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Neonatal mortality and vulnerable newborns in Qatar: A comparative epidemiological study of MENA women residing in Qatar and their home countries

Fawzia Alyafei [1], Ashraf Soliman [1,*], Mohamed Alkuwari [1], Tawa Olukade [1], Mai AlQubaisi [2], Nada Soliman [3] and Nada Alaaraj [1]

[1] *Department of Pediatrics, Hamad General Hospital, Hamad Medical Center (HMC), Doha, Qatar.*
[2] *Department of Neonatology, Women's Wellness and Research Centre, HMC, Doha, Qatar.*
[3] *Department of public health, North Dakota State University (NDSU), ND, USA.*

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Abstract

Objective: This study aimed to examine the distribution of newborn growth phenotypes and neonatal mortality rates (NM) among infants born to women from different Middle Eastern and North African (MENA) nationalities who gave birth in Qatar between 2016 and 2019.

Methods: A total of 62,362 livebirths were analyzed, with 35.4% born to Qatari women. Maternal age, mode of delivery, and newborn characteristics, including gender, preterm birth, low birth weight (LBW), and multiple pregnancies, were recorded for women from different MENA countries. The growth phenotypes (small for gestational age (SGA), appropriate for gestational age (AGA), and large for gestational age (LGA)) were determined, and NM rates were assessed for all nationalities. These data from Qatar were compared to the data reported on 2 occasions from the MENA countries.

Results: The study revealed a diverse distribution of newborn phenotypes across 18+ MENA nationalities. AGA babies constituted the largest group (79.2%), followed by LGA (14.6%) and SGA (6.2%). The prevalence of SGA and LBW was highest among babies born to UAE women and lowest among Syrian women. Neonatal mortality rates were relatively low across MENA nationalities in Qatar, with an overall rate of 0.25%. SGA babies exhibited the highest relative risk for NM (RR 6.3, 95% CI 4.5-8.9, $p<0.001$) compared to AGA babies. The addition of prematurity to any of the phenotypes (AGA, SGA, and LGA) markedly increased the risk of NM.

Conclusion: Neonatal mortality rates were significantly lower among different MENA nationalities in Qatar compared to those reported from their home countries. SGA babies showed the highest NM risk. Reducing the incidence of SGA in women from different MENA regions in Qatar compared to their home countries was associated with a significant decrease in neonatal mortality rates. These findings contributed to a better understanding of neonatal health in the region and underscored the importance of targeted interventions to improve newborn outcomes.

Keywords: MENA Nationalities; Qatar; Newborn Growth Phenotypes; Neonatal Mortality; Small For Gestational Age (SGA); Appropriate For Gestational Age (AGA); Large For Gestational Age (LGA); Qatar

* Corresponding author: Ashraf Soliman.

1. Introduction

Small newborns represent a vulnerable population, facing increased risks of mortality and long-term consequences for their future well-being. While previous assessments of vulnerability have largely focused on liveborn low-birthweight (LBW) infants, the progress in achieving LBW reduction targets has been inadequate [1].

The leading causes of LBW are preterm birth and fetal growth restriction (FGR), with the latter leading to infants classified as small for gestational age (SGA). Information on LBW infants is available from 81% of World Health Organization (WHO) member states and the occupied Palestinian territory, including east Jerusalem; however, only 58% of these countries possess national administrative data. In contrast, data on preterm births are available from 53% of countries and areas, with only 33% providing national administrative data. Furthermore, data on SGA newborns are available for only eight countries [2-4].

Recent global estimates indicate that 13.4 million live births were preterm in 2020, with rates remaining stable over the past decade. Additionally, there were 23.4 million live births classified as SGA during the same period. [4].

In 2020, 11.9 million global live births were preterm non-SGA, 21.9 million were term SGA, and 1.5 million were preterm (PT) SGA. Notably, more than half (55.3%) of the 2.4 million neonatal deaths worldwide in 2020 were attributed to one of these small vulnerable newborns (SVN) types, with 73.4% being preterm and the remaining cases term SGA. Stillbirth was associated with SGA based on population, ultrasound, and individualized norms (odds ratio (OR) (95% CI): 3.0 (2.2 to 4.0); 4.7 (3.7 to 5.9); 4.6 (3.6 to 5.9), respectively). Analyses of 0.6 million stillbirths at ≥22 weeks gestation revealed that approximately 74% of stillbirths were preterm, including 16.0% that were preterm SGA. Large for gestational age (LGA) was also associated with an increased risk of stillbirth using ultrasound and individualized norms (OR (95% CI): 3.5 (2.4 to 5.0); 2.3 (1.7 to 3.1), respectively). The associations were stronger with more severe SGA and LGA (<5th and >95th percentile) [4,5]. Notably, an estimated 1.9 million stillbirths annually are associated with similar vulnerability pathways, highlighting the critical importance of integrating stillbirths into burden assessments and relevant indicators [4].

