ORIGINAL ARTICLE

Exploring Perinatal Asphyxia and Its Determinants in Perinatal Mortality: A 2020-2022 Analysis From Kelantan, Malaysia

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ABSTRACT

Introduction: Perinatal asphyxia significantly contributes to perinatal mortality rates, particularly in low- and middle-income countries. Nevertheless, the exact prevalence and associated risk factors for perinatal asphyxia-related deaths in Malaysia, with a specific focus on the state of Kelantan, remain inadequately characterized. Therefore, this study aims to evaluate the prevalence of perinatal asphyxia and identify its associated determinants among cases of perinatal mortality in Kelantan, Malaysia, from 2020 to 2022. **Materials and Methods:** This cross-sectional study analyzed secondary data from 397 reported perinatal mortality cases (2020-2022), sourced from the Stillbirth and Under-five Mortality Notification System. It examined sociodemographic, obstetric, and intrapartum factors using descriptive statistics and logistic regression to identify potential correlations and risk factors for perinatal mortality. **Results:** The proportion of perinatal asphyxia among perinatal mortality cases in Kelantan was 25.9% (95% CI: 21.7, 30.6). The multivariable analysis revealed that non-Malay ethnicity (aOR=2.70, 95% CI: 1.18, 6.22; p=0.019), inadequate or unbooked antenatal care (aOR=2.95, 95% CI: 1.66, 5.22; p<0.001), late preterm gestational age (34-36 weeks) (aOR=2.49, 95% CI: 1.20, 5.18; p=0.014), and cesarean delivery (aOR=2.52, 95% CI: 1.51, 4.21; p<0.001) were significantly associated with an increased risk of perinatal asphyxia. **Conclusion:** Perinatal asphyxia remains a significant contributor to perinatal mortality in Kelantan, Malaysia. Non-Malay ethnicity, inadequate antenatal care, late preterm birth, and cesarean delivery were identified as key risk factors. Targeted interventions to improve antenatal care, enhance neonatal resuscitation skills, and ensure timely access to emergency obstetric care are crucial to mitigate the burden of perinatal asphyxia in the region.
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Keywords: Perinatal mortality, perinatal asphyxia, risk factors, Kelantan, Malaysia

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INTRODUCTION

While there has been considerable global advancement in lowering childhood mortality rates since 1990, the decline in neonatal mortality has lagged compared to the more pronounced reductions observed in post-neonatal mortality for children under five years of age. Tragically, approximately 6,400 infants still die every day, accounting for nearly 50% of all under-five deaths worldwide. Looking ahead, it is projected that around 26 million newborns will perish between 2019 and 2030, and the majority of these devastating losses could have been prevented (1). Perinatal mortality, encompassing both stillbirths and early neonatal deaths that happen during the first week after birth, poses a major public health issue worldwide (2, 3). It serves as a crucial indicator of the well-being of expectant mothers, new mothers, and newborns, as well as the standard of care provided throughout pregnancy, delivery, and the postpartum period (4).

Perinatal asphyxia, a condition characterised by impaired gas exchange during the perinatal period, remains a prominent contributor to neonatal morbidity and mortality. A particularly concerning manifestation of this is hypoxic-ischemic encephalopathy (HIE), which can result in profound neurological deficits. The long-

term effects of HIE often include serious impairments, such as cerebral palsy, cognitive dysfunction, and various behavioural disorders. These complications can substantially hinder overall developmental trajectories and adversely affect the quality of life for affected children (5). Perinatal asphyxia is responsible for 11% of child mortality among those under five globally, making it the third leading cause of death after pneumonia and preterm birth (6). It is also one of the three leading preventable and treatable conditions responsible for 80% of all newborn deaths (1).

In Ethiopia, which is a developing nation similar to Malaysia, perinatal asphyxia ranks as the second leading cause of perinatal deaths, accounting for 31.2% of fatalities (7). Similarly, in Malaysia, perinatal asphyxia was the second leading cause of preventable perinatal mortality, accounting for 28.8% of cases (8). A study at a university hospital in Kuala Lumpur found that the proportion of perinatal asphyxia over seven years from 2004 to 2010 was 22.3% (9).

Malaysia has achieved significant advancements in enhancing maternal and child health outcomes, decreasing the under-five mortality rate from 16.9 per 1,000 live births in 1990 to 7.8 per 1,000 live births in 2022 (10). Despite national efforts to standardise perinatal health outcomes, significant discrepancies in perinatal mortality rates remain across various states. Specifically, Kelantan consistently reports perinatal mortality rates exceeding the national benchmark of 6.5 per 1,000 live births. In 2020, the rate was documented at 7.39 per 1,000 live births, with an increase to 8.95 per 1,000 live births in 2021, before slightly decreasing to 7.64 per 1,000 live births in 2022. These figures highlight a persistent challenge in achieving equitable health outcomes in this region (11).

Despite perinatal asphyxia being a major contributor to global mortality, many of these fatalities are preventable. However, studies focusing on perinatal asphyxia and its causes in Malaysia, especially in Kelantan, are limited. Existing research has primarily focused on live births, leaving a significant gap in understanding the specific risk factors that contribute to perinatal asphyxia-related deaths. Identifying these risk factors is crucial, as it can provide valuable information for developing targeted interventions at the district and state levels.

Understanding the causes of perinatal asphyxia deaths in Kelantan will provide the evidence required to design and implement tailored interventions. These interventions may include improving antenatal and delivery care services, identifying risk factors early, and training healthcare providers to better recognise and manage perinatal asphyxia. Addressing this research gap has the potential to improve the effectiveness of prevention and intervention programmes by pinpointing the specific factors that increase the vulnerability of high-risk populations in Kelantan to perinatal asphyxia. Identifying these determinants is also crucial for tailoring targeted interventions that address the unique challenges faced by these groups.

