Sri Lanka Journal of Social Sciences 2025 ***48*** *(1): 55-77*
DOI: https://doi.org/10.4038/sljss.v48i01.9480

RESEARCH ARTICLE

Who Gets Counted: A Decomposition Analysis of Provincial Disparities in Birth Registration in Pakistan

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Abstract: According to UNICEF, one in four children under the age of five has had their birth unregistered worldwide, exposing them to the risks of statelessness, abuse, and discrimination. Despite the integrated global efforts, South Asia, particularly Pakistan, faces significant provincial disparities in birth registration. This study examines cross-sectional data from the 2017-2018 Pakistan Demographic and Health Survey (PDHS) on a sample of 8,638 children under age five. Only 42.54% of these children have their births officially registered. Using Fairlie decomposition as the core method of analysis, our study aims to investigate whether birth registration inequalities in Punjab-Sindh, Punjab-KPK, and Punjab-Balochistan groups stem primarily from compositional or behavioural differences. Additionally, it bifurcates the relative contribution of individual factors driving the observed disparities across all three inter-provincial groups. Fairlie decomposition results reveal that the differences in household characteristics are the primary driver that explains birth registration disparity in the Punjab-Sindh group. Wealth status and mother's education contribute 95.23% to the explained inequality. In contrast, the birth registration gap is mainly attributable to the differences in behavioural profiles in the Punjab-KPK group. Equalizing all selected characteristics would only eliminate 46.31% of the birth registration gap. On the other hand, all inequality in the Punjab-Balochistan group entirely results from differences in compositional factors. Here, variations in birth registration behaviour play no role in determining the observed disparity, distinguishing it from the previous two groups. Addressing provincial birth registration disparities requires situation-specific interventions to promote equitable birth registration and achieve the SDG target of 16.9 by 2030.

Keywords: birth registration, Pakistan, disparities, Fairlie decomposition, PDHS

INTRODUCTION

Birth registration continues to be a strategic intervention in early childhood development, marking the first formal recognition of a child's existence and identity by any society. Since 1948, the UN has endorsed it as a fundamental human right that serves as a prerequisite to citizenship, without which individuals are deprived of the national privileges they are rightfully entitled (Cappa et al., 2014). Documenting a child's birth in a civil registry is indispensable for securing legal status and a birth certificate (UNICEF, 2005). Article 7 of the 1989 United Nations Convention on the Rights of the Child (CRC), the world's most ratified international treaty, which over 190 countries have signed, mandates that every child must be registered immediately after birth and has an inherent right to a name and nationality (Todres, 2002). While birth registration alone does not guarantee protection, it is instrumental in systematic efforts to combat different forms of exploitation, including child labour, underage marriages, illicit inter-country adoption, trafficking, and prostitution (Brolan & Gouda, 2017; Cody, 2010; Hynes et al., 2018; Machel et al., 2013). It also establishes the legal foundation for accessing social services such as healthcare, education, social security benefits, and welfare programs, as well as for activities such as registering land, opening

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a bank account, acquiring a driver's license, getting a passport, and obtaining formal employment (Szreter, 2007; UNICEF, 2007). Additionally, it gives the right to vote, stand for public office, and civic participation. The benefits are not exclusive to the citizens. Data on birth registration supplies government and policymakers with vital statistics for planning, resource allocation, monitoring health metrics, and tracking progress toward Sustainable Development Goals (SDGs) (AbouZahr et al., 2015; Phillips et al., 2018).

While global campaigns have improved maternal and child health, birth registration has not received the same level of attention and commitment (Mohanty & Gebremedhin, 2018). According to UNICEF's report, one in four children under the age of five is unregistered, making them officially invisible (UNICEF, 2019b). There are significant regional disparities in birth registration coverage. North America, Europe, and Central Asia lead with 100 percent registration of children under five, followed by Eastern Europe and Central Asia at 99 percent, Latin America and the Caribbean at 95 percent, and the Middle East and North Africa at 91 percent. Conversely, Eastern and Southern Africa have the lowest registration levels at 41 percent, Sub-Saharan Africa at 51 percent, and South Asia at 76 percent (UNICEF, 2013). Despite the coordinated efforts of UNICEF, WHO, the World Bank, and Plan International over several decades, only 47 percent of children under five are registered in least-developed countries (LDCs), falling considerably short of achieving the SDG 16.9 target for universal birth registration by 2030 (Hereward et al., 2019).

As with many developing countries, Pakistan continues to grapple with an acute birth registration crisis. After gaining independence, Pakistan adopted the Births, Deaths, and Marriages Registration Act of 1886 from British India, and has since evolved it. Each provincial government, as required by law under Section 6, has set up a general registry office for birth records managed by the Union Council (Đoković, 2021). A landmark milestone was achieved in March 2010 with the establishment of the National Database and Registration Authority (NADRA), an autonomous institution responsible for logging and maintaining birth information in the computerized Civil Registration Management System (CRMS). From 2012 to 2017, the childbirth registration rate under age 5 increased from 34% to 42%, special thanks to the UNICEF-coordinated Digital Birth Registration (DBR) initiative in Punjab and Sindh provinces (Idris, 2021). However, the progress remains slow in comparison to India, Bangladesh, and Nepal. Pakistan homes 9% of 166 million unregistered children worldwide (30% in South Asia), and still has a long way to go (UNICEF, 2019a).

There has been extensive empirical research on the demand and supply side barriers obstructing an increase in global childbirth registration under age 5, particularly in Ethiopia (Ayele et al., 2024), Kenya (Pelowski et al., 2015), Nigeria (Adi et al., 2015; Isara & Atimati, 2015), and Zimbabwe (Chereni, 2016; Musizvingoza et al., 2023). Among the most predominant constraints are lack of awareness or knowledge, proximity to the registration office, fees, sex of the child, mother's age and education, household wealth, place of residency, inadequate infrastructure, and legislative and bureaucratic hurdles. Over the past two decades, several studies have spotlighted the expanding role of institutional deliveries in facilitating childbirth registration in the Lao PDR and Bangladesh (Nomura et al., 2018; Paul & Rumsey, 2002). Hospitals and clinics provide a structured environment for skilled birth attendants to counsel mothers about the legal and social benefits of registering childbirth. In contrast, home births often lack this intervention, thus making the registration process more prone to delays, incompleteness, or being entirely overlooked.

Recently, academic interest has grown in investigating how a mother's autonomy and bargaining power influence birth registration. Studies by Bloom et al. (2001), Ball et al. (2014), and Paleker et al. (2023) revealed that those mothers who receive prenatal care in institutional settings tend to have better access to resources and support systems, which helps them navigate and complete their childbirth registration process. Beyond these traditional socio-demographic factors, many researchers have started exploring new dimensions. Candia (2019) identified a positive correlation between mass media exposure and birth registration in Uganda. Other studies, including Li et al. (2010), linked certain under-registration cases to discrimination against marginalized groups. Abay and Gebre-Egziabher (2020) emphasized the shortage of local registration centres in rural areas as a key barrier to accessibility.