A recent study on 125.5 million live births found that risk ratios were highest among PT + SGA (median 67.2, interquartile range [IQR] 45.6-73.9), PT + AGA (median 34.3, IQR 23.9-37.5), and PT + LGA (median 28.3, IQR 18.4-32.3). At the population level, PT + AGA was the greatest contributor to NM (median PAR% 53.7, IQR 44.5-54.9). Mortality risk was highest among newborns born before 28 weeks compared with babies born between 37 and 42 complete weeks or with a birth weight less than 1000 g compared with those between 2500 g and 4000 g as a reference group [6].

In the USA, a total of 22,341 infant deaths were reported in 2017. Infants of non-Hispanic black women had the highest NM (7.16) compared with infants of other races and Hispanic-origin groups, while the lowest neonatal mortality rate was observed for infants of non-Hispanic Asian women (2.71). The overall U.S. infant mortality rate was 5.79 infant deaths per 1,000 live births. Infants born very preterm (less than 28 weeks of gestation) had the highest mortality rate (384.39), which was 183 times higher than that for infants born at term (37–41 weeks of gestation) (2.10). Preterm-related causes of death accounted for 34% of the 2017 infant deaths [7]. In 2021, the infant mortality rate in Europe was estimated to be 3.1 per 1,000 live births, compared with 82.2 in 1950 [8]. The current infant mortality rate for the U.K. in 2023 is 3.337 deaths per 1000 live births, representing a 2.48% decline from 2022 [9].

Several studies have proposed that various factors contribute to poor newborn survival rates and higher NM in developing countries. These factors include educational level, maternal illiteracy, sex of the neonate, duration of pregnancy, home delivery without skilled providers, pregnancy complications, birth weight, lack or poor prenatal, natal, and postnatal services, harmful cultural practices, economic status, social exclusion, negative parental attitudes arising from the social environment, and gender bias [10-14]. These NM determining factors differ significantly among pregnant women from different Middle East and Mediterranean Region (MENA) countries, and these differences are expected to affect the frequency of SNV as well as NM in these countries [15-18].

Therefore, there is a significant need to measure the prevalence of Neonatal Vulnerability groups (NVT) and NM in women from MENA countries who give birth in Qatar and compare these data with the prevalence of NVT and NM in their home countries. This can help identify the main factors contributing to increased NVT and/or NM in these groups and can facilitate prevention efforts and targeted specialized care for the most vulnerable groups and correctable factors.

Objectives

The objectives of this study are to estimate the prevalence of different NVT and NM in newborns of women from Middle Eastern and North African (MENA) countries using the INTERGROWTH-21st birth weight standard. Additionally, we aimed to compare these data from Qatar with the prevalence of NVT and NM in their home countries, as recently published in the literature.

Design

This study is a population-based retrospective data analysis of routinely collected hospital data in Qatar. We estimated the prevalence of SGA, AGA, and LGA and associated neonatal mortality from live births to each maternal nationality based on the INTERGROWTH-21st birth weight standard. The study was conducted over four years (2016 to 2019) and included births from the four main HMC hospitals, accounting for over 90% of all births in the country. The inclusion criteria were live births between 24+0 weeks and 42+6 weeks gestation to Qatari women and those from Middle Eastern or North African (MENA) nationalities.

2. Methods

We retrieved 95,906 newborn records and excluded records with missing liveborn or stillborn status, stillbirths, missing gestational age, and GA outside inclusion criteria. We also excluded babies with missing data on key variables required for growth estimation and implausible values. Finally, we excluded births from other nationalities. Giving A final Sample of 62362 live births of MENA nationals who live in Qatar. This study was approved by the Hamad Medical Corporation Institutional Review Board (MRC 01-21-277).

Data was available for women from the following countries: Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates (UAE), and Yemen.

2.1. Covariates and Outcomes

Maternal age at delivery was classified into three categories: < 20, 20 – 34, and ≥ 35 years. Birth weight was defined as low birth weight (< 2500 g) or non-low birth weight (≥ 2500 g). Preterm birth was defined as a gestational age < 37 completed weeks and term as gestational age 37+0 weeks to 42+6 weeks. In Qatar, most women underwent a first-trimester ultrasound in addition to using the menstrual calendar for pregnancy dating, and birth weight was measured immediately after birth. Almost all births occur in a health facility [19].

