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Maternal Mortality in a Rural District of Pakistan and Contributing Factors

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Abstract

Introduction Pakistan is among the ten countries that account for 60% of global maternal mortality. Lack of accurate data on maternal mortality and a complex interrelation of access and quality of healthcare services, healthcare delivery system, and socio-economic and demographic factors contribute significantly to inadequate progress in reducing maternal mortality.

Material and Methods A population-based prospective cohort study was conducted in a rural district of Pakistan using data obtained from an enhanced surveillance system. A total of 7572 pregnancies and their outcomes were recorded by 273 Lady Health Workers and 73 Community Health Workers over 2016–2017. Logistic regression was used to calculate the unadjusted and adjusted odds ratios (OR) for maternal mortality for each risk factor. Population Attributable Fraction (PAF) was derived from the ORs and risk factor prevalence.

Results The study recorded 18 maternal deaths. The maternal mortality rate was estimated at 238/100,000 pregnancies (95% CI 141–376), and the maternal mortality ratio was 247/100,000 live births (95% CI 147–391). Half of the maternal deaths (9) were from obstetric hemorrhage, and 28% (5) from puerperal sepsis. Postpartum hemorrhage was associated with a 17-fold higher risk of maternal mortality (PAF = 40%) and puerperal sepsis with a 12-fold higher mortality risk (PAF = 29%) compared to women without these conditions. Women delivered by unskilled birth attendants had a three-fold (PAF = 21%), and women having prolonged labour had a fourfold risk of maternal mortality compared to those with these conditions. Women with leg swelling (47%) and pre-eclampsia (26%) are at seven times the risk of maternal mortality compared to those without these conditions. Mortality in women delivered by unskilled birth attendants was three times higher than with skilled attendants.

Conclusion The study, among a few large-scale prospective cohort studies conducted at the community level in a rural district of Pakistan, provides a better understanding of the risk factors determining maternal mortality in Pakistan. Poverty emerged as a significant risk factor for maternal mortality in the study area and contributes to the underutilization of health facilities and skilled birth attendants. Incorporating poverty reduction strategies across all sectors, including health, is urgently required to address higher maternal mortality in Pakistan. A paradigm shift is required in Maternal and Child health related programs and interventions to include poverty estimation and measuring mortality through linking mortality surveillance with the Civil Registration and Vital Statistics system. Accelerated efforts to expand the coverage and completeness of mortality data with risk factors to address inequalities in access and utilization of health services.

Keywords Risk factors · Maternal mortality · Population attributable fraction · Pakistan

Abbreviations

BMI	Body Mass Index
DHS	Demographic Health Survey
OR	Odds ratio
CI	Confidence interval

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Significance

Lack of accurate data on maternal mortality, its causes and risk factors are barriers to reducing maternal mortality in Pakistan. The study provided evidence of the population-attributable fraction of risk factors for maternal mortality, estimated through a complete enumeration of births and deaths. The evidence may strengthen the cause of death reporting through civil registration and the vital statistics system in developing countries.

Introduction

Pakistan is among ten countries that account for 60% of global maternal mortality, according to the World Health Organization (WHO) (World Health Organization, 2015). (National Institute of Population Studies (NIPS) [Pakistan] and ICF, 2020). Lack of accurate data on maternal mortality and causes of death and the complex interrelation of access and quality of healthcare services, healthcare delivery systems, socio-economic and demographic factors contribute significantly to inadequate progress in reducing maternal mortality (Jolivet et al., 2018).

Risk factors for maternal mortality have been widely studied and reportedly differ widely with respect to socio-economic status and healthcare delivery systems in developed and developing countries (Simkhada et al., 2008). Due to wide variations in the healthcare delivery system and socio-economic status, it is important to understand the association of risk factors with maternal mortality considering the local context (Godefay et al., 2015).

The risk factors for maternal mortality have been well-established in the literature (Godefay et al., 2015). Poverty (Koch et al., 2014; Simkhada et al., 2008), education (Berhan & Berhan, 2014), age (Harrison et al., 2017), parity (Gitonga & Muiruri, 2016), anemia (Rahman et al., 2016), stunting (Harrison et al., 2015), BMI (Samuels-Kalow et al., 2007), hypertensive disorders (Samuels-Kalow et al., 2007), chronic diseases (Chatterjee et al., 2008), gestational diabetes (Mannan et al., 2012), hypertensive disorders (Say et al., 2014), abortions (Bearak et al., 2020), skilled births attendant (Tsegay et al., 2017) place of delivery (Gitonga & Muiruri, 2016), obstructed labor (Harrison et al., 2015), hemorrhage (Wang et al., 2017), puerperal sepsis (National Department of Health, 2015), twin pregnancy (Young & Wylie, 2012), lack of emergency transportation, quality of care and lack of availability of adequate services at health facilities are recognized as important determinants of maternal mortality (Jackson et al., 2017). These factors are associated with each other and influence the outcomes of pregnancy or its complications (McCarthy & Maine, 1992). Due to the difference in socio-economic, cultural, and healthcare system aspects, it is essential to understand their association with maternal mortality at the sub-national and local levels.

Few studies have examined the risk factors for maternal mortality in Pakistan, and most are hospital-based (Hashim et al., 2012; Riaz et al., 2011). Inadequate civil registration, vital statistics, and fragmented health information systems all contribute to the lack of accurate and complete data on maternal mortality. It has not been possible to determine the risk factors contributing to maternal mortality among various subgroups at the community level. This study aimed to determine the causes of death and risk factors for maternal mortality and to assess the proportion of these deaths which may be preventable.

