Costs-effectiveness Analysis of Elective Cesarean Section Compared with Vaginal Delivery: a prospective cohort study in a hospital in León, Nicaragua

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Abstract

Background
There is an increasing rate of cesarean section globally. Both low and high cesarean section rates are associated with maternal and neonatal mortality and morbidities. In Nicaragua, the rate of cesarean section is beyond the WHO recommendation of 10% to 15%.

Aim
The aim of this study was to evaluate the costs-effectiveness of elective caesarean section when compared with vaginal delivery in hospital in Nicaragua, a lower-middle income setting.

Methods
A 3 months prospective cohort study was conducted in a hospital in León, Nicaragua, from 1st May 2010 to 31st July 2010. Two questionnaires were used to obtain data, one on costs and maternal complications after delivery, and the other on postpartum complications. A descriptive analysis regarding maternal and neonatal outcomes, and a cost-effectiveness analysis were conducted comparing elective cesarean section with vaginal delivery, followed by a sensitivity analysis regarding change on rates of elective cesarean section.

Results
The cesarean section rate was 37.9%, and the elective cesarean section rate was 21%. The percentage of live births was 99.6% in elective cesarean section group and 98.9% in vaginal delivery group. Cesarean section had both positive and negative influences on maternal complications and postpartum complications. The costs of elective cesarean section was higher than vaginal delivery ($66 compared to $39.36). For one more live birth, 3805.71 US dollars were needed.

Conclusion
The maternal outcomes of cesarean section need to be improved. With the increasing cesarean section rates, more medical resources are needed in the future.
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Abbreviations

ICU: intensive care unit
WHO: world Health Organization
GDP: gross domestic product
ICER: incremental cost-effectiveness ratio
HALE: health-adjusted life expectancy
QALY: quality-adjusted life years
TOLAC: trial of labor after previous cesarean section
ERCD: elective repeat cesarean delivery
HEODRA: the University Hospital of León
SIP: Sistema Informatico Perinatal, Perinatal Information System
VD: vaginal delivery
CS: cesarean section
US: United States
PAHO: the ministry of Health in Nicaragua
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1. Background

1.1. Cesarean section and its complications

Cesarean section is a surgical procedure in which one or more incisions are made through a mother’s abdomen and uterus to deliver one or more babies (1). A cesarean section is performed when there is medical indication that the health of the mother or the baby is at risk if a vaginal delivery is performed. Without medical indication, a cesarean section could also be performed under maternal requests. Common medical indications for a cesarean section includes abnormal presentation, fetal distress, cord prolapse, uterine rupture, failed labor induction, large baby weighing, preeclampsia, and previous cesarean section (1). An elective cesarean section refers to the cesarean section that planned in advance, no matter it is out of medical reasons or it is under maternal requests. The cesarean section without plan is emergency cesarean section.

On one hand, cesarean section could save the mother or baby at risk; on the other hand, it could also lead to some maternal complications, such as puerperal febrile, wound infection, endometritis, and urinary tract infection (2). A worldwide study which included 24 countries and 373 health facilities found that compared with vaginal delivery, elective cesarean section without medical indication was associated with increased risk of maternal complications, such as maternal death, admission to intensive care unit (ICU), blood transfusion, and hysterectomy (3). Another study examined maternal complications after different mode of delivery, and found that compared with spontaneous vaginal delivery, cesarean section was associated with higher risks of endometritis, pneumonia, and the need of blood transfusion (4). A cohort study in Latin America found that cesarean section had increased the risk of severe maternal morbidity, as well as the risk of antibiotic treatment after delivery (5). However, the same study also found that cesarean section had a protective effect of fetal death for both cephalic presentation and breech presentation, while it also associated with increased risk of
neonatal intensive care (5). In addition, cesarean section could also increase the risk of abnormal presentation in subsequent pregnancies, which could lead to placenta accrete and cesarean scar pregnancies (6).

Besides maternal complications during and after delivery, cesarean section could be also associated with neonatal outcomes. Evidences showed that cesarean section is positively associated with risk of neonatal respiratory morbidity (7). Some data also showed that cesarean section could increase the risk of lacerations while it decreased the possibility of central and peripheral nervous system injury (8). For ongoing pregnancy, elective cesarean section resulted in higher neonatal mortality and in lower risk of fetal demise (8).

From the population point of view, low cesarean section rates were associated with increased maternal and neonatal mortality and morbidity, while high cesarean section rates also raised same concerns (9). Many studies have been conducted to assess the outcomes of cesarean section. From the WHO Global Survey on maternal and perinatal health, the cesarean section rates in Latin America was 33%, and was positively associated with severe maternal morbidity and mortality (10); while the cesarean section rates in Africa was 8.8%, and the adjusted elective cesarean section rates was associated with fewer perinatal deaths (11). Evidences also showed that cesarean section increased the risk of asthma (12), and was associated with offspring overweight and obesity (13).

1.2. Global trends and WHO recommendations

Differences in cesarean section rates exist among countries. A study showed that in 2008, 54 out of 137 countries had cesarean section rates below 10%, while 69 countries had cesarean section rates above 15% (14). Despite the differences among areas, the rates of cesarean section have increased globally in recent decades. The cesarean section rate in Canada was 18.0% in 1994/95, and it increased to 22.1% in 2000/01 (15). In Australia, the cesarean section rate has increased from 19.1% to 29.5% during 1998
to 2008 (16). In East Africa, cesarean section rates increased from 29.9% to 35.5% during 2005 to 2010 (17). The cesarean section rates reached 27.3% in 2007/08 in Asia (18). In India, cesarean section rate was 171.1 per 1 000 live births in 2001, and it increased to 289.3 per 1 000 live births in 2011 (19).

Regarding cesarean section, the World Health Organization (WHO) recommended that it should only be performed when there is medical indication. WHO also proposed that in order to avoid maternal deaths and improve maternal and neonatal outcomes, the ideal rates of cesarean section is 10% to 15% (20). However, in the year of 2008, only 10% of countries had the cesarean section rates of 10-15%; 24% of countries had cesarean section rates less than 5%, and 50% of countries had cesarean section rates more than 15% (14).

1.3. Situation in Nicaragua

The republic of Nicaragua locates in the Central American isthmus, occupies a land of 130,967 km², with a population of 6 million (21). Nicaragua was classified by the World Bank as lower middle income country, with a gross domestic product (GDP) of 11.81 billion US dollars in 2014 (22).

The public health expenditure in Nicaragua was the highest among its neighboring countries in Central America, in 2000, the public health expenditure was 6.8% of the GDP (23). The health sector in Nicaragua has made significant progress in the past decade, there were gradual but steady improvements in access to clean water, life expectancy, infant and child mortality, immunization rates, and child nutrition (23). However, inequity existed in different socio-economic groups, and in different regions. Despite the access of health care, lack of risk mitigation mechanism such as insurance and social security, leading to high burden of out of pocket money to the users, especially for medications and non-consultation items such as medical tests (23).
In order to promote the decentralization of health service delivery, the Ministry of Health in Nicaragua established a 10-year national health plan in 2004. The goal of the decentralization of health service delivery is to improve the access to health care among the poor and vulnerable groups, especially in maternal and child health care. This plan empowered the local health providers with decision making authority in resource management and allocation (23).