Fetal growth and newborn size measures were estimated according to the INTERGROWTH-21st newborn standards. SGA was defined as < 10th centile for birth weight for gestational age in completed weeks at birth by sex, AGA between the 10th and 90th centiles, and LGA above the 90th centile. The INTERGROWTH-21st international newborn size standards cover the gestational age range from 24 to < 43 weeks. Live births were classified into six mutually exclusive phenotypes based on combinations of preterm birth and INTERGROWTH-21st newborn growths. These phenotypes are preterm small for gestational age (SGA+PT), preterm appropriate for gestational age (AGA+PT), preterm large for gestational age (LGA+PT), term small for gestational age (SGA+T), term appropriate for gestational age (AGA+T) (as reference), and term large for gestational age (LGA+T) [20].

2.2. Statistical Analysis

The unit of analysis was each live newborn. We estimated the prevalence of preterm, SGA, and LBW individually and each combined vulnerable newborn phenotype. Descriptive statistics are presented for maternal demographic data and newborn characteristics. Statistical differences between the different NVT and NM in Qatar and their home countries were examined using chi-square tests. The relative risks for NM were calculated using the GLM procedure. The analysis was performed using STATA MP version 14. Statistical significance was set at $p < 0.05$.

3. Results

A total of 62,362 livebirths were examined in newborns born to women from 18 MENA nationalities who gave birth in Qatar between 2016 to 2019, with 22,091 (35.4%) born to Qatari women. The distribution of newborns according to nationalities was as follows: Egyptian 17.4%, Syrian 9.2%, Sudanese 6.9%, Jordanian 5.9%, Yemeni 5.8%, and Kuwaiti mothers 0.3%. The overall mean maternal age was 29.5 ± 5.5 years, and the age distribution of the women was as follows: teenagers (2.2%), 20 to 34 years (78.5%), and ≥35 years (19.3%). Among the newborns, 48.8% were females,

10.3% were preterm, and 9.2% were low birth weight babies (LBW). Additionally, 5% of the babies were products of multiple pregnancies, and 34.2% were delivered by cesarean section (Table 1).

Table 1 Maternal and Newborn Characteristics in Qatar (2016-2019)