Despite the rising international focus on this research area, studies in the context of Pakistan remain scarce. A prominent study by the Punjab Economic Research Institute (PERI) has found mothers' education, household's wealth status, and region as primary obstacles to childbirth registration (Nadeem et al., 2020). Building on this, UNESCAP's study employed the tree classification method, pointing out that lower wealth levels and linguistic diversity have substantially reduced birth registration opportunities across provinces (Boiteau—Montéville, 2020). The latest Pakistan Demographic and Health Survey (PDHS) 2017-2018 reveals a stark provincial disparity in de jure childbirth

registration under age five, with Punjab at 57.8%, Sindh at 27.6%, Khyber Pakhtunkhwa (KPK) at 18.8%, and Balochistan at 37.6%. At present, no study has bifurcated the impact of differences in household characteristics and birth registration behaviours in driving these provincial disparities, which restrict equitable access to legal identity for children.

Our research, therefore, aims to address this critical literature gap by decomposing the contribution of various factors that influence birth registration disparities across the Punjab-Sindh, Punjab-KPK, and Punjab-Balochistan groups. Additionally, it investigates whether the birth registration inequalities in each group are primarily determined by compositional or behavioural differences. This study is the first of its kind to provide policymakers with a detailed understanding of the contrasting situations in birth registration disparities that prevail among different groups. Using these insights, the policymakers can design strategic interventions that help bridge these provincial disparities more effectively in compliance with international human rights principles.

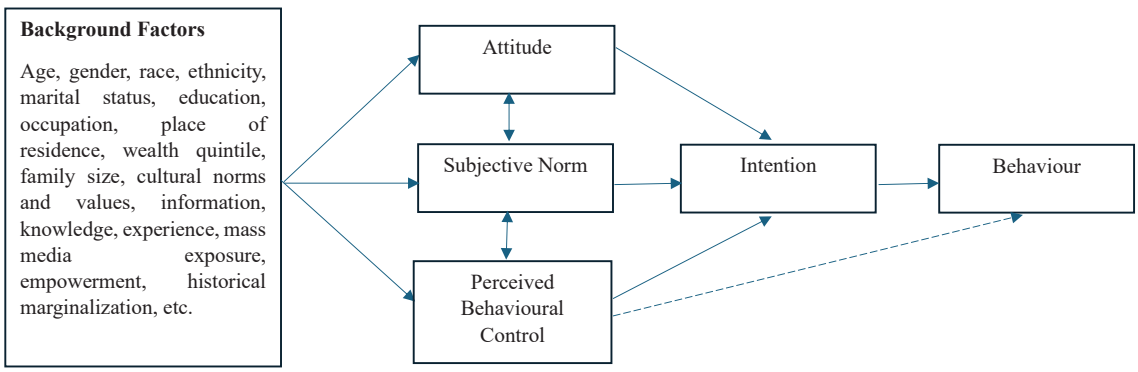
THEORETICAL FRAMEWORK

To shed light on the multi-dimensional nature of birth registration disparities among provinces, this study incorporates the theory of planned behaviour (TPB), an evolved version of the theory of reasoned action. Under TPB's framework, the core mechanism that drives a person to carry out behaviour is the intention, which is the function of three proximal determinants: attitude (ATT), subjective norm (SN), and perceived behavioural control (PBC) (Ajzen, 1980). Attitude can be defined as an individual's subjective evaluation of the likely positive and negative consequences of performing a specific behaviour. Subjective norm is the conviction about whether the people around that individual support or oppose engaging in the behaviour in question. Perceived behavioural control, on the other hand, considers the anticipated ease or difficulty in executing that behaviour based on the relative strength of facilitating and restricting factors. Together, these components interact with each other and guide an individual's intention to act, which directly influences the likelihood of carrying out a behaviour.

Over the past two decades, TPB has emerged as one of the most widely accepted social psychological theories (Ajzen, 2020). It has been extensively used to explain and predict human behaviour across diverse domains, from helmet use to alcohol consumption (Cooke et al., 2016; Quine et al., 1998), from academic misconduct to childhood obesity (Andrews et al., 2010; Stone et al., 2009), from educational technology adoption to healthcare empowerment of married women (Lee et al., 2010; Sabouri et al., 2019), to name a few. While this theory has been applied to investigate the motivations behind parents registering their child's birth (Williams et al., 2018), it can also be expanded to contextualize how differences in provincial demographic characteristics and behavioural responses steer birth registration inequalities. This is illustrated in Figure 1.

Figure 1

Transmission Mechanism of Expanded TPB



Note. Created by the authors.

This model depicts the transmission mechanism through which background factors, such as wealth quintile, education, place of residence, and other demographic characteristics, influence intentions and behaviours to register childbirth. Education, in particular, moulds an individual's attitude, subjective norms, and perceived behaviour control, which collectively translate into actual behaviour. For instance, a mother with a higher education level and mass media exposure is more likely to recognize the benefits of childbirth registration and feel empowered to act despite the potential disapproval from her social networks, than those without education or media exposure. Contradictorily, even with family support, mother may lack the capacity to follow the registration process due to mobility constraints, socio-political instability, lack of trust in institutions, or any other deterring factors. In such a case, low PBC can outweigh the positive influence of characteristics on attitudes and subjective norms, ultimately affecting intentions (Ajzen, 1985), as shown by the dashed line. This possible interaction effect has been empirically validated by Yzer and Van Den Putte (2014).

At the national level, the TPB framework outlines how differences in background factors and behavioural responses across provinces shape parents' intentions to register and contribute to birth registration disparities.

MATERIALS AND METHODS

Data source

Our research employed data from PDHS for the period 2017-2018. It is a nationally representative household cross-sectional survey that provides data on a diverse range of performance tracking indicators for population, health, and nutrition. The National Institute of Population Studies (NIPS) conducts this survey every five years under the Ministry of National Health Services, Regulations & Coordination (NHSR&C), Pakistan. Assistance for the survey was rendered by many institutions, including financial support from the United States Agency for International Development (USAID), logistical services from the United Nations Population Fund (UNFPA) and the Department for International Development (DFID), sample selection and household enumeration by the Pakistan Bureau of Statistics (PBS), and technical support from the ICF. Details about the questionnaires, methodology, sample design, and dataset are publicly accessible on the website of the National Institute of Population Studies.

Sample design and implementation

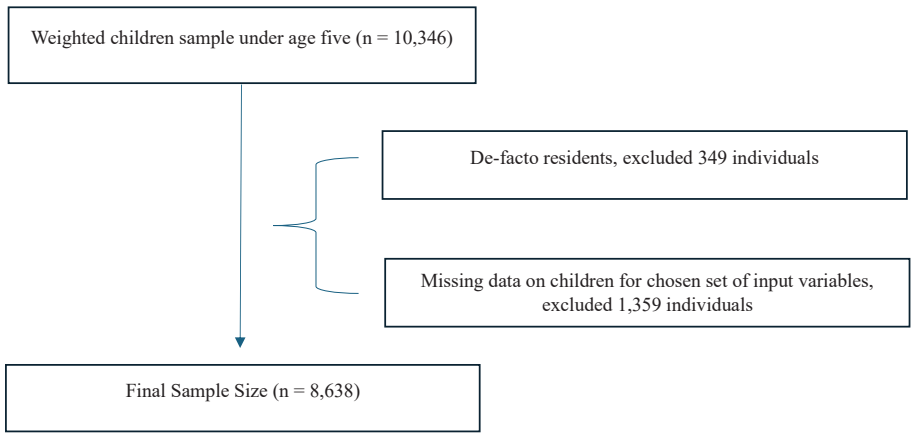
The PDHS uses a stratified two-way sample design, which splits each of the eight regions into urban and rural areas, thus creating 16 sampling strata. The first stage involves selecting 580 clusters, and within each cluster, enumeration blocks (EBs) were randomly chosen using the probability proportional to size method. EBs with larger populations had a higher probability of being selected than the smaller ones. Due to security concerns, 19 clusters were dropped. A household listing operation was carried out in the second stage across all selected clusters. A fixed number of 28 households per cluster was then picked based on an equal probability systematic selection process. The NIPS data processing office centrally managed the household selection process. Only the pre-selected households were interviewed. No substitutions or adjustments were made to avoid bias. To address non-proportionality in sample allocation, weighting factors were calculated and integrated into the data to achieve national level representation in the results.