The fertility rate in Nicaragua was 2.5 per woman in 2013 (24). In 2015, the neonatal mortality rate in Nicaragua was 9.8 per 1 000 live births, and the maternal mortality ratio was 150 per 100 000 live births (24). The data in 2001 showed that about 1 out of every 3 children born in Nicaragua was unwanted or not planned; and data in 2004 showed that about 117 of every 1 000 young women between 15 to 19 years old in Nicaragua had at least one child, although it has declined from 142 in 1997 to 117 in 2004, this indicator was the highest in all Latin American countries (23).

With the purpose of achieving the Millennium Development Goal 5, to reducing the maternal mortality by 75% compared with the level in 1990, Nicaragua focused on spreading skilled attendants and institutionalized delivery. Brigadistas (community health workers) and parteras (traditional birth attendants) performed as the link between patients and the hospitals, they identified the pregnant women and advocated them to have an institutional delivery (25). Although the share of delivery attended by trained personnel in Nicaragua is slightly above Latin American standards, there were large disparities across socio-economic groups and regions: 95% of all deliveries in the richest quintile were attended by a trained doctor, while the equivalent rate was only 56% among poor women (23). The cesarean section rate was estimated to be 29.7% in Nicaragua in 2011-12 (26), far above the WHO recommended rate of cesarean section.

1.4. Health economics

Health economics is a branch of economics concerned with issues related to efficiency,
effectiveness, value and behavior in the production and consumption of health and healthcare (27). Microeconomic evaluation is one of the focus of health economics, it refers to the comparison of two or more alternative choices in terms of the costs and outcomes (28). Four types of economic evaluations are commonly used in the health economic analysis, they are: cost-minimization analysis, cost-benefit analysis, cost-effectiveness analysis, and cost-utility analysis. The cost-minimization analysis compared the costs of alternatives when their outcomes are at similar level. The goals of the alternatives are the same, and the lower the costs the better. In cost-benefit analysis, all costs and outcomes are measured and valued in cash terms, and thus provide a direct comparison between costs and outcomes for each alternative. In cost-effectiveness analysis, outcomes are measured in their natural units, such as mmHg, number of heart failure, days of hospitalization, and life years gained. The cost-utility analysis measures outcomes in quality-adjusted life years (QALY), where all kind of illness and inconvenience are measured as loss of quality-adjusted life years (28).

Each of the four types of economic evaluations have strengths and limitations. The cost-minimization analysis could only be used to compare alternatives with same level outcomes, and it emphasis on the low costs. When two alternative have big differences in the outcomes, or when the improvement in outcomes is the key consideration of stakeholders rather than the low costs, it is not proper to use the cost-minimization analysis. In cost-benefit analysis, there is a direct comparison of the input (costs) and output (outcomes) in cash terms, as well as a comparison between alternatives. It can also be conducted when there is no alternative. However, not all the outcomes could easily converted into cash terms, especially for life saving interventions. The cost-effectiveness analysis emphasis on how much resources needed in order to achieve a certain outcome. However, for one intervention or treatment, there are always more than one outcomes. For two alternatives, one may have better cost-effectiveness in one outcome, and the other may be better in another outcome. So it could be hard to compare two alternatives when there are more than one outcomes. The cost-utility analysis is a
specific cost-effectiveness analysis. The use of quality-adjusted life years (QALY) could sum up the effects in several outcomes. However, the calculation of quality-adjusted life years is complex and based on hypothesis, as it is difficult to decide or assume that a certain illness equals to the reduction of how many healthy life years.

1.5. Cost-effectiveness analysis and ICER

In cost-effectiveness analysis, there is usually a cost analysis first. According to different perspective, cost analysis containing different components. A cost analysis from society perspective means that all costs related to the intervention or treatment are included in the analysis, containing direct costs and indirect costs. Direct costs means the resources used by a patient or participant, such as medicine costs, material costs, and staff costs, as well as hotel and transportation costs which was incurred because the participants take part in an intervention or receive a treatment. The indirect costs means the loss of value due to the fact that people with illness or patient who accept a certain treatment might not be able to work in a certain period, or not be able to enjoy their life. For example the productivity loss due to hospitalization, or the loss of leisure time due to taking care of a family member who is ill. In cost analysis from society perspective, all costs are put at the same place regardless of who pays for it, since all costs are consumption of resources or loss of resources production. However, costs from provider perspective only includes consumption of resources that provided by one or more specific providers, such as perspective from insurance company or perspective from health system.

The outcome analysis in cost-effectiveness analysis could vary a lot according to different subjects of the studies. The outcome could be the mortality if it is a lifesaving intervention, it could also be the incidence disease if it is a preventing intervention. Usually, there are more than one simple outcomes for one intervention, in that case, several outcomes could be analyzed. Several outcomes could be analyzed separately,
or it could be also combined together using questionnaires or scales. Quality-adjusted life years (QALY) and health-adjusted life expectancy (HALE) are two example of tools that could combine several outcomes into one variable.

The incremental cost-effectiveness ratio (ICER) is used to summarize the cost-effectiveness of an alternative choice compared with another. It defined by the differences in costs between two alternatives, divided by the differences in outcomes between the two alternatives (29). ICER means how much more costs needed in order to achieve one unit of progress in outcome. For example, how much US dollar is needed in order to prevent one case of malnutrition by providing free milk at schools. A small ICER means good cost-effectiveness of one alternative compared with another, the former one either has very low costs or good outcomes compared with the later, or both; while a big ICER may due to big differences in cost or close effectiveness of the two alternatives in comparison. When one alternative costs less and lead to better outcomes than another, it is described as this alternative dominates the other.

There is often a sensitivity analysis in the end of a cost-effectiveness analysis. Cost-effectiveness analysis is usually based on assumptions. For different study design, there could be more and less assumptions. The most common assumptions are for example the price of a drug as a part of the costs, and the prevalence of a disease if a model is set up to simulate the situation. Assumptions are inaccurate and thus introduces uncertainty to the cost-effectiveness analysis, and a sensitivity analysis is used to measure and evaluate the uncertainty. There are three sources of uncertainty: the parameter uncertainty, the structural or model uncertainty, and the methodological uncertainty (30). The parameter uncertainty emerges when the numerical values of the parameter are from external inputs, for example the unit costs, or using averages without adjustment in the calculation of incremental cost-effectiveness ratio (ICER); the structural or model uncertainty are introduced when combining parameters according to the model chose; the methodological uncertainty is the uncertainty
between different study designs (30). A sensitivity analysis is performed to show how the change of one or several variables affected the results, and thus show how the result could change if one or more assumptions change.