Methods

Setting and Study Population

A population-based prospective cohort study was conducted in Tehsil Havelian, a sub-district of the District Abbottabad in Khyber Pakhtunkhwa province, Pakistan. The multidimensional poverty headcount ratio in districts Abbottabad is 10.5% of the total population (Naveed et al., 2017). A total population of 368,454 was enumerated by the Lady Health Workers and Community Health Workers by visiting each household at the start of the study in June 2015.

Data Sources and Collection

An enhanced surveillance system was established from May 2015 to June 2016 and collected data on pregnancies, abortions, stillbirths, live births, early neonatal deaths, late neonatal deaths, and maternal deaths. A total of 273 Lady Health Workers were engaged in data collection, covering 79% of the population, and an additional 73 Community Health Workers were recruited for the remaining 21% of the study area. Of the total registered population, 293,344 (79%) resided in the LHWs areas, and 75,110 (21%) resided in the areas of CHWs. A total of 51,690 married women aged 18–49 years were listed by LHWs (40,952) and CHWs (10,738). The Lady Health Workers and Community Health Workers maintain a register of all married women aged 18–49 years for their assigned households and visit 7–10 houses per day to update the records. All households in the study areas were visited at least once a month, and the registration of pregnant women during visits continued throughout the study. Seven thousand five hundred seventy-two pregnancies were registered and followed up 42 days after delivery. Women delivering in the last month of the project were followed until the end of the month. Data from all sources, including the community health staff (LHWs and

CHWs), and public and private healthcare facilities, were collected to ensure all births and deaths were recorded in the study population. A detailed description of the enhanced surveillance system is presented elsewhere (Anwar et al., 2018b).

Existing Mother and Child Health cards were used to capture data on pregnancies, births, and deaths, which were already in use by the Lady Health Workers to capture data from pregnant women on all previous pregnancies, prenatal care, medical conditions, delivery, and pregnancy outcomes: including the vital status of newborn, birth weight, sex, and neonatal complications. The data on postpartum events collected by the mother and child health cards were limited to the first seven days after delivery. The WHO 2012 verbal autopsy questionnaire (World Health Organization, 2012a) was applied to all reported maternal deaths to verify and determine the cause of death. The district death review committee reviewed the completed verbal autopsy questionnaires and assigned the probable causes to all reported deaths.

A stratified random cross-sectional survey was conducted six months after the start of the enhanced surveillance system in the study area. Data was captured on pregnancies, abortions, stillbirths, live births, neonatal and maternal deaths of a woman during the last three years. The sisterhood method was used to ascertain maternal deaths in the household. Births and deaths recorded through the household sample survey matched the birth and death data collected by the Lady Health Workers and Community Health Workers for the enhanced surveillance system. The Petersen–Lincoln equation was applied to estimate the total number of births and deaths in the study population and measure underestimations in births and deaths. Ninety-nine percent of births, ninety percent of neonatal deaths, and five stillbirths captured by the survey were matched with the data recorded by the enhanced surveillance system. The details on the completeness of the enhanced surveillance system were published elsewhere (Anwar et al., 2018a).

Household poverty data were obtained using the "Poverty Scorecard for Pakistan' (Schreiner, 2010). The scorecard was constructed by Schreiner from the nationally representative survey data (15,439 households) of Pakistan's 2005/6 Social and Living Standards Measurement Survey that estimates the likelihood that a household has expenditure below a given poverty line (Federal Bureau of Statistics-Government of Pakistan, 2007). It has ten questions on location, number of household members, number of children aged 5 to 13 years, working status and education level of household members, source of drinking water, type of toilet, and ownership of household items (refrigerator, freezer, television, motorcycle, scooter, car, or other vehicle, the addition of which gives the final poverty score as a proxy of the household's socio-economic status (Table S2).

Households were ordered from lowest to highest poverty scores and then divided into equal quintiles having approximately 20% of the households in each group. Due to a small number of maternal deaths and similar mortality rates, the poorest with poor quintiles and richest with rich quintiles were merged for having more maternal deaths in each merged group and better statistical significance.

LHWs currently collect data on hypertension in pregnancy as blood pressure (BP) of ≥ 140 and ≥ 90 mmHg (hypertension). Pre-eclampsia is defined as hypertension with limb swelling (edema) or proteinuria. Skilled birth attendants include medical doctors, midwives, or nurses, whereas unskilled birth attendants are traditional birth attendants with no recognized qualifications. Obesity is divided using the WHO definition into class I obesity, having a BMI of 30– < 35; class II obesity having a BMI of 35– < 40, and class III obesity having BMI ≥ 40. Anemia is defined as diagnosed clinically or hemoglobin < 10 mg/dl. Fever is indicated by body temperature ≥ 37.8 °C (100°F). Pre-existing chronic disease includes asthma, hypertension, cancer, diabetes, epilepsy, cardiovascular diseases, hepatitis B and C, chronic renal disease, and thyroid disease (and/or) prior to the current pregnancy. These chronic diseases are grouped because of their small numbers in categories. Prolonged labour is defined as > 12 h (Onset of labour starts with the dilatation of the cervix and terminates at the delivery of the placenta), postpartum hemorrhage as a blood loss of ≥ 500 ml within the first 24 h of birth, and puerperal sepsis is defined by WHO as infection of the genital tract between the onset of rupture of the membranes or onset of labour, and the 42nd day following delivery or abortion (World Health Organization, 2008, 2012c). Puerperal sepsis was defined as the presence of a fever ≥ 37.8 °C (100°F) and foul-smelling vaginal discharge in the intrapartum or postpartum period.

A Maternal Death is defined as the death of a woman during pregnancy or within 42 days of termination of pregnancy, irrespective of duration and site of pregnancy, from any cause related to or aggravated by the pregnancy or its management, and excluding accidental external causes (World Health Organization, 2012b). The Maternal Mortality Rate is expressed as the number of maternal deaths per 100,000 pregnancies in a period of one year. The Maternal Mortality Ratio is expressed as maternal deaths per 100,000 live births over one year and is frequently employed as an approximation of the maternal mortality rate because of the availability of denominator data (births).

