ECONOMETRICS ASSIGNMENT

ECON F241

Predictive behaviour of maternal health inputs and child mortality in West Bengal

Under the supervision of Prof Bheemeshwar Reddy

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCES,

PILANI HYDERABAD CAMPUS

Name of Student	**ID Number**	**Contribution**
Aarav Haran	2022B3A70880H	YES
Aditya Pentiyala	2022B3A70522H	YES
Vaishnu Kanna	2022B3A71608H	YES
Anant Gupta	2022B3A71282H	YES
Samarth Tabakade	2022B3A71292H	YES
Sashank Sivakumar	2022B3AA1303H	YES
Parikshit Dashetwar	2022B3A70492H	YES
Akhil Mohammad	2022B3A70360H	YES
Nidhi Kolachana	2022B3A70387H	YES
Kaartavaraya Yadav	2022B3A70290H	YES

GROUP NUMBER:8

Table Of Contents

Motivation And Research Question

High child mortality in developing countries can be associated with the inadequate utilisation of maternal health care, a factor which is often overlooked. One of the major reasons for carrying out this research is to help design an effective health policy which is only possible with the use of relevant information about the efficiency of existing maternal healthcare and other related factors. Prenatal and postnatal care are essential for ensuring a safe delivery and promoting the health of both the mother and the newborn. We seek to explore the utilisation of these healthcare services among the different social groups and their impact on reducing child mortality rates.

The main question we seek to answer through the study is which variables and factors determine the demand for various maternal health inputs in West Bengal. The choice of prenatal care and the place of delivery are the first two health inputs we will determine as outcome variables. These two will form the basis for the analysis, and using these results we will determine the final outcome variable: child mortality. This would help the policymakers to identify the areas to focus on to pave the way for the formation of good quality human capital in the long run.

Data & Methodology

The research paper we are replicating uses data from the 2005-06 National Family Health Survey (NFHS-3), The survey was the third of its kind conducted, to explore the factors that affect women's preferences for prenatal care and their decision-making process regarding the place of delivery in West Bengal, India. The study also analyses how these factors, along with others, affect child mortality. The sample for the study consists of 1823 mothers who gave birth between 2001 and 2005 and were selected from the larger NFHS-3 dataset. We use various criteria to profile the women surveyed, such as religion, socioeconomic strata, and education level.

We replicated the paper using three probit regression models. The dependent variables in the model are binary. If the mother's child had died before the age of five (CM), if the mother gave birth in a hospital/institutional centre (HD), and if the mother used prenatal medical care services (PC). We aim to understand the factors contributing to child mortality, and we estimate the equations accordingly.

$$PC = \alpha_0 + \alpha_1 X_p + u_p + \varepsilon_p \tag{1}$$

$$HD = \beta_0 + \beta_1 X_h + u_h + \varepsilon_h \tag{2}$$

$$CM = \delta_0 + \delta_1 X_c + u_c + \varepsilon_c \tag{3}$$

p, h, and c subscripts denote prenatal care, hospital delivery, and child mortality. $\alpha0$, $\beta0$, and $\delta0$ are the constant terms for those equations. $\alpha1$, $\beta1$, and $\delta1$ represent the coefficients for the explanatory variables in these equations.

Xp, Xh, and Xc represent possible regressors that may have a significant influence on the demand for prenatal care, hospital delivery, and child mortality respectively. Therefore, the binary outcome variables are represented as

$$PC = \begin{cases} 1 & \text{if care is taken} \\ 0 & \text{if care is not taken} \end{cases} \tag{4}$$

