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# Factors Influencing the Number of Children Ever Born to a woman Using GLM in Punjab, Pakistan

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## ABSTRACT

To make policies for any country, it is very essential to estimate the growing rate of the population and to know the population to make better policies for the future. To do this, it is necessary to accumulate population and studying the children ever born. The objective of this study is to determine the average number of children ever born to a woman in Punjab, Pakistan and examine regional differences in fertility patterns within the rural and urban regions of the province, and among different people belonging to different educational and socioeconomic backgrounds, and also analyze how several socio demographic factors affect the number of children born to a woman in Punjab, Pakistan. We follow data sourced from the Bureau of Statistics Punjab Pakistan (2017-18). The Global MICS Programme, propelled by UNICEF. The Punjab MICS 2017-18 is the fifth such survey in the province since 2004, planned to provide reliable data on key indicators for both urban and rural areas, as well as for each of Punjab's 36 districts. The survey's sample size was set at 53,840 households. The Poisson regression is used to analyze children ever born and find trends. However, due to the existence of over dispersion, quasi-Poisson and negative binomial regressions are also applied. On average, every woman has approximately 3 children, with the most common children being 3 also. The Poisson regression output indicates the vital factors that influence the dependent variable. The woman's age

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increases the outcome significance while first-marriage age decreases it which demonstrates early marriages diminish the occurrence of the investigated event ($p<0.0001$). Health insurance coverage shows no importance toward the outcome variable. With higher education demonstrate increased negative impact on the outcome variable between various education levels with secondary (-0.0524, $p<0.0001$) and higher education (-0.1132, $p<0.0001$). Multiple education levels of the household head contribute to the results yet primary education stands alone as statistically significant (0.0179, $p=0.0162$). Household characteristics also contribute significantly. Totally renting a house raises the likelihood of vulnerable actions (0.0433, $p=0.0001$) and simultaneously land ownership results in a similar impact (0.0251, $p=0.0006$). The functional difficulties measurement and bank account ownership indicator do not demonstrate considerable effects on the study outcomes. Low television viewing habits play a crucial role since subjects who do not watch TV (-0.0280, $p=0.0303$) or do so at least once per week (-0.0267, $p<0.0001$) show lower values in the dependent variable. The lack of computer use positively affects likelihood values by a large margin (0.0815, $p<0.0001$), yet mobile phone ownership demonstrates no statistically significant result. Economic status improves across Wealth Index quintiles and the likelihood decreases accordingly until it reaches its most negative point at the richest quintile (-0.2552, $p<0.0001$). urban populations experience a negative impact (-0.0216) on the outcome which reaches statistical significance at $p=0.0046$. Among divisions, Gujranwala (0.0533, $p<0.0001$) and DG Khan (0.0492, $p=0.0002$) show positive impacts, whereas Rawalpindi (-0.0646, $p<0.0001$) and Sargodha (-0.0452, $p=0.0008$) exhibit significant negative effects. The mean is 3.2418 and variance is 5.1900 of children ever born which show over dispersion but by comparing the outcomes of Poisson regression, quasi-Poisson regression, and negative binomial regression, we memorandum that all three models yield the similar results, it proposes that the data might not show significant over dispersion. The elder age at marriage and upper levels of education are related with less children. In urban areas tend to have lesser families and less qualification families have more children. Health insurance coverage does not significantly affect fertility rates in Punjab, Pakistan.

**Keywords:** Fertility, Total Children Ever Born, Reproductive Behavior, Parity, Demographic Factors, Socioeconomic Determinants, Family Size, Birth Patterns, Women's Education And Fertility, Age At Marriage, Fertility Differentials, Population Studies

## Introduction

The number of children born to a woman, plays a serious role in determining the demographic and socioeconomic factors of any area. In Pakistan, population growth has been a significant alarm, with variations across different regions. According to the latest data the total fertility rate (TFR) of Punjab is 3.5 which has seen a decline over the past few years, but it is still higher than the national average which is 3.1 (Recorder Report, 2025). According to the latest data Punjab's population is recorded to be 110 million. The TFR is certainly lower in urban areas as compared to rural areas due to difference in the availability and access to basic health facilities and