MATERIALS AND METHODS

Study Design and Populations

This cross-sectional study employed a retrospective analysis of secondary data spanning a three-year period from 2020 to 2022. The study was conducted in Kelantan, a state located in the northeastern region of Peninsular Malaysia, which encompasses ten administrative districts: Bachok, Gua Musang, Jeli, Kota Bharu, Kuala Krai, Machang, Pasir Mas, Pasir Puteh, Tanah Merah, and Tumpat. The demographic profile is predominantly Malay, accounting for approximately 95% of the population, with minority groups that include Chinese, Indian, Thai, and indigenous Orang Asli communities. The healthcare infrastructure in Kelantan consists of 114 health clinics, nine government hospitals, one university-affiliated hospital, and a variety of private healthcare facilities distributed across the districts (12, 13). The Maternal and Child Health Unit obtains notifications and investigation forms regarding stillbirths and under-five mortality cases from these healthcare facilities.

Criteria for sample selection

This study encompasses all reported cases of perinatal mortality in the state, as documented by the Kelantan State Health Department from 2020 to 2022, that satisfy the predetermined inclusion and exclusion criteria. The inclusion criteria for the study were focused on all deaths involving the perinatal age group (including stillbirth > 22 weeks and birth weight > 500 grams and early neonatal death (from birth until seven days of life) from 2020 until 2022. The exclusion criteria aimed to refine the dataset by eliminating duplicate notifications and cases with incomplete data. This methodology aims to eliminate redundancy and enhance data accuracy, thus facilitating a more precise and accurate analysis.

Sample size determination and sampling method

The sample size for this study was calculated using a web-based calculator that utilizes single proportions for estimation. The calculation was calculated on a Type I error rate of 5% and a Type II error rate of 20%, with a 20% margin for data errors. After considering all variables and sample size calculations, 397 respondents were deemed sufficient to achieve the study's objectives. The sampling frame included all 866 perinatal deaths in Kelantan between 2020 and 2022, and the sample was selected using a simple random sampling method.

Data collection and research tools

This study utilized secondary data sourced from the Stillbirth and Under-five Mortality Notification System (SU5MR) and the Stillbirth and Under-five Mortality

Investigation Form (SU5MR-1/2012). These datasets were provided by the Maternal and Child Health Unit of the Kelantan State Health Department. The SU5MR System was established by the Malaysian Ministry of Health in 2013 to facilitate the reporting of under-five mortality, encompassing cases from both private healthcare facilities and deaths occurring outside hospital settings. Each reported death is subject to thorough investigation, categorization, and classification as either preventable or non-preventable. Notifications regarding stillbirths and under-five deaths are required to be submitted to the District Health Office via the U5MR-N form within 24 hours post-event. These notifications are subsequently forwarded to the Kelantan State Health Department for verification before being transmitted to the Ministry of Health for further reporting (14).

For each case, a manual investigation is performed by healthcare facilities, with findings documented on the SU5MR-1/2012 form. This form is submitted to the District Health Office within one week, followed by subsequent submissions to the Kelantan State Health Department and the Ministry of Health within a 12-week timeframe. Data from these forms are systematically extracted into a proforma checklist and organized in an MS Excel spreadsheet. Each case is assigned a unique identification number, and the variables from the proforma are subsequently imported into SPSS version 28 for comprehensive statistical analysis.

Variables and Statistical Analysis

The analysis was centred around two primary categories of variables. The independent variables encompassed maternal factors such as maternal age, ethnicity, marital status, education level, occupation, and household income as well as obstetric history, which included comorbidities, booking status, parity, and pregnancy status. Additionally, intrapartum factors were considered, including mode of delivery, birth weight, gestational age, place of delivery, and the qualifications of the healthcare personnel present during delivery. The outcome variable of interest was the cause of death, classified into asphyxia-related and non-asphyxia-related categories.

Descriptive statistics were employed to summarize the demographic and clinical characteristics of the participants, presenting categorical data in terms of frequencies and percentages. To investigate the relationships between the independent variables and the outcome, simple logistic regression was performed to generate crude odds ratios for each variable. Variables exhibiting p-values less than 0.25, or those identified as clinically significant, were selected for inclusion in multivariable logistic regression analysis. This analysis was conducted utilizing both forward and backward selection techniques to pinpoint the significant predictors. The results from the final model were reported as adjusted odds ratios, with accompanying 95% confidence intervals and respective p-values. A p-value threshold of <0.05 was established to determine statistical significance.

RESULTS

Characteristics of perinatal mortality in Kelantan from 2020 – 2022

The characteristics of perinatal mortality in Kelantan from 2020 to 2022 are outlined based on data from 397 subjects (Table I). Most mothers (67.5%) were aged between 20–35 years, with a smaller percentage being 36–47 years old (28.2%) or teenagers (4.3%). The majority were Malay (92.9%) and married (97.2%). Around 63.7% of the mothers were not working, and most had secondary (67.8%) or tertiary education (24.4%). A large proportion (87.9%) belonged to the lowest household income group (below RM3,000).

Table I: The characteristics of perinatal mortality in Kelantan from 2020-2022 (n=397)