Final sample size

To refine the analysis, we performed a systematic filtering process, as illustrated in Figure 2, to narrow

Figure 2

Final Sample Size



down the original dataset to the final sample size utilized in our study.

Out of the final sample of 8,638 children, approximately 42.54% of children have had their births registered, while 57.46% remain unregistered.

Study variables

Outcome variable

A dependent variable, birth registration (BR), is defined as the total number of de jure children (usual residents) under age five whose births have been officially registered with NADRA or Union Council. It is a binary variable, where the value of 1 indicates that the child's birth has been registered and 0 if it has not.

Predictor variables

Based on the previous relevant studies, including Bhatia et al. (2021), Chomba (2016), Juma et al. (2016), Comandini et al. (2016), Duff et al. (2016), Duryea et al. (2006), Ebbers and Smits (2022), Flygge (2009), Melnik et al. (2015), Tobin et al. (2013), Wodon and Yedan (2019), and guided by the TPB framework, we selected nine explanatory variables and divided them into four distinct categories, as shown in Table 1.

After selecting these explanatory variables, the Variance Inflation Factor (VIF) test was conducted to assess the degree of correlation among the variables across the provinces. Its results are reported in Annexure 1. The mean VIF is less than 2 in all provinces, indicating that the variables are weakly correlated with each other. Hence, the issue of multicollinearity does not exist.

Empirical methodology

Our methodological approach begins with the application of the logit regression model, which is the most suitable technique for estimating a binary categorical outcome variable (BR = 1 or BR = 0) using a set of predictor variables (Hellevik, 2009; Stoltzfus, 2011). Its general form in vector notation can be written as;

$$logit(BR) = ln\left(\frac{\Pr\ (BR = 1/X)}{1 - \Pr\ (BR = 1/X)}\right) = X\beta + v \quad (1)$$

This equation models the log of the odds ratio of the binary dependent variable BR using a vector of explanatory variables X. Here, β represents the vector of parameters corresponding to independent variables

Table 1

Variable Description

Indicator	Description	Response (%)
Demographic variables		
Child's sex	This binary variable specifies the child's gender as either male or female.	Male (49.68)
		Female (50.32)
Socioeconomic variables		
Wealth status	The wealth status of households is grouped into five main categories: poorest, poorer, middle, richer, and richest. The details of the construction of the wealth index are available on the website of the DHS Program.	Poorest (22.38)
		Poorer (19.61)
		Middle (21.37)
		Richer (19.19)
		Richest (17.45)
Father's education	The highest educational level completed by husbands/partners during the survey was grouped as illiterate, primary, secondary, and higher.	Illiterate (29.90)
		Primary (17.48)
		Secondary (33.79)
		Higher (18.82)

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Mother's education	The highest educational level acquired by women aged 15-49 during the survey was categorized as illiterate, primary, middle, secondary, and higher.	Illiterate (48.18) Primary (16.75) Middle (9.58) Secondary (12.59) Higher (12.90)
Mother's mass media exposure	This variable is binary, based upon the responses of the respondents about reading the newspaper, watching TV, and listening to radio. For each media type, the responses have been taken as "Yes" (less than a week or at least once a week) and "No" (Not at all). This variable takes value 1 if the female has exposure to any type of media and 0 otherwise.	No (50.03) Yes (49.97)
Behavioural/Cultural variables		
Mother's decision-making empowerment	This indicator captures the degree of an ever-married woman's involvement in making decisions regarding her healthcare, large household expenditures, family/relatives visits, and allocating her husband's earnings. All these factors serve as indicators of women's empowerment. The variable takes the value 1 (Yes) if she is involved in decision-making alone or with her husband at least in one dimension and 0 (No) otherwise.	No (53.42) Yes (46.58)
Place of residence	The place of residence for households is divided into two main categories: rural and urban.	Rural (68.16) Urban (31.84)
Child's parity	This variable classifies ever-married women aged 15-49 by the number of children they have given birth to in their lifetime. It is a trichotomous variable grouped into categories of 1 child, 2-3 children, and 4 or more children.	1 (12.65) 2-3 (42.15) 4 or more (45.20)
Healthcare variables		
Institutional delivery	This variable records the place of delivery for ever-married women aged 15-49 during childbirth. Institutional delivery is binary in nature and takes values 0 (No) and 1 (Yes). If the childbirth took place at a health facility, it is classified as 1 and 0 otherwise. The health facilities are grouped into different healthcare settings, including government and private hospitals, rural health centres, basic health units (BHUs), and community midwives.	No (33.68) Yes (66.32)

and ν is the error term capturing unobserved factors. Using the estimated values ($\hat{\beta}$), we calculated the predicted probability of childbirth registration under age five (BR = 1) conditional on X using the following transformed odds ratio equation.

$$\hat{p} = \widehat{Pr}(BR = 1|X) = \frac{\exp(X\hat{\beta})}{1 + \exp(X\hat{\beta})} \quad (2)$$

While reporting results in odds ratios is standard practice, it is often misunderstood as relative risks/ probabilities, which are distinct concepts. Additionally, this conventional approach fails to provide a clearer sense of magnitude which limits the interpretative value of the findings (Jann, 2013). In response to this limitation, we computed average marginal effects (AME), which translates effect sizes into a probability scale ranging from 0 to 1, making regression output results more intuitive

and easier to interpret (Howell-Moroney, 2023).

The marginal effect for a categorical variable can be expressed as;

$$AME = \widehat{Pr}(BR = 1|X, X_k = 1) - \widehat{Pr}(BR = 1|X, X_k = 0) \quad (3)$$

This equation measures the change in the likelihood of childbirth registration (BR = 1) for a particular category in comparison to its base category of a variable X_k from the vector of explanatory variables X.

For our core analysis, we employed Fairlie decomposition, which builds on the Oaxaca-Blinder decomposition to handle non-linear regression models with binary outcome variables (Fairlie, 2005). The methodological advantage is that it uses coefficient estimates from the logit or probit model to quantify the contribution of differences in compositional factors and behaviour responses in explaining the observed disparity between the two groups of interest.

Following Fairlie (1999), the aggregate non-linear decomposition equation $Y = F(X\hat{\beta})$ can be defined as,

$$\bar{Y}^P - \bar{Y}^O = \underbrace{\left[\sum_{i=1}^{N^P} \frac{F(X_i^P \hat{\beta}^P)}{N^P} - \sum_{i=1}^{N^O} \frac{F(X_i^O \hat{\beta}^P)}{N^O}\right]}_{1^{st}\ \text{Term}} + \underbrace{\left[\sum_{i=1}^{N^P} \frac{F(X_i^O \hat{\beta}^P)}{N^P} - \sum_{i=1}^{N^O} \frac{F(X_i^O \hat{\beta}^O)}{N^O}\right]}_{2^{nd}\ \text{Term}} \quad (4)$$

where $\bar{Y}^P$ and $\bar{Y}^O$ represents the predicted probabilities of childbirth registration in Punjab and other province respectively; X_i denotes the observable characteristics of the group being studied, $\hat{\beta}$s are the estimated coefficients, $F(.)$ is the normal cumulative distribution function (CDF), and N is the sample size of registered births of children under age 5 in each group, Punjab (P) and other province (O).

