

Correlation of Caesarean Section Rates to Maternal and Neonatal Mortality in the Eastern Mediterranean Region; A Population-Based Ecological Study

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Abstract: Purpose: This study aims to explore the relationship between population-level caesarean section rates (CSRs) with maternal and neonatal mortality rates (MMR, NMR) in the Eastern Mediterranean Region (EMR). **Design:** A population-based ecological study was performed with data obtained from the World Health Organization, Global Health Observatory database, 2015, United Nations Inter-agency Group for Child Mortality Estimation (UN-IGME) and the United Nations Maternal Mortality Estimation Inter-Agency Group (UN-MMEIG) 2015). Mean \pm standard deviation (SD), range, median and Inter-quartile range (IQR) were used to describe the quantitative data. We performed multivariate logistic regression analysis to explore the effect (a) of (a) Antenatal clinic visits (ANC %), (b), Skilled Birth Attendance (SBA) rate (% of deliveries attended by SBA), (c) Total Health Expenditure (THE) per capita and (d) Female Literacy Rate (FLR%) on the studied relationship. Spline linear regression was used to find the most predictive variable for MMR, and the NMR. Statistical significance was accepted at $P < 0.05$. **Results:** The mean CSR was 21.20 ± 13.38 , (1.8-52). The CSR of $< 10\%$ was linked with the highest NMR and MMR, 33.0 (24.0-39.0) and 390.5(329.5-648.0) respectively. The most predictable variables for NMR and MMR were SBA % [$B = -0.875$; $p < .001$; $R^2 = 0.766$ and adjusted $R^2 = 0.754$] and FLR (F=15-24) [$B = 0.877$; $P < 0.001$; $R^2 = 0.77$ and adjusted $R^2 = 0.758$] respectively. **Conclusions:** We found a statistically significant inverse relationship between CSRs and maternal and neonatal mortality in MSs with $< 10\%$ of CSR. The improved mortality rates in MSs with $> 15\%$ of CSR were significantly linked with better socioeconomic and healthcare variables than higher CSRs.

Keywords: Caesarean Section, Maternal and Neonatal Mortality, Eastern Mediterranean Region.

INTRODUCTION

The caesarean section (CS) was introduced as a life-saving procedure in managing obstetric emergencies involving both the mother and the child. Evidence suggests that the caesarean section rate of up to 10-15% at the population level is associated with reduced maternal and neonatal mortality.¹ Despite the current evidence, extreme CS trends have been observed around the world, with 29.7 million births occurred through CS in 2015.^{2,3} Studies have reported CS as an independent risk factor for postpartum maternal death after controlling for indication bias and confounders.⁴ The risk of stillbirth has been quoted as 23 times higher in women with previous CS than other women.⁵

The Eastern Mediterranean Region (EMR), one of the six regions defined by the World Health Organization (WHO) shows extreme trends of CS among its twenty-two Member States (MSs). The Regional CSR ranges from the lowest level of 2% in Somalia to as high as 54% in Egypt. The MMR ranges from 4/100,000 (Kuwait) to 396/100,000 (Afghanistan) live births and NMR from 1/1000 (Bahrain) to 46/1000 (Pakistan) live births (Table 1). To date, around 26,000 mothers and 845,000 children under five years of age still die every year in the Region.⁶ There is a need to explore the effect of CS trends on mortality outcomes in the region. Evidence from other Regions yielded inconsistent results as the factors related to socioeconomic and healthcare sectors were not considered in the analysis of the studied relationship.^{3,7} The latest evidence revealed that a substantial part of the crude association between CSR and mortality outcomes is highly dependent on these factors.⁸ For that purpose, we conducted a study to explore the relationship between country levels of CSRs of EMR MSs with their corresponding MMR and NMR by adjusting their socioeconomic and healthcare indicators.

METHODS

Settings

A population-based ecological study was conducted to explore the relationship between CSRs and maternal and neonatal outcomes among twenty-two MSs of the EMR. The year of analysis was 2016.

Definition of variables: The independent variable was CSR and is defined as the percentage of caesarean deliveries among all live births, irrespective of cause or indication. The dependent variables were MMR and NMR. The MMR is defined as the annual number of female deaths per 100,000 live births from any cause related to or aggravated by the pregnancy or its management (excluding accidental or incidental causes) during pregnancy and childbirth or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy. The NMR is defined as the number of death during the first 28 days of life per 1000 live births in a given year or other periods. We selected four indicators related to socioeconomic and health care system as potential confounders for this study. They were Antenatal Care Coverage (ANC, 4+ visits), Female Literacy rate (FLR) % (15-24 years), Total Health Expenditure (THE) per capita in U.S. dollars and Skilled Birth Attendance rate (SBA, % of deliveries attended by skilled health personnel).

