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A Retrospective Analysis of Adolescent Pregnancy and Child Mortality Cases in Kota Kinabalu, Sabah

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ABSTRACT

Introduction	Under-five mortality remains a critical public health challenge, particularly among vulnerable and underserved populations. This study aimed to identify distinct socio-clinical profiles associated with under-five deaths in Kota Kinabalu from 2020 to 2024 and to compare risk patterns between adolescent and adult mothers using cluster analysis.
Methods	A retrospective analysis of district health records was conducted. A total of 818 under-five mortality cases were included, of which 55 involved adolescent mothers (10–19 years). K-means clustering was applied to maternal-socioeconomic and clinical variables to identify distinct profiles. The optimal number of clusters was determined using silhouette scores and stability testing. Associations between cluster membership and maternal-child health variables were evaluated using chi-square tests.
Results	Three clusters emerged. Cluster 2 represented the most vulnerable group, predominantly comprising non-citizen adolescent mothers with no formal education, household incomes below RM 1,000, and inadequate antenatal care. This cluster exhibited the highest rates of preterm births and preventable under-five deaths. Significant associations were identified between cluster membership and maternal age, citizenship status, education level, antenatal care, and birth outcomes. Under the death category, 61.7% of child deaths were classified as preventable, highlighting areas for intervention, while 38.3% were deemed not preventable.
Conclusions	Intersecting social disadvantages such as young maternal age, non-citizenship, low education, and poverty amplify risks for both mothers and children. Addressing these broader determinants through culturally sensitive, accessible maternal health services and targeted adolescent outreach is essential. Integrating cluster analysis into surveillance can enable early identification of high-risk groups and support equity-focused interventions to reduce preventable child mortality.
Keywords	Under 5 mortalities; Adolescent pregnancy; Cluster analysis; Maternal health; Social determinants; Antenatal care; Preterm birth; Health equity

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INTRODUCTION

Adolescent pregnancy is a globally recognized public health concern with serious implications for both maternal and child health outcomes. Teenage pregnancy refers to pregnancy occurring in girls aged 10–19 years, and adolescents are typically categorized into early (10–14), middle (15–17), and late adolescence (18–19). Young adolescent girls are especially at risk of serious health complications from pregnancy and childbirth, as their bodies are often not fully developed for safe delivery. They may experience severe conditions such as obstetric fistula, eclampsia, postpartum infections like puerperal endometritis, and other systemic infections. Globally, maternal health issues remain one of the leading causes of disability-adjusted life years (DALYs) and mortality among girls aged 15 to 19.[1]

Young maternal age often coincides with socioeconomic disadvantages, such as poverty, limited education, and weak family or social support systems. These vulnerabilities elevate the risk of adverse maternal outcomes such as hypertensive disorders, anemia, and delivery complications, as well as neonatal issues like low birth weight, preterm birth, and higher infant mortality.[2]

In Southeast Asia, countries such as Malaysia, Philippines, and Indonesia continue to report significant adolescent pregnancy rates, especially in rural and marginalized communities. Data shows that Malaysia's adolescent birth rate at 10.3 per 1,000 women aged 15–19, though this figure underrepresents the actual burden in East Malaysian states like Sabah and Sarawak.[3]

Teenage births have remained a significant concern in Malaysia, with reported cases peaking at approximately 18,000 in 2012 and around 7,700 in 2018. On average, 14 out of every 1,000 adolescent girls become pregnant each year, amounting to an estimated 18,000 pregnancies annually. Evidence suggests that teenage pregnancies are more prevalent among girls from low-income households, those who are unmarried, and school dropouts. Sabah has been ranked 8th among ASEAN countries for its teenage pregnancy rate. Contributing risk factors include socioeconomic hardship, limited parental guidance, inadequate educational opportunities, and peer pressure all of which increase vulnerability to early pregnancy.[4]

Between 2020 and 2022, 256 baby-dumping cases were recorded. A recent incident also involved a newborn found in a box at an Islamic education center in Perak. From 2010 to May 2019, 292 babies were abandoned near residential areas and 115 in toilets. These figures underscore the need for stronger guidance and support for unwed adolescents, including timely information, counselling, and services to help them manage pregnancy and build resilience. [15]

