 2004]. A recent systematic review suggests that VBAC is a reasonable choice for the majority of women and found that adverse outcomes were rare for both elective repeat cesarean delivery and trial of labor [Guise JM et al., 2010a, 2010b]. The need for studies identifying patients at greatest risk is of primary importance in sub-Saharan Africa where high levels of morbidity are often reported.

Overall, in sub-Saharan Africa a selective policy of trial of labor after a previous cesarean delivery has a success rate comparable to that observed in developed countries. Vaginal birth after cesarean appears to be relatively safe and applicable in this context and contributes significantly to the global cesarean delivery rate.

4.6 Low rates of elective delivery

There are many reports emphasising on the high levels of emergency delivery in sub-Saharan hospitals and health centres [Fesseha et al, 2011; Shah et al, 2009; Wylie & Mirza, 2008; Dumont et al, 2001]. In contrast to wealthier countries, planned delivery remains an underused option in Sub-Saharan Africa [Stavrou E. P. et al, 2011]. For example, during the

two decades at Point G teaching hospital, only 212 pregnant women underwent labor induction. In many sub-Saharan African countries, labor induction is not common as necessary medications are not readily available. Before the year 2000, oxytocine was the only medication available in Mali for labor induction and was only used for very favorable cases with a Bishop cervical score ≥ 7 . Despite the lower rates of labor induction, we observe a mean rate of post-induction cesarean delivery of approximately 90% (Robson group 2). High levels of cesarean delivery following labor induction in nulliparas have been qualified as universal [Brennan et al, 2009 ; Main et al., 2006; McCarthy et al, 2007; Robson, 2001; Costa et al 2010; Yeast et al, 1999]

Unpublished data from the WHO Global Survey on Maternal and Perinatal Health, which included 373 health-care facilities in 24 countries and nearly 300 000 deliveries, showed that 9.6% of the deliveries involved labor induction. Overall, the survey found that facilities in African countries tended to have lower rates of induction of labor (lowest: Niger, 1.4%) compared with Asian and Latin American countries (highest: Sri Lanka, 35.5%) [WHO, 2010].

One point is that many indications of labor induction are associated with preterm delivery. The lack of neonatal resuscitation facilities [Hofmeyr et al, 2009] and the poor outcomes of preterm neonates lead many sub-saharan obstetric teams to avoid preterm labor induction or preterm elective cesarean delivery. Even in hospitals, staffs are frequently not trained in resuscitation and equipment is not available. A national service provision assessments in 6 African countries demonstrated that only 2%–12% of personnel conducting births had been trained in neonatal resuscitation and only 8%–22% of facilities had equipment for newborn respiratory support [Wall et al, 2009]. This important gap certainly impacts clinical decision making in Sub-Saharan obstetric units.

Therefore, it is a challenge for healthcare workers and policymakers dealing with pregnancy management in developing countries to examine critically ways to increase percentage of planned delivery. This challenge can be met firstly with preventive measures at a public health level (e.g. counselling and education), at the pregnant women's level (e.g. improved utilisation of the antenatal care services), and at the caregiver's level (e.g. better selection of cases in order improve the percentage of pregnant referred without emergency, an overt contracted pelvis mustn't begin labor at the level of primary care where obstetric surgery is not available).

5. Conclusion

From 1985 to 2003, cesarean delivery rates at Point G National Hospital increased substantially. Most of the increase in cesarean delivery rates is explained by higher proportions of outside referrals, cephalopelvic disproportion, and history of previous cesarean delivery. The increased cesarean delivery rate cannot, however, be fully explained by these factors or other characteristics collected by this study, and is likely the multifactorial impact of psychosocial determinants of healthcare utilization and systemic problems of healthcare delivery. These variables are beyond the scope of this study. Future ecological studies addressing clinical, financial, and geographical considerations as well as cultural acceptability of cesarean delivery are needed. Since emergency referrals for caesarean during delivery significantly worsen the maternal and fetal prognosis, more

widespread access to facilities capable of performing caesarean sections as well as earlier referrals of high risk pregnancies from primary health centers before the onset of complications would likely lead to substantial improvements in maternal and neonatal outcomes. A holistic need assessment will govern improved healthcare delivery strategies and aid progress towards meeting the millennium development goals in developing countries.

