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Maternal and infant outcomes of Syrian and Palestinian refugees, Lebanese and migrant women giving birth in a tertiary public hospital in Lebanon: a secondary analysis of an obstetric database

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ABSTRACT

Objectives This study aims to assess whether the characteristics, management and outcomes of women varied between Syrian and Palestinian refugees, migrant women of other nationalities and Lebanese women giving birth at a public tertiary centre in Beirut, Lebanon.

Methods This was a secondary data analysis of routinely collected data from the public Rafik Hariri University Hospital (RHUH) between January 2011 and July 2018. Data were extracted from medical notes using text mining machine learning methods. Nationality was categorised into Lebanese, Syrian, Palestinian and migrant women of other nationalities. The main outcomes were diabetes, pre-eclampsia, placenta accreta spectrum, hysterectomy, uterine rupture, blood transfusion, preterm birth and intrauterine fetal death. Logistic regression models estimated the association between nationality and maternal and infant outcomes, and these were presented using ORs and 95% CIs.

Results 17 624 women gave birth at RHUH of whom 54.3% were Syrian, 39% Lebanese, 2.5% Palestinian and 4.2% migrant women of other nationalities. The majority of women had a caesarean section (73%) and 11% had a serious obstetric complication. Between 2011 and 2018, there was a decline in the use of primary caesarean section (caesarean section performed for the first time) from 7% to 4% of births (p<0.001). The odds of preeclampsia, placenta abruption and serious complications were significantly higher for Palestinian and migrant women of other nationalities compared to Lebanese women, but not for Syrian women. Very preterm birth was higher for Syrians (OR: 1.23, 95% CI: 1.08 to 1.40) and migrant women of other nationalities (OR: 1.51, 95% CI: 1.13 to 2.03) compared to Lebanese women.

Conclusion Syrian refugees in Lebanon had similar obstetric outcomes compared to the host population, except for very preterm birth. However, Palestinian women and migrant women of other nationalities appeared to have worse pregnancy complications than the Lebanese women. There should be better healthcare access and support for migrant populations to avoid severe complications of pregnancy.

STRENGTH AND LIMITATIONS OF THIS STUDY

⇒ This study is one of the very few ones to compare maternal and infant outcomes between Syrian refugees, Palestinian refugees and migrant women of other nationalities to the host population.
⇒ This study leveraged the use of classification through machine learning methods to develop the data set, which is an innovative approach to curating data sets where data would normally be absent.
⇒ Classification of 'free-text' through machine learning methods is susceptible to misclassification.
⇒ The maternal outcomes and characteristics of women were not representative of each nationality.

INTRODUCTION

The war in Syria, which commenced in 2011, led to the mass forced displacement of Syrian civilians to neighbouring countries, primarily Lebanon, Turkey, and Jordan.[1] Lebanon currently hosts approximately 1 million Syrian refugees registered with the United Nations High Commission for Refugees (UNHCR), which imposed further and unprecedented challenges on the Lebanese health system.[2 3] Of all the maternities in Lebanon during 2018, 46% were among non-Lebanese parents, most of whom are Syrians followed by Palestinians.[4] Unlike other host countries, Syrian refugees receive healthcare within the Lebanese health system and the UNHCR covers the majority of the fees for four antenatal care visits and 75% of delivery costs.[5] Despite the availability of subsidised services in Lebanon and the efforts invested by different NGOs (non-governmental organizations), studies have shown limited uptake of antenatal care for Syrian women and breaks in the continuum of maternal care due to the

costs of the subsidised services.[3 5] A study conducted by UNHCR in Lebanon in 2016 showed that only 41% of Syrian pregnant women attended four or more antenatal care visits.[6]

Lebanon hosts over 450 000 registered Palestinian refugees.[7] Antenatal care for Palestinian refugees is mostly provided by United Nations Relief and Work Agencies (UNRWA) primary healthcare services; thereafter a subsidised care is provided for childbirth.[8] As for migrant women of other nationalities giving birth in Lebanon, the majority are migrant domestic workers. Theoretically, these women should receive healthcare insurance purchased by their employer; however, many domestic workers pay out-of-pocket for healthcare in Lebanon,[9] which may be an underlying cause for lack of access to quality healthcare. There is limited research on maternal health outcomes of the female domestic workers who reside in Lebanon.[9] We conducted a scoping review and found no studies on maternal outcomes of migrant domestic workers in the Arab region. In Lebanon, nationality is a proxy measure of socioeconomic status, reproductive rights and ability to access quality healthcare, and as a result, health outcomes are likely to vary according to nationality due to these structural and social factors.