This equation decomposes the difference in the mean predicted probabilities between the P and O groups into two terms. The first term calculates the difference in birth registration outcomes by comparing the actual situation in Punjab with its counterfactual scenario where children in Punjab are given the other province's distribution of characteristics. The resulting gap in the outcome, therefore, accounts for a portion of provincial birth registration inequality explained by the differences in observed characteristics such as wealth status, child's sex, mother's education, *etc*. This is called the endowment or composition effect.

On the contrary, the second term compares the counterfactual situation in Punjab with the actual situation in other province to see what would happen if the other province experienced Punjab's behavioural response ($\hat{\beta}$) after controlling for all variations in characteristics. It isolates the share of provincial birth registration disparity resulting from differences in behavioural responses conditioned by prevailing societal norms, cultural values, government policies, *etc*. This is referred to as the coefficient or behavioural effect.

To determine the contribution share of each predictor variable, detailed decomposition is required. Refer to Annexure 2. It is important to note that the relative contribution of any independent variable can be positive or negative. If it is positive, that variable contributes to increasing the childbirth registration gap between the two provinces. However, if it is negative, that variable contributes to narrowing down the group differences.

We performed three Fairlie decompositions using the statistical software STATA 18. In each case, Punjab was set as the base category for comparisons with Sindh, KPK, and Balochistan. To address a potential dependency path issue, the order of all explanatory variables was randomized across 1000 replications, as suggested by Fairlie (2017), and the results were averaged to compute the contribution share of each variable.

As a robustness check, the Yun decomposition is carried out to test the reliability of Fairlie decomposition results.

RESULTS

The results section provides a comprehensive analysis of the childbirth registration in each province using diverse statistical approaches. It starts with a descriptive analysis that illustrates the disparity in birth registration rates and examines the distribution of household characteristics across provinces. This is followed by an association test to assess the statistical significance of explanatory variables in determining birth registration rates in each province. Next, the Average Marginal Effects (AMEs) are calculated to estimate the likelihood of each variable influencing provincial birth registration rates. Lastly, the Fairlie decomposition partitions the mean difference in the observed birth registration disparity into endowment and coefficient effect for each group, measuring the contribution share of each independent variable.

Descriptive analysis

Figure 3 displays a clustered bar chart illustrating a visual comparison of birth registration rates among the provinces based on our sample size. The largest disparity

is observed between Punjab and KPK at an alarming 39.3%, trailed by Punjab and Sindh at 30.4%, and then Punjab and Balochistan at 21.5%.

Table 2 provides a comparative descriptive analysis of the socio-economic profile of women and their husbands, categorized by the province in which they live.

According to the findings, the gender distribution of children is fairly balanced across four provinces. Female children comprise 51.42% of the population in Sindh and whereas male children hold a slight majority at 50.87% in Punjab, 50.42% in KPK and 51.70% in Balochistan. Secondly, Punjab has a higher rural population at 64.54%, followed by Sindh at 50.51% and KPK at 50.05%. It contrasts with Balochistan, where 51.02% of the population lives in urban settings. This gap in urban and rural residency patterns sheds light on the inequalities in distribution of opportunities and resources, mainly between Punjab and Balochistan. Wealth status further exposes these regional disparities. The percentage of the poorest population in Balochistan is about 2.5 times higher compared to Punjab. The difference between the richest and poorest segments of the Balochistan population is 24.75%, which is greater than the difference observed in Sindh, then Punjab, and finally KPK. This indicates that the wealth gap is relatively larger in Balochistan where poverty is more widespread.

Education level also varies significantly across the provinces. In Balochistan, an alarming 45.19% of fathers are illiterate, which reflects the region's limited access to educational opportunities. Conversely, the educational profile is more diverse in Punjab and KPK, where 38.72% and 35.71% of the fathers have attained secondary education, respectively. Mother's education also mirrors this trend. The percentage of mothers without schooling in Balochistan is 2.24 times higher than in Punjab. By comparison, around 16.36% of the mothers in Punjab have completed higher education, which surpasses those in Sindh and KPK.

Regional differences in mother's mass media exposure are evident, with Punjab leading at 73.61% and Sindh at 64.05%. On the other hand, KPK and Balochistan lag, with only 45.62% and 48.30% of women having access to mass media, respectively. It suggests that areas with greater access to mass media, like Punjab, benefit from better awareness and information dissemination, which is essential for women to understand their rights. In line with our expectations, Sindh reports the highest levels of mother's decision-making empowerment at 58.14%

Figure 3

Differences in Childbirth Registration Rates Between Punjab and Other Provinces

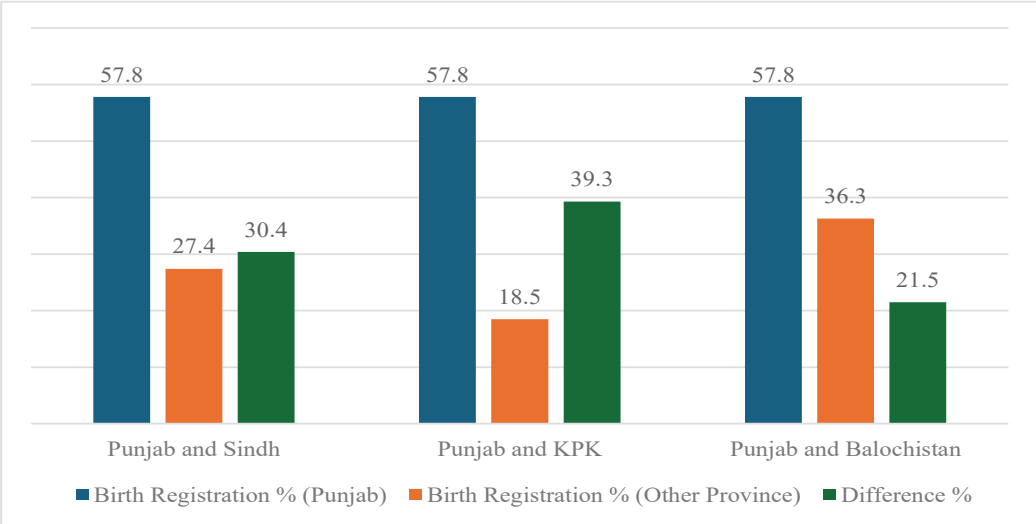

Table 2
Descriptive Statistics

		Weighted %			
Indicator	Classification	Punjab	Sindh	KPK	Balochistan
Child's sex	Male	50.87	48.58	50.42	51.70
	Female	49.13	51.42	49.58	48.30
Place of residence	Urban	35.46	49.49	49.95	51.02
	Rural	64.54	50.51	50.05	48.98
Wealth status	Poorest	12.85	38.12	14.56	32.17
	Poorer	19.27	13.85	19.41	31.04
	Middle	23.22	14.26	23.31	16.35
	Richer	22.48	18.10	20.94	13.02
	Richest	22.18	15.67	21.78	7.42
Father's education	Illiterate	24.26	34.18	26.85	45.19
	Primary	19.27	16.94	12.24	7.34
	Secondary	38.72	25.13	35.71	26.34
	Higher	17.75	23.76	25.21	21.12
Mother's education	Illiterate	34.55	56.67	57.91	77.37
	Primary	21.31	13.35	11.55	6.43
	Middle	11.76	7.48	8.39	4.24
	Secondary	16.02	10.06	9.86	6.59
	Higher	16.36	12.44	12.29	5.37
Mother's mass media exposure	Yes	73.61	64.05	45.62	48.30
	No	26.39	35.95	54.38	51.70
Mother's decision-making empowerment	Yes	52.78	58.14	22.42	24.68
	No	47.22	41.86	77.58	75.32
Institutional delivery	Yes	68.88	73.41	66.30	34.97
	No	31.12	26.59	33.70	65.03
Child parity	1	13.37	12.89	10.92	11.66
	2-3	43.88	43.33	42.41	36.71
	4-15	42.75	43.78	46.68	51.63

with Punjab and Balochistan behind. KPK has the lowest women empowerment rate at 22.42%, which indicates a relatively weaker autonomy and decision-making power.