1.6. Previous health economics studies on cesarean section

Although many researchers had the same concerns on cesarean section, the previous study on cost-effectiveness of cesarean section varied regarding study design, component of costs that included in analysis, outcome variables, and study settings. Some analyses were based on the models which set up by using data from literature and government reports (31–33), while others were based on real cohort studies (34–36). The costs were analyzed from provider perspective (34), health system perspective (35), unstated perspectives with listed components (36), or based on data from literature, database, and experts (31,33). The outcomes were measured in maternal mortality and morbidity, neonatal mortality and morbidity (35,37), health-adjusted life expectancy (HALE) for mothers and newborns (34), as well as quality-adjusted life years (QALY) (32,33).

A cost analysis conducted in Texas in 2000-01, showed that compared with elective cesarean section, attempted vaginal delivery without Pitocin or epidural anesthesia had a 15.1% lower costs among nulliparous, and a 20% lower costs among multiparous. However, if Pitocin and epidural anesthesia were used, the costs of attempted vaginal delivery exceeded the costs of elective cesarean section. Moreover, failed attempt at vaginal delivery leaded to much higher costs than elective cesarean section (38). One 18-year population-based cohort study, using Nova Scotia Atlee Perinatal Database, analyzed the costs for nulliparous women who experienced different mode of delivery. The costs constituted of physician fees, nursing hours in labor and delivery, postpartum and neonatal Intensive Care Unit, epidural use, induction of labor agents, and consumables. The results showed that the average costs per spontaneous vaginal
delivery was 1340 US dollars, and costs per assisted vaginal delivery was 1594 US dollars; while for cesarean section without labor, the cost was 1532 US dollars, and for cesarean section with labor, 2137 US dollars (36). These two studies presented the same result that a cesarean section after labor, or a failed labor followed by a cesarean section led to much higher costs than other modes of delivery.

A cost-effectiveness analysis in Serbia took successful delivery as the outcome, and emergency cesarean section as complication, finding that the risks of complication were much higher in vaginal labor than in induced vaginal labor (OR=17, 95% CI: 8 to 35), and that induced vaginal labor had the lowest cost of 461 Euro with effectiveness of 98.17% (39). Two other studies concerned the cost-effectiveness of maternal request cesarean section, and showed the adverse results. Both of the two studies were based on models, and took quality-adjusted life years (QALY) as the outcome measurement. One showed maternal request cesarean section had a probability of 82% to be cost-effective when compared with vaginal delivery (32), while the other study showed that trial of labor dominated maternal request cesarean section (33).

One cost-effectiveness analysis of cesarean section was conducted in the Democratic Republic of Congo in 2008, in a post-conflict environment. The cost was estimated to be 103.514 US dollars per cesarean section, from the perspective of service provider. The health-adjusted life expectancy (HALE) was used to measure both the maternal and newborn outcomes. The results showed that the cost per HALE gained was 3.8~9.2 US dollars (34).

In 2009, another study in Burkina Faso examined the cost-effectiveness of cesarean section conducted by clinical officers, general practitioners, and obstetricians. The costs was calculated from health system perspective, and newborn fatality rate was taken as the outcome variable. Cesarean section conducted by obstetricians had the lowest newborn fatality rate, while the cesarean section conducted by clinical officers resulted
in highest newborn fatality rate. The incremental cost ratio (ICER) was 11,757 international dollar per newborn death avoided comparing obstetric group and general practitioner group, while the ICER for general practitioner group compared with clinical officer group was 200 international dollar per newborn death avoided (35). The high ICER was caused by the almost same level newborn fatality rate in obstetrician group and general practitioner group, and the low ICER was because of the big differences in newborn fatality rate in general practitioner group and clinical officer group. Comparing the two ICER, cesarean section conducted by general practitioner was the most cost-effective strategy and thus the following training of medical staff should focus on the training of general practitioners (35).

Other studies comparing cesarean section with vaginal delivery under selected clinical contexts. One study targeted breech presentation, and results showed that cesarean section had significantly lower risks in perinatal mortality, neonatal mortality, and serious neonatal morbidity than vaginal delivery (37). Some studies focused on mother to child HIV transmission, and the results showed that cesarean section was cost-effective compared with vaginal delivery among HIV infected women, but the cost-effectiveness was sensitive to vertical transmission rates (40–42). Another study targeting women infected with hepatitis C virus, also found that the cost-effectiveness of elective cesarean section was highly depend on mother to child transmission rate (43).

Besides the studies on cost-effectiveness of cesarean section compared with vaginal delivery, recent studies in United States concerned about the cost-effectiveness of trial of labor after previous cesarean section (TOLAC) compared with elective repeat cesarean delivery (ERCD). Took into consideration the maternal and neonatal mortality and morbidity and converted into quality-adjusted life years (QALY), the results showed that TOLAC dominated ERCD with less costs and more QALY gained (44) (45) (46).
1.7. Rationale for this study

Take into consideration the relatively high public health expenditure in Nicaragua when compared with other Latin American countries, as well as the high burden of high out of pocket money in Nicaragua, it is important to adopt cost-effectiveness interventions for Nicaragua to promote the utility of health care and increase the affordability of health services. As Nicaragua has made institutional delivery of newborn the key strategy to reduce maternal and child mortality, it is reasonable to evaluate the cost-effectiveness of different mode of delivery in hospitals of Nicaragua.

No previous studies on the cost-effectiveness of cesarean section compared with vaginal delivery were conducted in Nicaragua. In lower-middle income settings, caesarean sections could increase the risk of maternal and postpartum complications due to the limited resources available, the access to the health care, and the affordability of health services. The costs of cesarean section and vaginal delivery could also vary in a lower-middle income country compared with high income countries. Considering the increased rates of cesarean section in Nicaragua, it is important to assess the cost-effectiveness of caesarean sections compared with vaginal delivery.

1.8. Aim and objectives

The aim of this thesis is to evaluate the costs-effectiveness of elective caesarean section when compared with vaginal delivery in hospital in León, Nicaragua, a lower middle income country.

The specific objectives of this study are:

1) To estimate the rate of cesarean section in hospital in León, Nicaragua;
2) To describe the newborn and maternal outcomes by different modes of delivery in hospital in León, Nicaragua;
3) To evaluate the cost-effectiveness of elective cesarean section compared with vaginal delivery in hospital in León, Nicaragua;

2. Methods

2.1. Study design

A prospective cohort study was conducted at the University Hospital of León (HEODRA), in León, Nicaragua, as a part from the WHO Global Survey on Maternal and Perinatal Health. A cohort study was chosen rather than setting up a model based on the data from literatures and reports, because that there were limited data in Nicaragua regarding delivery modes as well as maternal and neonatal outcomes under each delivery modes, and that with limited data, a lot of assumptions were needed in order to set up a model. Too many assumptions may weaken the reliability and generalizability of the study. Thus, a cohort study design was used in this study.

2.2. Study setting

The republic of Nicaragua is located in the Central American isthmus, with Honduras at the North, Costa Rica at the South, the Pacific Ocean in the West, and the Caribbean Sea in the East (see Annex 1). León is located in the west of Nicaragua, close to the Pacific Ocean coast of Nicaragua (see ANNEX 2). It is the second largest city in Nicaragua, with the population of 200 thousands. León has long been the political and intellectual center of Nicaragua, as well as important industrial, agricultural, and commercial center (47).