Antenatal care is vital for the prevention, early detection and management of complications of pregnancy.[10] Studies have shown that underutilisation of antenatal care has been associated with maternal and infant morbidity and mortality.[11 12] According to Benage *et al* 2015, maternal and reproductive health standards are not being met for Syrian refugees attending primary healthcare centres in Lebanon. Limited uptake of antenatal care may be a potential reason for the increased risk of maternal mortality among Syrian women in Lebanon.[13]

The Lebanese healthcare system is complex where healthcare is provided mainly through the private sector;[14] however, care is also provided through the public, and third (NGO) sector. Within and between sectors, there is a large variation in the content and quality of clinical care.[15] During the Syrian refugee crisis, Rafik Hariri University Hospital (RHUH) and other hospitals in Lebanon have experienced challenges in meeting the increased demand for obstetric services for the Lebanese, Syrian, Palestinian and other migrant populations. RHUH is the only public hospital providing emergency obstetric care for Beirut, its surrounding areas and, in some cases, across all Lebanon.[16] It is the last resort for complicated cases without private medical insurance, not only for Lebanese, but for Syrians, Palestinians and migrant women of other nationalities. Thus, anecdotally, delays in women presenting to RHUH are common due to the structure of the Lebanese healthcare system. It remains important to understand whether maternal and perinatal outcomes during this period differ by nationality in those attending a public hospital in Lebanon. This will inform the design of services and policies for equitable access to healthcare services. Therefore, in this study, we aim to compare the characteristics, management and outcomes of women giving birth at a public tertiary hospital by nationality.

METHODS

Study design and setting

This was a secondary data analysis of routinely collected data from RHUH between January 2011 and July 2018. RHUH is the principal public tertiary hospital located in Beirut. RHUH serves as the main public referral hospital for major obstetric complications and women without medical insurance. In addition, RHUH extended their maternity services by opening a midwife-led unit operated by Médecins Sans Frontières (MSF) to provide maternity services from Shatila and Bourj Al Barajneh clinics for low-risk pregnancies. The data from this study do not include the MSF midwife led unit owing to the availability of data from RHUH only.

RHUH, given both its public status and expertise in the management of high-risk births, therefore cares for women with high-risk pregnancies of socioeconomically deprived or vulnerable populations. These include migrant workers who lack insurance or means to obtain obstetric care in the private healthcare sector.

Data set curation using machine learning methods

Data from the electronic health records (EHR) from the Department of Obstetrics and Gynaecology at RHUH were extracted from the hospital's database. The data sets included the date of birth, nationality, ICD-10-CM and 'free-text' medical records for each woman.

The EHR stored multiple sheets at different stages of the hospital episode, and these were linked using a unique anonymised patient identifier and date of the hospital episode. If there were multiple records for the same women with differing dates, these were considered part of the same hospital episode if they occurred within 6 months of each other (eg, antenatal or postnatal appointments for the maternity). Their predicted labels were aggregated according to hierarchical rules. If multiple records for the same women were beyond 6 months and had delivery codes, they were considered as separate maternities.

Machine learning methods were used for classification to extract codes for prespecified variables from the 'free-text' medical records. Prior to classification, each data set was cleaned by removing duplicate records (online supplemental figure 1). A training data set was manually created for prespecified obstetric variables. If the medical notes indicated that a case had the specified variable, it was coded as 1, and if there was no mention of the variable, the case was coded 0. Approximately, 1000 records were manually labelled to be used by the machine learning models for training; for rare outcomes or variables with few events, more records were coded to increase the model's discriminative ability. For the classification, data sets were split into train, test and validation data sets. Splitting was based on the distribution of

the data, given that it was imbalanced for some variables. Models were trained to label each of the variables; these models included, long short-term memory (recurrent neural networks), random forest, logistic regression and linearSVC and regular expressions (Regex). The best-performing models were chosen and optimised to get the highest precision, recall and F1 score, by choosing the hyperparameters, most appropriate vectorisers and their parameters. All models for all variables achieved over 90% in terms of accuracy, precision, recall and F-measure, with the exception of gestational age and previous number of caesarean sections. The models and their metrics for each variable can be found in online supplemental table 1. The machine learning classification was conducted using Python V.3.7.3.