Turning to cultural dynamics, Sindh's mothers top the list with the highest percentage of institutional deliveries, outpacing KPK by 7.11%. In contrast, these deliveries are less standard in Balochistan at 34.97%, as the majority of births continue to take place outside of healthcare institutions. Lastly, child parity also differs across provinces. Approximately 51.63% of families in Balochistan are predominantly larger, with 4-15 children, compared to Punjab, where smaller families with 1-3 children are more common. This trend is consistent in

Sindh and KPK.

Association test

The Pearson chi-square test result in Table 3 reveals the statistical significance of the explanatory variables influencing childbirth registration across the provinces. Among all the selected variables, birth registration is strongly associated with place of residence, wealth status, father's education, mother's education, mass media exposure, and institutional delivery in all provinces. Interestingly, the mother's decision-making empowerment is statistically significant in Punjab and KPK but not in Sindh and Balochistan. In contrast, child parity is statistically significant only in Sindh. Child's sex, on the other hand, does not play a meaningful role in impacting birth registration in any province.

Average Marginal Effects (AME)

The Average Marginal Effects (AME) were estimated from the logistic estimates of childbirth registration in each province. The White Test results, as reported in Annexure 3, detected heteroscedasticity in the data. Therefore, robust AME was calculated for each independent variable, showing how a change in any factor influences the predicted probability of childbirth registration under age five across provinces. The results are shown in Table 4.

In Punjab, wealth status significantly affects the likelihood of childbirth registration. Households in the poorer, middle, richer, and richest categories are 22.4, 31.6, 43.9, and 54.2 percentage points more likely to register their children's births, respectively, than those in the poorest category. The probability of this outcome increases by 6 percentage points when a father completes his secondary education compared to those who are uneducated. However, it decreases by 5.2 percentage points as fathers achieve higher education. In contrast, mothers who have a higher school degree have a 16.3 percentage points greater likelihood of getting their children's birth documented than illiterate ones. Mother's decision-making empowerment, mass media exposure, and institutional delivery exhibit similar positive trends. Moving towards child parity, the probability rises as the total number of children ever born increases. Lastly, a child's sex and place of residence have a negligible impact on the probability of childbirth registration.

Next, in Sindh, the probability of birth registration jumps dramatically by 60.4 percentage points when the household's wealth status improves from poorer to richest. Contrary to expectations, fathers with any level of education are less likely to register their child's birth

Table 3

Association Test Results of Birth Registration

	If child's birth is registered or not			
	Punjab	Sindh	KPK	Balochistan
Variable	Pearson chi-square statistic			
Child's sex	0.403	2.036	1.844	0.432
Place of residence	73.218***	394.265***	36.695***	23.723***
Wealth status	373.790***	668.598***	168.218***	214.446***
Father's education	152.411***	166.916***	70.281***	109.237***
Mother's education	245.200***	382.947***	71.328***	87.755***
Mother's mass media exposure	130.557***	131.183***	48.769***	42.164***
Mother's decision-making empowerment	19.368***	0.651	65.719***	0.014
Institutional delivery	83.378***	132.984***	30.564***	52.908***
Child parity	1.856	47.106***	1.676	0.017

*$p < .1$. **$p < .05$. ***$p < .01$.

Table 4

Average Marginal Effects (AMEs) of Childbirth Registration

		If the child's birth is registered or not			
Variable	Dimension	Punjab	Sindh	KPK	Balochistan
		Coefficients			
Child's sex	Female (ref. group)				
	Male	-0.007	0.004	-0.040**	0.053
Place of residence	Rural (ref. group)				
	Urban	-0.038	0.083***	-0.017	-0.100**
Wealth status	Poorest (ref. group)				
	Poorer	0.224***	0.111***	-0.036	0.184***
	Middle	0.316***	0.323***	0.003	0.263***
	Richer	0.439***	0.444***	0.124**	0.526***
	Richest	0.542***	0.604***	0.204***	0.557***
Father's education	Illiterate (ref. group)				
	Primary	0.019	-0.001	0.070*	-0.063
	Secondary	0.060**	-0.025	0.086***	0.120***
	Higher	-0.052	-0.064**	0.049	0.133**
Mother's education	Illiterate (ref. group)				
	Primary	0.075**	0.023	0.125***	0.078
	Middle	0.120***	0.080**	0.066	0.024
	Secondary	0.121***	0.066**	0.029	-0.005
	Higher	0.163***	0.064*	0.039	0.195**
Mother's mass media exposure	No (ref. group)				
	Yes	0.034	-0.021	0.030	-0.010
Mother's decision-making empowerment	No (ref. group)				
	Yes	0.057***	0.029*	0.126***	-0.120***
Institutional delivery	No (ref. group)				
	Yes	0.055**	0.034	0.018	-0.014
Child parity	1 (ref. group)				
	2-3	0.012	0.057**	0.040	0.023
	4 or more	0.084***	0.039	0.038	0.054
Observations		2,304	1,978	1,896	1,321
Log pseudo-likelihood		-2609.7501	-759.50704	-606.7255	-264.2094
Chi-square		368.21	432.06	197.20	147.31
p-value		0.0000	0.0000	0.0000	0.0000
Pseudo-R^2		0.1647	0.3811	0.1491	0.1505

Note. Ref.: reference

*$p < .1$. **$p < .05$. ***$p < .01$.

than those who are illiterate, and this effect intensifies as educational qualifications increase. The opposite is true in the case of the mother's education. Considering cultural/behavioural dimensions, empowered women have a 2.9 percentage points higher likelihood of officially recording their child's birth than disempowered ones. Similarly, this probability increases by 5.7 percentage points if a mother has 2-3 children rather than having a single child. However, it decreases as the number of children born rises to 4 or more. Mass media exposure also reduces the likelihood of childbirth registration.

Transitioning to KPK, the likelihood of the predicted outcome rises with higher wealth status and mother's educational level. However, child gender reveals a contrasting picture compared to Punjab and Sindh. Male children are 4 percentage points less likely to have their birth registered than female children. Similarly, this likelihood increases by 12.6 percentage points for empowered women as opposed to those who are not. Mother's mass media exposure and institutional delivery also positively influence the probability; however, the difference is minute. Regarding healthcare variable, mothers with 2-3 children are 4 percentage points more likely to register their childbirth than those with only one. Conversely, this likelihood reflects a decrease of 0.01 percentage points for urban households compared to rural ones.