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education. The rural woman is not aware of the family planning methods, have low education levels as compared to women in urban areas. Children ever born is the most vital factor in a population demography (Family Planning, 2023). This biotic event plays the most important role in determining the societies universally. The definition of a child in Pakistan is any human being having age between 0 to 17 years. For this study we follow data sourced from the Bureau of Statistics Panjab Pakistan (2017-18). The Global MICS Programme, propelled by UNICEF in the 1990s.The Punjab MICS 2017-18 is the fifth such survey in the province since 2004, designed to provide consistent data on key indicators for both urban and rural areas, as well as for each of Punjab's 36 districts (PUNJAB at a GLANCE -, 2022). The survey's sample size was set at 53,840 households, Women (age 15-49). The demography of a region and its fertility trends are very closely related. While shaping policies about health care and socioeconomic dynamics of a society, these factors play a central role. we shall explore about the fertility trends specifically in Punjab, Pakistan. We shall observe that which factors affect the number of children ever born to a household or a woman, by using stepwise Poisson regression for weighted survey design which is statistical model to study and analyze the relationship between a dependent variable and one or more independent variables (Cherie et al., 2023). This statistical approach is well-suited for considerate the connection between the number of children ever born and a set of predictor variables, which include health insurance coverage, area of residence (urban or rural), wealth index quintiles, divisions, functional difficulties, educational levels, household living conditions, financial inclusion, and marital status. By studying these factors, we aim to deliver an inclusive understanding of how socio-economic, demographic, and health-related variables influence fertility rates in Punjab Pakistan, thereby offering understandings that can inform policy-making and family planning programs. There are various factors e.g. age, income, religion, occupation, education, no. of family members etc. which play an essential role (Gebrehiwot et al., 2025).

## Literature Review

Fertility behaviour is a fundamental demographic measure of the number of children ever born to a woman known as the Number of Children Ever Born (CEB) and one that has continued to be important in explaining population dynamics, reproductive health and socio economic development. The fertility rate in Pakistan is very diverse per province and the socio-economic group because Punjab is the largest province with urban-rural and socio-cultural diversity. According to the data of national surveys (Pakistan Demographic and Health Survey, 201718), women education and age at marriage, household wealth, and contraceptive use are the factors that have a strong impact on fertility outcomes.

Because variable CEB is count data (non-negative number), the traditional Ordinary Least Squares (OLS) regression cannot be used because it assumes normality Thus, Poisson, Negative Binomial, and Zero-Inflated models are more appropriate in the analysis of fertility behavior under the name of Generalized Linear Models (GLMs).

The Poisson regression model is the simplest GLM that uses count data in demographic studies assuming that the mean and the variance of the dependent variable are equal (equidispersion). Nevertheless, the data of fertility are usually over

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dispersed, i.e. when the variance is higher than the mean, the estimates in the Poisson model are biased. In order to overcome that, either the Negative Binomial model or the Generalized Poisson model is used.

Moreover, in cases where the data include a large number of zero observations (e.g., women with no children) or are missing (zero truncation, e.g. data restricted to married women), Zero-Inflated or Zero-Truncated Poisson/Negative Binomial models are applied. Fit indices used to determine the model selected are AIC, BIC, residual diagnostics, and dispersion tests.

A number of studies founded on PDHS and regional data have found congruent determinants of CEB:

Women Age Older women CEB is higher during old age, because they are exposed to longer reproductive age.

Age at Marriage – Earlier marriage creates more exposure hence more fertility.

Educational Attainment -The higher the education level of females and spouses, the lower the children.

The poor households have more children, and the reason is usually the lack of family planning.

Contraceptive Use - Fertility is reduced drastically by regular use of contraceptives.

Place of Residence -The rural women tend to be more fertile than the urban women mainly because of the cultural factors and the ease of access.

Child Mortality- Mortality of a child tends to increase replacement fertility.

Indicatively, PDHS recent research on the use of Poisson and Negative Binomial regression on Poisson regression data established that the most prominent predictors of CEB were education, contraceptive use and wealth index. Analyses, which were specific to Punjab, also recorded significant intra-provincial variation that was attributed to socio-cultural norms, gender preferences, and accessibility to health facilities.

Overdispersion The data in the Punjab on fertility commonly do not follow Poisson distributions; the Negative Binomial or Generalized Poisson regression gives more accurate results.

Excess Zeros / Zero Truncation - Zero-Inflated or Zero-Truncated GLMs are better when the study is restricted to ever-married women, or when the proportion of zero births is high.

Clustering and Survey Design- DHS data are hierarchically organized (individuals in households, households in clusters). Clustering should not be ignored, and Multilevel GLM or Generalized Estimating Equations (GEE) can help to eliminate underestimated standard errors.

Spatial Variation – There are spatial differences in fertility determinants across the districts of Punjab; it is possible to characterize the geographical variations by using the spatial random effects (Spatial GLM).