A study found that adolescent pregnancy in Malaysia occurs through various pathways, not all linked to marriage or cohabitation. Therefore, it is important to provide girls with accurate and timely sexual and reproductive health (SRH) information before they become sexually active. This includes ensuring access to comprehensive sexuality education in schools and community programmes and addressing social and legal barriers to contraceptive use.[16]

The objective of this study is to use cluster analysis to identify and compare socio-clinical maternal profiles associated with under-five mortality in Kota Kinabalu from 2020 to 2024, with a focus on adolescent pregnancy and key factors contributing to child mortality risk.

METHODS

Study Design, Setting and Population

This retrospective cross-sectional study examined all under-five mortality cases recorded by the Kota Kinabalu District Health Office from 2020 to 2024. A total population approach was employed, including all 818 cases with complete sociodemographic and maternal-neonatal data (55 adolescent mothers aged 10–19 years and 763 adult mothers). This approach minimized sampling bias and enabled comprehensive profiling. The study was registered with the National Medical Research Registry (ID-25-01927-GV1 (IIR)) and approved by the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia.

Statistical Analysis

All statistical analyses were performed using R version 4.3.3 (packages: readxl, dplyr, factoextra, cluster, ggplot2, stats). Secondary data were cleaned by removing duplicates, harmonizing categorical variables, and standardizing key fields prior to descriptive analysis.

Cases with more than 20% missing data were excluded. Variables with less than 5% missing values were imputed using median (continuous variables) or mode (categorical variables). Outliers were identified using boxplots and Z-scores (±3 SD) and verified against source records before exclusion.

K-means clustering was conducted separately for adolescent (≤19 years) and adult (>19 years) mothers. The optimal number of clusters (k) was determined using the Elbow Method (within-cluster sum of squares) and silhouette coefficients, both of which supported a three-cluster solution.

Chi-square tests of independence were performed to evaluate associations between maternal characteristics and preventability of under-five deaths.

RESULTS

Sociodemographic Characteristics and Maternal-Neonatal Factors

A total of 10 sociodemographic and clinical variables were analyzed among the study population (n = 818), including maternal age, citizenship, education level, marital status, household income, occupation, antenatal care status, pregnancy complications, gestational age, and death category. The distribution is presented in Table 1.

Table 1 Sociodemographic characteristics and maternal-neonatal factors.

Variable	Parameter (n=818)	Frequency	Percentage (%)
Age (years)	≤19	55	6.8
	20-30	374	45.8
	31-40	352	43
	>41	37	4.5
Citizenship	Yes	453	55.4
	No	365	44.6
Education	No formal education	439	53.7
	Primary	83	10.1
	Secondary	211	25.8
	Tertiary	85	10.4
Marital status	Married	702	85.8
	Unmarried	116	14.2
Income	<1000	473	57.8
	1001-3000	239	29.2
	3001-5000	60	7.4
	5001-7000	23	2.8
	>7000	23	2.8
Occupation	Housewife	114	13.9
	Employed	698	85.4
	Student	6	0.7
Antenatal status	Complete	385	47.1
	Incomplete	263	32.1
	Nonclinical case	170	20.8
Pregnancy Complication	Yes	317	38.8
	No	501	61.2
Gestational age	Extremely preterm	167	20.6
	Very preterm	149	18.2
	Moderate to late preterm	119	14.5
	Term	327	39.9
	Unsure of date (USOD)	56	6.8
Death category	Preventable	505	61.7
	Not Preventable	313	38.3

Cluster Analysis

K-means clustering, an unsupervised machine learning method, was used to group under-five mortality cases based on shared characteristics without prior labels or training. The analysis divided the data into three distinct maternal clusters for both adolescent and adult mothers. Cluster 0 represented higher income, educated, and employed mothers (mostly citizens) with complete antenatal care who experienced complications during term deliveries, yet the deaths were categorized as not preventable. Cluster 1 included mothers with low income and no formal education but who received complete antenatal care and delivered at term; deaths in this group were also not preventable, suggesting that adequate healthcare access alone does not always eliminate risk.