In the case of Balochistan, wealth status has a strong positive impact on the probability of childbirth registration just like in other provinces. Similar to KPK, the probability is lower for households living in urban areas than rural ones. Considering the child's sex, this likelihood increases by 5.3 percentage points for male children compared to their female counterparts. Parental education also plays a vital role. As fathers' and mothers' education climbs to a higher level, the probability of birth registration increases by 13.3 and 19.5 percentage points, respectively, compared to those with no education. On the other hand, those women who are empowered are less likely to register their childbirth than the disempowered ones. This trend is also consistent in mass media exposure and institutional delivery. However, the opposite is true in case of child parity.

Fairlie decomposition

Table 5 presents the aggregate and detailed decomposition findings of the childbirth registration gap among different provincial groups, based on selected predictor variables.

Of the observed birth registration disparity in the Punjab-Sindh group, the endowment and coefficient effect accounts for 60.19% and 39.18%, respectively. This indicates that the birth registration inequality between Punjab and Sindh is mainly caused by the differences in household characteristics. Among this explained difference, wealth status emerges as the dominant factor responsible for 76.96% of this inequality. It reveals a crucial insight. If the distribution of household wealth quintiles in Sindh becomes identical to those in Punjab, then the birth registration gap can be diminished by up to 76.96%. Next, the education levels of mothers and fathers, at 18.27% and 4.79%, have a relatively moderate contribution to increasing birth registration inequality. However, mothers' decision-making empowerment and child parity work towards narrowing this gap. Lastly, the contribution of a child's gender, mass media exposure, and institutional delivery is statistically insignificant in explaining the disparity in this group.

Shifting focus to the Punjab-KPK group, the findings present a situation contrasting to the previous group. In this case, the endowment and coefficient effects are 46.31% and 53.69%. Therefore, the observed disparity between Sindh and KPK is primarily driven by the differences in birth registration behaviour rather than variations in household compositions. Here, mother's education surfaces as the largest positive contributor, explaining 27.93% of the differences in childbirth registration rates. Wealth status is the next major determinant at 26.70%, closely followed by mass media exposure at 22.06% and women's decision-making empowerment at 21.21%. Meanwhile, the father's education makes a relatively minor positive contribution. On the other hand, the place of residence and the child parity negatively contribute to the group gap. This means that the distribution of these two factors in Punjab and KPK decreases rather than exacerbates the birth registration gap. Finally, the contribution of child's sex remains statistically insignificant.

Moving onto the Punjab-Balochistan group, the endowment effect is 100.93%, pointing out that the observed birth registration disparity is almost entirely due to differences in population characteristics. This finding gives a unique insight. Unlike the comparison in previous groups, the birth registration inequality will be eliminated if all the characteristics of households in Balochistan become equal to those in Punjab. Here, the same characteristics would not produce different birth registration outcomes by any means since their behavioural profile are approximately identical. Wealth status has the leading positive contribution, accounting for 54.71% of the explained difference, while mother's education adds 25.71%. Similarly, the father's education, the mother's decision-making empowerment, mass media

Table 5

Fairlie Decomposition Results of Birth Registration Rates Disparity across Provinces

	Punjab vs Sindh		Punjab vs KPK		Punjab vs Balochistan	
BR (%) of Punjab	0.578		0.578		0.578	
BR (%) of other provinces	0.274		0.185		0.363	
BR gap	0.304		0.393		0.215	
Explained gap	0.183*** (60.19%)		0.182*** (46.31%)		0.217*** (100.93%)	
Unexplained gap	0.121*** (39.81%)		0.211*** (53.69%)		-0.002 (-0.93%)	
Indicator	Coefficients	% Contribution	Coefficients	% Contribution	Coefficients	% Contribution
Child's sex	0.000	0.01	-0.000	-0.13	0.000	0.01
Place of residence	0.005***	3.08	-0.003*	-2.11	-0.001**	-0.74
Wealth status	0.141***	76.96	0.048***	26.70	0.118***	54.71
Father's education	0.008***	4.79	0.008***	4.63	0.010***	4.75
Mother's education	0.033***	18.27	0.050***	27.93	0.056***	25.71
Mother's mass media exposure	0.000	0.29	0.040***	22.06	0.008*	3.86
Mother's decision-making empowerment	-0.003***	-1.64	0.038***	21.21	0.017***	7.90
Institutional delivery	-0.000	-0.24	0.003***	1.85	0.017***	7.87
Child parity	-0.002***	-1.52	-0.003***	-2.14	-0.008***	-4.07

Note. BR - Birth registration

*$p < .1$. **$p < .05$. ***$p < .01$.

exposure, and institutional delivery have a relatively lesser contribution. All these factors intensify childbirth registration inequality between Punjab and Balochistan, whereas the place of residence and child parity help in bridging this gap. On the other hand, child's sex does not have any meaningful contribution to explaining this group difference.

Robustness check

To determine whether the results of Fairlie decomposition differ significantly when employing alternative techniques, we applied the Yun decomposition using the mvdcmp command (Powers et al., 2011). This method uses a first-order Taylor expansion to linearly approximate a nonlinear model, providing an effective remedy to the dependency path issue (Yun, 2004). Unlike Fairlie decomposition, it also computes asymptotic standard errors and resolves identification problems related to choosing reference categories for dummy variables (Yun, 2005, 2008). The results are reported in Table 6.

Starting from the aggregate results, the Yun decomposition sheds light on the unique situations that explain birth registration disparity in each group. In Punjab-Sindh, it is mainly attributable to differences in population characteristics. For Punjab-KPK, it is primarily due to differences in birth registration behaviour. While in Punjab-Balochistan, all inequality stems from differences in compositional factors. These findings match with Fairlie decomposition results. While the differences in estimation between the two methods are minor to moderate, both consistently identify household wealth status and mother's education as the main positive drivers of birth registration disparity across all three groups.

A clear divergence is observed in Punjab-KPK group regarding which variable has the largest contribution in driving the birth registration inequality. Fairlie decomposition attributes it to mother's education, whereas Yun decomposition links it to wealth status. From Table 4, we can see that the differences in the coefficients of wealth status between Punjab and KPK

Table 6

Yun Decomposition Results of Birth Registration Disparity across Provinces

	Punjab vs Sindh		Punjab vs KPK		Punjab vs Balochistan	
BR (%) of Punjab	0.5782		0.5783		0.5783	
BR (%) of other provinces	0.2745		0.1854		0.3640	
BR gap	0.3037		0.3929		0.2143	
Explained gap	0.1528*** (50.31%)		0.1239*** (31.53%)		0.2251*** (105.03%)	
Unexplained gap	0.1508*** (49.69%)		0.2688*** (68.47%)		-0.0109 (-5.03%)	
Indicator	Coefficients	% Contribution	Coefficients	% Contribution	Coefficients	% Contribution
Child's sex	-0.0003	-0.23	-0.0002	-0.23	0.0001	0.05
Place of residence	0.0047**	3.12	-0.0060**	-4.86	-0.0009**	-0.40
Wealth status						
Poorest	0.0853***	55.85	0.0147***	11.91	0.0529***	23.51
Poorer	-0.0031***	-2.07	0.0063***	5.12	0.0101***	4.53
Middle	0.0007	0.46	-0.0002	-0.22	0.0002	0.13
Richer	0.0055***	3.61	0.0098***	7.96	0.0124***	5.51
Richest	0.0221***	14.52	0.0231***	18.69	0.0412***	18.31
Father's education						
Illiterate	0.0007	0.52	0.0006	0.50	0.0017	0.78
Primary	0.0001	0.10	0.0008	0.69	0.0013	0.61
Secondary	0.0082***	5.40	0.0028***	2.33	0.0067***	2.98
Higher	0.0033***	2.19	0.0023***	1.93	-0.0001***	-0.05
Mother's education						
Illiterate	0.0240***	15.71	0.0297***	24.00	0.0456***	20.28
Primary	-0.0020	-1.31	-0.0021	-1.77	-0.0032	-1.44
Middle	0.011	0.73	0.0011	0.95	0.0020	0.90
Secondary	0.0014	0.96	0.0020	1.64	0.0028	1.27
Higher	0.0037***	2.43	0.0054***	4.42	0.0088***	3.93
Mother's mass media exposure	0.0036**	2.37	0.0143***	11.58	0.0095**	4.26
Mother's decision-making empowermen	-0.0046***	-3.06	0.0197***	15.92	0.0214***	9.50
Institutional delivery	-0.0009***	-0.63	0.0044***	3.8	0.0205***	9.12
Child parity						
1	-0.0000**	-0.05	-0.0008**	-0.72	-0.0006**	-0.27
2-3	-0.0002**	-0.15	-0.0007**	-0.63	-0.0019**	-0.85
4 or more	-0.0007***	-0.48	-0.0034***	-2.80	-0.0059***	-2.65