Data sources: The CS data was obtained from the World Health Statistics report, Global Health Observatory database, 2015 (Table 1). Most MSs have their CS data available from 2005 to 2013, apart from Egypt and the United Arab Emirates, for which the data was from 2014. The maternal and neonatal mortality rates were obtained from the UN-IGME: United Nations Inter-agency Group for Child Mortality Estimation and UN-MMEIG; United Nations Maternal Mortality Estimation Inter-Agency Group, 2015 estimates. The selected four indicators were obtained from various databases, as shown in (supplementary data file).

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Table 1: The Caesarean Section Rates (CSR) (%), Maternal Mortality Rates (MMR) (/100,000 live birth rate) and Neonatal Mortality Rates (NMR) in 22 MSs of the Eastern Mediterranean Region (EMR).

	Member States	MMR (2015)/100, 000	NMR (2015)/1000	CSR %
1	Afghanistan	396	36	4
2	Bahrain	15	1	26
3	Djibouti	229	33	15
4	Egypt	33	13	52
5	Iran	25	10	48
6	Iraq	50	18	22
7	Jordan	58	11	28
8	Kuwait	4	3	12
9	Lebanon	15	5	46
10	Libya	9	7	21
11	Morocco	121	18	16
12	Oman	17	5	17
13	Pakistan	178	46	14
14	Palestine	45	12	19.1
15	Qatar	13	4	20
16	Saudi Arabia	12	8	21
17	Somalia	732	40	2
18	Sudan	311	30	7
19	Syria	68	7	21
20	Tunisia	62	8	27
21	United Arab Emirates	6	4	24
22	Yemen	385	22	5

Source for CS rate: World Health Organization (WHO) 2015, World Health Statistics 2015, Source for MMR: Trends in Maternal Mortality: 1990 to 2015: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nation Population. Source of NMR: Levels & Trends in Child Mortality Reports 2015, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation

Statistical analysis: For convenience purposes, we have divided twenty-two MSs into three groups based on the optimal CSR of 10-15% (Table 2). We examined the unadjusted relationship between the country-level CSRs and their maternal and neonatal mortality in each Group. Mean \pm standard deviation (SD), range, median and Inter-quartile range (IQR) were used to describe quantitative data and frequency and percentage were used to describe qualitative data. We used the Kruskal Wallis test to compare CSR% groups (Non-parametric data). Multivariate logistic regression analysis was conducted with the adjustment of four study indicators. Spline linear regression analysis was performed to find the most predictive indicator for NMR and MMR. A two-way ANOVA was conducted to examine the interaction effect of independent variables (CS-ANC, CS-THE, CS-SBA, CS-FLR) on dependent variables (NMR, MMR). Statistical significant was accepted at $P < 0.05$. All statistical analysis was performed using SPSS (Statistical package for social science) version 20 and STATA program version 11. No ethical approval was needed as the data is openly available for official and public review.

Results: The mean CSR was 21.20 % (Mean \pm SD, range \pm 13.38, 1.8-52) with median of 20.3%. The NMR ranges from 1.0 to 46.0 (mean = 15.5 and median =10.5) while the MMR ranges from 4.0 to 732.0 (mean =126.55

and median =47.5) [Table 3]. The CSR of $<10\%$ was linked with the highest rate of neonatal and maternal mortality in the Region [(33.0 (24.0-39.0) and 390.5(329.5-648.0)] respectively. MSs with CSR of $>15\%$ showed the highest values of all four indicators i.e SBA%, ANC coverage (4 visits at least), female literacy rate and total expenditure on health per capita in US dollars [Median (IQR) = 99.0 (91.0-99.0), 85.0(71.0-96.0), 96.0 (91.0-99.0) and 366.0 (160.0-1190.0) respectively] (Table 4). The most predictable indicator for NMR was SBA [B=-.875; $p < .001$; $R^2=0.766$ and adjusted $R^2=0.754$]. While for the MMR, FLR was the most predictable indicator (F=15-24) [B=0.877; $P < .001$; $R^2=0.77$ and adjusted $R^2=0.758$].