Variables		n (%)
Maternal Age		
	10 – 19 years old	17 (4.3)
	20 - 35 years old	268 (67.5)
	36 – 47 years old	112 (28.2)
Ethnicity		
	Malay	369 (92.9)
	Chinese	5 (1.3)
	Iban	1 (0.3)
	Indonesian	2 (0.5)
	Burmese	8 (2.0)
	Orang Asli	9 (2.3)
	Siamese	3 (0.8)
Marital Status		
	Married	386 (97.2)
	Unmarried	11 (2.8)
Mother's Occupation		
	Working	144 (36.3)
	Not Working	253 (63.7)
Educational level		
	Tertiary	97 (24.4)
	Secondary	269 (67.8)
	Primary	21 (5.3)
	No formal education	10 (2.5)
Household income		
	Highest (≥ RM7000)	24 (6.0)
	Middle (RM3000 – RM6999)	24 (6.0)
	Lowest (< RM3000)	349 (87.9)
Mother's Comorbid		
	No	101 (25.4)
	Yes	296 (74.6)
Antenatal Follow Up		
	Adequate	304 (76.6)
	Inadequate/Unbooked	93 (23.4)
Parity		
	Multiparous	299 (75.3)
	Primiparous	98 (24.7)
Pregnancy Status		
	Singleton	378 (95.2)
	Multiple Pregnancy	19 (4.8)
Gestational Age		
	Term (≥37weeks)	132 (33.2)
	Moderate - Extreme Preterm (<33weeks)	190 (47.9)
	Late Preterm (34 – 36 weeks)	75 (18.9)
Mode of Delivery		
	Vaginal Delivery	286 (72.0)
	Caesarean Section	108 (27.2)
	Instrumental	3 (0.8)
Birth Weight		
	Normal (2500 – 4000grams)	122 (30.7)
	Macrosomia (>4,000grams)	4 (1.0)
	Low (<2,500grams)	271 (69.3)
Place of delivery		
	Hospital with specialists	364 (91.7)
	Hospital without specialists	14 (3.5)
	Private hospital/maternity home	7 (1.8)
	Health clinic	2 (0.5)
	Delivery outside health facility	10 (2.5)
Personnel who conducted the delivery		
	Specialist	61 (15.4)
	General Doctor	271 (68.3)
	Nurse	51 (12.8)
	Non-Medical Personnel / Unattended	14 (3.5)
Death Preventability		
	No	279 (70.2)
	Yes	115 (29.0)
	Undetermined	3 (0.8)

CONTINUE

Regarding health conditions, 74.6% of mothers had underlying comorbidities, and 76.6% had adequate antenatal follow-ups. Most were multiparous (75.3%) with singleton pregnancies (95.2%). A significant number of the infants were born preterm, with 47.9% delivered between 22–33 weeks of gestation and 18.9% between 34–36 weeks. About 72% of the perinatal deaths occurred in babies born vaginally, and 69.3% were born with low birth weight (<2,500 grams). Most deliveries took place in hospitals with specialists (91.7%), with general doctors attending the majority of births (68.3%). In terms of death preventability, 70.2% of the cases were classified as non-preventable, while 29% were deemed preventable, and 0.8% remained undetermined.

Proportion of Perinatal Asphyxia Among Perinatal Mortality in Kelantan

In the study population of 397 perinatal deaths, the proportion of perinatal asphyxia was found to be 25.9% (95% CI: 21.7, 30.6), while non-perinatal asphyxia accounted for 74.1% of cases (95% CI: 69.4, 78.3) (Table II).

Table II : The proportion of perinatal asphyxia among perinatal mortality in Kelantan for 2020 to 2022 (n=397)

Variables	n (%)	95% CI
Perinatal Asphyxia	103 (25.9)	21.7, 30.6
Non-perinatal Asphyxia	294 (74.1)	69.4, 78.3

Factors Associated with Perinatal Asphyxia

This analysis aimed to identify the factors associated with perinatal asphyxia among perinatal death cases in Kelantan by determining the odds ratio for each variable. In the univariable analysis using simple logistic regression, several factors were found to be significantly associated with perinatal asphyxia (Table III). Non-Malay mothers had a notably higher likelihood of experiencing perinatal asphyxia (OR: 2.69, 95% CI: 1.23, 5.86, p=0.013). Mothers with comorbidities also had a higher risk of perinatal asphyxia (OR: 1.86, 95% CI: 1.05, 3.28, p=0.033).

Table III: Simple Logistic Regression analysis for factors associated with perinatal asphyxia among perinatal mortality in Kelantan from 2020 – 2022 (n=397)

Variables	Crude OR (95% CI)	Wald Statistic (df)	p-value
Maternal Age			
10 – 19 years old	1.19 (0.39, 3.68)	0.09 (1)	0.759
20 - 35 years old	0.99 (0.60, 1.64)	0.001 (1)	0.976
36 – 47 years old	Ref		
Ethnicity			
Malay	Ref		
Non Malay	2.69 (1.23, 5.86)	6.17 (1)	0.013
Marital Status			
Married	Ref		
Unmarried	1.07 (0.28, 4.12)	0.01 (1)	0.919
Mother's Occupation			
Working	Ref		
Not Working	1.15 (0.71, 1.83)	0.32 (1)	0.574
Educational level			
Tertiary	Ref		
Secondary	1.59 (0.90, 2.80)	2.54 (1)	0.111
Primary	1.28 (0.42, 3.94)	0.19 (1)	0.664
No formal education	2.74 (0.70, 10.67)	2.10 (1)	0.147
Household income			
Highest (≥ RM7000)	Ref		
Middle (RM3000 – RM6999)	1.00 (0.27, 3.69)	0.001 (1)	>0.95
Lowest (< RM3000)	1.06 (0.41, 2.75)	0.013 (1)	0.908
Household income			
Highest (≥ RM7000)	Ref		
Middle (RM3000 – RM6999)	1.00 (0.27, 3.69)	0.001 (1)	>0.95
Lowest (< RM3000)	1.06 (0.41, 2.75)	0.013 (1)	0.908
Mother's Comorbid			
No	Ref		
Yes	1.86 (1.05, 3.28)	4.56 (1)	0.033
Antenatal Follow Up			
Adequate	Ref		
Inadequate/Un-booked	2.09 (1.27, 3.45)	8.44 (1)	0.004
Parity			
Multiparous	Ref		
Primiparous	1.04 (0.62, 1.75)	0.02 (1)	0.879
Pregnancy Status			
Singleton	Ref		
Multiple Pregnancy	0.75 (0.24, 2.32)	0.25 (1)	0.619
Gestational Age			
Term	Ref		
Moderate-Extreme Prem	0.82 (0.49, 1.38)	0.58 (1)	0.448
Late Prem	1.62 (0.88, 2.99)	2.40 (1)	0.122
Mode of Delivery			
Vaginal Delivery	Ref		
Caesarean Section	2.55 (1.58, 4.11)	14.55 (1)	<0.001
Instrumental	1.92 (0.17, 21.58)	0.28 (1)	0.596
Birth Weight			
Normal	Ref		
Macrosomia (>4,000grams)	0.80 (0.08, 7.91)	0.04 (1)	0.846
Low (<2,500grams)	0.77 (0.48, 1.24)	1.16 (1)	0.282