In Nicaragua, 79% of all deliveries were conducted in facilities, and the maternal and perinatal morality were 97 per 100 000 live births and 35 per 1 000 live births
respectively (10). In León, about 6 000 mothers deliver at the University Hospital of León (HEODRA) annually, which account for 60% of all parturient in the catchment area. Among the other parturient, half of them delivers at private clinics, and half of them at home. The cesarean section rate is about 40% in hospital, and 80% in private clinics (48).

2.3. Study population and data collection

Participants were recruited at the obstetrical department in the University Hospital of León (HEODRA). All women who delivered at HEODRA within a three months period (from 1st May 2010 to 31st July 2010), were included in this study.

Two questionnaires were used in the study to obtain data, both of them were originally in French, the local language, and then translated into English during the data analyses. The delivery questionnaire was a part of the WHO Global Survey on Maternal and Perinatal Health, containing information on delivery mode, maternal complications after delivery, neonatal states, and the costs that related to the delivery. As a part of the WHO Global Survey on Maternal and Perinatal Health, The SIP (Sistema Infomatico Perinatal, Perinatal information system) data collection at HEODRA has been integrated in the hospital routines since 2004.

The postpartum questionnaire was answered 3 months after the delivery, containing information on postpartum complications and recovery. A total of 964 participants (84.5%) who gave births at HEODRA during the study period (1st of May 2010 to 31st July 2010) were followed 3 months after the delivery. Figure 1 showed the procedure of the data collection.

Figure 1. Flow-chart of data collection
2.4. Data analysis

Three analyses have been conducted, they were: descriptive analysis, cost-effectiveness analysis, and sensitivity analysis. Microsoft Excel 2013 and R 3.2.2 were used as tools for statistical analysis in this study. Excel was used in descriptive analysis, cost-effectiveness analysis, and sensitivity analysis, regarding the count of cases, the calculation of percentages, the calculation of average costs, and the calculation of incremental cost-effectiveness ratio (ICER). R 3.2.2 was used in the descriptive analysis to exam the statistical significance of the differences in maternal and newborn outcomes between groups.

2.4.1. Descriptive analysis

A background description of the sample was conducted firstly, regarding the demographic, socio-economic, and pregnancy related variables. The demographic variables including age and height of the pregnant women. All pregnant women were classified into 3 age groups: below 20 years old, from 20 to 34 years old, and above 34
years old. Three height groups were used in this study: below 145 cm, from 145 cm to 150 cm, and beyond 150 cm. The socio-economic variable was poverty index, which consisted of three levels: not poor, poor, and extremely poor. The poverty index was based on the living condition (walls of household, water source and sewage elimination, electricity, number of bedrooms), number of family members, and total family income. The pregnancy related variables included number of prenatal visits and pregnancy complications. The number of prenatal visits varied from 0 to 3 times. A total of 15 pregnancy complications were included in the questionnaire and then analyzed, they are: premature rupture of membranes, pregnancy induced hypertension, chronic hypertension, preeclampsia, eclampsia, cardiac or renal disease, chronic respiratory insufficiency, diabetes, malaria, megaloblastic anemia, severe anemia, vaginal blood, urinary tract infection, and ulcerative genital disease. Number of participants that belong to each age groups, height groups, poverty levels, and had different times of prenatal visits, as well as participants suffered from each pregnancy complications were counted and then the percentages were calculated.

Then, the numbers of participants that went through different way of delivery were counted, including spontaneous vaginal delivery, elective cesarean section, emergency cesarean section, and intra partum emergency cesarean section. All participants were then grouped according to their way of delivery, which were vaginal delivery (VD), elective cesarean section (Elective CS), and all cesarean section (All CS).

Next, the maternal and newborn outcomes were analyzed for VD, Elective CS, and All CS group separately. Newborn outcomes referred to whether it was a live birth or not. Maternal outcomes consisted of two components: maternal complications and postpartum complications. Maternal complications included blood transfusion, 3rd or 4th degree tearing, admission to intensive care unit, and urinary tract infection. Postpartum complications included fever, wound infection, urinary tract infection, and thrombosis.
For each maternal and newborn outcome variable, Pearson’s Chi-square test was used to exam whether the differences were statistically significant when compared with vaginal delivery group. Fisher’s exact test was used when the number of cases were less than 5. The differences were considered statistically significant when p value was less than 0.05.

2.4.2. Cost-effectiveness analysis

To begin a cost-effectiveness analysis, a cost analysis was conducted. The cost analysis in this study was conducted from a society perspective, all costs related to the delivery were included, regardless of who paid for it. The costs constituted of medicine costs, blood transfusion costs, material costs, laboratory costs, hotel costs, personnel costs, and pocket costs. The productivity loss was excluded as it might be not proper o assume that all women at reproductive age were employed, in addition to that, no data of the average salary of woman in different age groups in Nicaragua was available. The average costs of vaginal delivery group, elective cesarean section group and all cesarean section group was calculated in Cordoba, the local currency, and then converted into US dollars, according to the exchange rate in 2010 (1 US dollar equals to 22 Cordoba).

A cost-effectiveness analysis was then conducted comparing vaginal delivery group and elective cesarean section group. The incremental cost effectiveness ratio (ICER) was then calculated for each of the maternal and newborn outcomes which showed better results in elective cesarean section group than in vaginal delivery group. ICER showed how much costs were needed in order to achieve one unit progress in each outcomes, for example how much US dollars were needed in order to avoid one case of postpartum fever.
2.4.3. Sensitivity analysis

A sensitivity analysis was conducted later, in order to provide an overview of the total costs and outcomes under different cesarean section rates. The assumed cesarean section rate varied among 5%, 10%, 15%, 20%, 30%, 40%, 50%, and 60%, and the assumed total population was 6,000, in accordance with the annual deliveries at the University Hospital of León (HEODRA). The total costs were then calculated under each assumed cesarean section rates, with the data of average costs of each mode of delivery from this study. The live birth rate was also calculated with each assumed cesarean section rates. The total number of cases were then counted for each assumed cesarean section rates for the 4 kinds of maternal complications: blood transfusion, 3rd or 4th degree tearing, admission to intensive care unit, and urinary tract infection; as well as 4 kinds of postpartum complications: fever, wound infection, urinary tract infection, and thrombosis.

3. Ethical approvals

The prospective data collection at HEODRA hospital has been approved by PAHO, the ministry of Health in Nicaragua, and by Ethical committee of the UNAN-León.
4. Results

4.1. Description of sample, maternal and newborn outcomes

Table 1 showed the background description of the participants in this study. A total of 1141 pregnant women were included in this study, with the ages varied between 14 years old to 43 years old. Among all of the participants, 347 were younger than 20 years old, which accounted for 30.4% of the total study population. 67 participants were elder than 34 years old, which accounted for 5.9% of all participants. 727 participants had the age between 20 to 34 years old, and constituted 63.7% of the total study population.