We tested both the NMR and MMR of subjects against combined independent variables in different CSR groups through a two-way analysis of variance (ANOVA) test. It showed a significant interaction effect between CSR-SBA, CSR-FLR, CSR-THE for NMR (Table 5). For the MMR, such interaction effect of CSR was non-significant [F (2.15) =1.38, $P = 0.281$, partial η squared=0.156 and observed power= 0.251], [F (2.15) =918, $P = 0.421$, partial η squared=0.109 and observed power=0.179], [F (1.16) =3.2, $P = 0.093$, partial η squared=0.166 and observed power= 0.390] and [F (2.15) =1.29, $P = 0.305$, partial η squared=0.146 power=0.236] showing an insufficient evidence to reject the null hypothesis.

Table 2: Member States (MSs) are classified in to three groups according to the recommended optimal CSR* of (10-15%) by the World Health Organization.

CSR	Member States in Eastern Mediterranean Region
CSR <10%	Afghanistan ^{LI} , Somalia ^{LI} , Sudan ^{LI} , Yemen ^{LI} (18% MS)
CSR 10-15%	Djibouti ^{LI} , Kuwait ^{HI} , Pakistan ^{LI} (14% MS)
CSR >15%	Jordan ^{MI} , Lebanon ^{MI} , Egypt ^{MI} , Syria ^{MI} , Tunisia ^{MI} , Libya ^{MI} , Iraq ^{MI} , Iran ^{MI} , Palestine ^{MI} , Saudi-Arabia ^{HI} , Bahrain ^{HI} , Morocco ^{MI} , Oman ^{HI} , United Arab Emirates ^{HI} (68%MS)

*CSR: Caesarean section rate *LI: Low income *MI: Middle income *HI: High income

Table 3: Prevalence of the studied variables and indicators among three groups of *MSs.

Studied Variables and indicators	N	The studied group (22)	
		Mean \pm SD (range)	Median (IQR)
*CSR% 2015 (WHO)	22	21.20 \pm 13.38 (1.8-52)	20.3 (13.48-26.25)
<10%	4	4.45 \pm 2.16	
10-15%	3	13.63 \pm 1.58	
>15%	15	27.17 \pm 11.68	
*SBA %	22	83.14 \pm 22.39 (40-100)	96.0 (69.25-99.0)
*ANC coverage 4 visits	22	70.05 \pm 26.59 (23-100)	80.5 (40.75-90.25)
Female Literacy rate	22	84.04 \pm 20.89 (26.0-99.0)	93.5 (76.85-98.0)
Total expenditure on health per capita in US dollars	22	489.95 \pm 554.24 (13.0-2030)	257.5 (79.5-776.0)
*NMR	22	15.5 \pm 13.27 (1.0-46.0)	10.5 (5.0-24.0)
*MMR	22	126.55 \pm 183.01 (4.0-732.0)	47.5 (14.5-190.75)

SD: standard deviation IQR: interquartile range *CSR: Caesarean section rate *SBA: Skilled birth attendance *ANC: Antenatal clinic *NMR: Neonatal mortality rate *MMR: Maternal mortality rate *MSs: Member states

Table 4: Mean National Estimates of NMR*, MMR*, SBA*, ANC*, LR* and THE* per Capita in US dollars for three groups according to their CSR*.

	*CSR% 2015			Kruskal-wallis test	P value
	<10% Median (IQR)	10-15% Median (IQR)	>15% Median (IQR)		
NMR	33.0 (24.0-39.0)	33.0 (3.0-46.0)	8.0 (5.0-12.0)	8.27	0.016*
MMR	390.5 (329.5-648.0)	178.0 (4.0-229.0)	25.0 (13.0-58.0)	9.93	0.007*
SBA %	44.5 (41.0-69.75)	58.0 (40.0-100.0)	99.0 (91.0-99.0)	8.40	0.015*
ANC (4 visits at least)	25.5 (23.5-65.75)	60.0 (37.0-88.0)	85.0 (71.0-96.0)	7.32	0.026*
FLR (F=15-24)	54.9 (27.5-83.2)	64.0 (63.0-94.0)	96.0 (91.0-99.0)	10.41	0.005*
THE per capita in US dollars	66.0 (24.75-132.0)	82.0 (38.0-1169.0)	366.0 (160.0-1190.0)	8.25	0.016*

*Significant at p<0.05 *CSR: Caesarean Section Rate *SBA: Skilled Birth Attendance *ANC: Antenatal Clinic *FLR: Female Literacy rate *THE: Total Health Expenditure *NMR: Neonatal Mortality Rate *MMR: Maternal Mortality Rate

Table 5: A two-way analysis of variance between *NMR, *CSR% and selected variables.