CONTINUE

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Variables	Crude OR (95% CI)	Wald Statistic (df)	p-value
Place of delivery			
Hospital with specialists	Ref		
Hospital without specialists	0.47 (0.10, 2.15)	0.94 (1)	0.331
Private hospital/maternity home	1.13 (0.22, 5.94)	0.02 (1)	0.883
Health clinic	2.83 (0.18, 45.72)	0.54 (1)	0.463
Delivery outside health facility	1.21 (0.31, 4.78)	0.08 (1)	0.782
Personnel who conducted the delivery			
Specialist	Ref		
General Doctor	0.23 (0.13, 0.41)	24.29 (1)	<0.001
Nurse	0.25 (0.11, 0.58)	10.63 (1)	0.001
Non-Medical Personnel/ Unattended	0.50 (0.15, 1.68)	1.25 (1)	0.264

Additionally, inadequate or unbooked antenatal follow-up was strongly associated with an increased risk of perinatal asphyxia (OR: 2.09, 95% CI: 1.27, 3.45, p=0.004). The mode of delivery played a significant role, with cesarean sections being linked to greater odds of perinatal asphyxia (OR: 2.55, 95% CI: 1.58, 4.11, p<0.001). Conversely, deliveries attended by general doctors (OR: 0.23, 95% CI: 0.13, 0.41, p<0.001) and nurses (OR: 0.25, 95% CI: 0.11, 0.58, p=0.001) were associated with lower odds of perinatal asphyxia. Although not statistically significant (p<0.25), maternal education level and late-preterm gestational age were included in the multivariable analysis as clinically relevant variables.

The multiple logistic regression model identified four significant factors associated with perinatal asphyxia among perinatal mortality: maternal ethnicity, antenatal follow-up status, gestational age, and mode of delivery, as detailed in Table IV. Mothers of non-Malay ethnicity were found to have a substantially higher risk of perinatal asphyxia compared to Malay mothers. Specifically, non-Malay mothers had 2.70 times higher odds of experiencing perinatal asphyxia (aOR = 2.70, 95% CI: 1.18, 6.22; p = 0.019) after adjusting for antenatal follow-up, gestational age, and mode of delivery.

Table IV: Multiple Logistic Regression analysis of factors associated with perinatal asphyxia among perinatal mortality in Kelantan from 2020 – 2022 (n=397)

Factor	B	Adjusted OR (95% CI)	Wald Statistic (df)	p-value
Ethnicity				
Malay		Ref		
Non Malay	0.99	2.70 (1.18, 6.22)	5.47 (1)	0.019
Antenatal Follow Up				
Adequate		Ref		
Inadequate/ Unbooked	1.08	2.95 (1.66, 5.22)	13.74 (1)	<0.001
Gestational Age				
Term		Ref		
Moder-ate-Extreme Prem	0.83	2.30 (0.72, 7.38)	1.96 (1)	0.161
Late Prem	0.91	2.49 (1.20, 5.18)	5.99 (1)	0.014
Mode of Delivery				
Vaginal Delivery		Ref		
Caesarean Section	0.93	2.52 (1.51, 4.21)	12.53 (1)	<0.001
Instrumental	0.61	1.83 (0.16, 21.28)	0.23 (1)	0.628

Constant = -6.123
Forward LR and Backward LR method for Multiple Logistic was applied.
No multicollinearity and no interaction
Hosmer-Lemeshow test, p-value = 0.401
Classification table 76.8% correctly classifiedThe area under the Receiver Operating Characteristics (ROC) curve was 70.2%

Additionally, inadequate antenatal care or being unbooked significantly increased the likelihood of perinatal asphyxia. Mothers who received inadequate care or were categorized as unbooked had nearly three times the odds of perinatal asphyxia compared to those who received adequate antenatal care (aOR = 2.95, 95% CI: 1.66, 5.22; p < 0.001), after adjusting for maternal ethnicity, gestational age, and mode of delivery.

Gestational age also played a significant role, with late preterm infants (34–36 weeks) showing 2.49 times

higher odds of perinatal asphyxia compared to term infants (aOR = 2.49, 95% CI: 1.20, 5.18; p = 0.014) when controlling for maternal ethnicity, antenatal follow-up status, and mode of delivery.

Lastly, the mode of delivery was significantly associated with the risk of perinatal asphyxia. Caesarean sections were linked to 2.52 times higher odds of perinatal asphyxia compared to vaginal deliveries (aOR = 2.52, 95% CI: 1.51, 4.21; p < 0.001), after adjusting for maternal ethnicity, antenatal follow-up status, and gestational age.

The final model demonstrated good fit, as indicated by the Hosmer-Lemeshow test (p=0.401), and correctly classified 76.8% of cases. The area under the ROC curve was 70.2%, suggesting moderate predictive power. There was no evidence of multicollinearity or interaction between variables.

DISCUSSION

The characteristics of perinatal mortality in Kelantan

This study analyzed the sociodemographic, obstetric, and intrapartum factors contributing to perinatal mortality in Kelantan from 2020 to 2022. We found that several maternal and obstetric characteristics significantly influenced the likelihood of perinatal mortality, with age, ethnicity, antenatal care, and maternal comorbidities standing out as key determinants.