Data Analysis

The study adapted the conceptual framework of McCarthy and Maine to guide the data analysis (McCarthy & Maine, 1992) (Fig. 1). The risk factors for maternal mortality are grouped into socio-economic factors, individual health

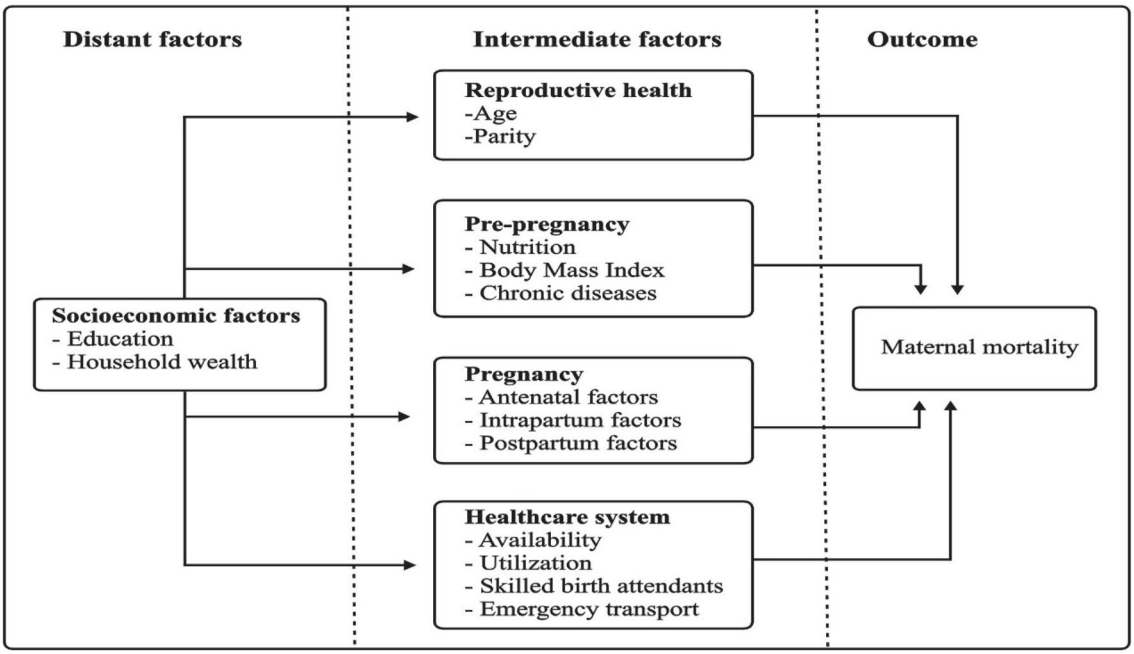

Fig. 1 Framework for analysis of risk factors for maternal mortality. Adapted from Mccarthy and Maine (1992)

status, chronic conditions, reproductive health status, complications of pregnancies, and health services utilization. Distant factors include socio-economic status (education and household wealth), and intermediate factors were broadly grouped into two categories: (1) individual factors and; (2) healthcare system factors. The individual risk factors were divided into three groups: (1) demographic, (2) prepregnancy, and; (3) pregnancy factors. Pregnancy factors are subdivided into antenatal, intrapartum, and postpartum factors (Fig. 1).

Statistical significance of variables and 95% confidence intervals (CIs) were derived from chi-square and chi-square for trend, Poisson testing, and regression analysis. A multicollinearity test was performed to examine the association of variables. The association of risk factors with maternal mortality was explored using logistic regression. Univariate logistic regression was performed to examine the association between maternal mortality and independent variables, including putative causes, confounders, or effect modifiers. Putative risk factors with p-values > 0.05 were excluded from subsequent analyses. Multivariate logistic regression was performed using individual factors and healthcare system factors. Each group of variables was adjusted for confounding variables. The framework guided the analysis. To assess the proportion of maternal deaths attributable to each risk factor, population-attributable fractions (PAF) were calculated using the formula:

$$\mathrm{PAF} = P(\mathrm{OR}-1)/[1+P(\mathrm{OR}-1)]$$

where P is the prevalence of the risk factor in pregnant women, and the OR is the odds ratio for maternal mortality. Statistical analyses were performed using SPSS Version 24 (SPSS Inc., Chicago, IL, USA).

Results

Mortality Rate and Ratio

A total of 7572 pregnancies, 7273 live births, 18 maternal deaths, 290 neonatal deaths, 239 stillbirths, and 60 abortions were recorded over the study period. A maternal mortality rate of 238 per 100,000 pregnancies (95% CI 141–376), a maternal mortality ratio of 247 per 100,000 live births (95% CI 147–391), a neonatal mortality rate of 40 per 1000 live births (95% CI 35–44) and stillbirth rate of 32 per 1000 pregnancies (95% CI 28–36) were estimated. Maternal mortality attributed to obstetric hemorrhage (n = 9) was 119 per 100,000 pregnancies (95% CI 54–226), and both pregnancy-related infection (n = 3) and embolism (septic and pulmonary) attributed to the maternal mortality rate of 40 per 100,000 pregnancies (95% CI 8–116) (Table 1).