Study participants

The study population were women who gave birth at RHUH between 2011 and 2018 and and for whom data on nationality were available. Maternities were classified as women who either had a delivery related ICD-10-CM code or had a delivery-related note in their medical record. The ICD-10-CM codes used to identify the study participants are in online supplemental table 2.

Variables

Nationality was considered as the exposure, and women were categorised into four groups, namely, Lebanese, Syrian, Palestinian and migrant women of other nationalities who are mainly domestic workers (online supplemental table 3). Other than maternal age, ICD-10-CM codes and nationality, all other variables were imputed by classification using ML methods. Caesarean section in the current pregnancy was generated using a combination of ICD-10-CM codes and classification. Other characteristics extracted from the 'free-text' were gestational age, parity, consanguinity, smoking, current number of caesarean sections, diabetes, hypertension and episiotomy. Primary caesarean section was defined as performing the caesarean section for the first time.

Maternal outcomes extracted from the 'free-text' included diabetes, hypertension disorders during pregnancy (including pregnancy induced hypertension and preeclampsia), placenta abruption, placenta praevia, placenta accreta spectrum, hysterectomy, uterine rupture and blood transfusion. Infant outcomes extracted were preterm birth (<37 weeks of gestational age), very preterm birth (<32 weeks of gestational age) and intrauterine fetal death (IUFD). Use of caesarean section was calculated as a proportion by dividing the number of caesarean sections by the total number of maternities for each nationality. Serious complication of pregnancy was a composite outcome that included preeclampsia, hysterectomy, placenta accreta spectrum, placenta praevia, blood transfusion, placenta abruption and uterine rupture.

Missing data

Women were excluded if they had missing data on nationality (n=269 out of 20 884 women). All other variables had no missing data as these variables were extracted from the 'free-text'; if there was no mention of the variable of interest in the free-text within the 'free-text' then it was assumed not to have the characteristics, management or outcome of interest.

Statistical methods

Proportions and frequencies were presented with descriptive statistics. Median and interquartile range were used for skewed continuous variables. Maternal age and gestational age, and nationality were compared using Kruskal-Wallis test. χ^2 test and Fisher's exact test were used to assess the difference between pregnancy characteristics and nationality. Each binary maternal and infant outcome was modelled separately against nationality and clustered by women, using logistic regression models and presented as ORs and 95% CIs. In these models, nationality was the exposure and Lebanese women were considered as the reference group. Using causal inference methods, no confounders of nationality were identified or available in the data set; as a result, unadjusted models were presented. Data analysis was conducted using STATA V.13.

Ethical approval and reporting

This study was approved by the RHUH and American University of Beirut (AUB) IRB committees (AUB: reference SBS-2018–0096). This study was reported according to the STROBE statement.[17]

Patients and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

RESULTS

Data on 20 884 women were extracted from RHUH data set between January 2011 and July 2018. Women who had a maternity with available data on nationality at RHUH (n=17 624) were included in the study (online supplemental figure 2). Of the 17 624 maternities, 9569 (54.3%) were to Syrian women, 6880 (39%) to Lebanese women, 444 (2.5%) to Palestinian women, and 731 (4.2%) were to migrant women of other nationalities.

During 2011, the majority of maternities were to Lebanese women (83%), during 2012, the proportion of Lebanese and Palestinian women giving birth at RHUH declined (From 2011 to 2012: 83%–67% and 5.4%–4.9%, respectively), while the proportion of Syrian women giving birth increased (7.1% in 2011 to 23.7% in 2012) (figure 1). There are fluctuations in the absolute number of maternities for Syrians across the years; however, they remained higher than Lebanese, Palestinian and migrant women of other nationalities for the rest of the study period (figures 1 and 2). The proportion of migrant
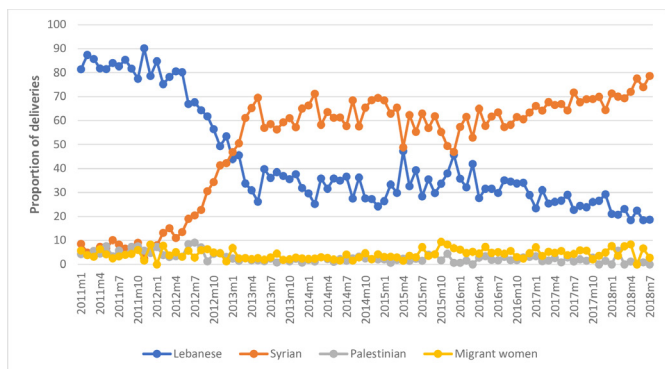
Figure 1 The proportion of women giving birth at RHUH by month and nationality of the mother. RHUH: Rafik Hariri University Hospital.