NMR	F	P value	Partial η squared	Observed power
CSR-*SBA	(2.15)=11.43	.001	.604	.978
CSR-*ANC coverage	(2.15)=2.08	.16	.217	.359
CSR-*LR	(1.16)=26.4	.000	.623	.998
CSR-*THE	(3.13)=7.35	.004	.629	.936

Significance : P value of <0.05 *CSR: Caesarean section rate *SBA: Skilled birth attendance *ANC: Antenatal clinic *FLR: Female literacy rate *THE: Total health expenditure *NMR: Neonatal mortality rate *MMR: Maternal mortality rate

DISCUSSION

Our study revealed that MSs with a CSR of less than 10 % has the highest maternal and neonatal mortality rate in the Region. Those MSs belong to Group 1 and have an average CSR of 4.45%.⁹ They are predominantly African countries and suffer from poor socioeconomic conditions, lack of health care infrastructure and insufficient access to healthcare services. These factors account for more than 60% of the Regional healthcare inequities.¹⁰ Among those factors, insufficient access to facility-based delivery is identified as the main underlying factor for the low CSR in those MSs. For example, 48% of direct maternal deaths in Northern Somalia occur at home as women cannot reach the hospital in an emergency.¹¹

According to our study, the two main predictors for NMR and MMR were low SBA rate and FLR. The role of these indicators in improving access to health care services has been well established in the literature; however, their application at the country level is facing contextual challenges, including a lack of finances, essential equipment, medications, and poor quality of training in the Region. The WHO has adopted the SBA rate as a key coverage-monitoring indicator for the Sustainable Development Goal 3.1; however, achieving its standard level in MSs with limited resources and highest mortality figures is challenging.¹² For example, only 20% of births in Sudan, 45% in Yemen, 46% in Afghanistan, and 9.4% in Somalia are attended by SBAs.¹³ Similarly, in Afghanistan, the low FLR of only 17% undermines the increased SBA coverage, as women with a poor understanding of good maternal health during childbirth do not know when to seek help.¹⁴ Evidence suggests that the substandard care during and after the procedure in low- and middle-income countries is associated with 100 times higher maternal death than in high-income countries.¹⁰ That is in contrast to MSs like Saudi Arabia and Qatar (Group 3) with 99% and 96% female literacy rate accordingly, showing much better maternal and child health outcomes.¹⁵

We observed the lowest MMR and NMR in Group 3 (middle and high-income MSs) with CSR of more than 15%, much above the WHO's cut-off. We also found the highest values for all four indicators in that Group, highlighting better socioeconomic conditions and healthcare facilities among its MSs. Further analysis revealed significant interaction effect of SBA, FLR and THE per capita with CSR on NMR. That may explain that the crude association between reduced mortality outcomes with high CSR in that particular Group is mainly due to better socioeconomic and healthcare indicators due to the high rate of facility-based deliveries. That is in line with the available evidence that increasing the caesarean section rate above a certain threshold is no longer associated with reduced mortality; instead, the socioeconomic factors play a significant role in improving maternal and neonatal outcomes after.³ However, our data was insufficient to show any such significant interaction effect on MMR. The same phenomenon was observed in Group 2. Pakistan and Djibouti from this Group have optimal CSRs. However, they show much higher mortality ratios than Kuwait in the same Group, which exhibit better socioeconomic and health care infrastructure indicators.

Egypt, Iran, and Lebanon have shown the highest increase in their CSR of >40%. That high trend of CS could