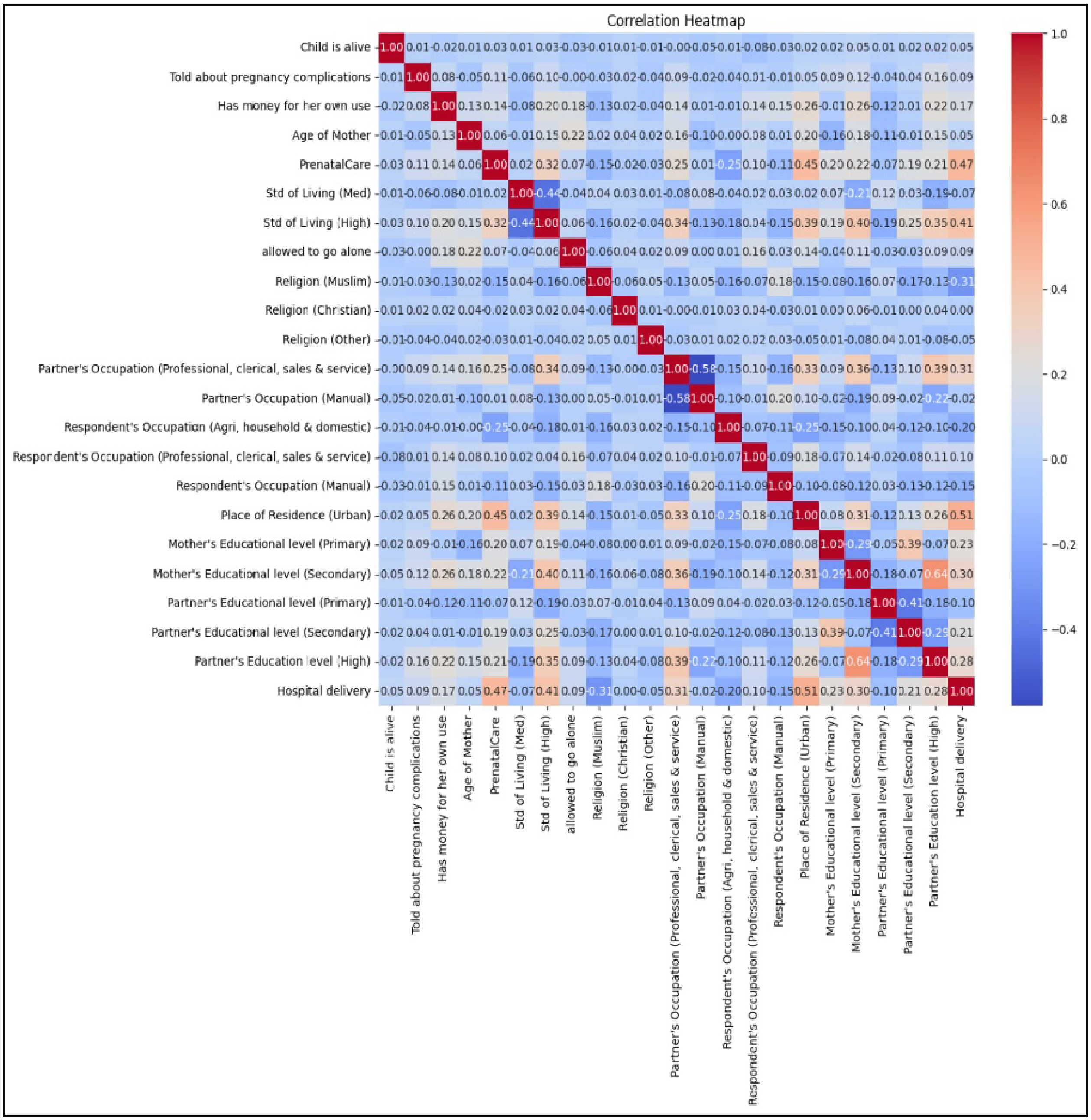
$$HD = \begin{cases} 1 & \text{if delivery is in hospital} \\ 0 & \text{if delivery is not in hospital} \end{cases} \tag{5}$$

$$CM = \begin{cases} 0 & \text{if at least one child of less than 5 years age is dead} \\ 1 & \text{if no child of less than 5 years age is dead} \end{cases} \tag{6}$$