women of other nationalities giving birth remained between 4.7% and 9.9% throughout the study period.

Syrian women were younger than Lebanese, Palestinian and migrant women of other nationalities (26 years vs 28 years old, p<0.001) (table 1). In addition, there was a larger proportion of Syrian teenage mothers (14.1% Syrians, 7.7% Lebanese, 5.6% Palestinian and 2.3% migrant women of other nationalities, p<0.001). The presence of consanguinity did not differ by the groups. Smoking during pregnancy was higher in Lebanese women compared to Syrian and Palestinian women. Use of caesarean section in current pregnancy, and over the years on average, was the highest among Palestinian women (table 1 and online supplemental figure 3).

The use of primary caesarean section was higher for Lebanese women compared to Syrian and Palestinian women (6.7% vs 5.4% vs 6.3%, p<0.001). After the year 2016, the use of primary caesarean section declined for all the nationalities (7.2% in 2011 to 4.2% in 2018, p<0.001). Moreover, women who delivered between 2015 and 2018 had lower odds of primary caesarean section compared to those who delivered between 2011 and 2014 (OR: 0.72 (95% CI: 0.62 to 0.85)). Stratifying the data by nationality, the use of more than one caesarean section was the
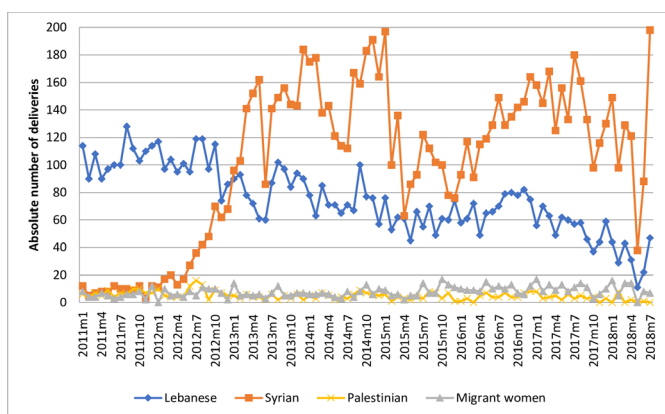

Figure 2 Absolute number of women giving birth at RHUH by month and nationality of the mother. RHUH: Rafik Hariri University Hospital.

highest mostly among Palestinian women, and lowest among migrant women of other nationalities (table 2).

Syrian women did not have statistically significant increased odds of any maternal outcome compared to Lebanese women (table 3). There was no statistically significant difference between nationality and gestational diabetes, blood transfusion, placenta accreta spectrum and hysterectomy. Syrian and migrant women of other nationalities had increased odds of very preterm birth OR: 1.23 (95% CI: 1.08 to 1.40) and OR: 1.51 (95% CI: 1.13 to 2.03) compared to Lebanese women, respectively.

Palestinian women had an increased odds of hypertension disorder during pregnancy OR: 1.62 (95% CI: 1.22 to 2.15), placenta abruption OR: 1.95 (95% CI: 1.24 to 3.07), serious complications OR:1.56 (95% CI: 1.22 to 1.98) and preterm birth OR: 1.80 (95% CI: 1.40 to 2.30) compared to Lebanese women.

Migrant women of other nationalities had an increased odds of hypertension disorder during pregnancy OR: 1.51 (95% CI: 1.21 to 1.89), placenta abruption OR: 1.65 (95% CI: 1.12 to 2.45), serious complications OR:1.38 (95% CI: 1.13 to 1.67), IUFD OR: 2.13 (95% CI: 1.53 to 2.95) compared to the Lebanese women.