The majority of participants were above 150 cm height (n = 884, 77.5%), 246 of them were between 145 cm to 150 cm (21.6%), and 11 were below 145 cm (1.0%). According to the living conditions and family income, 43.2% of all participants were not poor (n = 493), 42.2% were poor (n = 469), and the remaining 15.7% were extremely poor (n = 179). Participants who had 3 or 2 prenatal visits accounted for 40.8% and 41.2% of the total study population respectively (n = 465, n = 470), while participants who had 1 prenatal visit counted for 13.2% (n = 151), and the other 4.8% of participants had no prenatal visits (n = 55).

Number of cases as well as proportions of pregnancy complications were also presented in table 1 below. The most common pregnancy complication was urinary tract infection, a total of 508 participants (44.5%) had experienced it. There were 107 participants (9.4%) had premature rupture of membranes, 41 participants (3.6%) had pregnancy induced hypertension, and 36 participants (3.2%) had preeclampsia. Some pregnancy complications were less prevalent, including genital warts (n = 15, 1.3%), severe anemia (n = 12, 1.1%), chronic hypertension (n = 11, 1.0%). Other pregnancy complications such as megaloblastic anemia (n = 8, 0.7%), eclampsia (n = 6, 0.5%), diabetes (n = 4, 0.4%), Cardiac or renal disease (n = 3, 0.3%), vaginal blood (n = 3,
0.3%), and ulcerative genital disease (n = 3, 0.3%) were also found. No case of chronic respiratory insufficiency and malaria was found in this study.

Table 1. Background description of participants

<table>
<thead>
<tr>
<th></th>
<th>N=1141</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>347</td>
</tr>
<tr>
<td>20-34</td>
<td>727</td>
</tr>
<tr>
<td>&gt;34</td>
<td>67</td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;145</td>
<td>11</td>
</tr>
<tr>
<td>145-150</td>
<td>246</td>
</tr>
<tr>
<td>&gt;150</td>
<td>884</td>
</tr>
<tr>
<td><strong>Poverty</strong></td>
<td></td>
</tr>
<tr>
<td>Not poor</td>
<td>493</td>
</tr>
<tr>
<td>Poor</td>
<td>469</td>
</tr>
<tr>
<td>Extreme poor</td>
<td>179</td>
</tr>
<tr>
<td><strong>Prenatal visits</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>1</td>
<td>151</td>
</tr>
<tr>
<td>2</td>
<td>470</td>
</tr>
<tr>
<td>3</td>
<td>465</td>
</tr>
<tr>
<td><strong>Pregnancy complications</strong></td>
<td></td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>508</td>
</tr>
<tr>
<td>Premature rupture of membranes</td>
<td>107</td>
</tr>
<tr>
<td>Pregnancy induced hypertension</td>
<td>41</td>
</tr>
<tr>
<td>Preeclampsia</td>
<td>36</td>
</tr>
<tr>
<td>Genital warts</td>
<td>15</td>
</tr>
<tr>
<td>Severe anemia</td>
<td>12</td>
</tr>
<tr>
<td>Chronic hypertension</td>
<td>11</td>
</tr>
<tr>
<td>Megaloblastic anemia</td>
<td>8</td>
</tr>
<tr>
<td>Eclampsia</td>
<td>6</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4</td>
</tr>
<tr>
<td>Cardiac or renal disease</td>
<td>3</td>
</tr>
<tr>
<td>Vaginal blood</td>
<td>3</td>
</tr>
<tr>
<td>Ulcerative genital disease</td>
<td>3</td>
</tr>
</tbody>
</table>

*no chronic respiratory insufficiency and malaria was found in this study

Table 2 showed different modes of deliveries that all participants went through in this
study. A total of 708 out of 1141 participants experienced vaginal delivery, which accounted for more than 60%. About 21% of participants went through elective cesarean section, and 13% and 3.9% of participants had emergency cesarean section and intra partum emergency cesarean section respectively.

Table 2. Modes of delivery

<table>
<thead>
<tr>
<th>Way of delivery</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous vaginal delivery</td>
<td>708</td>
<td>62.1</td>
</tr>
<tr>
<td>Elective cesarean section</td>
<td>240</td>
<td>21.0</td>
</tr>
<tr>
<td>Emergency cesarean section</td>
<td>148</td>
<td>13.0</td>
</tr>
<tr>
<td>Intra partum emergency cesarean section</td>
<td>45</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Four kinds of maternal complications were analyzed and presented in table 3 below, they were: blood transfusion, 3rd or 4th degree tearing, admission to intensive care unit (ICU), and urinary tract infection. Compared with vaginal delivery group, elective cesarean section group had a lower proportion of participants that needed blood transfusion (VD: 3.0%, elective CS: 2.5%); the proportion increased to 4.2% when included emergency cesarean section. Only 2 cases of 3rd or 4th degree tearing were found in vaginal delivery group, 1 case founded in elective cesarean section group, and 3 cases in all cesarean section group. No participant was admitted to intensive care unit in elective cesarean section group, and only 1 participant in vaginal delivery was admitted to intensive care unit; while a total of 6 participants were admitted to intensive care unit in all cesarean section group. 1.1% of participants in vaginal delivery group had urinary tract infection, while 5.4% of participants of elective cesarean section group had it, and the all cesarean section group had a similar level (5.3%). The differences regarding urinary tract infection between elective cesarean section group and vaginal delivery group were statistically significant, so was the differences in urinary tract infection between all cesarean section group and vaginal delivery group. The differences in admission to intensive care unit between all cesarean section group and
vaginal delivery group was also statistically significant. All the other differences were not statistically significant.

Table 3. Maternal complications

<table>
<thead>
<tr>
<th>Maternal complications</th>
<th>VD (N=708)</th>
<th>Elective CS (N=240)</th>
<th>All CS (N=433)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>21</td>
<td>3.0</td>
<td>6</td>
</tr>
<tr>
<td>3rd or 4th degree</td>
<td>2</td>
<td>0.3</td>
<td>1</td>
</tr>
<tr>
<td>tearing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admitted to ICU</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>8</td>
<td>1.1</td>
<td>13*</td>
</tr>
</tbody>
</table>

*p value<0.05, compared with vaginal delivery group

A total of 964 participants has answered the postpartum complications questionnaire, including 597 participants who had experienced vaginal delivery, 197 participants who had had elective cesarean section, and other 170 participants who had emergency cesarean section or intra partum emergency cesarean section. 177 participants were lost in the follow up. The follow up rate was 84.5%. Table 4 showed the results of postpartum complications.