Model Diagnostics- Fit indices (AIC/BIC), residual analysis and likelihood ratio tests guarantees adequacy of the model

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**Methods**

For fixed interval of time and the situation in which rare events occurred, the Poisson regression is used. Poisson regression is suitable for discrete, non-negative and count variable (Adams, 2024). For studying fertility level in Punjab, Pakistan we select children ever born as a dependent variable, which is count variable.

Y = dependent variable  $\lambda$ = rate parameter of Poisson distribution

Both the mean and variance of dependent variable are almost same in Poisson regression. mean and variance of dependent variable are also equal to the rate parameter of Poisson distribution.

If $Y_i \sim$ Poisson ($\lambda_i$)  $Y_i$ = count if events for ith observation

Then the probability mass function of Poisson distribution is given below.

$$P(Y=y) = \frac{e^{-\lambda}\lambda^{x}}{\lambda!}$$ were x = 0, 1, 2, 3, ….(Hayat & Higgins, 2014).

Model for Poisson regression is given bellow,

$$\lambda = \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots \beta_i X_i)$$ (Hayat & Higgins, 2014)

For the complex survey design, when we analyzing count variable (as we have number of children ever born) then weighted survey design is appropriate for Poisson regression. When conducting a survey, sampling is used instead of taking the information of the entire population. In this way, we will try to learn about the entire population by studying the information of some population, then the results from our analysis may not give us the full information, so we face this problem by using weighted survey design in regression analysis. By doing this we can get better results by analyzing our count data in this study. Because we used Multiple Indicator Surveys (MICS) data for our study, this data is obtained from the survey which helps us to provide complete information about our variables which is count data. Data sourced from Bureau of statistics Panjab, Pakistan. In this case we can get better information about fertility level in Punjab, Pakistan by using weighted survey design.
Model for Poisson regression is given bellow,

$$\lambda = \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots \beta_i X_i)$$

$X_1, X_2, \ldots\ldots X_i$ are the covariates of ith observation.

$\beta_0, \beta_1, \beta_2, \beta_3 \ldots\ldots \beta_i$ are the regression coefficients to be estimated.

The weighted survey design for Poisson regression model is written as,

$$\text{Log}(\lambda_i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots \beta_i X_i$$

Where $\lambda_i = \frac{y_i}{\Omega_i}$ = weighted count

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**Goodness-of-fit test for Poisson distribution**

For checking the model is good fit or not we use chi-square goodness-of-fit test. chi-square is a statistical test which is used to test the goodness-of-fit of the Poisson distribution. To measures the difference between log- likelihood of the fitted model and saturated model the deviance statistic is used (The Chi Squared Test - Statistical Modeling and Forecasting, 2021).

$H_0$: Y follow Poisson distribution

$H_1$: Y not follow Poisson distribution

p-value = probability value  df = degree of freedom

If p-value is less than the level of significance, then $H_0$ is rejected and model is best fitted (Kurosawa et al., 2020).

**Z-Test for Over dispersion in Poisson Regression**

Over dispersion happens when the variance of the count data surpasses the mean, which disrupts the norms of Poisson regression. A Z-test can help control if the observed variance is meaningfully greater than expected below the Poisson assumption. In Poisson regression, λ is equal to the variance. If the data shows larger variance than the mean, it recommends over dispersion, which can lead to undervalued standard errors and overblown test statistics. For over dispersion, we can complete a Z-test based on the residual deviance or the Pearson chi-square statistic from Poisson regression model. (Hagiwara & Matsuyama, 2024)

The Pearson Chi-Square Statistic is given by,

$$\chi^2 = \sum \left( \frac{(Yi-\mu i)^{\wedge}2}{\mu i} \right)$$

Where $Y_i$ are the observed counts and $\mu_i$ are the predicted counts from the model.

The df is the degrees of freedom, can be intended as:

df = n−$k$, where $n$ is the number of observations and $k$ is the no. of parameters estimated. The over dispersion statistic can be intended as: Over dispersion Statistic = $\chi^2$/df

we can perform a Z-test by equating the over dispersion statistic to 1. If this statistic is significantly larger than 1, it shows over dispersion.

The Z-test can be expressed as,

$$Z = \text{Over dispersion Statistic} - 1/ (2/n)^2$$

we equate the Z statistic to a standard normal distribution to get the p-value. A lesser p-value (e.g., < 0.05) specifies significant over dispersion.