DISCUSSION
Main findings
Syrian women became the primary nationality giving birth at RHUH after 2012, where the majority of women giving birth at this centre had a caesarean section. Yet, the use of primary caesarean section declined across time for all nationalities. Moreover, maternal outcomes and fetal death did not differ between Lebanese and Syrian women. However, Palestinian and migrant women of other nationalities appeared to have more severe maternal complications than Lebanese women. Importantly, migrant women of other nationalities had increased likelihood of IUFD than Lebanese women. Additionally, Syrian and migrant women had a higher likelihood of very preterm birth compared to Lebanese women.

Results in context
Since the Syrian crisis that began in 2011, the increase in the refugee population, with the majority being women and children under 18 years, has placed extra burden on the resource limited healthcare system in Lebanon.[3] This study showed that during the Syrian crisis, there was a shift from Lebanese women to Syrian women being the majority nationality attending the maternity unit in RHUH, Beirut. It is likely that the Lebanese population shifted from RHUH to use private healthcare for childbirth. It could be speculated that this is related to lack of public hospitals in the surroundings of Beirut area, and that RHUH mainly provides care for low-income populations and those without medical insurance.

Syrian and Lebanese women had similar levels of pregnancy complications, while Palestinian women and migrant domestic workers had a higher likelihood of

Table 1 Characteristics and history of women who gave birth at RHUH according to nationality

		Nationality				
		Lebanese (n=6880)	Syrian (n=9569)	Palestinian (n=444)	Migrant women (n=731)	P value
		No. (Col %)	No. (Col%)	No. (Col%)	No. (Col%)	
Maternal age Median (IQR)		28 (23–34)	26 (21–31)	28 (24–33)	28 (25–33)	<0.001
Age	<20	530 (7.7)	1344 (14.1)	25 (5.6)	17 (2.3)	<0.001
	20–24	1569 (22.9)	2656 (27.9)	106 (23.9)	159 (21.8)	
	25–29	1728 (25.2)	2449 (25.7)	125 (28.2)	233 (31.9)	
	30–34	1366 (19.9)	1868 (19.6)	99 (22.4)	191 (26.1)	
	>34	1671 (24.3)	1211 (12.7)	88 (19.9)	131 (17.9)	
Parity	Nulliparous	1907 (27.7)	2496 (26.2)	131 (29.5)	304 (41.8)	<0.001
	Multiparous	4957 (72.3)	7040 (73.8)	313 (70.5)	424 (58.2)	
Gestational age Median (IQR)		38 (37–39)	38 (37–40)	38 (36–39)	39 (37–40)	<0.001
Consanguinity	None	6694 (97.3)	9288 (97.1)	425 (95.7)	720 (98.5)	0.044
	Yes	186 (2.7)	281 (2.9)	19 (4.3)	11 (1.5)	
Smoking	Non-smoker	4174 (60.7)	8058 (84.2)	275 (61.9)	587 (80.3)	<0.001
	Current smoker	2602 (37.8)	1439 (15.0)	163 (36.7)	138 (18.9)	
	Ex-smoker	104 (1.5)	72 (0.8)	6 (1.4)	6 (0.8)	
Caesarean section in current pregnancy	No	1662 (24.2)	2817 (29.4)	86 (19.4)	195 (26.7)	<0.001
	Yes	5218 (75.8)	6752 (70.6)	358 (80.6)	536 (73.3)	
Number of caesarean sections	None	755 (10.9)	1209 (12.6)	41 (9.2)	115 (15.7)	<0.001
	Primary caesarean section	460 (6.7)	514 (5.4)	28 (6.3)	68 (9.3)	
	More than one caesarean section	5378 (78.2)	7541 (78.8)	360 (81.1)	529 (72.4)	
	Unspecified number of caesarean sections	287 (4.2)	305 (3.2)	15 (3.4)	19 (2.6)	
Episiotomy	No	6814 (99)	9503 (99.3)	437 (98.4)	721 (98.6)	0.041
	Yes	66 (1.0)	66 (0.7)	7 (1.6)	10 (1.4)	

IQR, Interquartile Range; RHUH, Rafik Hariri University Hospital.