Maternal age played a pivotal role in perinatal mortality, with mothers aged 20-35 years accounting for the highest percentage of cases (67.5%), consistent with previous studies. Bayou and Berhan (2012) reported that 77.4% of perinatal deaths in Ethiopia occurred among mothers aged 20-35, while Behal and Vinayak (2015) found a similar distribution in Haryana, India, where 65% of perinatal deaths were in mothers aged 19-34 years (15, 16). These findings suggest that the perinatal mortality burden is highest among women in the typical childbearing age range, likely due to their higher birth rates, which naturally lead to a greater absolute number of perinatal complications.

Notably, a large majority of the perinatal mortality cases (92.9%) occurred among Malay mothers, reflecting the demographic composition of Kelantan, where Malays form the vast majority (95%) of the population (17). The predominance of Malay mothers in perinatal deaths was also reported in other local studies, such as those by Mahat et al. (2016) in Selangor and Hamzah et al. (2008) in Pasir Mas (18, 19). Ethnicity-related health disparities may play a role in this pattern, though the high proportion of Malay individuals in the population likely contributes to this finding.

Most of the mothers in this study were married (97.2%), which is reflective of the high marriage rates in the region among women of childbearing age. This is consistent with findings from a large-scale study in Nepal, where 99.1% of mothers in perinatal mortality cases were married (20). Marital status is often linked to better social and economic support, which can influence maternal health outcomes. However, our findings show that despite being married, other factors may override the protective benefits of marital support in preventing perinatal deaths.

Interestingly, we found that the majority of mothers who experienced perinatal mortality were not working (63.7%) despite having secondary (67.8%) or tertiary education (24%). This contrasts with findings from India and Ethiopia, where mothers with lower education levels were more likely to experience perinatal mortality (16, 21). The higher education levels observed among mothers in Kelantan suggest that factors other than educational attainment may be at play. The socio-economic context of Malaysia, with better access to education and healthcare, could explain the relatively high education levels, but other determinants like employment status and income inequality could still impact health outcomes. For example, the vast majority of impacted households in our study were from the lowest income bracket (88%), consistent with global findings linking poverty to higher perinatal mortality (22).

Maternal comorbidities significantly contributed to perinatal mortality, with 74.6% of deaths occurring in mothers with comorbid conditions. This aligns with other studies emphasizing the impact of chronic health conditions on perinatal outcomes. For instance, research from Addis Ababa found that maternal illnesses such as preeclampsia and preterm labour heightened the risk of perinatal death (23). Hypertensive disorders, particularly early-onset preeclampsia, were shown to have severe consequences for both mothers and infants (24).

A significant proportion of the mothers in our study (76.6%) received adequate antenatal care, while 23.4% had inadequate or no follow-up. This finding is consistent with previous studies from Ethiopia, which also noted that perinatal mortality often occurs even among mothers receiving adequate antenatal care (23, 25). These outcomes suggest that while antenatal care is critical, it is not always sufficient to prevent perinatal deaths. Complex factors such as the quality of care, missed diagnoses, or inadequate management of high-risk pregnancies may still lead to adverse outcomes.

We also observed a higher incidence of perinatal mortality among multiparous women (75.3%) compared to primiparous women (24.7%). Previous studies have shown that multiparous women, due to their reproductive history, may accumulate health risks or complications from prior pregnancies, which could influence outcomes in subsequent pregnancies (26).

Our findings show that preterm births were a significant factor in perinatal mortality, with moderate to extreme preterm births (47.9%) accounting for the highest proportion of deaths, followed by late preterm births (18.9%) and term births (33.2%). This is consistent with global research identifying preterm birth as the leading cause of perinatal mortality. Preterm infants, particularly those born before 32 weeks, face a higher risk of mortality due to complications like respiratory distress and infections (27).

Vaginal deliveries were associated with a higher proportion of perinatal deaths (72%), which is similar to findings from Bangladesh, where perinatal mortality was higher in vaginal deliveries, particularly in cases with obstetric complications (28). Delayed access to emergency obstetric care during labour and inadequate monitoring may have contributed to these outcomes.

A large proportion of perinatal mortality cases in Kelantan involved low birth weight infants (69.3%), a known risk factor for perinatal mortality (29). Infants born with low birth weight are at heightened risk for a range of complications, including increased susceptibility to infections and respiratory distress syndrome. These factors significantly elevate their mortality risk (30). Addressing maternal health issues, such as malnutrition and poor prenatal care, is crucial to reducing the incidence of low birth weight and associated mortality risks.

Most perinatal deaths in our study occurred in hospitals with specialists (91.7%) and were delivered by general doctors (68.3%). This is not surprising, as high-risk pregnancies are more likely to be referred to and managed in specialist care settings, where more complicated cases naturally lead to higher mortality rates. This finding is consistent with a study in Pakistan, which found higher perinatal mortality rates in tertiary care hospitals due to the severity of the cases they handled (31).

A notable proportion of perinatal deaths (29%) in Kelantan were classified as preventable, comparable to the 35% reported in Tanzania (32). These deaths could potentially have been avoided with timely and appropriate medical interventions. Research from rural India also highlighted the preventable nature of many stillbirths with improved healthcare infrastructure and access to emergency obstetric care (33). The relatively lower proportion of preventable deaths in Kelantan, compared to countries like Brazil, may reflect differences in healthcare system performance and socio-economic conditions (34).

The proportion of perinatal asphyxia among perinatal mortality in Kelantan

In this study, perinatal asphyxia accounted for 103 out of 397 perinatal deaths in Kelantan from 2020-2022, representing 25.9% of total cases. This is a noticeable rise from 2002 data, which showed that asphyxia caused 21.1% of perinatal deaths in Malaysia, second only to macerated stillbirths at 35.9% (35). By 2016, the percentage had increased to 28.8%, indicating persistent challenges in managing perinatal asphyxia (8). These trends emphasize the growing importance of addressing perinatal asphyxia in Malaysia through enhanced medical care and public health strategies.