Table 1 Maternal mortality by cause. Tehsil Havelian, District Abbottabad, Pakistan, 2015/16

Causes of death	ICD code[†]	n[*]	%	Maternal mortality			
				Rate[^]	95% CI	Ratio[¢]	95% CI
Pregnancies		7572		–	–	–	–
Live births		7273		–	–	–	–
Maternal deaths		18		238	141–376	247	147–391
Direct causes							
Obstetric hemorrhage		9	50	119	54–226	124	57–235
Postpartum hemorrhage	O72.1	5		66	21–154	69	22–160
Intrapartum hemorrhage	O67.8	3		40	8–116	41	9–121
Antepartum hemorrhage	O46.9	1		13	0–74	14	0–77
Other obstetric complications		3	17	40	8–116	41	9–121
Septic embolism	O88.3	2		26	3–95	27	3–99
Pulmonary thrombolism	O88.2	1		13	0–74	14	0–77
Pregnancy-related infection		3	17	40	8–116	41	9–121
Puerperal sepsis	O85	2		26	3–95	27	3–99
Septicopyemic embolism	O08.2	1		13	0–74	14	0–77
Hypertensive disorders		2	11	26	3–95	27	3–99
Eclampsia	O15.2	1		1	0–74	14	0–77
Severe pre-eclampsia	O14.1	1		13	0–74	14	0–77
Indirect causes							
Non-obstetric complications		1	6	13	0–74	14	0–77
Epilepsy	G40.9	1		13	0–74	14	0–77

Italic fonts ICD-MM groups for maternal deaths. Cause of death was assigned by the local maternal review committee

[†]International Classification of Disease Maternal Mortality (ICD-MM) classification adapted by WHO from ICD-10 used to assign codes

*Number of pregnancies, births, or deaths

[^]Per 100,000 pregnancies

[¢]Per 100,000 live births

Socio-economic Status

Women in the poorest two quintiles were at 6.5 times the risk of maternal death compared to women in the two wealthiest quintiles (Table 2). These women in the poorest two quintiles were twice as likely to be delivered by unskilled births compared to skilled birth attendants (95% CI 1.93 2.69, OR 2.28, $p < 0001$). Living in a household that does not own a refrigerator was strongly associated with maternal mortality (OR 4.5, 95% CI 1.48–13.67), as was the non-availability of motorized transport (zero maternal deaths in households with transport) (Table 2).

Parity

Nulliparity conferred a higher risk of maternal mortality by two-fold and grand-multiparity by 4.5-fold compared to parity 1–5. Both nulliparous women (OR 2.56, 95% CI 2.10–3.13) and grand multiparous (OR 2.04, 95% CI 1.55–2.74) were more likely to be delivered by a skilled birth attendant compared to women with parity 1–5.

Chronic Diseases

Women with pre-existing chronic diseases (including asthma, hypertension, cancer, diabetes, epilepsy, cardiovascular diseases, hepatitis B and C, chronic renal disease, or Thyroid disease) had seven times the risk of maternal death compared to women without chronic disease (OR 6.70, 95% CI 2.19–20.47) (Table 2).

Previous Pregnancies

Women with hypertension or epileptic seizures in previous pregnancies were five times more likely to die than women with no such history (OR 5.23, 95% CI 1.71–16) (Table 3). Although women with a history of abortions, prolonged labour, cesarean section, and heavy vaginal bleeding in prior pregnancies had higher maternal death rates than women without these histories, such differences were not statistically significant.

Table 2 Maternal mortality in relation to household and maternal characteristics, Tehsil Havelian, District Abbottabad, Pakistan, 2015/16

Household characteristics	Pregnancies n = 7572	Live births n = 7273	Maternal deaths			Unadjusted	
			n = 18	Rate[α]	Ratio[β]	OR	95% CI
Household poverty							
Poverty scores quintiles							
1–2[‡]	2887	2767	13	450	470	**6.53^**	1.47–28.95
3	1444	1383	3	208	217	3.00^	0.50–17.99
4–5[‡^]	2886	2774	2	69	72	1.00^	
Refrigerator							
Yes	4053	3901	4	99	103	1.00	
No	3166	3023	14	442	463	**4.50**	1.48–13.67
Motorized transport*							
Yes	1691	1625	0	0	0		
No	5528	5299	18	326*	340*	*	-
Maternal characteristics							
Parity							
0	2052	1962	7	341	357	2.00	0.74–5.37
1–5	5261	5069	9	171	178	1.00	
≥ 6	259	238	2	772	840	4.54	0.98–21.13
Body Mass Index^							
< 18.5	522	498	2	383	402	1.54^	0.33–7.13
18.5–24.9	3603	3449	9	250	261	1.00^	
≥ 25.0	3419	3294	7	205	213	0.82^	0.30–2.20
Chronic diseases[^^]							
No	7259	6987	14	193	200	1.00	
Yes	313	282	4	1278	1418	**6.70**	2.19–20.47

Bold = $p < 0.05$

*$p = 0.011$ (Fisher's Exact Test)

[α]Per 100,000 pregnancies

[β]Per 100,000 live births

[‡]1–2 = Poorest and Poor, 4–5 = Rich and Richest; [‡]grouped due to same mortality rates and ratio

^Chi-square test for linear trend significant for poverty scores and BMI

[^^]Includes asthma, hypertension, cancer, diabetes, epilepsy, cardiovascular diseases, hepatitis B and C, chronic renal disease, or thyroid disease; 1.00 as Reference group

Antepartum Conditions

Women with swelling in lower limbs had a seven-fold (OR 6.93, 95% CI 2.72–17.60) risk of maternal mortality compared with those without. Despite considerable missing data, pre-eclampsia (hypertension with leg edema or proteinuria) in the current pregnancy had a higher risk of maternal mortality seven-fold (OR 7.41, 95% CI 2.59–21.23), and women with hypertension (≥ 140 and/or ≥ 90 mmHg) higher a higher mortality risk by five times (OR 4.79, 95% CI 1.76–13.04) (Table 3). Women with anemia (clinical anemia or hemoglobin < 10 mg/dl) have a two-fold higher risk for maternal mortality compared to a woman with no anemia (OR 1.95, 95% CI 0.77–4.93). Antenatal vaginal bleeding and abnormal baby position had higher maternal death rates than women without these conditions, but these findings were not statistically significantly higher.