pregnancy-related complications than Lebanese women. RHUH provides emergency obstetric care to those without health insurance, and those covered by UNRWA and UNHCR, so all women should receive the same content and quality of care regardless of nationality. The reason for this disparity among migrant domestic workers may be the result of differences in healthcare received before childbirth. In particular, UNHCR provides subsidised antenatal care to Syrian refugees; however, there is no provision for migrant workers and these women are unlikely to afford private antenatal care. Studies that address obstetric outcomes among migrant workers are limited in the Middle East. However, these results are consistent with studies in Europe, which showed that migrant workers are at higher risk of obstetric

complications compared to the host population.[18 19] In addition, domestic workers in Lebanon are not allowed to marry or get pregnant, hence many may tend to hide their pregnancies for fear of deportation or detention.[9] Therefore, they experience inequitable access to healthcare due to their nationality and legal status, which may lead to a higher risk of pregnancy complications and infant morbidities.[9] It is recognised that female migrant workers are vulnerable to physical, psychological, and sexual violence, and are at risk of unintended pregnancies, which could also hinder or delay their access to antenatal care.[20] Previous studies have shown that women who experience physical, psychological, and sexual abuse have higher rates of maternal and infant complications than women who are not abused.[21–23] Furthermore, the

Table 2 Use of caesarean sections over time

Number of caesarean sections	Year (%)							
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
	Col %	Col %	Col %	Col %	Col %	Col %	Col %	Col %
None	11.5	12.9	14.9	11.8	13.7	8.2	8.1	17.7
Primary caesarean section	7.2	6.7	6.6	9.1	4.3	5.7	3.9	4.2
More than one caesarean section	77.2	75.4	73	75.6	78.9	84.4	85.4	74.9
Unspecified caesarean section number	4.1	5	5.5	3.5	3.1	1.7	2.6	3.2
Lebanese								
None	11.3	12	13.2	11.1	12.6	7.5	6.4	13.7
Primary caesarean section	6.5	7	8.9	9.1	4.1	6.1	4.5	4.3
More than one caesarean section	77.9	76	72.4	74.9	79.5	83.8	87.3	77.7
Unspecified caesarean section number	4.3	5	5.5	4.9	3.8	2.5	1.8	4.3
Syrian								
None	20.3	15.3	15.6	12.1	14	8.5	8.8	17.7
Primary caesarean section	6.5	5.6	5.1	9	4.2	5	3.6	4.1
More than one caesarean section	70.4	74.5	73.6	76.2	78.8	85.3	84.7	75.2
Unspecified caesarean section number	2.8	4.6	5.7	2.7	3	1.2	2.9	3
Palestinian								
None	4.9	15.4	16.7	11.3	2	11.1	0	8.3
Primary caesarean section	9.8	3.3	6.2	9.7	4.1	9.3	2.2	0
More than one caesarean section	80.5	73.6	77.1	75.8	93.9	79.6	95.7	83.3
Unspecified caesarean section number	4.8	7.7	0	3.2	0	0	2.1	8.4
Migrant women								
None	8.7	11.5	20.7	13.6	23.8	8.3	10.6	32.9
Primary caesarean section	17.4	12.8	8.5	11.1	6.9	10.7	4.1	6.6
More than one caesarean section	72.5	71.8	65.9	70.4	68.3	79.3	82.1	60.5
Unspecified caesarean section number	1.4	3.9	4.9	4.9	1	1.7	3.2	0

mechanisms resulting in poor maternal outcomes have been suggested to be poor communication between the health system and migrants, language barriers and limited economic resources.[18 24] Further research is needed to identify the underlying causes for the disparities in maternal and infant outcomes.

The explanation for the higher maternal complication and the use of caesarean section among Palestinian refugees is reflective of the case mix. Palestinian refugees mainly receive obstetric care from UNRWA funded health centres and these centres would only refer the most severe and complicated pregnancies to RHUH. To the best of our knowledge, studies that compare pregnancy and infant outcomes among Palestinian refugees and Lebanese women are limited in the region, hence future studies should aim to be representative of all the nationalities to understand the difference in outcomes at the population level.