Participants in elective cesarean section group and all cesarean section group had lower percentages of postpartum fever (5.1% and 5.7% respectively) than the vaginal delivery group (7.9%); while they had higher percentages of wound infection (2.5% and 1.9% respectively) when compared with vaginal delivery group (0.7%). Participants who experienced urinary tract infection accounted for 6.5% in vaginal delivery group, 4.1% in elective cesarean section group, and 6.8% in all cesarean section group. Only 1 case of thrombosis founded. All the differences regarding postpartum complications between elective cesarean section group and vaginal delivery group, and between all cesarean section group and vaginal delivery group were not statistically significant.
Table 4. Postpartum complications

<table>
<thead>
<tr>
<th></th>
<th>VD (N=597)</th>
<th>Elective CS (N=197)</th>
<th>All CS (N=367)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Postpartum complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td>47</td>
<td>7.9</td>
<td>10</td>
</tr>
<tr>
<td>Wound infection</td>
<td>4</td>
<td>0.7</td>
<td>5</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>39</td>
<td>6.5</td>
<td>8</td>
</tr>
<tr>
<td>Thrombosis</td>
<td>1</td>
<td>0.2</td>
<td>0</td>
</tr>
</tbody>
</table>

*no statistically significant differences found

Table 5 showed the neonatal outcomes in this study. For all the delivery in this study, the live birth rate was 99.2% (n = 1132). For the newborns in each group, the live births rate were 98.9% in vaginal delivery group (n = 700), 99.6% in elective cesarean section group (n = 239), and 99.8% in all cesarean section group (n = 432). Only 1 case stillbirth was found in elective cesarean section (0.4%), while 8 cases of stillbirth were found in vaginal delivery group (1.1%).

Table 5. Newborn states

<table>
<thead>
<tr>
<th></th>
<th>VD (N=708)</th>
<th>Elective CS (N=240)</th>
<th>All CS (N=433)</th>
<th>Total (N=1141)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Newborn states</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live birth</td>
<td>700</td>
<td>98.9</td>
<td>239</td>
<td>99.6</td>
</tr>
<tr>
<td>Stillbirth</td>
<td>8</td>
<td>1.1</td>
<td>1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

4.2. Cost-effectiveness of elective cesarean section compared to vaginal delivery

Table 6 presented the average costs of vaginal delivery group, elective cesarean section group, and all cesarean section group. Compared with vaginal delivery, elective cesarean section led to a much higher medicines costs (277.65 Cordoba compared
to 85.85 Cordoba), hotel costs (385.95 Cordoba compared to 228.36 Cordoba), and out of pocket costs (231.57 Cordoba compared to 136.88 Cordoba), and also slightly higher costs in materials costs (221.72 Cordoba compared with 156.59 Cordoba) and personnel costs (191.42 Cordoba compared with 117.93 Cordoba). The costs in lab and blood transfusion were at similar level for all three groups. When including emergency cesarean section, all costs increased a little bit compared with elective cesarean section, with the hotel costs and personnel costs increased the most. In total, the average costs was 865.86 Cordoba (39.36 US dollars) for vaginal delivery, 1451.61 Cordoba (65.98 US dollars) for elective cesarean section, and 1604.48 Cordoba (72.93 US dollars) for all cesarean section.

Table 6. Average costs

<table>
<thead>
<tr>
<th></th>
<th>VD</th>
<th>Elective CS</th>
<th>All CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average costs</td>
<td>Medicines</td>
<td>85.85</td>
<td>277.65</td>
</tr>
<tr>
<td>(Cordoba)</td>
<td>Blood</td>
<td>9.66</td>
<td>4.93</td>
</tr>
<tr>
<td></td>
<td>Materials</td>
<td>156.59</td>
<td>221.72</td>
</tr>
<tr>
<td></td>
<td>Lab</td>
<td>130.60</td>
<td>138.38</td>
</tr>
<tr>
<td></td>
<td>Hotel</td>
<td>228.36</td>
<td>385.95</td>
</tr>
<tr>
<td></td>
<td>Personnel</td>
<td>117.93</td>
<td>191.42</td>
</tr>
<tr>
<td></td>
<td>Pocket</td>
<td>136.88</td>
<td>231.57</td>
</tr>
<tr>
<td>Total (Cordoba)</td>
<td></td>
<td>865.86</td>
<td>1451.61</td>
</tr>
<tr>
<td>Total (USD)</td>
<td></td>
<td>39.36</td>
<td>65.98</td>
</tr>
</tbody>
</table>

The ICER of elective cesarean section compared with vaginal delivery were presented in table 7. In order to assure one more live birth by adopting elective cesarean section instead of vaginal delivery, 3805.71 more US dollars are needed; to avoid one blood transfusion in the delivery process, 5328 more US dollars are needed; to avoid one ICU admission, 26640 US dollars. By spending 951.42 more US dollars, one postpartum fever could be avoid through elective cesarean section; 1110 US dollars for one postpartum urinary tract infection; and 13320 US dollars for one postpartum thrombosis.
Table 7. ICER of elective CS compared with VD

<table>
<thead>
<tr>
<th></th>
<th>ICER (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cost per live birth assured</td>
<td>3805.71</td>
</tr>
<tr>
<td>cost per blood transfusion avoid</td>
<td>5328.00</td>
</tr>
<tr>
<td>cost per ICU admission avoid</td>
<td>26640.00</td>
</tr>
<tr>
<td>cost per postpartum fever avoid</td>
<td>951.43</td>
</tr>
<tr>
<td>cost per postpartum urinary tract infection avoid</td>
<td>1110.00</td>
</tr>
<tr>
<td>cost per postpartum thrombosis avoid</td>
<td>13320.00</td>
</tr>
</tbody>
</table>

4.3. Sensitivity analysis

In sensitivity analysis, the total population was assumed to be 6000, in accordance with the annual number of delivery at HEODRA, where the data of costs and outcomes were obtained. The objective of this sensitivity analysis was the rate of cesarean section, and it varied among 5%, 10%, 15%, 20%, 30%, 40%, 50%, and 60%.

The results of the sensitivity analysis are presented in table 8. With the increase of cesarean section rates from 5% to 60%, the number of live births raised from 5937 to 5966. However, the number of cases of each maternal complications and postpartum complications also increased, except postpartum fever and thrombosis. The total costs for the 6000 delivery increased from 246 231 US dollars to 357 012 US dollars when the cesarean section rates raised from 5% to 60%.

Table 8. Sensitivity analysis

<table>
<thead>
<tr>
<th>Assumed CS rate</th>
<th>(Assumed) N=6000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Live births</td>
<td>5937</td>
</tr>
<tr>
<td>Blood Transfusion</td>
<td>184</td>
</tr>
<tr>
<td>Tearing</td>
<td>19</td>
</tr>
<tr>
<td>ICU</td>
<td>10</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>79</td>
</tr>
<tr>
<td>------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Postpartum complications</td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td>467</td>
</tr>
<tr>
<td>Wound infection</td>
<td>46</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>391</td>
</tr>
<tr>
<td>Thrombosis</td>
<td>11</td>
</tr>
<tr>
<td>Total costs (USD)</td>
<td>246231</td>
</tr>
</tbody>
</table>

5. Discussion

5.1. Key findings

In this study at HEODRA León Nicaragua, the total cesarean section rate was 37.9%, the elective cesarean rates was 21%, and the rest 62.1% was vaginal delivery. The proportion of live births was slightly higher in elective cesarean section group than in vaginal delivery group (99.6% compared to 98.9%).