**Results and discussion**

The children ever born is the study variable(Y). Descriptive analysis of this variable typically includes measures of central tendency (mean, median, mode) and dispersion (variance, standard deviation, Skewness, kurtosis), as well as visualizations like histograms is given bellow.

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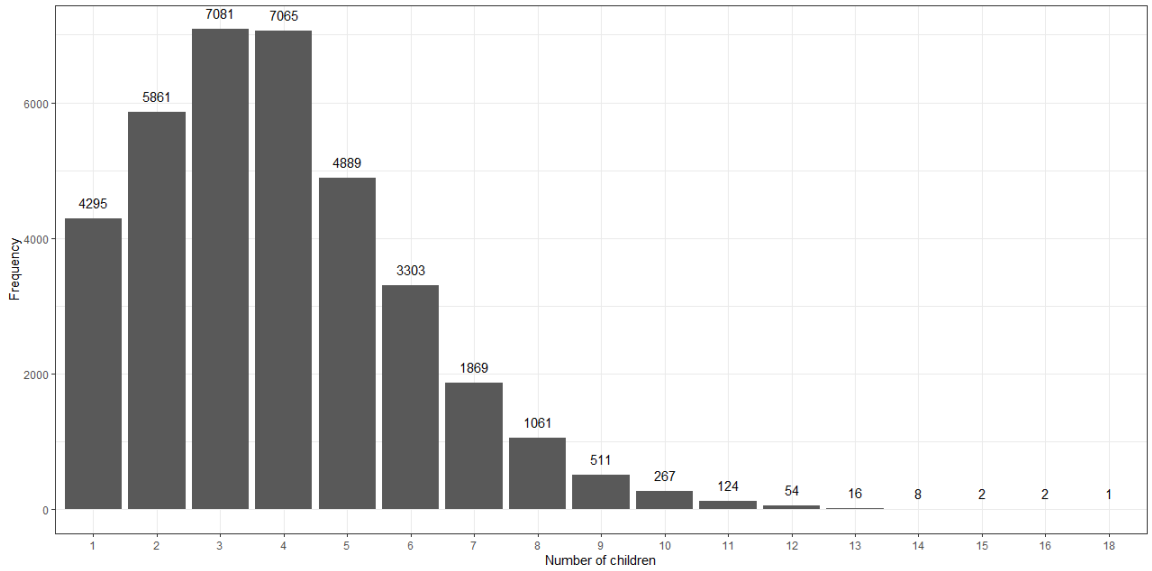



**Figure 4.1: Children ever born(Y)**

The number of children ranges from 1 to 16, with most frequencies between 1 and 10 children. The highest frequencies occur at 3 and 4 children, with counts of 7081 and 7065 respectively. There is a noticeable decline in frequencies as the number of children increases beyond 4. Beyond 10 children, the frequencies drop significantly, with very few instances recorded. There is a trend where families with 3 or 4 children are most common, followed by families with 2 or 5 children. As the number of children increases beyond 5, the number of such families decreases drastically.

The Fitted Poisson regression for weighted survey design is exposed in Table 1. This table tests the resulting hypothesis. For each predictor, we obtain an estimate of its effect, which is expressed as a coefficient. Together with these estimates, we calculate standard errors, which amount how much the estimates might vary from sample to sample. The t-value is a statistic used to define if an estimate is significantly diverse from zero, which helps us assess whether a predictor has an expressive effect on the outcome. To appreciate the range within which the true effect likely falls, we also compute a 95% confidence interval (CI). This interval gives us a range of values that we are 95% confident contains the true result size, if insight into the precision and consistency of our estimates.

$$H0: \beta_{i=0} \text{ for all } i= 1,2,3,\ldots.$$
$$H1: \beta_{i\neq0} \text{ for all } i= 1,2,3,\ldots.$$