Since the year 2016, the use of primary caesarean section have declined for all the nationalities at RHUH. This is in contrast to the increasing trend of caesarean section within Lebanon.[25] In 2015, WHO recommended the implementation of the Robson Classification to reduce unnecessary caesarean sections. It is a global standard with the purpose to assess and monitor the use of caesarean section in different hospitals. RHUH is one of the first hospitals in Lebanon to adopt the classification, which may explain the decline in primary caesarean section during the study period. These findings are similar to another study within a private tertiary hospital in Lebanon, which showed that primary caesarean section use declined after the implementation the Robson Classification.[26] As for the use of repeated caesarean section, it was higher for Palestinian and Syrian women compared to the host population. This could be related to high fertility rates among Syrian refugees and limited access and utilisation of antenatal care, which often lead to undetected pregnancy complications resulting in emergency caesarean section.[27]

Very preterm birth was higher for Syrian women and migrant domestic workers compared to the Lebanese women. Our results are consistent with a Swedish study, which reported that pregnant women who were war refugees were at a higher risk of very preterm birth.[28]

Table 3 Pregnancy complications and comorbidities of women who delivered at RHUH according to nationality

	No **No (%)**	Yes **No (%)**	Crude OR (95% CI)
Diabetes			
Lebanese	6843 (99.5)	37 (0.5)	Reference
Syrian	9514 (99.4)	55 (0.6)	1.07 (0.70 to 1.62)
Palestinian	442 (99.6)	2 (0.5)	0.84 (0.20 to 3.49)
Migrant women	727 (99.4)	4 (0.6)	1.02 (0.36 to 2.87)
Hypertension complication			
Lebanese	6200 (90.1)	680 (9.9)	Reference
Syrian	8682 (90.7)	887 (9.3)	0.93 (0.83 to 1.03)
Palestinian	377 (84.9)	67 (15.1)	1.62 (1.22 to 2.15)
Migrant women	627 (85.8)	104 (14.2)	1.51 (1.21 to 1.89)
Placenta abruption			
Lebanese	6701 (97.4)	179 (2.6)	Reference
Syrian	9314 (97.3)	255 (2.7)	1.02 (0.84 to 1.24)
Palestinian	422 (95.1)	22 (4.9)	1.95 (1.24 to 3.07)
Migrant women	700 (95.8)	31 (4.2)	1.65 (1.12 to 2.45)
Placenta praevia and accrete			
Lebanese	6775 (98.5)	105 (1.5)	Reference
Syrian	9449 (98.7)	120 (1.3)	0.82 (0.63 to 1.07)
Palestinian	435 (98)	9 (2)	1.33 (0.67 to 2.65)
Migrant women	715 (97.8)	16 (2.2)	1.44 (0.84 to 2.45)
Placenta accreta spectrum			
Lebanese	6797 (98.8)	83 (1.2)	Reference
Syrian	9478 (99)	91 (1)	0.79 (0.58 to 1.06)
Palestinian	436 (98.2)	8 (1.8)	1.5 (0.72 to 3.12)
Migrant women	721 (98.6)	10 (1.4)	1.14 (0.59 to 2.20)
Hysterectomy			
Lebanese	6663 (96.8)	217 (3.2)	Reference
Syrian	9279 (97)	290 (3)	0.96 (0.80 to 1.14)
Palestinian	429 (96.6)	15 (3.4)	1.07 (0.63 to 1.83)
Migrant women	709 (97)	22 (3)	0.95 (0.61 to 1.49)
Uterine rupture			
Lebanese	6870 (99.9)	10 (0.1)	*
Syrian	9547 (99.8)	22 (0.2)	*
Palestinian	443 (99.8)	1 (0.2)	*
Migrant women	731 (100)	0 (0)	*
Transfused blood			
Lebanese	6851 (99.6)	29 (0.4)	*
Syrian	9529 (99.6)	40 (0.4)	*
Palestinian	442 (99.5)	2 (0.5)	*
Migrant women	731 (100)	0 (0)	*
Serious complications*			
Lebanese	5809 (84.4)	1701 (15.6)	Reference
Syrian	8105 (84.7)	1464 (15.3)	0.98 (0.90 to 1.07)
Palestinian	345 (77.7)	99 (22.3)	1.56 (1.22 to 1.98)
Migrant women	583 (79.8)	148 (20.2)	1.38 (1.13 to 1.67)
Intrauterine fetal death			