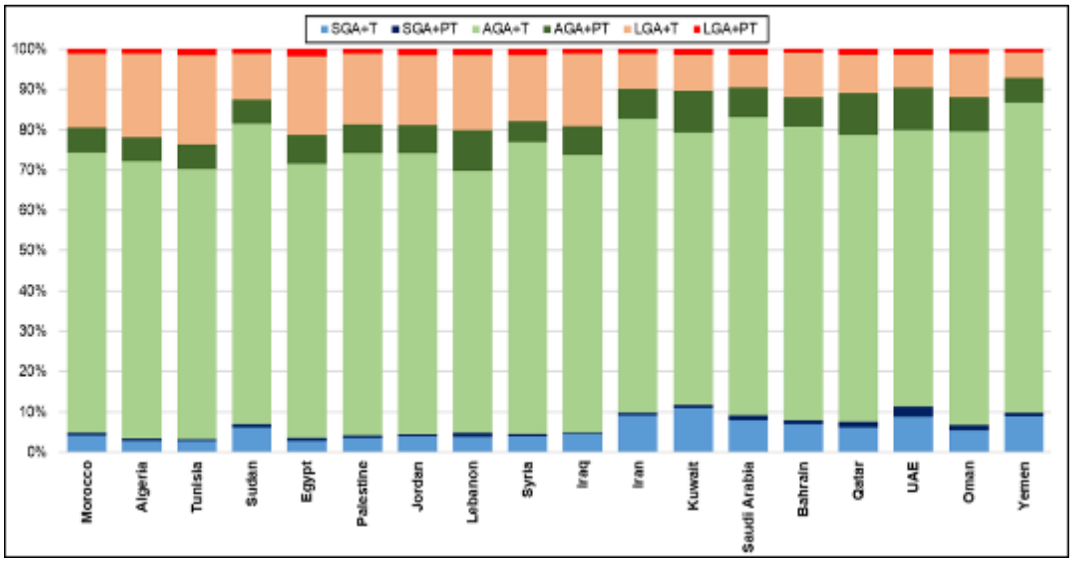
		Maternal characteristics				Newborn characteristics (%)							
Country	**Count**	**Mean age (years)**	**% <20 (years)**	**% 20-34 (years)**	**% ≥35 (years)**	**Female**	**PT**	**LBW**	**Multiple**	**C/S**	**AGA**	**SGA**	**LGA**
Algeria	572	29.9 ± 4.7	0.7	83.6	15.7	49.7	7.7	6.8	3.5	27.5	74.8	3.3	21.9
Bahrain	545	27 ± 5.4	5.1	83.9	11.0	46.8	9.2	9.9	4.3	21.6	80.2	7.9	11.9
Egypt	10,839	30.2 ± 4.7	0.5	80.9	18.5	48.1	9.6	6.9	5.9	48.4	75.3	3.5	21.2
Iran	1,313	29.9 ± 5.6	1.2	77.4	21.4	48.7	9.1	8.9	2.9	27.6	80.4	9.7	10.0
Iraq	336	29.7 ± 5.6	3.0	75.6	21.4	43.5	8.6	8.0	6.0	27.4	76.2	4.8	19.1
Jordan	3,683	30 ± 4.8	0.5	81.0	18.5	48.2	8.9	7.0	5.6	30.2	76.8	4.4	18.9
Kuwait	155	29.8 ± 6	1.3	78.7	20.0	49.7	12.3	14.2	5.8	40.3	78.1	11.6	10.3
Lebanon	806	30.4 ± 4.7	0.7	80.4	18.9	50.5	12.7	10.9	8.1	39.1	75.2	4.7	20.1
Morocco	1,078	29.7 ± 5.2	1.4	79.8	18.8	49.7	8.3	7.3	5.7	33.2	75.8	4.8	19.4
Oman	647	30 ± 5.5	2.0	76.5	21.5	47.0	11.1	11.4	2.8	25.4	81.5	6.7	11.9
Palestine	1,671	29 ± 5.5	2.2	80.0	17.9	49.6	9.0	7.1	5.7	25.7	77.2	4.2	18.6
Qatar	22,091	29.8 ± 5.8	1.7	76.1	22.2	49.3	13.1	12.4	5.9	34.2	81.6	7.5	10.9
Saudi Arabia	2,562	27.2 ± 5.5	5.9	83.8	10.3	48.4	9.9	10.4	3.3	29.1	81.5	9.1	9.5
Sudan	4,328	30.3 ± 5.8	2.0	73.6	24.4	47.8	7.8	8.0	3.1	33.9	80.7	6.9	12.5
Syria	5,735	28.2 ± 5.5	5.4	81.1	13.5	48.2	7.2	5.3	4.2	27.7	77.6	4.5	17.9
Tunisia	1,982	30.5 ± 4.5	0.3	80.9	18.8	49.2	8.1	5.8	3.9	37.1	73.2	3.2	23.6
UAE	379	29.9 ± 6.1	2.6	72.8	24.5	48.8	14.5	15.6	4.5	29.0	79.2	11.4	9.5
Yemen	3,640	27.6 ± 6	6.7	77.9	15.4	50.4	7.6	8.2	1.6	19.9	83.2	9.6	7.1
Total	62,362	29.5 ± 5.5	2.2	78.5	19.3	48.8	10.3	9.2	5	34.2	79.2	6.2	14.6

*Abbreviations: C/S → Caesarean section, PT: Preterm, LBW: Low birth weight, AGA: Appropriate for gestation age, SGA: Small for gestation age, LGA: Large for gestation age

The proportion of newborns of older women (>34 years) was the least in women from Saudi Arabia (10.3%), while the proportion in women from Kuwait, Iran, Iraq, Oman, and Qatar ranged between 20% and 22.2%. The highest proportions of older age women were observed in Sudan and UAE, 24.4% and 24.5%, respectively. (Table 1) The number of newborns for teenage mothers was generally low, with less than 5% in 14 out of the 18 countries. Yemen had the least multiple births, while Lebanon had the highest. The prevalence of preterm and LBW was the highest among babies born to UAE women and lowest in babies born to Syrian women. (Figure 1).

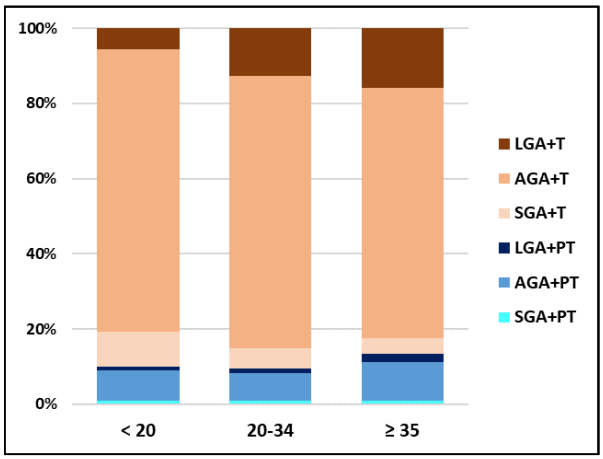
The prevalence of SGA, AGA, and LGA in all studied babies was 6.2%, 79.2%, and 14.6%, respectively. Among term live births, the prevalence of SGA, AGA, and LGA was 5.3%, 71.2%, and 13.3%, respectively. Among preterm live births, these distributions were 0.9%, 8%, and 1.4%, respectively. The prevalence of SGA in preterm and term babies was 9.1% vs 5.9%, respectively, while the prevalence of AGA was 77.5% vs 79.3%, respectively. The prevalence of LGA was 13.4% vs 14.8%, respectively. The distribution of the six phenotypes was as follows: AGA+T (71.2%), SGA+T (5.3%), LGA+T (13.3%), AGA+PT (8%), SGA+PT (0.9%), and LGA+PT (1.4%). Fifty-three percent of SGA babies were LBW, while 36% of all LBW babies were SGA. Sixty percent of preterm babies were LBW compared to 3.3% of term babies. In general, the prevalence of both SGA or LBW was high in mothers younger than 20 years, whereas LGA+T and LGA+PT were