**Table 1: Fitted Poisson Regression Model**

| | Variable | Estimate | Std. Err | t - value | Pr(>\|t\|) | Conf. Int. | |
|---|---|---|---|---|---|---|---|
| | | | | | | 2.5% | 97.5% |
| Const. | | 0.394201 | 0.041042 | 9.605 | 0.0000 | 0.313722 | 0.47468 |
| W1 | Age of | 0.04977 | 0.00058 | 85.009 | 0.0000 | 0.04862 | 0.05092 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | woman | 7 | 6 | | | 8 | 5 |
| W2 | Age at first marriage | -0.04462 | 0.000725 | -61.533 | 0.0000 | -0.04605 | -0.0432 |
| W3 | Covered by health insurance | | | | | | |
| 2 | No | 0.000363 | 0.013122 | 0.028 | 0.9779 | -0.02537 | 0.026094 |
| W4 | Woman Education level | | | | | | |
| 1 | Primary | -0.02134 | 0.007247 | -2.945 | 0.0032 | -0.03555 | -0.00713 |
| 2 | Middle | -0.0184 | 0.010211 | -1.802 | 0.0716 | -0.03842 | 0.001624 |
| 3 | Secondary | -0.05243 | 0.009971 | -5.258 | 00000 | -0.07198 | -0.03288 |
| 4 | Higher | -0.11322 | 0.0126 | -8.986 | 0.0000 | -0.13793 | -0.08852 |
| W5 | Functional difficulties (age 18-49 years) | | | | | | |
| 2 | Has no Functional difficulties | 0.012664 | 0.012152 | 1.042 | 0.2974 | -0.01116 | 0.036493 |
| H1 | Age of husband | 0.003825 | 0.000509 | 7.519 | 0.0000 | 0.002828 | 0.004823 |
| H2 | Husband has more wives | | | | | | |
| 2 | No | 0.166364 | 0.018489 | 8.998 | 0.0000 | 0.130109 | 0.202619 |
| H3 | Education of household head | | | | | | |
| 1 | Primary | 0.017954 | 0.007468 | 2.404 | 0.0162 | 0.00331 | 0.032598 |
| 2 | Middle | 0.005436 | 0.00845 | 0.643 | 0.5200 | -0.01113 | 0.022005 |
| 3 | Secondary | 0.003146 | 0.008537 | 0.368 | 0.7125 | -0.01359 | 0.019886 |
| 4 | Higher | 0.002063 | 0.010733 | 0.192 | 0.8475 | -0.01898 | 0.023109 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HA | Age of household head | -0.00641 | 0.000255 | -25.106 | 0.0000 | -0.00691 | -0.00591 |
| HG | Gender of household age | | | | | | |
| 2 | Female | -0.03871 | 0.010595 | -3.653 | 0.0002 | -0.05948 | -0.01793 |
| C1 | Household own dwelling | | | | | | |
| 2 | Rent | 0.043277 | 0.009866 | 4.387 | 0.0001 | 0.023931 | 0.062622 |
| 6 | Other | 0.027459 | 0.008781 | 3.127 | 0.0017 | 0.010241 | 0.044678 |
| C2 | Household own land for agriculture | | | | | | |
| 2 | No | 0.025141 | 0.006271 | 4.009 | 0.0006 | 0.012845 | 0.037437 |
| C3 | Household own any animal | | | | | | |
| 2 | No | 0.001324 | 0.006383 | 0.207 | 0.8356 | -0.01119 | 0.01384 |
| C4 | Any household member own bank account | | | | | | |
| 2 | No | 0.013867 | 0.006283 | 2.207 | 0.0274 | 0.001546 | 0.026188 |
| 8 | | 0.042084 | 0.029618 | 1.421 | 0.1554 | -0.01599 | 0.10016 |
| M1 | Frequency of watching TV | | | | | | |
| 1 | Not at all | -0.02801 | 0.012926 | -2.167 | 0.0303 | -0.05335 | -0.00266 |
| 2 | Less than once a week | -0.00633 | 0.009639 | -0.657 | 0.5111 | -0.02524 | 0.012568 |
| 3 | At least | -0.02668 | 0.00645 | -4.134 | 0.0000 | -0.03933 | -0.01403 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | once a week | | 4 | | | | |
| M2 | Ever used computer | | | | | | |
| 2 | No | 0.081451 | 0.01254 | 6.496 | 0.0000 | 0.056862 | 0.106039 |
| M3 | Own mobile phone | | | | | | |
| 2 | No | -0.01079 | 0.005937 | -1.818 | 0.0692 | -0.02243 | 0.000851 |
| TA1 | Ever tried smoking | | | | | | |
| 2 | No | -0.00066 | 0.01581 | -0.042 | 0.9669 | -0.03166 | 0.030338 |
| WI | Wealth index quintile | | | | | | |
| 2 | Second | -0.08182 | 0.008618 | -9.494 | 0.0000 | -0.09872 | -0.06492 |
| 3 | Middle | -0.13504 | 0.009916 | -13.618 | 0.0000 | -0.15448 | -0.11559 |
| 4 | Fourth | -0.18118 | 0.011706 | -15.477 | 0.0000 | -0.20413 | -0.15823 |
| 5 | Richest | -0.25519 | 0.014487 | -17.615 | 0.0000 | -0.2836 | -0.22678 |
| LS1 | Estimation of overall happiness | | | | | | |
| 2 | Very happy | 0.010685 | 0.005832 | 1.832 | 0.0670 | -0.00075 | 0.022121 |
| 3 | Somewhat happy | 0.003259 | 0.007846 | 0.415 | 0.6778 | -0.01212 | 0.018644 |
| 4 | Neither happy nor unhappy | -0.03042 | 0.015737 | -1.933 | 0.0533 | -0.06128 | 0.000436 |
| 5 | Somewhat unhappy | -0.07844 | 0.026736 | -2.934 | 0.0033 | -0.13087 | -0.02601 |
| AREA | Area | | | | | | |
| 2 | Urban | -0.02156 | 0.007615 | -2.831 | 0.0046 | -0.03649 | -0.00663 |
| DIV | Division | | | | | | |
| 2 | DG Khan | 0.049187 | 0.013386 | 3.674 | 0.0002 | 0.022938 | 0.075437 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | Faisalabad | -0.00161 | 0.012991 | -0.124 | 0.9016 | -0.02708 | 0.023867 |
| 4 | Gujranwala | 0.053322 | 0.012554 | 4.248 | 0.0000 | 0.028706 | 0.077938 |
| 5 | Lahore | 0.022992 | 0.013057 | 1.761 | 0.0783 | -0.00261 | 0.048596 |
| 6 | Multan | 0.008915 | 0.012755 | 0.699 | 0.4846 | -0.0161 | 0.033925 |
| 7 | Rawalpindi | -0.06455 | 0.014181 | -4.552 | 0.0000 | -0.09236 | -0.03674 |
| 8 | Sahiwal | 0.005019 | 0.015469 | 0.324 | 0.7456 | -0.02531 | 0.035351 |
| 9 | Sargodha | -0.04515 | 0.013535 | -3.336 | 0.0008 | -0.07169 | -0.01861 |