Table 3 Continued

	No **No (%)**	Yes **No (%)**	**Crude OR (95% CI)**
Lebanese	6665 (96.9)	215 (3.1)	Reference
Syrian	9217 (96.3)	352 (3.7)	1.18 (0.99 to 1.41)
Palestinian	433 (97.5)	11 (2.5)	0.79 (0.43 to 1.45)
Migrant women	684 (93.6)	47 (6.4)	2.13 (1.53 to 2.95)
Preterm birth	≥ 37 weeks	<37 weeks	
Lebanese	4260 (81.8)	949 (18.2)	Reference
Syrian	6171 (80.9)	1460 (19.1)	1.06 (0.97 to 1.16)
Palestinian	242 (71.4)	97 (28.6)	1.8 (1.40 to 2.30)
Migrant women	432 (78.7)	117 (21.3)	1.22 (0.98 to 1.51)
Very preterm birth	≥ 32 weeks	<32 weeks	
Lebanese	4826 (92.6)	383 (7.4)	Reference
Syrian	6953 (91.1)	678 (8.9)	1.23 (1.08 to 1.40)
Palestinian	305 (90)	34 (10)	1.4 (0.97 to 2.04)
Migrant women	490 (89.2)	59 (10.8)	1.51 (1.13 to 2.03)

*Serious complication includes pre-eclampsia, hysterectomy, placenta accreta spectrum, placenta praevia, blood transfusion, placenta abruption, uterine rupture.
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95% CI, 95% Confidence Interval; OR, Odds Ratio; RHUH, Rafik Hariri University Hospital.

Furthermore, a study conducted among African American pregnant women showed that exposure to stressful life events such as homelessness prior to or during pregnancy was associated with shortened gestational age.[29]

IUFD was higher among migrant women of other nationalities compared to Lebanese women. Similar to our findings, a study in Germany found that migrants women were more likely to experience stillbirth compared to the host population.[30] Underlying mechanisms may be related to inadequate access to antenatal care, limited access to healthcare, stressful work environments and economic status.[31] Provision of antenatal care to this often hidden and neglected population is required to prevent stillbirths. Future research is required to understand the biological mechanisms between preterm birth and IUFD and exposure to traumatic events such as war.

Strength and limitations
This study is an important addition to the literature since there are very few studies that have compared maternal and infant outcomes between Syrian refugees, Palestinian refugees and migrant domestic workers to the host population. RHUH receives women with obstetric emergencies without medical insurance in the Beirut area, hence our sample is representative of the most vulnerable population living in Lebanon. Furthermore, this study leveraged the use of classification through machine learning methods to develop the data set. This innovative approach is a mechanism for other hospitals in the global south to curate data sets where data would normally be absent. All

models for most of the variables achieved over 90% in terms of accuracy, precision, recall and F-measure.

This study had some limitations. Classification of 'free-text' through machine learning methods is susceptible to misclassification; however, we chose the best-performing model and manually coded rare outcomes to improve the discriminative ability of models. In addition, similar to other studies using electronic health records, this study is susceptible to misclassification as it relies on clinicians entering the correct and complete data for each hospital episode. Moreover, RHUH is a public hospital, so the maternal outcomes and characteristics of women were not representative of any nationality as a whole. Therefore, further population-based studies are required to verify our findings. Data about socioeconomic status was not available for pregnant women; however, giving birth at RHUH itself is reflective of low socioeconomic status. This study could be further strengthened by including patients in the knowledge production process.

Recommendations
Further studies that target antenatal care among migrants in the Arab region are needed to better understand gaps in healthcare delivery. Given the availability of antenatal care services in Lebanon, strategies to improve access to antenatal care to vulnerable populations, mainly migrants and refugees, should be implemented in order to ensure equitable access to healthcare and reduce adverse pregnancy outcomes. In addition, the implementation of the Robson Classification in all hospitals in Lebanon is

crucial to prevent unnecessary intervention. Further representative obstetric studies in Lebanon are crucial to better understand the infant and obstetric outcomes and whether they differ by nationality at a population level.

CONCLUSION

Despite the influx of Syrian refugees into a large public tertiary centre's obstetric ward, Syrian women had similar maternal and infant outcomes compared to the host population. This demonstrates the success of this particular centre to adapt to the challenges of refugee crisis. However, migrant women had poorer outcomes than the host population; highlighting that this population does not receive the necessary international assistance to receive adequate healthcare. Further efforts are required to ensure that the most vulnerable populations, such as migrant domestic workers who are deprived of their basic reproductive rights, receive the antenatal care needed to prevent severe complications of pregnancy.

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