Intrapartum Factors

Women with prolonged labor (≥ 12 h) had a higher risk of maternal death by 4.3-fold (Table 3). Women delivered by unskilled birth attendants had three times the risk of maternal death compared to women delivered by a skilled birth attendant (OR 3.05, 95% CI 1.07–8.67) (Table 3). Women delivered by cesarean section had a higher risk of maternal mortality (OR 3.40, 95% CI 1.14–10.14) than vaginal delivery. Further, sub-analysis showed that there was an association between prolonged labour (> 12 h) and cesarean section (OR 3.33, 95% CI 2.85–3.89).

Postpartum Factors

A very high risk of maternal death was observed among women with postpartum hemorrhage (OR 16.58, 95% CI

Table 3 Prior and current pregnancy conditions as a risk of maternal mortality, Tehsil Havelian, District Abbottabad, Pakistan, 2015/16

Characteristics	Pregna-ncies* n	Live births n	Maternal deaths**			Unadjusted	
			n	Rate[α]	Ratio[β]	OR[+]	95% CI
Prior pregnancies							
Prolonged labour > 12 h							
No	7312	7037	16	219	227	1.00	
Yes	260	232	2	769	862	3.53	0.81–15.45
Hypertension or epileptiform seizures							
No	7177	6919	14	195	202	1.00	
Yes	395	350	4	1013	1143	**5.23**	1.71–15.98
Current pregnancy							
Antepartum conditions							
Anemia							
No	5006	4831	9	180	186	1.00	
Yes	2566	2438	9	351	369	1.95	0.77–4.93
Swelling lower limbs							
No	6408	6168	8	125	130	1.00	
Yes	1164	1101	10	859	908	**6.93**	2.72–17.60
Blood pressure, mmHg							
< 140 and < 90	3228	3110	11	341	354	1.00	
≥ 140 and/or ≥ 90	372	303	6	1613	1980	**4.79**	1.76–13.04
Preeclampsia[a]							
No	3375	3230	12	356	372	1.00	
Yes	194	161	5	2577	3106	**7.41**	2.59–21.23
Intrapartum conditions							
Birth attendants							
Skilled[†]	6611	6403	12	182	187	1.00	
Unskilled[‡]	907	865	6	661	694	**3.05**	1.07–8.67
Labour, Hrs							
≤ 12	6697	6503	10	149	154	1.00	
> 12	777	708	5	644	706	**4.33**	1.48–12.70
Mode of delivery							
Vaginal	5999	5786	7	117	121	1.00	
Cesarean section	1515	1483	6	396	405	**3.40**	1.14–10.14
Postpartum conditions							
Postpartum hemorrhage							
No	7217	7000	6	83	86	1.00	
Yes	294	266	4	1361	1504	**16.58**	4.65–59.06
Sepsis^							
No	7241	7027	7	97	100	1.00	
Yes	264	233	3	1136	1288	**11.88**	3.05–46.19

Bold = $p < 0.05$; 1.00 = Reference group

*Pregnancies = 7219

**Maternal deaths = 18

[α]Per 100,000 pregnancies

[β]per 100,000 live births

[+]p-values derived from chi-square

[a]Blood pressure ≥ 140 and/or ≥ 90 and swelling on lower limbs or proteinuria

[†]Doctor, midwife, or a nurse

[‡]Tradition births attendant

^Indicated by temperature ≥ 37.8 °C and foul-smelling vaginal discharge

4.65–59) and women with puerperal sepsis (OR 11.88, 95% CI 3.05–46.19; Table 3). An odd of postpartum hemorrhage among women delivered at home by unskilled birth attendants were two-and-half-times higher compared to women delivered at home by skilled birth attendants (OR 2.49, 95% CI 1.50–4.12), and the difference was statistically significant ($p < 0001$). The PAF for postpartum hemorrhage was 40%, and for puerperal sepsis, PAF = 29%. Of women who died of postpartum hemorrhage, 50% were delivered by an unskilled birth attendant. The proportion of women who had a postpartum hemorrhage and antenatal anemia was 58% compared to 33% of women with anemia and postpartum hemorrhage.

Adjusted ORs

After adjustment for age and parity, risk factors significantly associated with maternal mortality included poverty indices, maternal characteristics, complications in prior pregnancies, and complications with the current pregnancy (Table 4). The association between nulliparity and maternal death became statistically significant (OR 3.32, 95% CI 1.10–10.45) (Table 4) but not grand multiparity.

Discussion

The study documented statistically significant risk factors and population-attributable fractions for maternal mortality from the data recorded through a complete enumeration of pregnancies, births, and deaths over one year by an enhanced surveillance system in a rural district of Pakistan. A higher maternal mortality rate of 247 per 100,000 live births was estimated in the study area compared to the mortality rate reported by the Pakistan Demographic and Health Surveys (Anwar et al., 2018b). Our findings are consistent with a prospective multicounty country study, having pregnancy registration sites in peri-urban and rural areas of the Democratic Republic of Congo, Guatemala, India, Kenya, Zambia, and Pakistan. The study using data from all pregnancies from 2010 to 2018 reported persistently high maternal mortality in Pakistan at the end of the study period (Bauserman et al., 2020).

A significant proportion of maternal deaths were attributed to postpartum hemorrhage and puerperal sepsis and were associated with unskilled birth attendants. Among the significant antecedent factors, women living in a poor household, nulliparity, pre-existing chronic disease, and a history of hypertension in previous pregnancies were associated with a higher risk of maternal mortality. Among the factor related to current pregnancy, pre-eclampsia, delivery by an unskilled birth attendant, prolonged labor, postpartum hemorrhage or puerperal sepsis, and foul-smelling vaginal discharge in the postpartum period all contributed significantly to maternal mortality.