Cluster 2 emerged as the most vulnerable group, consisting mainly of non-citizen mothers with very low incomes, no formal education, and incomplete antenatal care, who experienced preventable term deaths. These clusters illustrate a clear gradient from socio-economically advantaged to disadvantaged mothers, highlighting how social and healthcare inequities contribute to preventable under-five mortality.

The optimal number of clusters ($k = 3$) was confirmed using the Elbow Method, supported by silhouette indices, ensuring meaningful and robust segmentation.

Table 2 Sociodemographic characteristics and maternal-neonatal factors.

Variable	CLUSTER					
	Adolescent			Adult		
	0	1	2	0	1	2
Population (n)	94	245	424	94	245	424
Mean age	33.4	31	29.4	33.4	31	29.4
Citizenship	Yes	Yes	No	Yes	Yes	No
Education	Tertiary	No formal	No formal	Tertiary	No formal	No formal
Marital status	Married	Married	Married	Married	Married	Married
Income	RM3001–5000	< RM1000	< RM1000	RM3001–5000	< RM1000	< RM1000
Occupation	Employed	Housewife	Housewife	Employed	Housewife	Housewife
Antenatal status	Complete	Complete	Incomplete	Complete	Complete	Incomplete
Complication	Yes	Yes	No	Yes	Yes	No
Gestational age	Term	Term	Term	Term	Term	Term
Death category	Not Preventable	Not Preventable	Preventable	Not Preventable	Not Preventable	Preventable

Table 3 Chi-square test of independence between maternal and clinical characteristics and preventability of under-five deaths.

	Death Category		χ^2	df	p-value
	Not Preventable n (%)	Preventable n (%)			
Mother age			47.96	35	0.071
Adolescent	20 (36.4)	35 (63.6)			
Adult	396 (51.9)	367 (48.1)			
Education			39.4	3	< 0.001*
No formal education	257 (58.5)	182 (41.5)			
Primary	38 (45.8)	45 (54.2)			
Secondary	102 (48.3)	109 (51.7)			
Tertiary	19 (22.4)	66 (77.6)			
Income			50.02	4	< 0.001*
<1000	286 (60.5)	187 (39.5)			
1001-3000	101 (42.3)	138 (57.7)			
3001-5000	20 (33.3)	40 (66.7)			
5001-7000	4 (17.4)	19 (82.6)			
>7000	5 (21.7)	18 (78.3)			
Occupation			120.33	2	< 0.001*
Employed	110 (98.2)	2 (1.8)			
Housewife	301 (43.0)	399 (57.0)			
Student	5 (83.3)	1 (16.7)			
Gestational age			723.12	4	< 0.001*
Extremely preterm	167 (100.0)	0 (0.0)			
Very preterm	149 (100.0)	0 (0.0)			
Moderate to late preterm	95 (79.8)	24 (20.2)			
Term	0 (0.0)	327 (100.0)			
USOD	5 (8.9)	51 (91.1)			
Marital status			17.6	1	< 0.001*
Married	378 (53.9)	323 (46.1)			
Unmarried	38 (32.5)	79 (67.5)			
Citizenship			1	1	0.316
No	178 (48.8)	187 (51.2)			
Yes	238 (52.5)	215 (47.5)			
Antenatal status			704.84	2	< 0.001
Complete	385 (100.0)	0 (0)			
Incomplete	26 (9.9)	237 (90.1)			
Nonclinical case	5	165			
Complication			373.99	1	< 0.001*
No	390 (77.8)	111 (22.2)			
Yes	26 (8.2)	291 (91.8)			

USOD: unsure of date
p-value: <0.05 (significant)*

Bivariate Analysis of Maternal Characteristics and Preventability

To strengthen the interpretability of findings derived from the cluster analysis, a bivariate analysis was conducted to statistically assess the associations between key sociodemographic and clinical variables and under-five death categories. While clustering served as an exploratory, unsupervised method to identify latent subgroups based on shared characteristics, it does not offer inferential validation. This complementary approach provided a deeper understanding of the underlying data structure.