Note. BR - Birth Registration
*$p < .1$. **$p < .05$. ***$p < .01$.

are relatively large, thereby, making the latter method prone to errors in estimating the contribution accurately (Schwiebert, 2015). As a result, the linear approximation is likely to be poor in this case.

Another key similarity is that the birth experience works toward reducing the birth registration gap in all groups across the methods. The type of place of residence also follows a similar trend except in the Punjab-Sindh group, where the contribution is the opposite. Likewise, father's education, mother's decision-making empowerment, mass media exposure, and institutional delivery make smaller contributions but with mixed directional influences. In contrast, the contribution of child's sex continues to be largely insignificant across all groups in both methods.

Although Yun decomposition produces certain different outcomes, its core findings remain overall consistent with Fairlie decomposition. The deviations in the explanatory power of two models, therefore, can be attributable to the difference in their specifications and estimation techniques. Hence, the results of Fairlie decomposition are method-insensitive and robust.

DISCUSSION

Using the cross-sectional data from the latest PDHS, this study discovered that a concerning 57.46% of the de jure children under age five did not have their births registered, leaving them vulnerable to exploitation, abuse, and discrimination. Studying this issue in the context of Pakistan makes our research highly relevant. Being the world's fifth most populous country, Pakistan has been battling severe economic and social challenges, including higher inflation, unemployment, poverty, illiteracy, and inadequate access to healthcare. All these pressing issues are intertwined, which perpetuates the systematic barriers to birth registration and further marginalizes society. Drawing on the foundational concepts of TPB, this study goes beyond calculating the AMEs by decomposing the contribution of differences in characteristics and birth registration behaviour to explain the birth registration gap in each group. It offers valuable insights that are missing from the current literature.

Our study found that belonging to a poorer family substantially reduces the likelihood of childbirth registration, which aligns with the findings of previous studies (Aboagye et al., 2023; Ebbers & Smits, 2022; Onagoruwa & Wodon, 2021). The determinative factors are direct and indirect costs, such as fees, wage loss due to work absenteeism and transportation expenses, which deter under-privileged households from actively participating in the birth registration process (Amo-Adjei & Annim, 2015). According to the survey in 2015, a single trip to the nearest Union Council office cost a household PKR 736 ($7.40) and PKR 297 (USD $3.0) in Punjab and Sindh, respectively. This amount equals an average daily wage for a worker living in remote regions, therefore, compelling poverty-stricken families to fulfil their basic survival needs (UNICEF, 2022). From a TPB perspective, these financial barriers curtail perceived behaviour control despite the positive intentions of parents to register their child's birth. To address this challenge, the DBR initiative has been recently expanded to Thatta and Pakpattan districts which is expected to decrease the birth registration gap between the two provinces (GSMA, 2018).

The sex of the child is largely irrelevant in determining birth registration, contradicting many earlier studies. A Kenyan study by Mathenge et al. (2013) pointed out that male children are more likely to be registered than their female counterparts, a trend attributable to patriarchal societal norms. In contrast, Kumar and Saikia (2021) reported a higher probability of birth registration for female children primarily due to the benefit payments and educational scholarships offered by the Indian government. In another study, Dake and Fuseini (2018) unveiled that Ghanaian parents do not discriminate against gender when registering their child's birth. This supports our unusual result, which is further reinforced by UNICEF's report (2021) stating that many Pakistani respondents believe birth registration is crucial for all children, irrespective of gender. It indicates that the subjective norms related to gender bias in birth registration is minimal in Pakistan.

Regarding the impact of parents' education, our findings differ across provinces. Greater maternal education significantly raises the likelihood of childbirth registration in all provinces, consistent with prior studies in Nigeria and Indonesia (Isara & Atimati, 2015; Jackson et al., 2014). Educated mothers tend to be more conscious of the legal importance of documenting birth, which is essential for their children to secure school admission, access to healthcare services, and inheritance rights. Father's education also plays an equally important role in boosting their child's social and economic welfare, as hypothesized by human capital theorists (Guryan et al., 2008). While higher levels of father's education increases the probability of childbirth registration in KPK and Balochistan, this is not the case in Punjab and Sindh. One plausible explanation for this inconsistency is that fathers in these provinces may have more demanding careers, which limits the attention required to complete administrative birth registration tasks on time.

Contrary to our expectations, households residing in rural areas are more likely to get register their child's birth than those in urban areas, excluding Sindh. Conflicting findings have been reported in India and Vietnam, where rural residents are at a higher risk of being legally non-existent due to greater geographical distance from registration centres and inadequate transportation access (Flygge, 2009; Giang et al., 2016). Lack of awareness and knowledge further aggravate under-registration issues (Mouravieff-Apostol, 2001). However, this situation appears to be less pronounced in Punjab, KPK, and Balochistan, thanks to the active rural community outreach programs that have been pivotal in reshaping parents' attitudes by educating them about the socio-economic benefits of getting their child's birth recorded (UNICEF, 2015).

Mass media exposure is strongly associated with higher childbirth registration rates. Mothers who engage with mass media have a greater probability of registering their children's birth than those who do not in Punjab and KPK, which is in line with the results of other studies (Candia, 2019; Fisker et al., 2019). Radio and newspapers disseminate public service messages about the locations of birth registration units, required documents, deadlines, and the long-term consequences of non-registration. This widespread flow of information helps bypass obstacles related to low literacy and geographical isolation (Alemu et al., 2023), encouraging mothers to take proactive steps to safeguard their children's rights and future. Despite the extensive outreach efforts, the impact of mass media in inducing behavioural transformation has been ineffective in Sindh and Balochistan, implying that subjective norms in these provinces are more resistant to change.

Similarly, decision-making empowerment plays a central role in boosting childbirth registration rates. Those mothers who exercise greater control over key household decision-making matters are more likely to get their child's birth registered than the disempowered ones. A study by Mohanty and Gebremedhin (2018) supports this finding, stating that highly empowered mothers often possess strong negotiation power, which allows them to mobilize sufficient resources to support their children's well-being, such as immunization, routine medical check-ups, and birth registration. From TPB's lens, the perceived behavioural control is likely to increase as the mother becomes more empowered in decision-making. This pattern is observable in Punjab, Sindh, and KPK, except in Balochistan, where frequent tribal conflicts and political insurgency may have undermined their efforts to register children's births before the age of five (Aslam, 2011; Mushtaq & Mirza, 2022).