Socio-economic Factors

The risk of maternal death among women in the most deprived households is significantly higher than in the upper two quintiles. Ownership of refrigerators was strongly associated with maternal mortality and emerged as a strong indicator of household poverty. The effects of poverty on maternal mortality are multifaceted through various direct and indirect pathways, including lower delivery at health facilities (Herwansyah et al., 2022, Atake, 2021) and delivered by unskilled birth attendants (Bain et al., 2022), lower antenatal visit (Schmidt et al., 2021), muti-parity and multigravidity (Hochler et al., 2020), and lower caesarian section (Kibe et al., 2022). According to the Pakistan Demographic Health Survey 2017–2018, 97% of women in the highest wealth quintile visits a doctor for antenatal check-up compared to 63% of women in the lowest wealth quintile. Similarly, 89% of women in the highest wealth quintile delivered by a doctor compared to 37% in the lowest wealth quintile (National Institute of Population Studies (Pakistan) and ICF International, 2018). These findings were consistent with another study conducted in Pakistan that women in the wealthiest quintile were four times more likely to deliver at a health facility by skilled birth attendants than women in the poorest quintile (Agha & Williams, 2016). The effect of poverty on the utilization of maternal health services and health facilities is similar in other developing countries. A study using DHS 2015–16 data from 3642 women in Myanmar reported rural areas with poverty and poor households were negatively associated with institutional delivery (Lwin & Punpuing, 2022). Similar findings were reported by a study using secondary data from a large randomized controlled trial conducted in 18 health facilities of Rwanda, that higher age > 35 year, lower education, multigravidity, multiparity, and food insecurity were positively associated with a delayed presentation to ANC at > 24 weeks of gestation (Schmidt et al., 2021).

Demographics

Grand-multiparous (≥ 6 parity) and nulliparous women were at higher risk of maternal mortality in this study compared to women with 1–5 parity. The maternal mortality ratio of 840 per 100,000 live births was highest among grand-multipara (≥ 6 parity), compared to the maternal mortality ratio of 178 per 100,000 live births among women with 1–5 parity (reference group). Similarly, the maternal mortality ratio of 357 per 100,000 live births was found among the nulliparous women compared to the reference group. This non-linear trend of higher maternal mortality in nulliparous

Table 4 Significant risk factors for maternal mortality in Tehsil Havelian, District Abbottabad, 2015/16

Characteristics	Pregnancies* n	Prev-elance %	Unadjusted		Adjusted‡		PAF %
			OR	95% CI	OR	95% CI	
Household poverty							
Poverty score							
1–2 (Poor and Poorest)	2887	40.0	6.53	1.47–28.95	**6.48**	1.44–29.22	68.7
4−5 (Rich and Richest)	2887	40.0	1.00		1.00		
Maternal characteristics							
Parity$							
0	2052	27.1	2.00	0.74–5.37	**3.43**	1.08–10.84	39.7
1−5	5261	69.5	1.00		1.00		
≥6	259	3.4	4.54	0.98–21.13	3.95	0.67–23.28	9.2
Chronic diseases^							
No	7259	95.9	1.00		1.00		
Yes	313	4.1	6.70	2.19–20.47	**6.05**	1.95–18.79	17.3
Prior pregnancies							
Hypertension/fits							
No	7177	94.8	1.00		1.00		
Yes	395	5.2	5.23	1.71–15.98	**5.32**	1.68–16.89	18.4
Current pregnancy							
Antepartum conditions							
Blood pressure, mmHg							
<140 and <90	3228	89.7	1.00		1.00		
≥140 and/or ≥90	372	10.3	4.79	1.76–13.04	**4.65**	1.70–12.69	27.4
Swelling lower limbs							
No	6408	84.6	1.00		1.00		
Yes	1164	15.4	6.93	2.72–17.60	**6.85**	2.69 – 17.39	47.3
Pre-eclampsia							
No	3375	94.6	1.00		1.00		
Yes	194	5.4	7.41	2.59–21.23	**7.42**	2.58–21.33	25.9
Intrapartum conditions							
Birth attendants							
Skilled	6611	87.9	1.00		1.00		
Unskilled	907	12.1	3.05	1.07–8.67	**3.26**	1.12–9.47	21.4
Labour, Hrs							
≤12	6697	98.7	1.00		1.00		
>12	777	1.3	4.33	1.48–12.70	**4.20**	1.42–12.41	4.1
Mode of delivery							
Vaginal	5999	79.8	1.00		1.00		
Cesarean	1515	20.2	3.40	1.14–10.14	**3.15**	1.04 – 9.59	30.2
Postpartum conditions							
Postpartum hemorrhage							
No	7217	96.1	1.00		1.00		
Yes	294	3.9	16.58	4.65–59.06	**18.06**	5.05–64.58	40.0
Puerperal sepsis							
No	7241	96.5	1.00		1.00		
Yes	264	3.5	11.88	3.05–46.19	**12.42**	3.18–48.45	28.7

Bold = $p < 0.05$

‡Adjusted for age and parity

$Adjusted for age only; 1.00 = Reference group

^Asthma or Hypertension, or Cancer or Diabetes, or Epilepsy, or cardiovascular diseases, or Hepatitis B and C, or Chronic renal disease, or Thyroid disease

and grand multiparity is consistent with other studies that reported nulliparous and grand-multiparous women were at higher risk of maternal mortality compared to primiparous women (Anthopolos & Becker, 2010). A recent study compared 4937 births to young grand-multiparous women (< 35 years) and 6414 births of older grand-multiparous women (> 35 years) and reported that young grand-multiparous women were not at an increased risk for most intrapartum and perinatal complications compared with young women with lower parity. These findings add to a better understanding of the effect of age on maternal morality and its complications (Hochler et al., 2020). Another study reported that nulliparous women are more likely to be delivered by cesarean section compared to multiparous women, and cesarean section is associated with an increased risk of maternal mortality, but this is not necessarily causative (Harrison et al., 2017).