Regional studies corroborate these findings, highlighting that perinatal asphyxia remains a significant cause of neonatal mortality across Malaysia. In Pasir Mas, a five-year study revealed a prevalence of 21.9% (19), and a seven-year study in Kuala Lumpur reported a similar figure of 22.3% (9). These consistent rates suggest that healthcare facilities throughout Malaysia face ongoing difficulties in reducing perinatal asphyxia rates.

On a global scale, the challenge of perinatal asphyxia is comparable to that in Malaysia. In Tanzania, perinatal asphyxia accounted for 22% to 30% of neonatal deaths, reflecting similar struggles with maternal and neonatal care in sub-Saharan Africa (36). Brazil, despite having different healthcare and socio-economic conditions, reported a similar proportion of perinatal asphyxia-related deaths (37).

Within Southeast Asia, the situation remains equally concerning. A study in Yogyakarta, Indonesia, revealed that perinatal asphyxia caused 24% of perinatal deaths, and across Indonesia, 34% of perinatal mortality was due to asphyxia (38). The study emphasized that improved prenatal care, timely interventions, and effective neonatal resuscitation could help mitigate the impact of perinatal asphyxia.

Factors associated with perinatal asphyxia among perinatal mortality in Kelantan

Perinatal asphyxia is a critical factor in perinatal mortality, influenced by various interconnected elements from preconception to postnatal stages. Our study in Kelantan from 2020-2022 highlights significant correlations between ethnicity, antenatal follow-up status, gestational age, and mode of delivery with perinatal asphyxia.

The study found that non-Malay infants have a 2.70 times higher likelihood of experiencing perinatal asphyxia compared to Malay infants. Ethnic disparities in perinatal mortality have been documented in other studies. For instance, research in Amsterdam noted higher mortality rates among Surinamese and other non-Western mothers compared to native Dutch mothers (39). While those studies did not emphasize asphyxia's role in ethnic disparities, they highlighted increased perinatal mortality in certain ethnic groups.

In the U.S., non-Hispanic Black women had more

than double the perinatal mortality rate compared to non-Hispanic White women, even after adjusting for socioeconomic and medical factors (40). This suggests underlying factors beyond socioeconomic differences, possibly including genetic variations and health conditions like diabetes and hypertension, which are more prevalent in certain ethnic groups.

Cultural norms and health literacy also play roles. Limited health literacy among immigrant and minority women can lead to delayed or irregular prenatal care, increasing asphyxia risk. Some cultural practices may prioritize traditional remedies over formal healthcare, missing opportunities for early intervention. Nutritional and lifestyle differences between ethnic groups can further impact perinatal outcomes.

Inadequate antenatal care is associated with a nearly threefold increase in the risk of perinatal asphyxia. Early antenatal check-ups allow for timely interventions. A study by Kupek et al. emphasized the benefits of early antenatal care, which includes essential screenings for conditions like diabetes and infections (41).
Regular antenatal visits enable monitoring of fetal growth, aiding in the early detection of complications. A systematic review in Ethiopia linked high birth asphyxia prevalence to inadequate antenatal care (42). Antenatal care also involves educating mothers about the signs of labour and expectations for delivery, thus reducing the risk of late hospital presentations and prolonged labour, both of which are significant risk factors for asphyxia. High-risk pregnancies can be managed more effectively with planned early interventions, such as elective cesarean sections, to avoid labor stress.

Late preterm infants have a 2.49 times higher risk of perinatal death due to asphyxia compared to term infants. Premature infants are vulnerable due to underdeveloped respiratory systems. Late preterm infants, despite appearing more mature, still face significant risks due to this transitional vulnerability. Moderate and extremely preterm infants require intensive care due to their severely immature organs. However, late preterm infants might not receive the same level of care as the attending healthcare professionals might underestimate their risk, and leading to delayed interventions (43). Small for gestational age (SGA) preterm infants are particularly susceptible to asphyxia due to compromised intrauterine environments and chronic hypoxia. A study by Ishiguro et al. highlighted the increased risk of respiratory distress in late preterm infants, reinforcing the need for careful monitoring and customized interventions to prevent asphyxia (44).

Caesarean-section delivery presents a 2.52-fold increased risk of asphyxia compared to vaginal delivery. Vaginal delivery involves mechanical forces and hormonal changes that aid in the newborn's respiratory transition (45). C-sections can delay this transition, increasing asphyxia risk. The absence of mechanical stimuli during C-section may affect lung maturation and surfactant production, crucial for effective gas exchange. Surgical risks, such as maternal complications, can also impact fetal well-being. The timing of C-sections is critical. Elective procedures before labor onset or full fetal maturity can lead to respiratory distress. Studies have shown higher perinatal mortality rates associated with C-sections, particularly for births before 39 weeks.

Strength and Limitations

This study benefits from strong and reliable data sources, specifically the SU5MR System and SU5MR-1/2012, known for effectively monitoring stillbirth and under-five mortality in Malaysia. The use of extensive sampling from all healthcare facilities, both public and private, ensures the representativeness of the Kelantan population and enhances the applicability of findings to broader health policy decisions. A comprehensive data collection approach such as incorporating self-reported interviews, clinical findings, and event analyses, provides a detailed understanding of factors related to perinatal asphyxia. The diagnostic process involves a multi-tiered review, ensuring precision through evaluations at district and state levels by healthcare professionals. Additionally, trained personnel conducted data entry, improving accuracy and reliability.

The study has several notable limitations. Its cross-sectional design, while resource-efficient and utilizing secondary data, raises concerns regarding data quality and completeness, which restricts the exploration of additional relevant variables. While this design is effective for identifying associations, it cannot inherently establish causal relationships. Additionally, the inclusion of unhealthy infants specifically preterm and low birth weight subjects may introduce confounding variables that could skew the results. The study's reliance on pre-existing records further compounds potential issues, as any inaccuracies or biases present in these datasets could significantly impact the observed findings. Ultimately, the reliability of the study is contingent upon the rigour and accuracy of data collection and recording processes.