highest in older mothers >34 years (Figure 2). The differences observed in maternal age, mode of delivery, and the prevalence of premature and/or LBW babies were statistically significant at $p<0.05$.



Abbreviations: LGA+T: Large for gestational age + Term, AGA+T: Appropriate for gestational age +Term, SGA+T: Small for gestational age +Term, LGA+PT: Large for gestational age+ preterm, AGA+PT: Appropriate for gestational age +Preterm, SGA+PT: Small for gestational age +Preterm

Figure 1 The distribution of fetal growth (Intergrowth-21st standard) phenotypes in different maternal nationality groups in Qatar



Abbreviations: LGA+T: Large for gestational age + Term, AGA+T: Appropriate for gestational age +Term, SGA+T: Small for gestational age +Term, LGA+PT: Large for gestational age+ preterm, AGA+PT: Appropriate for gestational age +Preterm, SGA+PT: Small for gestational age +Preterm, yr: years.

Figure 2 Distribution of neonatal growth phenotype among different maternal age groups

3.1. Nationalities and newborn growth phenotypes

All women from different nationalities who gave birth in Qatar had SGA prevalence below 10% and LGA prevalence above 10%, with comparable distribution of newborn phenotypes across close geographical boundaries. The fetal growth patterns for the North African countries were similar to their neighboring Middle Eastern countries, i.e. from Morocco to Iraq and from Iran to Yemen, except for Sudan (Table 1, Figure 1). Livebirths to mothers from Tunisia, Algeria, Egypt, Palestine, Jordan, Syria, Lebanon, Iraq, Morocco had the least prevalence of SGA (3.2% to 4.8%), and they had the highest prevalence of LGA babies (17.9% to 23.6%). In contrast, mothers from Oman, Sudan, Qatar, Bahrain, Saudi Arabia, Yemen, Iran, UAE, and Kuwait had a relatively higher prevalence of SGA babies (6.7% to 11.6%) and a lower prevalence of LGA babies (7.1% to 12.5%).

Most of the babies born to mothers from different nationalities were AGA+T babies.

The prevalence of SGA+PT phenotype was generally <1% except in Lebanon (1%), Saudi Arabia (1.1%), Oman (1.4%), Qatar (1.4%), and UAE (2.6%). SGA+T babies were the least in Tunisia (2.8%) and the highest in Kuwait (11%). (Figure 1)

3.2. Neonatal mortality (NM) in mothers from different nationalities

Neonatal mortality (NM) was relatively low across the various nationalities in Qatar. The overall NM in Qatar was 0.25% (153/62,362), and it ranged from 0% - 0.37% across the different nationalities. The contribution of different phenotypes to NM (n=153) was as follows: 31% (47/153) from the SGA group, 62% (95/153) from the AGA group, and 7% (11/153) from the LGA group. Within these groups, the mortalities were higher in preterm phenotypes, where 64% (30/47) of SGA mortalities were from SGA+PT, 74% (70/95) of AGA mortalities from AGA+PT, and 73% (8/11) of LGA mortalities from LGA+PT.

The effect of LBW was also examined. The combination of prematurity and LBW significantly increased NM rates (Figure 3). The relative risk for NM was significantly higher in SGA babies (RR 6.3, 95% CI 4.5-8.9, p<0.001) when compared to AGA+T babies but not increased in LGA babies (RR 0.6, 95% CI 0.3-1.2, p=0.141). Considering the different phenotypes and using AGA+T as reference, NM was significantly lower in LGA+T babies compared to the other phenotypes (Table 2).