The results of a fitted Poisson regression model, accent the relationship between the response variable and several predictors. The intercept is extremely significant with an estimate of 0.394, and the predictors W1 and H1 are also extremely significant, viewing strong positive effects with p-values less than 0.000. Equally, variables like W2 and HA show significant negative effects with p-values likewise below 0.000. Some variables, such as W32, H32, and H33, do not significantly donate to the model as their p-values are above the typical significance threshold of 0.05.
Several predictors, with WI4, WI5, and DIV7, have robust negative effects with very low p-values, signifying robust negative relations. Temporarily, variables like C48 and TA12 do not significantly affect the result, as their p-values are high. General, the model climaxes significant predictors that affect the response variable, with several degrees of impact and significance.

## Conclusion

The analysis is showing that both the variables the age of the woman and the age at first marriage significantly affect the fertility rates. Women who married at an older age have fewer children and women who married younger have more children. Means, along with the increase in age, the decrease in the number of children will be noted. Both women education levels and household education levels are showing a significant negative effect on number of children ever born, meaning if education level is high, the number of children will be less and if education is low, the number of children will be high. The effect of wealth index has also been negative, those who are economically well off will have less number of children and those whose economic conditions are weak will have more number of children. The number of children will be found to be less in urban areas and more in rural areas. This means that family planning is prioritized in cities and not in villages.
Coverage by health insurance did not have a significant impact on fertility, which might reflect the broader limitations in access to comprehensive reproductive health services or awareness in the region. However, functional difficulties within the household were positively associated with fertility, indicating potential

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socioeconomic or cultural factors that might necessitate larger family sizes for economic or support reasons. In this way, computer users and TV watchers have also been studied to find out that the number of children who use computers regularly will be higher.

we can estimate the number of children in the coming times and lead to the solution of the problem of growing population. In order to reduce the growing population, education should be made public, especially in rural areas, because of the lack of education, the number of children will be high.

The inverse relationship between wealth and fertility suggests that improving socio-economic conditions could have a direct impact on reducing fertility rates. Policies that enhance economic opportunities, particularly in rural areas, could help reduce the economic rationale for larger families, thereby contributing to sustainable population growth.

this study contributes to the understanding of fertility dynamics in Punjab, Pakistan. The findings have important implications for policymakers and development practitioners aiming to implement effective family planning programs and socio-economic policies. Addressing the determinants identified in this study could lead to more balanced population growth and improved health and economic outcomes for families in Punjab.

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