CONCLUSION

Our study in Kelantan highlights significant associations between perinatal asphyxia and factors such as ethnicity, antenatal care, gestational age, and delivery mode. Non-Malay mothers face higher risks, emphasizing the need for tailored interventions that address cultural and socioeconomic barriers.

Given that Kelantan’s perinatal mortality rate exceeds the national average, implementing region-specific strategies is essential. One of the key takeaways from our study is that non-Malay mothers and those with inadequate antenatal care face a much higher risk of

perinatal asphyxia. This highlights the urgent need for targeted interventions. Expanding antenatal care outreach especially in rural and non-Malay communities, can help bridge gaps in access and improve maternal health outcomes. Simple yet effective solutions like mobile health clinics and community health workers can make a real difference by ensuring earlier and more frequent check-ups. At the same time, culturally sensitive health education programs can help build trust, improve health literacy, and encourage mothers to seek care earlier in their pregnancy. By tailoring these efforts to the needs of different communities, we can reduce preventable cases of perinatal asphyxia and improve overall neonatal survival rates in Kelantan.

Understanding which cases of perinatal asphyxia are truly preventable is critical for improving maternal and neonatal care. Future research should focus on identifying specific, modifiable risk factors like delays in emergency caesarean sections, missed antenatal visits, and gaps in maternal health education that could be addressed through better policies and healthcare practices. A prospective cohort study, combining both qualitative and quantitative methods, could provide valuable insights into how social and systemic barriers contribute to these risks. Additionally, a structured audit system within healthcare facilities could help pinpoint weaknesses in the referral system, clinical decision-making, and resource availability. By focusing on these areas, we can create more effective, targeted strategies to reduce preventable deaths and improve the quality of care for mothers and newborns.

Future research should employ a prospective cohort study with mixed methods to gain deeper insights into the social, cultural, and systemic factors contributing to perinatal asphyxia. This approach can guide evidence-based decision-making and interventions, ultimately improving maternal and neonatal health outcomes. Additionally, future studies should systematically classify preventability by assessing the impact of delayed caesarean sections, inadequate antenatal care, and other modifiable risk factors. A thorough evaluation of healthcare system shortcomings, such as ineffective referral practices and facility limitations, is essential to identifying preventable maternal and neonatal health risks and informing targeted improvements in care delivery. Implementing a structured audit framework to categorize perinatal deaths and differentiate modifiable from non-modifiable risk factors can help healthcare professionals develop more targeted interventions. A systematic audit process will further refine strategies, prioritize preventable cases, and enhance healthcare delivery in Kelantan.

Ethical Approval and Consent to Participate

This research was carried out following authorization from the Human Research Ethics Committee at USM, bearing reference number USM/JEPeM/KK/23110868, as well as from the Medical Research Ethics Committee (MREC) with reference number NMRR ID-23-03339-DJP (IIR). Consent for utilizing the stillbirth and under-five mortality data in Kelantan was granted by the State Health Director.

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REFERENCE

1. UNICEF. Ending Preventable Newborn Deaths And Stillbirths By 2030: Moving Faster Towards High-Quality Universal Health Coverage In 2020–2025. 2020.
2. McMicking J, Vieira MC, Pasupathy D. Understanding perinatal mortality. 2020.
3. Khobragade Y, Y KS, S Z, A LA. A Cross-Sectional Study on Perinatal Mortality in Jasin District, Malaysia. Manipal Journal of Medical Sciences. 2021;6(2):4.
4. Malaysian Healthcare Performance Unit M. Malaysian Health At A Glance 2018. 2020.
5. Crovetto F, Fumagalli M, De Carli A, Baffero GM, Nozza S, Dessimone F, et al. Obstetric risk factors for poor neonatal adaptation at birth. The Journal of Maternal-Fetal & Neonatal Medicine. 2018;31(18):2429-35.
6. WHO. World health statistics 2015. 2015.
7. Ethiopian Public Health Institute E. National Maternal and Perinatal Death Surveillance and Response (MPDSR) System Annual Report of 2013 EFY. 2014.
8. Family Health Development Division MOH. Under-5 Mortality Review 2016: Looking into The Preventable Deaths. 2022.
9. Hassan H, Sutan R, Azmi NAM, Ahmad S, Jaafar R. Trend of stillbirths and neonatal deaths in university Kebangsaan Malaysia Medical Centre (UKMMC) from 2004-2010. International Journal of Public Health Research. 2013;3(1):241-8.
10. Bank W. Mortality rate, under-5 (per 1,000 live births) - Malaysia 2024 [cited 2024 30 May]. Available from: https://data.worldbank.org/indicator/SH.DYN.
11. Family Health Development Division MOH. Laporan Tahunan SU5MR 2022. 2023.
12. MOH. Fasiliti Kesihatan - Hospital 2024 [cited 2024. Available from: https://www.moh.gov.my/index.php/pages/view/4374?mid=1448.
13. MOH. Fasiliti Kesihatan - Klinik Kesihatan: MOH; 2024 [cited 2024. Available from: https://www.moh.gov.my/index.php/pages/view/4378?mid=1501.
14. MOH. Guideline For Stillbirth And Under Five Mortality Reporting System. 2018.
15. Bayou G, Berhan Y. Perinatal mortality and associated risk factors: a case control study.