Contrary to this finding, although the magnitude of risk of maternal mortality due to nulliparity and grand-multiparity reduced when adjusted for confounding effects of maternal age, they remained a significant risk factor for maternal deaths in our study. Hence, other socio-economic and health service utilization factors should be considered when examining the effects of age and parity. A higher cesarean section rate among nulliparous women and worse outcomes associated with the cesarean section may explain higher odds of mortality with nulliparity (Kibe et al., 2022).

Prepregnancy Factors

Women with pre-existing chronic conditions, including hypertension, diabetes, chronic hepatitis, epilepsy, heart diseases, thyroid disorders, and tuberculosis (grouped because of small numbers of specific diseases), were at seven times the risk of maternal death. Other studies have reported a higher risk of maternal death in people with diabetes, possibly due to a higher prevalence of pre-eclampsia, ischemic heart diseases, obstetric complications due to fetal macrosomia, and higher frequency of puerperal sepsis in women with diabetes compared to non-diabetic women (Karasneh et al., 2021; Negrato et al., 2012; Wolka et al., 2021).

Previous Obstetric Complications

In this study, the maternal mortality ratio was considerably higher among women with a previous history of abortions (414 per 100,000 live births) and prolonged labour (862 per 100,000 live births) than women without these conditions. However, these differences did not reach statistical significance, most likely due to the small number of maternal deaths. Several studies reported previous obstetric complications, including a history of prolonged labor in previous pregnancies, as a risk factor for mortality in subsequent pregnancies (Ntoimo et al., 2018; Singh et al., 2014).

Current Pregnancy Factors—Antenatal Factors

Pre-eclampsia in the current pregnancy was associated with a higher risk of maternal mortality in the present study (OR = 7.4). This may be due to a higher risk of cerebrovascular hemorrhage and pulmonary edema caused by severe hypertension (Anthony et al., 2016). Similar findings of increased risk of maternal death with pregnancy-induced hypertension were reported in a hospital-based study conducted in Rawalpindi, Pakistan, in 2010 (Riaz et al., 2011). The finding of a considerable prevalence of anemia among pregnant women in the study population is consistent with the literature. Anemia in the cohort as a risk factor for maternal death is consistent with a systematic review that reported a more than three-fold increased risk of maternal mortality among women with severe anemia (< 5 g/dl) (Brabin et al., 2001). Although the odds of maternal deaths in anemic women when two folds higher than in non-anemic women, and MMR in anemic women was 369 per 100,000 live births versus 186 in non-anemic women, the results could not reach statistical significance, possibly due to a small number of maternal deaths.

Intrapartum Factors

This study found a higher maternal mortality rate among women who experienced prolonged labor. This may be explained by the higher risk of cesarean section in women who experienced prolonged labour. Possible reasons include obstructed labour and cephalon-pelvic disproportion. Several studies noted higher maternal mortality with the cesarean section (Bauserman et al., 2015; Bodner et al., 2011). Postpartum infection has been reported to be higher among women who had a cesarean-section (4%) compared to vaginal birth (2%) (Harrison et al., 2017), and these postpartum infections are reported to be associated with an increased risk of maternal mortality (van Dillen et al., 2010).

Women in this study who had a cesarean section had an MMR of 405 per 100,000 live births, compared to 121 per 100,000 women who had vaginal births. Although these differences did not reach statistical significance, most likely due to the small numbers of maternal deaths, the results are in the expected direction. This finding may be partly a result of the confounding effects of the reasons for cesarean section. In Pakistan, maternal mortality among women who had a cesarean section was reported at 563 per 100,000 live births, compared to 177 per 100,000 live births among women who had a vaginal birth (Harrison et al., 2017). These factors are confounded by the indication that the increased risk of maternal death among women who deliver by cesarean

section may be attributed to the fact that the women who seek care from a physician or in a hospital are at higher risk for pregnancy complications and require a higher level of medical care. We noted a negligible effect of poverty when adjusted for its confounding effects on cesarean section. This is contrary to a cross-sectional study conducted in 28 states of India, with a population of over 139 billion, using data from the National Family Health Survey year 2015–2016, which reported poverty negatively associated with delivery by cesarean section (Marbaniang et al., 2022).

Postpartum Factors

Postpartum hemorrhage was a significant risk factor with ORs of 17 for maternal death (PAF = 40%) and sepsis; the OR was 12 times with a PAF of 29%. In this study, a higher proportion of women who had a postpartum hemorrhage also had antenatal anemia (58%). This may have been a common factor responsible for higher mortality among women with postpartum hemorrhage due to aggravating the circulatory shock following severe blood loss. The rate (1361/100,000 pregnancies) of postpartum hemorrhage was higher in women delivered by unskilled birth attendants than in women delivered by skilled birth attendants. The risk of postpartum hemorrhage in women delivered by unskilled birth attendants was more than two-fold higher than those delivered by skilled birth attendants. This may be due to improper delivery protocols and a lack of knowledge and skills for managing the 3rd stage of labour.