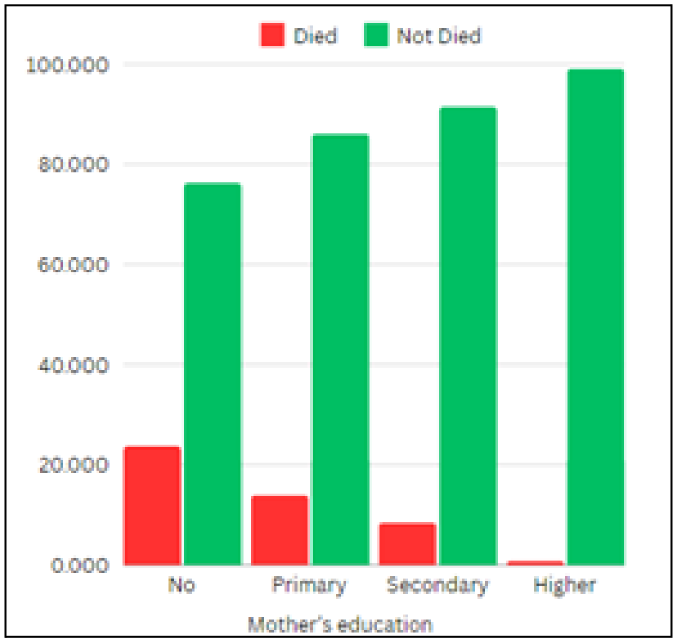
In the given paper, 1 was assigned at least one child of less than 5 years being dead while 0 was used for the opposite. However, in our analysis, we have used the child being dead as the base case while 1 is assigned to the cases where the child was alive.

Here ui (i = p,h,c) is an error term that accounts for unobserved heterogeneity due to the mother. So ui~N(0,σi^2) where σi^2 is the variance of unobserved factors, if any. Again ε considers all other residual variation and follows εi ~ IID N(0,1) (i=p,h,c). Our study estimates three binary probit and equations (having a binary dependent variable) with the three outcome variables: PC, HD, and CM. These are assumed to be exogenous.

Descriptive Statistics

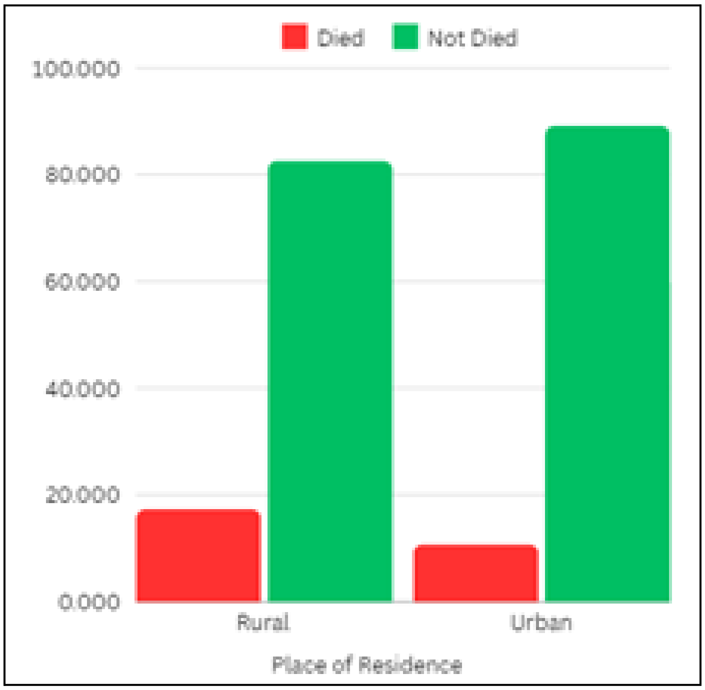


Correlation heatmap shows correlation between all combinations of the explanatory and dependent variables