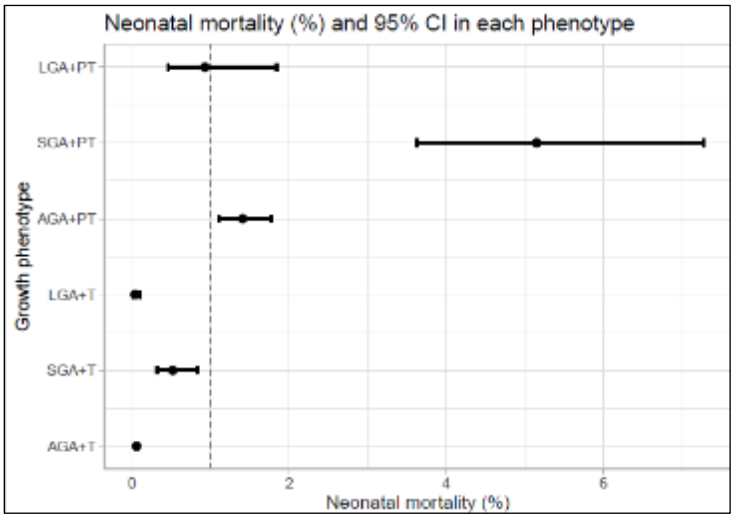


Figure 3 Neonatal mortality in the 6 different phenotypes

Table 2 Relative risks for neonatal mortality (NM) in different neonatal phenotypes.

	count	RR	95% CI		P value
AGA	95	Reference	--	--	--
SGA	47	6.3	4.5	8.9	<0.001
LGA	11	0.6	0.3	1.2	0.141
AGA+T	25	Reference	--	--	--
SGA+T	17	9.2	5.0	17.0	<0.001
LGA+T	3	0.6	0.2	2.1	0.472
AGA+PT	70	25.0	15.8	39.4	<0.001
SGA+PT	30	91.4	54.1	154.4	<0.001
LGA+PT	8	16.4	7.4	36.3	<0.001

Abbreviations: AGA: Appropriate for gestation age, SGA: Small for gestation age, LGA: Large for gestation age, LGA+T: Large for gestational age + Term, AGA+T: Appropriate for gestational age +Term, SGA+T: Small for gestational age +Term, LGA+PT: Large for gestational age+ preterm, AGA+PT: Appropriate for gestational age +Preterm, SGA+PT: Small for gestational age +Preterm

We compared the NM of different newborn phenotypes born in Qatar to women of different nationalities versus NM data published in their home countries (Table 3). The NM of all nationalities who gave birth in Qatar was markedly lower compared to the NM in their home countries (Table 3). Neonatal mortality correlated significantly with the prevalence of SGA among all the studied populations (r= 0.702, p <0.001). (Figure 4) Decreased prevalence of SGA from 12.59/1000 to 6.54/1000 was associated with decreased NM from 11.26/1000 to 1.97/1000 (Table 3).

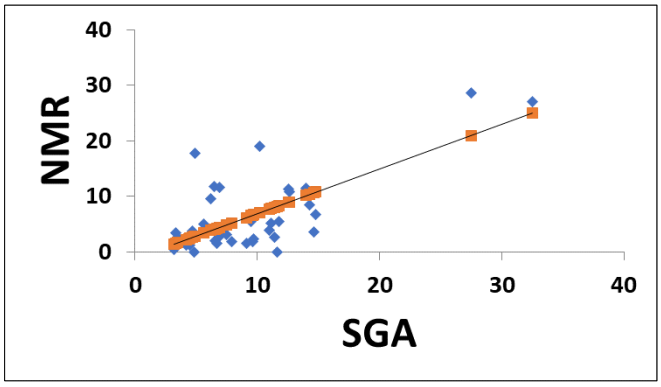


Figure 4 Correlation between neonatal mortality rate (NMR) and prevalence of SGA (r = 0.70, P < 0.001)

Table 3 Comparison of NM (per 1000) and Neonatal phenotypes (%) of different nationalities in Qatar compared to their home countries.