A cross-sectional retrospective cohort study conducted in tribal areas of Pakistan from 2005 to 2006 reported a four-fold higher risk of maternal deaths in women delivered by unskilled birth attendants compared to skilled birth attendants (Gani & Ali, 2013). Maternal postpartum sepsis was significantly associated with an increased risk of maternal mortality in this study. The 12-fold higher risk of maternal deaths associated with postpartum sepsis is consistent with the literature that has reported very high maternal mortality from maternal sepsis (compared with no sepsis) (Lisonkova et al., 2017; Wang et al., 2017). In Pakistan, the DHS reported that sepsis is the second leading cause of reported maternal death after postpartum hemorrhage (National Institute of Population Studies (NIPS) [Pakistan] and ICF, 2008). These findings are consistent with a recent case–control hospital-based study conducted in Ethiopia in 2018 (Demisse et al., 2019).

A recent systematic review of the trial conducted in Low-and Middle-Income Countries between January 2020 to December 2019 on causes of maternal mortality reported that abortion contributed eight percent, embolism three percent, hemorrhage 27%, hypertensive disorders 14%, sepsis 11%, delivery complications three percent, HIV related six percent and pre-existing medical conditions 15% per maternal mortality in developing countries (Eggleston et al., 2022).

Healthcare System Factors

Skilled Birth Attendants

This study showed that delivery by unskilled birth attendants is associated with a threefold higher risk for maternal mortality. A PAF of 21% was attributed to unskilled birth attendants. This highlights the need to improve the skills and competencies of unskilled birth attendants with improved access to emergency obstetric care services. Inadequate competencies of birth attendants were identified as factors contributing to an inadequate reduction in maternal mortality (Jolivet et al., 2018). A study using DHS 2015–16 data from 3642 women in Myanmar reported that rural areas with poverty and poor households were negatively associated with institutional delivery (Lwin & Punpuing, 2022).

Emergency Transport

This study noted two-fold increased odds of maternal death among women without emergency transport compared to women with emergency transport (24/7 availability of vehicle) (non-significant). However, the present study found a significantly higher proportion of health facility deliveries among women with emergency transport than women without emergency transport. Transport plays an essential role in access to health facilities, and lack of emergency transport is one of the barriers to health facility deliveries, exposing women to the risk associated with home-based delivery (Tesfay et al., 2022). Several studies reported similar findings that increasing distance and travel time is adversely associated with worse maternal outcomes (Banke-Thomas et al., 2022), and difficult geographic access negatively affects the utilization of maternal health services (Tounkara et al., 2022).

Strengths and limitations

This is the first population-based study to examine risk factors and the proportion of maternal deaths that may be preventable in Pakistan through a complete enumeration of pregnancies, births, and deaths at the community level. The accuracy of data on clinical signs and symptoms of maternal conditions (clinical anemia, swellings of limbs, and vaginal bleeding) depended upon the skills and competencies of the Lady Health Workers and Community Health Workers who collected these data. Previous pregnancy history may be subject to recall bias from subjects in the study.

The data capturing tool (Mother and Child Health Card) did not collect data on twins (due to the limitation of using the existing data collection tools). Nevertheless, verbal autopsies were performed on all deaths, including maternal and stillbirths, and collected data on multiple births along with other variables. Nevertheless, verbal autopsies were performed on all deaths, including maternal and stillbirths, and collected data on multiple births along with other variables. Twelve twins and three triplet deaths were recorded in the study population. The twin birth rate in the US was 32.1 per 1000 births in 2020. Extrapolating the same twin births rate in the study area, an estimated 243 twins would have been recorded, whereas literature reported a two to four-fold increased risk in women with a twin pregnancy compared to a singleton pregnancy (Young & Wylie, 2012).

The poverty scorecard used only two categories of women's education, 'any education' versus 'no education,' which is insufficient for a detailed analysis of the association of education with maternal mortality.

Due to ethical, cultural, and religious reasons, pregnancies and births to unmarried women were not reported during the study. There may be underreporting of maternal deaths due to complications of such spontaneous and induced abortions. No maternal deaths were reported due to violence, injuries, malaria, or HIV. Nevertheless, verbal autopsies were conducted on all material deaths and did not find deaths attributed to such causes.

Conclusion

The study, among a few large-scale prospective cohort studies conducted at the community level in a rural district of Pakistan, provides a better understanding of the risk factors determining maternal mortality in Pakistan. Poverty emerged as a significant risk factor for maternal mortality in the study area and contributes to the underutilization of health facilities and skilled birth attendants. Pakistan is a signatory to the UN resolution to achieve 17 Sustainable Development Goals (SDGs) by 2023. The SDG one of reducing poverty, directly and indirectly, affects a sustained reduction of maternal mortality. Incorporating poverty reduction strategies across all sectors, including health, is urgently required to address higher maternal mortality in Pakistan. A paradigm shift is required in Maternal and Child health related programs and interventions to include poverty estimation and measuring mortality through linking mortality surveillance with the Civil Registration and Vital Statistics system. Accelerated efforts to expand the coverage and completeness of mortality data with risk factors to address inequalities in access and utilization of health services. The timely identification of high-risk pregnancies based on pregnancy, antenatal, intrapartum, and postpartum risk factors and referral mechanisms, including the provision of transport services to the appropriate health facilities capable of handling high-risk pregnancies, are urgently needed.

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Author Contributions JA was the principal investigator of the study and conceptualized the research. He collected the data and performed analyses, interpreted the results and drafted the article. RT and ST were supervisors of JA's PhD candidature and assisted in performing analyses and provided overall guidance to JA. JA, RT and ST participated in the study design, methodology and ethics applications. MS contributed in performing statistical analysis. All authors contributed significantly to towards drafting and editing the manuscript. All authors have read and approved the final version of the manuscript.

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Code Availability Not applicable.

Declarations

Conflict of interest The authors declare they have no conflict of interest.

Consent to Participate Written informed consent was obtained from all study participants.

Consent for Publication Not applicable.

Ethical Approval Ethics approval was obtained from the Pakistan Medical Research Council (ref. no. 4–87/15/NBC-186/RDC411), and the UNSW (ref. no. HC14338).

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