be an indication of easy access to facility-based delivery, but such an exponential rise does indicate overuse of this procedure without any medical indications.¹⁶ The subsequently repeat CSs has resulted in an increasing number of severe but uncommon and potentially fatal maternal complications such as abnormal placenta (AbP i.e. Placenta accreta/ increta and percreta), postpartum haemorrhage (PPH), emergency hysterectomy (removal of the uterus) and maternal death. PPH is the leading cause of maternal death in the developing world and accounts for 28% of global maternal death (RR), whereas emergency hysterectomy with reported maternal morbidity of 60 %, and mortality of 7%.^{17,18} Previous studies in those MSs have shown various underlying determinants for high CSR, including high women's wealth quintile, lack of evidence-based practice for the management of labour, lack of instrumental deliveries, women's preference, and financial incentives associated with CS and clinician's fear of litigation.^{19,20,21} MSs with extreme CS trends have reasonable healthcare infrastructure but cannot deal with a high number of complications associated CSs. Therefore their maternal and child health indexes have not shown the same improvement rate as high-income MSs of the Region with lower CSRs. For example, Saudi Arabia, Qatar, UAE, Bahrain, Abu Dhabi and Oman have shown a moderate increase in CSR of up to 25% but achieved a reduction in MMR between 25 and 50% compared to levels in 1990.²² Policymakers, healthcare providers, and government officials have expressed their concern about the financial impact of medically unnecessary CSs have on the health care system. For example, the average cost of CS in Egypt is 1,076 L.E., while vaginal delivery costs 664 L.E (1US \$=8.8EGP). In 2014, overuse of CS deliveries cost the Egyptian health care system L.E. 929,664,000 (calculated based on the number of deliveries of 2.7 million, a current CSR of 52% using 20% as the threshold rate to define the overuse of CS.²³ According to the study conducted among refugee women in Lebanon, \$1.4 million were spent by UNHCR (United Nation High Commission for Refugees) on 2,244 CSs, in comparison to the same amount of money spent on 4,131 natural vaginal deliveries, extracting financial portions from other essential medical procedures.²⁴ Evidence suggests that the cost of the global saving of reducing the CS rates to 15% is about \$2.32 billion (U.S. dollars); the cost to attain a 10% CSR is \$432 million (U.S. dollars). If all the resources currently devoted to 'excess' CS be directed towards countries where additional procedures are 'needed', the 'needed' procedures could be fully financed.²⁵

To our knowledge, this is the first study conducted to explore the relationship of CSR with MMR and NMR in the EMR. We used the most updated data from sources that use rigorous methods and quality assurance practices. However, that was population-based data and can mask substantial CSR variations within healthcare facilities in each MSs. The results are, therefore, open to bias and may not be applicable at a facility level. We could not use a single data point as for some MSs; the most recent data was not available. We have mainly focused on mortality as a primary outcome in our study; however, the morbidity associated with CS is highly accountable for a better quality of women's life and should be explored for future research.

Although progress in reducing maternal and child mortality has accelerated in the past 15 years in the EMR,

there is still much to do to reduce preventable deaths. The MSs who underuse the CS with high maternal and neonatal mortality should promote the increased access to emergency and urgent CS. The evidence suggests that maternal mortality may decrease by as much as 92% with increase access.²⁶ The task-shifting strategy, skill upgrade training, and capacity building (one institution be able to provide comprehensive Emergency Obstetric Care, requires the ability to perform a safe CS and blood transfusion with availability to per 500,000 people), with focus on the safety, quality of the procedure of the health care system can result in better overall maternal and child health outcomes.^{27,28} MSs with high caesarean section rates needs training and education for standard intrapartum care and instrumental deliveries to reduce unnecessary CSs. Other non-clinical factors, such as a change in health-seeking behaviours through community education and legislative changes with political commitment, should also be addressed to improve maternal and child health care quality. Many authors have identified them as significant drivers to improve the uptake or to reduce the unnecessary CS. That is in line with the WHO recommendation that reducing mortality outcomes requires improvements in overall maternal health care quality rather than striving to achieve a particular CSR.²⁹

CONCLUSIONS

In conclusion, the Regional CSR and mortality outcomes follow the socioeconomic inequities in maternal and child health services. We found a statistically significant inverse relationship between CSR and maternal and neonatal mortality in MSs with a CSR of <10%. The improved mortality rates in MSs with >15% of CSR was strongly linked with better socioeconomic conditions and healthcare facilities. The SBA, FLR and THE per capita have significant interaction effect with CSR for NMR in all three groups of the study; however, there was insufficient evidence to prove such effect for MMR.

Funding

No funding has been applied for this research

Ethical Approval

The WHO Maternal and Child Health Department approved the study protocol.

Abbreviations

CSR: Caesarean Section Rate, NMR: Neonatal Mortality Rate, MMR: Maternal Mortality Rate, EMR: Eastern Mediterranean Region, MS: Member State, ANC: Antenatal Clinic, SBA: Skilled Birth Attendant, THE: Total Health Expenditure, FLR: Female Literacy rate

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Received on 15-03-2021

Accepted on 30-03-2021

Published on 28-04-2021

DOI: <https://doi.org/10.31907/2309-4400.2021.09.1>© 2021 Bismeen Jadoon *et al.*; Licensee Green Publishers.

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