	QATAR VN-MENA STUDY					Home country data for 2012 (Lee et. al 2017)				WHO
Country	**NMR**	**Preterm**	**SGA**	**SGA+T**	**SGA+PT**	**NMR**	**Preterm**	**SGA**	**SGA+PT**	**NMR**
Algeria	0.35	7.7	3.3	2.8	0.5	11.6	7.4	6.9	0.6	15.6
Bahrain	0.18	9.2	7.9	7	0.9	3.6	14	14.6	1.6	3
Egypt	0.27	9.6	3.5	2.8	0.7	11.8	7.3	6.5	0.6	10
Iran	0.23	9.1	9.7	9.1	0.5	10.8	12.9	12.6	1.5	8.1
Iraq	0	8.6	4.8	4.5	0.3	19	6.5	10.2	0.8	14
Jordan	0.22	8.9	4.4	3.9	0.5	11.5	14.4	14	1.7	8.5
Kuwait	0	12.3	11.6	11	0.7	5.5	10.6	11.8	1.2	4.9
Lebanon	0.37	12.7	4.7	3.7	1	5.4	7.9	9.5	0.9	4.8
Morocco	0.28	8.3	4.8	4.1	0.7	17.8	6.7	4.9	0.6	11.1
Oman	0.15	11.1	6.7	5.3	1.4	6.7	14.3	14.8	1.7	4.6
Palestine	0.12	9	4.2	3.6	0.6	NA	NA	NA	NA	NA
Qatar[a]	0.31	13.1	7.5	6.1	1.4	3.9	10.5	11	1.3	3.3
Saudi Arabia	0.16	9.9	9.1	8	1.1	5.2	6	11.1	0.7	3.3
Sudan	0.28	7.8	6.9	6.2	0.7	28.6	13.2	27.5	1.1	NA
Syria	0.12	7.2	4.5	4	0.5	8.5	10.9	14.3	1.3	10.8
Tunisia	0.05	8.1	3.2	2.8	0.4	9.5	8.9	6.2	0.7	11.5
UAE	0.26	14.5	11.4	8.7	2.6	5	7.6	5.6	0.9	3.5
Yemen	0.19	7.6	9.6	8.9	0.7	27	13.2	32.5	1.6	28
Mean	1.97	9.71	6.54	5.69	0.84	11.26	10.14	12.59	1.11	9.06
SD	1.07	2.08	2.71	2.55	0.54	7.66	3.05	7.38	0.41	6.48

Qatar home country data includes other nationalities disaggregated for in this study.

4. Discussion

Over the past 17 years, neonatal mortality rates (NM) have declined significantly; however, they have not decreased at the same pace as mortality rates of older children. This has resulted in a higher proportion of deaths occurring within the first four weeks of life among children under 5 years old. In 91% of countries, NM increased as a proportion of total deaths of children under 5. To achieve the Sustainable Development Goal (SDG) of the United Nations to "end preventable deaths of newborns by 2030," understanding the reasons behind persistently high neonatal mortality is crucial for decision-makers at all levels [21, 22]. National interventions should focus on addressing correctable causes of NM. However, some causes of neonatal death, such as severe preterm birth complications, remain challenging to prevent completely with existing medical resources. Achieving substantial improvements in NM may require significant investments in health system development [23-28].

In low- and middle-income countries, an estimated 606,500 (495,000 to 773,000) neonatal deaths were attributable to infants born small for gestational age (SGA), accounting for 21.9% of all neonatal deaths. The largest burden was observed in South Asia, where the prevalence of NM was the highest at 34%, and approximately 26% of neonatal deaths were attributable to infants born SGA. Reducing the prevalence of SGA from 19.3% to 10.0% in these countries could potentially decrease NM by 9.2% (254,600 neonatal deaths: 164,800 to 449,700) [21].

A large cohort study across 11 community-based research sites in South Asia and sub-Saharan Africa, between July 2012 and February 2016, reported that NM rates were about two times higher in South Asia (43.0 per 1000 live births) compared to sub-Saharan Africa (20.1 per 1000 live births). The most common causes of neonatal deaths were perinatal asphyxia (40% and 34% respectively), severe neonatal infections (35% and 37% respectively), followed by complications of preterm birth (19% and 24% respectively). Addressing perinatal asphyxia, newborn infections, and preterm birth is critical to achieving survival goals in the Sustainable Development Goals era [29].

According to a 2020 report by the World Health Organization (WHO), most neonatal deaths (75%) occurred during the first week of life, and about 1 million newborns died within the first 24 hours. Preterm birth, intrapartum-related complications (birth asphyxia or lack of breathing at birth), infections, and birth defects were the leading causes of neonatal deaths in 2017. The top 10 countries with the highest number (thousands) of newborn deaths were India, Nigeria, Pakistan, Ethiopia, the Democratic Republic of Congo, China, Indonesia, Bangladesh, Afghanistan, and the United Republic of Tanzania [30].

In the African Region, approximately 1.12 million newborn deaths occur annually. The main causes include prematurity and low birth weight, infections, lack of oxygen at birth, and birth trauma. In Kenya and South Africa, NM has gradually declined from 35.4 and 27.9 deaths per 1000 live births in 1975 to 19 and 10.7 deaths per 1000 live births, respectively, in 2018. Most neonatal deaths resulted from preterm birth complications followed by intrapartum-related events for the two countries [31, 32].

Between 1990 and 2021, the NM in the Middle East region declined from 31.9 to 12.2 per 1000 live births. The countries included in this decline were Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, the United Arab Emirates, and Yemen [33].