Regarding maternal complications during and after delivery, cesarean section had both positive and negative influences. The occurrences of blood transfusion and admission to intensive care unit were slightly lower in elective cesarean section group when compared with vaginal delivery group (2.5% compared to 3.0%; 0.0% compared to 0.1%), while the occurrences of 3rd or 4th degree tearing and urinary tract infection were higher in elective cesarean section group than in vaginal delivery group (0.4% compared to 0.3%; 5.4% compared to 1.1%).

The postpartum complications questionnaire that answered three months after delivery
included 964 participants. Elective cesarean section also showed adverse effects on postpartum complications. The elective cesarean section group had lower proportion of postpartum fever when compared with vaginal delivery group (5.1% compared to 7.9%), and also lower proportion of urinary tract infection (4.1% compared to 6.5%), but higher proportion of wound infection (2.5% compared to 0.7%).

The total costs of elective cesarean section was 66 US dollars per delivery, while vaginal delivery cost 39.36 US dollars per delivery. Comparing elective cesarean section and vaginal delivery, the ICER (incremental cost effectiveness ratio) for one more live birth was 3805.71 US dollars.

### 5.2. Costs of cesarean section and vaginal delivery

The costs analysis was conducted from society perspective, which means that all resources used were included, regardless of who paid for it, the government, the insurance companies, or the patients. In this study, the costs constituted of medicine costs, blood transfusion costs, material costs, laboratory costs, hotel costs, personnel costs, and out of pocket costs (see table 6).

The highest costs for both elective cesarean section group and the vaginal delivery group were hotel costs (385.9 Cordoba and 228.36 Cordoba respectively). A high hotel costs implied that pregnant women need long recovery time after delivery. The higher hotel costs in elective cesarean section group than in vaginal delivery group might because of that participants who went through cesarean section stay longer at the hospital than participants who went through vaginal delivery. The biggest difference between the costs of elective cesarean section and vaginal delivery was the medicine costs (277.6 Cordoba and 85.85 Cordoba respectively). It could be explained by the fact that many medicines were needed before, during, and after a surgical operation, such as anesthetics and antibiotics. The same reason could also explain the differences
between vaginal delivery group and elective cesarean section group in material costs (221.7 Cordoba and 156.59 Cordoba respectively), and personnel costs (191.4 Cordoba and 117.93 Cordoba respectively). The only costs which was lower in elective cesarean section group than in vaginal delivery group was the blood transfusion costs (4.9 Cordoba and 9.66 Cordoba respectively). It could partially due to the fact that elective cesarean section group had lower incidence of blood transfusion than vaginal delivery group (2.5% vs. 3.0%).

When including emergency cesarean section, all costs increased. This result was in accordance with previous studies, that cesarean section after labor or failed labor followed by cesarean section was most costly (36,38). However, data in this study did not show how many of the emergency cesarean section was after a failed labor.

From the society perspective, the productivity loss due to illness or treatment should also be included. In this study, it might be not proper to assume that all women at reproductive age were employed. But the missing data on productivity loss might influence the comparison of cost-effectiveness between elective cesarean section and vaginal delivery. On one hand, women went through these two modes of delivery might had different length of hospital stay; and on the other hand, whether there was a difference in the average salary level for elective cesarean section group and vaginal delivery group remained unexamined. Both of them lead to differences in productivity loss, and thus may change the total costs. However, there was no available data showing the average salary of women in different age groups in Nicaragua. But considering the fact that all employed mothers should have maternal leave in the delivery period, the productively loss may linked with how long the maternal leave was rather than how long they could recover, and thus the differences caused by mode of delivery was very limited.

Besides, all the costs that included in this study were happened during the delivery
process, once the participants discharged from the hospital after delivery, the counting on costs stopped. So the costs due to the treatment of postpartum complications were not included. Considering the fact that the vaginal delivery group and the elective cesarean section group had different incidences of postpartum complications, the average costs of each mode of delivery could change if included the costs due to the treatment of postpartum complications. However, the average costs of each postpartum complications were not available in this study.

5.3. Outcomes of cesarean section and vaginal delivery

For newborn outcomes, the only variable in this study was neonatal mortality. The total neonatal death was 0.8% of all delivery in this study, which equal to 7.95 per 1000 live births. The neonatal mortality rate observed in this study was lower than the neonatal mortality rate of Nicaragua in 2008 from WHO database, which was 12.7 per 1000 live births (24).

The elective cesarean section group had a higher proportion of live births than the vaginal delivery group (99.6% compared to 98.9%). When including emergency cesarean section, the proportion of live births increased slightly to 99.8%, as only 1 case of neonatal death happened among all the cesarean sections, and it was an elective cesarean section.

No maternal death happened in this study, while the WHO database showed a maternal mortality rate of 150 per 100 000 live births in Nicaragua, in 2015 (no data in 2008) (24). This, as well as the comparable low neonatal mortality observed in this study was quite reasonable, as this study only lasted 3 months and it was conducted at a university hospital in the second large city in Nicaragua.

For both maternal complications and postpartum complications, elective cesarean
section showed adverse effects. From the results showed in table 3 and table 4, it could draw the conclusion that elective cesarean section did not lead to better outcomes than vaginal delivery. One possible reason is that the key element or restricted factors that influenced maternal complications and postpartum complications in this study setting was not the mode of delivery. These factors could be related to the economic level of Nicaragua. As a lower middle income country, there are gaps when comparing with high income countries, such as the knowledge and skills of medical staffs, the sufficiency of medical supplies. Besides, the nutrition states of the mother, as well as whether there were pregnancy complications, also play an important role regarding the maternal outcomes. Even the education level of the mother, the level of gender equality in the setting could influence the maternal outcomes.

5.4. The cost-effectiveness of elective cesarean section compared with vaginal delivery

In the cost-effective analysis in this study, neonatal death was the main outcome variable. The incremental cost effectiveness ratio for elective cesarean section compared with vaginal delivery was 3805.71 US dollars (see table 7).

It is hard to compare this figure with the results from other studies on the cost-effectiveness of cesarean section, as some of the previous studies were based on model rather than real life data. For the studies using real life data, the perspective taken and whether included productivity loss could also made the results incomparable.

Besides the different ways of calculating the costs, the measurement of outcomes also varied a lot. Some use maternal or neonatal death as outcome, some use quality-adjusted life years (QALY) and health-adjusted life expectancy (HALE). The most comparable outcome variables are maternal and neonatal deaths, but it neglect the maternal and
neonatal complications which were not fatal. Both QALY and HALE using adjusted variables, the different way of adjusting could make big differences. Especially for the newborns, no one can tell to what extent the good quality life has been affected due to neonatal complications.

In addition, even the costs and outcomes were measured in the same manner, it could be hard to compare studies in different settings. In cost-effectiveness analysis, all costs were calculated in currency, the incremental cost effectiveness ratio (ICER) also presented in currency. But the same amount of money could mean different in high income setting and low income setting.

Thus, the ICER in this study could only serve as a reference for the policy makers in Nicaragua. This is also in accordance with the aim of this study. If policy maker would like to promote cesarean section in Nicaragua in order to achieve better neonatal outcomes, a lot more input are needed.