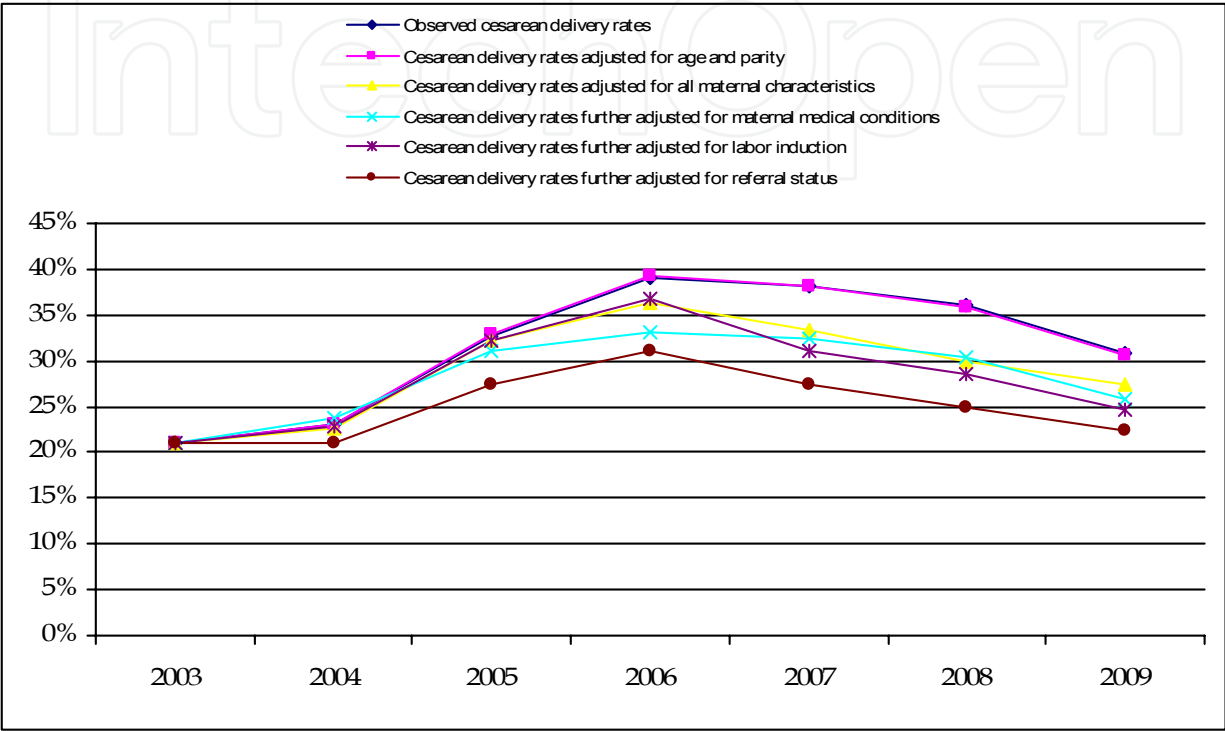


Fig. 9. Observed rates of cesarean delivery and adjusted rates after sequentially adjusting for age, parity, maternal conditions, obstetric practice and referral status (Teguate I. et al, 2010b).

6. Acknowledgments

To Evan and Lauren Oreinstein, for their valuable contribution to this work.

To all the medical students who participated in the Point G obstetric database completion: Seydou Traore, Sekou Coulibaly, Marie Lea Dakouo, Aïssata Nene Bah, Seydou Fané, Amadou Fomba, Adama Diarra, Nouhoum Camara, Yakouni dite Hawa Dougnon, Sandrine Eyoko.

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Cesarean Delivery

Edited by Dr. Raed Salim

ISBN 978-953-51-0638-8

Hard cover, 200 pages

Publisher InTech

Published online 23, May, 2012

Published in print edition May, 2012

This book provides broad, science-based information regarding the most common major surgical procedure performed, i.e. Cesarean Delivery. The book provides relevant scientific literature regarding epidemiology and rates of cesarean delivery in low and high income countries and the impact of the disparities in the rate of cesarean delivery between countries. In addition, the book systematically reviews the relevant scientific literature regarding all perioperative considerations with a broad cover of anesthetic techniques, drugs and difficulties that anesthesiologists may encounter during cesarean delivery. Care of the neonate after cesarean and crucial guidelines for obese women undergoing cesarean are also provided. The book was written by distinguished experts from different disciplines to ensure complete and accurate coverage of the recent scientific and clinical advances and to bring care providers and purchasers up to date including essential information to help improve health care quality.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

I. Teguede, Y. Traore, A. Sissoko, M. Y. Djire, A. Thera, T. Dolo, N. Mounkoro, M. Traore and A. Dolo (2012). Determining Factors of Cesarean Delivery Trends in Developing Countries: Lessons from Point G National Hospital (Bamako - Mali), Cesarean Delivery, Dr. Raed Salim (Ed.), ISBN: 978-953-51-0638-8, InTech, Available from: <http://www.intechopen.com/books/cesarean-delivery/determining-factors-of-cesarean-delivery-trends-in-developing-countries-lessons-from-point-g-nat>

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