Ethiopian journal of health sciences. 2012;22(3).
16. Behal M, Vinayak R. Maternal risk factors for perinatal mortality. Indian J Obstet Gynecol Res. 2015;2(2):92-6.
17. DOSM. Key Findings Population And Housing Census Of Malaysia 2020. 2022.
18. Mahat D, Chandran A, S R, Mr R. Recent Trends In Under-Five Mortality In The District Of Petaling, Selangor2016.
19. Hamzah TNT, Ibrahim WN, Daud A. A Five-Year Review of Perinatal Deaths at Pasir Mas District. International Medical Journal. 2008;15(3):193-8.
20. Ghimire PR, Agho KE, Renzaho AM, Nisha MK, Dibley M, Raynes-Greenow C. Factors associated with perinatal mortality in Nepal: evidence from Nepal demographic and health survey 2001–2016. BMC pregnancy and childbirth. 2019;19:1-12.
21. Liyew EF, Yalew AW, Afework MF, Essйn B. Maternal near-miss and the risk of adverse perinatal outcomes: a prospective cohort study in selected public hospitals of Addis Ababa, Ethiopia. BMC Pregnancy and Childbirth. 2018;18(1):345.
22. Khobragade S, Khobragade Y, Abas AL. Comparative study of Perinatal Mortality, Stillbirths, and Neonatal Mortality from 2010 to 2018 in developing and developed nations with reference to Malaysia. Manipal Journal of Medical Sciences. 2021;6(1):6.
23. Getiye Y, Fantahun M. Factors associated with perinatal mortality among public health deliveries in Addis Ababa, Ethiopia, an unmatched case control study. BMC Pregnancy and Childbirth. 2017;17(1):245.
24. Teka H, Yemane A, Abraha HE, Berhe E, Tadesse H, Gebru F, et al. Clinical presentation, maternal-fetal, and neonatal outcomes of early-onset versus late onset preeclampsia-eclampsia syndrome in a teaching hospital in a low-resource setting: A retrospective cohort study. PLoS One. 2023;18(2):e0281952.
25. Wondie WT, Zeleke KA, Wubneh CA. Incidence and predictors of mortality among low birth weight neonates in the first week of life admitted to the neonatal intensive care unit in Northwestern Ethiopia comprehensive specialized hospitals, 2022. Multi-center institution-based retrospective follow-up study. BMC Pediatrics. 2023;23(1):489.
26. Benjamin A, Sengupta P, Singh S. Perinatal mortality and its risk factors in Ludhiana: a population-based prospective cohort study. Health and Population: Perspectives and Issues. 2009;32(1):12-20.
27. Blencowe H, Cousens S, Oestergaard MZ, Chou D, Moller A-B, Narwal R, et al. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. The lancet. 2012;379(9832):2162-72.
28. Yousuf NA, Yousuf IA, Talukder NU, Kutubi A, Nahar PAS, Hena SB. Maternal risk factors for perinatal mortality. Higher education. 2011;2:02.
29. WHO. Low birth weight: WHO; 2024 [cited 2024 26 May]. Available from: https://www.who.int/data/nutrition/nlis/info/low-birth-weight#:~:text=Low%20birth%20weight%20is%20caused,and%20NCDs%20later%20in%20life.
30. WHO. Global nutrition targets 2025: low birth weight policy brief. Geneva: World Health Organization; 2014.
31. Bhutta ZA, Darmstadt GL, Hasan BS, Haws RA. Community-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. Pediatrics. 2005;115(Supplement_2):519-617.
32. Msemo G, Massawe A, Mmbando D, Rusibamayila N, Manji K, Kidanto HL, et al. Newborn mortality and fresh stillbirth rates in Tanzania after helping babies breathe training. Pediatrics. 2013;131(2):e353-e60.
33. Neogi SB, Sharma J, Negandhi P, Chauhan M, Reddy S, Sethy G. Risk factors for stillbirths: how much can a responsive health system prevent? BMC pregnancy and childbirth. 2018;18:1-10.
34. Sala A, Luppi CG. Trend of preventable deaths up to the 6th day of life in the state of Sro Paulo–2008 to 2017. Revista de saude publica. 2020;54.
35. Sutan R. A review of determinant factors of stillbirths in Malaysia. Journal Community Health. 2008;14:68-77.
36. Schmiegelow C, Minja D, Oesterholt M, Pehrson C, Suhrs HE, Bostrum S, et al. Factors associated with and causes of perinatal mortality in northeastern Tanzania. Acta obstetricia et gynecologica Scandinavica. 2012;91(9):1061-8.
37. Daripa M, Caldas HMG, Flores LPO, Waldvogel BC, Guinsburg R, Almeida MFBd. Perinatal asphyxia associated with early neonatal mortality: populational study of avoidable deaths. Revista Paulista de Pediatria. 2013;31:37-45.
38. Rifqatussa'adah, Purnamawati D. Determinants of birth asphyxia in the province of Yogyakarta. Public Health Department Faculty of Sports Science Semarang State University Accessed March. 2021;10:201-6.
39. Alderliesten ME, Stronks K, van Lith JMM, Smit BJ, van der Wal MF, Bonsel GJ, et al. Ethnic

differences in perinatal mortality: A perinatal audit on the role of substandard care. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2008;138(2):164-70.
40. Muglia LJ, Katz M. The enigma of spontaneous preterm birth. New England Journal of Medicine. 2010;362(6):529-35.
41. Kupek E, Petrou S, Vause S, Maresh M. Clinical, provider and sociodemographic predictors of late initiation of antenatal care in England and Wales. BJOG: An International Journal of Obstetrics and Gynaecology. 2002;109(3):265-73.
42. Bayih WA, Birhane BM, Belay DM, Ayalew MY, Yitbarek GY, Workie HM, et al. The state of birth asphyxia in Ethiopia: An umbrella review of systematic review and meta-analysis reports, 2020. Heliyon. 2021;7(10):e08128.
43. Hibbard JU, Wilkins I, Sun L, Gregory K, Haberman S, Hoffman M, et al. Respiratory morbidity in late preterm births. Jama. 2010;304(4):419-25.
44. Ishiguro A, Namai Y, Ito YM. Managing "healthy" late preterm infants. Pediatr Int. 2009;51(5):720-5.
45. Jain L, Dudell GG, editors. Respiratory transition in infants delivered by cesarean section. Seminars in perinatology; 2006: Elsevier.