5.5. Other concerns on maternal and newborn health

In the background description of all participants, attention should be paid to two points. Firstly, there was a very high incidence of urinary tract infection, almost half of all the participants in this study had experienced urinary tract infection during pregnancy. Considering this study was conducted at a big hospital in a large city, the situation of pregnancy women in small cities, rural areas, and mountain areas could be even worse. Attention are needed in the pregnant period regarding knowledge and practices of the pregnant women. In addition, although Nicaragua has promoted institutional delivery through the community health workers and traditional birth attendants, the number of prenatal visits were quite low in this study. Only 40.8% of the participants had 3 prenatal visits, and 41.2% had 2 times of prenatal visits. More intervention or strategy is needed to improve the prenatal visits.
The second concern was the young mother age that found in this study. 30.4% of the participants in this study were under 20 years old, with the youngest of 14 years old. Young mothers face higher risks as they are less mature both physiologically and mentally, and they may less knowledgeable. In 2006, the contraceptive prevalence among girls aged 15 to 19 years old was 61.1% in Nicaragua, and the unmet need for family planning among girls aged 15 to 19 years old was 19.9% (24). With more available contraceptive, this could be improved, thus the access to family planning need to be promoted.

The overall rate of cesarean section was 37.9%, and the elective cesarean section rate was 21% in this study, much higher than the WHO recommended cesarean section rates of 10% to 15%. The reasons of such high cesarean section rates need to be explored.

5.6. Policy implications

The results from this study showed positive effects of cesarean section on neonatal death, and adverse effects on maternal complications and postpartum complications. The rate of cesarean section in this study was far above the WHO recommendations. And the average cost of one cesarean section was higher than the average cost of one vaginal delivery.

From the results of the sensitivity analysis in this study, with the increase of cesarean section rates, the costs increased, so as the number of cases with maternal complications and some postpartum complications. These complications also lead to more consumption of medical resources in the treatment, which were not included in this study. Thus if the cesarean section rates keep growing in León or in Nicaragua, much more medical resources are needed in the future.

In addition, the maternal outcomes of cesarean section also need improvement. With
increasing rate of cesarean section, more attention should be paid to assure a better outcome of cesarean section, for example the training of medical staff on cesarean section.

To promote the maternal and newborn health is never only about child delivery at hospital. The gender equality, the education of girls, the access to contraceptive methods, and the nutrition states, anything related to the health of a girl could influence the maternal and newborn health. Wherever the daily life take place, the information spread, and the people gathered, is good place to take action.

5.7. Strengths and limitations

The strength of this study was that the cost-effectiveness analysis was based on real life data. Although a good model could simulate the different stages that participants went through in alternative interventions, the use of model requires assumptions on certain things such as the incidence of a disease. Thus it highly based on data from literatures and reports, where the external validity could be a problem. This study however, was based on real life data. Assumptions were only made in the sensitivity analysis.

Nevertheless, real life data also leaded to limitations of this study. Although a society perspective was taken, the cost analysis did not contain the productivity loss since the data on average salary of the participants were not collected. Also, the costs due to the treatment on postpartum complications were not included, as the postpartum complication questionnaire did not include questions on the costs.

In addition, the average costs in vaginal delivery group and in elective cesarean section group were used in the calculation of incremental cost-effectiveness ratio (ICER), without adjusting to any background parameters such as age and poverty index. This brought inaccuracy if there were differences between vaginal delivery group and elective cesarean section group in the distribution of participants in age groups and
poverty index.

The measurement of outcomes also brought limitations to this study. For neonatal outcomes, only mortality was included, the possible neonatal morbidity were neglected, let alone possible long term consequences of cesarean section on the offspring, such as obesity and overweighting that had been found in other study (13). For maternal outcomes, cesarean section showed adverse effects on both maternal complications and postpartum complications. Under this circumstances, it is better to convert all maternal morbidities into quality-adjusted life years (QALY), so the result could be more comparable. However, in this study, no questionnaires regarding QALY had been sent out to the participants. Thus there was no data on how to adjust the quality of life for participants who suffered from each maternal complications. For the thinking of avoiding assumptions that based on studies out of the local setting, the maternal outcomes in this study were not converted into QALY.

Besides, this study was conducted in only one hospital in Leon, a big city in Nicaragua. Considering the disparities, the results of maternal and neonatal outcomes that found in this study might be better than it in rural areas or mountain areas in other part of Nicaragua. Thus the results in this study could only represent a very limited area in Nicaragua.

5.8. Further study

Focus on Nicaragua, a lower middle income setting, further studies could be conducted in several directions.

Firstly, regarding the high cesarean section rates found in this study, it is important to explore the reasons of cesarean section in Nicaragua, whether it is out of medical reasons or it is under maternal requests. If the major reason of cesarean section is
medical indication, then what could be done to improve the health states of pregnant women?

Secondly, concerning about the maternal outcomes of cesarean section in this study, it is also important to improve the outcomes of cesarean section in Nicaragua. Further studies could also focus on how to improve the outcomes of cesarean section. Qualitative studies such as interview and group discussion could be conducted to health service providers, in order to know why the outcomes of cesarean section was not good.

Thirdly, this study was conducted in one hospital in León, a big city in Nicaragua, and only one neonatal outcome was measured. Attention should also be paid to the long term effects on the offspring. Further studies which conducted in mountain areas and rural areas, with longer study period are needed in order to know the big picture of child delivery in Nicaragua.

Next, the cost-effectiveness of cesarean section compared with vaginal delivery in subgroups could be conducted, regarding age groups, nulliparous, multiparous, and whether there is medical indication or not.

In addition, considering the intention to treat principal, cost-effectiveness analysis could be conducted comparing planned cesarean section and planned vaginal delivery, rather than actual cesarean section and actual vaginal delivery. Since when a planned vaginal delivery failed, it leads to the highest costs.

Lastly, considering the fertility rate in Nicaragua was 2.5 per women (24), and this study showed a cesarean section rate of 37.9%, further study could focus on the cost-effectiveness of subsequent delivery after previous cesarean section.
6. Conclusion

This study estimated the cesarean section rate in Nicaragua, analyzed the maternal and newborn outcomes by different modes of delivery, and evaluated the cost-effectiveness of elective cesarean section compared with vaginal delivery in facility in Nicaragua.

The results showed that the total cesarean section rate was 37.9% in Nicaragua, while elective cesarean section rate was 21%. The costs of elective cesarean section was higher than of vaginal delivery (66 US dollars compared to 39.36 US dollars). The neonatal live births accounted for 99.6% in elective cesarean section group, and 98.9% in vaginal delivery group. For the maternal outcomes, cesarean section showed both positive and negative effects. The incremental cost effectiveness ratio (ICER) per neonatal death avoided was 3805.71 US dollars, which meant that to avoid one neonatal death through conducting cesarean section rather than vaginal delivery, 3805.71 US dollars were needed to cover all the costs.

The outcomes of cesarean section need to be improved, and with the cesarean section rates keep increasing, more medical resources are needed in the future.
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ANNEX 1 the map of Nicaragua

ANNEX 2 the map of León, Nicaragua