Moreover, those women who give birth in an institutional healthcare setting are more likely to have their child's birth registered than those who deliver at home, except in the case of Balochistan. This result mirrors previous studies undertaken in Indonesia, Latin America and the Caribbean (Brito et al., 2013; Pont et al., 2023). A similar study by Anaduaka (2022) emphasized that many skilled birth attendants, driven by social responsibility, often inform first-time parents about the necessity and procedure for childbirth registration, thereby raising awareness and motivating mothers to acquire official recognition of their child's identity. Our findings further reveal that the likelihood of birth registration increases with the child parity, a proxy of the mother's age, in Punjab only. In other provinces, this variable becomes statistically insignificant in our model.

CONCLUSION AND POLICY RECOMMENDATIONS

Childbirth registration is a fundamental gateway that unlocks citizenship rights and access to vital services. Despite extensive worldwide collaborative efforts, around 166 million children under the age of five are unregistered to this day. Many destitute children, particularly in developing countries, die without leaving a trace on official records, who might have had a chance at survival if they had access to life-saving immunization, healthcare, and nutrition. Poverty is not only an obstacle to birth registration. There are multiple demand and supply-side barriers, as discussed earlier, that amplify the under-registration problem. Our study, therefore, utilized cross-sectional data from recent PDHS to perform association tests, AMEs, Fairlie and Yun decompositions, while integrating TPB to thoroughly examine the diverse realities that explain provincial birth registration inequalities in Pakistan.

Of the 8,638 de jure children under age five included in the weighted sample, around 4,936 were found to be unregistered in this study. A provincial breakdown presents stark differences, with Punjab and KPK experiencing the largest disparity, followed by Punjab and Sindh, and then Punjab and Balochistan. Fairlie decomposition probed deeper into its underlying reasons, bifurcating the impact of differences in compositional and birth registration behaviour using selected variables. Its findings reveal dissimilar patterns that shape birth registration inequalities across each group. In the Punjab-Sindh group, the birth registration gap is primarily driven by differences in household characteristics. Wealth status and mother's education are the leading positive contributors responsible for 95.23% of the explained disparity. Equalizing the

distribution of these two factors alone would lead to the largest reduction in the explained birth registration gap. Therefore, improving household economic conditions and expanding educational opportunities for mothers should be at the forefront of policy efforts in Sindh.

Implementing this strategy would likely bring limited success in decreasing the Punjab-KPK birth registration gap, as mothers' mass media exposure and decision-making empowerment also substantially affect outcomes. However, integrating these factors into policy design as a standalone approach would be insufficient. Most of the birth registration inequality is fuelled by differences in behavioural responses in this group. It suggests that even if the distribution of all chosen characteristics becomes equivalent to those in Punjab, around 53.69% of the inequality would continue to exist. In light of these insights, the interventions should also address cultural norms, stereotypes, and myths that deter parents from registering their child's birth in KPK. Community engagement initiatives can be taken to raise awareness about the legal and socio-economic benefits of birth registration. To provide a supportive environment, the government must strengthen the integrity of its institutions to build trust within the community.

The birth registration behaviour is uniform in the Punjab-Balochistan group, so all inequalities stem from differences in household characteristics, unlike in the previous two groups. Wealth status, mother's education, decision-making empowerment, and institutional delivery contribute 96.19% to the observed disparity. Hence, the government should target these factors to significantly narrow the birth registration gap in this group.

In conclusion, a one-size-fits-all strategy is inadequate for mitigating provincial birth registration disparities in Pakistan. Our study, therefore, calls for situation-specific interventions that are tailored to address each group's unique challenges. This approach will help increase equitable childbirth registration, driving substantial progress toward achieving SDG target 16.9 by 2030.

Limitations

Despite conducting a detailed analysis, this study has certain limitations. The PDHS does not require participants to provide evidence of their childbirth registration; Therefore, the answers may be susceptible to misreporting due to desirability or recall bias. The fear of penalties can also make them hesitant to tell the truth, as emphasized by Adair and Lopez (2021). Secondly, this study does not establish causation between birth registration under age five and the selected independent variables.

ACKNOWLEDGEMENT

This research is part of our Final Year Project, a mandatory requirement for the completion of the BS Economics degree at the Department of Social Sciences and Humanities (S^3H) in National University of Sciences and Technology (NUST). The Final Year Project was supervised by Dr Muhammad Irfan Malik. We sincerely thank discussants for their constructive criticism and valuable feedback, which significantly contributed to improving the quality of this paper.

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Annexure 1: Variance Inflation Factor (VIF) test results of birth registration

	Correlation of predictor variables across the provinces			
	Punjab	Sindh	KPK	Balochistan
Variable	VIF statistic			
Child's sex	1.00	1.00	1.01	1.01
Place of residence	1.34	2.30	1.28	1.37
Wealth status	2.62	3.81	2.07	1.77
Father's education	1.60	1.61	1.55	1.23
Mother's education	2.01	2.20	1.62	1.47
Mother's mass media exposure	1.35	1.27	1.39	1.27
Mother empowerment	1.05	1.02	1.03	1.07
Institutional delivery	1.26	1.27	1.12	1.24
Child parity	1.10	1.09	1.13	1.02
Mean VIF	1.48	1.73	1.36	1.27

Annexure 2: Fairlie decomposition

To determine the contribution share of each predictor variable, detailed decomposition is required. Based on the coefficient estimates derived from the logit regression model for a pooled sample, $\check{\boldsymbol{\beta}}^*$, the contribution of an explanatory variable in explaining group differences can be written as,

$$\frac{1}{N^O}\sum_{i=1}^{N^O} F\left(\check{\alpha}^* + X_{1i}^P\check{\beta}_1^* + X_{ki}^P\check{\beta}_k^*\right) - F\left(\check{\alpha}^* + X_{1i}^O\check{\beta}_1^* + X_{ki}^P\check{\beta}_k^*\right) \qquad (5)$$

The individual contribution of a variable to the inter-group difference is calculated by sequentially replacing the observations of that variable in one province with those of the other province, while keeping the distribution of other covariates fixed. The coefficient is then divided by the value of estimated explained difference to find out the contribution of each predictor variable. This technique ensures that the combined contribution of independent variables is equal to the total contribution of all the variables examined in the sample.

For carrying out this detailed decomposition, it is assumed that,

$$N_P = N_O \qquad (6)$$

This suggests that a natural one-to-one matching exists which allows for a direct comparison of observations between Punjab and other province. However, it is not applicable in this study due to the differing sample size across provinces, with Punjab having the largest sample. A viable method to deal with this problem outlined by Fairlie and Robb (2007) is to select a random sub sample of the larger group (Punjab) with replacement that is equal to the full smaller sample size of other province. Each observation in randomly drawn Punjab subsample is then paired at random with the observations from the complete sample of other province to achieve hypothetical matching.

The main drawback is that the decomposition estimates obtained in this way is sensitive to the randomly chosen Punjab subsample. To counter this issue, a large number of random subsamples from Punjab are drawn, their observations are randomly matched to the full sample size of the other province, and separate decomposition results are then calculated.

Annexure 3: Heteroscedasticity White Test results of birth registration

Province	Chi2 statistic
Punjab	174.48***
Sindh	495.12***
KPK	283.55***
Balochistan	172.03***

***p < 0.01, **p < 0.05, *p < 0.1.