Our study showed relatively low NM in all the studied groups of different nationalities (women from different MENA countries) (<5/1000) compared to NM in their home (MENA) countries. The relatively high NM in many of these countries, exceeding 10/1000 (Tunisia, Algeria, Morocco, Syria, Iraq, and Yemen), decreased significantly when women from these countries resided in Qatar.

These results strongly suggest that improving antenatal care and the economic status of women can markedly decrease NM in all groups of women from different countries and with variable genetic backgrounds. These significant changes in NM can be explained by two major factors: higher economic status with higher income and the existence of effective antenatal care through the Primary Health Care Corporation, which operates 28 health centers across Qatar. This service provides community-based primary care services to Qatar's population in all parts of the country and offers 3 to 4 antenatal visits to each pregnant woman. These primary health centers offer a wide range of preventive, diagnostic, and treatment healthcare services, including antenatal and postnatal care, family planning programs, diet and nutrition counseling, immunization, radiology, and wellness services. Family physicians conduct initial pregnancy tests and antenatal packages that include all the necessary initial lab investigations and ultrasound screening. Ultrasound checks and fetal heart monitoring are done during the visits. The PHCC holds weekly antenatal classes to provide vital education to expectant mothers about their health during pregnancy and after delivery. More than 90% of pregnant women receive adequate antenatal care in Qatar, comparable to the rates reported by the US in 2021 (88.9%). In addition, the

high facility birth rate (almost 99% in Qatar) and the compulsory 24-hour stay in the facility postnatally play a role in preventing many complications. The postnatal care contacts/visits delivered at the health facility are offered free for all women [34-36].

In our study, NM was higher in SGA and preterm phenotypes. The relative risk for NM was significantly higher in SGA babies; RR 6.3 (95% CI, 4.5 - 8.9, $p<0.001$) when compared to AGA+T babies. Sixty-four percent of SGA mortalities were from SGA+PT, 74% of AGA mortalities were from AGA+PT, and 73% of LGA mortalities were from LGA+PT. The addition of prematurity to all the neonatal phenotypes increased NM rates (Figure 3). It was evident from our study that women from different countries had a significantly lower incidence of giving birth to SGA and, to a lesser extent, SGA+PT newborns in Qatar compared to their home countries. Decreasing SGA from 12.59/1000 to 6.54/1000 was associated with decreased NM from 11.26/1000 to 1.97/1000. Moreover, the prevalence of SGA was higher in the young women group, which may explain the higher NM in this group.

Supporting our findings, a cross-sectional study in Brazil (n=9,349 live births in 2010 in Cuiabá-MT Brazil) found that NM was associated with maternal age less than 20 years, prematurity, and low birth weight. The results highlighted the need to improve the quality of prenatal care to prevent low birth weight and prematurity. The association between neonatal death and low Apgar scores at 1 and 5 minutes indicates the importance of investments in delivery care [37].

From our study, it can be deduced that it is possible to improve the survival and health of newborns by achieving high coverage of quality antenatal care and skilled care at birth. In settings with well-functioning antenatal programs, the provision of 3 to 4 antenatal visits can reduce SGA and preterm births. With the increase in facility births (almost 99% in Qatar), there is a great opportunity for providing essential newborn care and identifying and managing high-risk newborns. The 24-hour stay of women in health facilities postnatally can prevent many complications. In addition, recommended postnatal care contacts carried out at health facilities play an important role in following these newborns and their families.

5. Conclusion

Our comparative study highlights that accelerating progress for neonatal survival requires strengthening the quality of care (antenatal, natal, and postnatal) and ensuring the availability of quality health services for all pregnant women, especially those at high risk. In developing countries, reducing the occurrence of prematurity and SGA should be an important target after addressing neonatal infection and intrapartum asphyxia.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

These retrospective cohort data were obtained and analyzed after receiving the appropriate Institutional Review Board (IRB) approval from the HMC Research Center.

Statement of informed consent:

Informed consent was obtained from all individual participants included in the study.

Authors' Contributions

Fawzia Alyafei and Ashraf Soliman led the study as the main authors, contributing to the study conception, design, data collection, and manuscript drafting. Mohamed Alkuwari and Nada Alaaraj contributed to the study design, data collection, and critical revisions. Mai AlQubaisi, as the neonatologist, provided clinical expertise in neonatal health and contributed to the interpretation of neonatal outcomes. Tawa Olukade conducted biostatistical analysis and contributed to data interpretation. Nada Soliman provided expertise in public health analysis and contextualized the findings within a broader epidemiological framework. All authors participated in manuscript drafting, provided critical revisions, and approved the final version for submission.

The authors declare that there are no conflicts of interest regarding the publication of this review. All authors have reviewed and approved the final manuscript for publication

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