DISCUSSION

The cluster analysis revealed three clinically and socially distinct profiles among both adolescent and adult mothers, with Cluster 2 emerging as a particularly vulnerable group. All mothers in adolescent Cluster 2 (n = 17) and most in adult Cluster 2 were non-citizens, had no formal education, household incomes below RM 1,000, and received incomplete or non-clinical antenatal care. Among adolescents, 60–70 % experienced extremely preterm births, and all resulted in preventable deaths, reflecting compounded social and clinical disadvantages that heighten mortality risk.

This study identified three distinct maternal profiles among adolescent and adult mothers, with Cluster 2 emerging as the most vulnerable, mainly non-citizens with no formal education, very low income, and incomplete or non-clinical antenatal care. Among adolescents, 60–70 % experienced extremely preterm births, and all deaths were preventable, indicating overlapping social and clinical disadvantages. In line with earlier findings, teenage mothers had higher rates of low-birth-weight infants because their bodies compete with the foetus for nutrients, restricting growth and increasing neonatal mortality risk. [2]

Education proved to be the strongest protective factor against adolescent pregnancy, higher attainment delays marriage and improves reproductive health knowledge.[6] In Nepal, under-five mortality among children of uneducated mothers was more than double that of those with secondary or higher education (73 vs 32 per 1,000 live births), a pattern also observed in Bangladesh, India, and Pakistan.[7] Educated and employed women are more likely to practise healthy behaviours, seek healthcare, and breastfeed, improving maternal and infant outcomes.[8]

Adolescent pregnancy also imposes biological and nutritional strain, increasing the likelihood of low birth weight, preterm birth, and neonatal death.[9] Poverty further compounds this risk whereby adolescents in deprived settings often face low self-esteem, abuse, or transactional relationships for financial survival.[10] Similar dynamics are reported in Ghana, South Africa, and Tanzania, where poverty drives sexual relationships with older men, and some adolescents intentionally conceive to access welfare support.[11]

Citizenship and antenatal-care access were also critical determinants. Incomplete or non-clinical care, particularly among non-citizens, was strongly associated with preterm birth and preventable deaths.[12] Without proper follow-up, young mothers face complications such as low birth weight, infections, and sudden infant death. Regular antenatal care helps identify high-risk women and reduces premature deliveries.[13] Data from 18 countries show that children born to mothers under 18 are 50 % more likely to die before age five than those born to mothers aged 20–34.[7]

Lack of information remains a major barrier; adolescent mothers need accurate guidance on risks, accessible antenatal services, and empathetic maternity care.[14] The high prevalence of extreme prematurity among adolescents highlights the link between inadequate antenatal care and neonatal mortality. This underscores the need for early antenatal-care registration, nutritional support, and adolescent friendly maternal health services. Rigorous cluster validation and chi-square analysis confirmed these relationships, though causal inference is limited by the retrospective design and small adolescent sample (n = 55). Future studies should integrate predictive models, such as logistic regression, to estimate risk more precisely.

CONCLUSION

This study identified three distinct maternal clusters among 818 under-five mortality cases, revealing significant differences in socioeconomic and clinical risk profiles. Cluster 2 comprising mainly non-citizen, low-income mothers with incomplete antenatal care accounted for the highest proportion of preventable deaths, while higher education, adequate antenatal follow-up, and income were strongly associated with improved survival outcomes.

These findings highlight that improving child survival demands more than clinical interventions; it requires a comprehensive approach addressing the structural and social determinants of health.

By linking interventions directly to the identified needs of each cluster, this approach ensures more efficient resource allocation and greater program impact. Moreover, integrating cluster-based surveillance into routine public health monitoring can facilitate timely identification of high-risk trends and ensure that no vulnerable group is overlooked. Overall, these quantitative and policy insights align with Malaysia's broader effort to reduce under-five mortality through equity-driven,

data-informed, and context-sensitive maternal and child health planning.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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