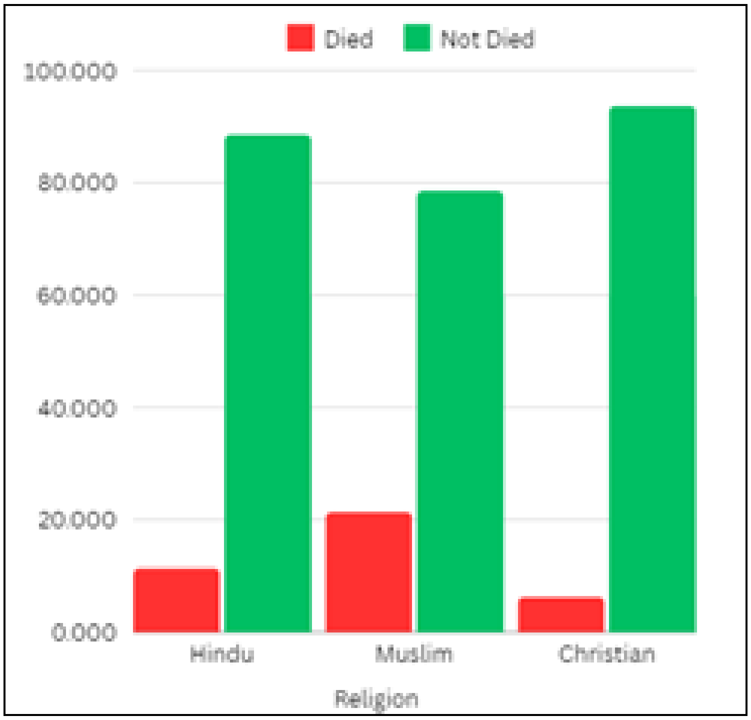


Higher the mother's education lower the child mortality rates

Child mortality rates decrease as standard of living increases



Those living in the rural areas have a higher child mortality rate.



Muslims exhibit unusually high rates of child mortality compared to Hindus and Christians

Regression analysis

Even though the research paper has dealt with both endogenous and exogenous models, we will only present the results and analysis of the exogenous models. We employed a probit regression analysis which is based on MLE(Maximum likelihood estimation). The signs of the coefficients have matched for most of the variables, however there is a difference in magnitude from the results in the research paper.

The discrepancy in results between the paper and our analysis is possibly because of other advanced techniques that the research paper employs to obtain results like Joint Estimation technique which is a Full Information Maximum Likelihood(FIML) Method, Conditional Mixed Process and accountancy for heterogeneity.

Here's our results from the exogenous model:

(i) Prenatal Care

Regression Coefficients using Probit:

```
> summary(PC_probit)

Call:
glm(formula = PC ~ Residence_urban + motherAge + ReligionMuslim +
    ReligionChristian + ReligionOther + LivingStdMed + LivingStdHigh +
    PartnerOcc_manual + PartnerOcc_agri_household_domes + PartnerOcc_prof_cler_sales_service +
    allowedtogo + hasmoneyforownuse + pregcomplication + MotherEduPrimary +
    MotherEduSecondary + PartnerEduPrimary + PartnerEduSecondary +
    PartnerEduHigh, family = binomial(link = "probit"), data = dataset)
```

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.8378  -0.8797   0.2744   0.7324   1.6954

Coefficients:
                                   Estimate Std. Error z value Pr(>|z|)
(Intercept)                        0.363308   0.887205   0.409 0.682175
Residence_urban                    1.123955   0.100548  11.178  < 2e-16 ***
motherAge                         -0.004963   0.007364  -0.674 0.500372
ReligionMuslim                    -0.147749   0.078506  -1.882 0.059835 .
ReligionChristian                 -0.872827   0.456310  -1.913 0.055775 .
ReligionOther                     -0.254471   0.741689  -0.343 0.731526
LivingStdMed                       0.181288   0.086692   2.091 0.036512 *
LivingStdHigh                      0.452841   0.122860   3.686 0.000228 ***
PartnerOcc_manual                 -0.336601   0.455624  -0.739 0.460047
PartnerOcc_agri_household_domes   -0.491545   0.455831  -1.078 0.280878
PartnerOcc_prof_cler_sales_service -0.302234   0.458406  -0.659 0.509694
allowedtogo                        0.077875   0.077342   1.007 0.313989
hasmoneyforownuse                  0.003938   0.082278   0.048 0.961829
pregcomplication                   0.197277   0.096016   2.055 0.039914 *
MotherEduPrimary                   0.385689   0.091159   4.231 2.33e-05 ***
MotherEduSecondary                 1.012926   0.307072   3.299 0.000971 ***
PartnerEduPrimary                  0.182949   0.099956   1.830 0.067205 .
PartnerEduSecondary                0.264403   0.103837   2.546 0.010886 *
PartnerEduHigh                     0.501460   0.248097   2.021 0.043257 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 2089.6  on 1698  degrees of freedom
Residual deviance: 1522.2  on 1680  degrees of freedom
AIC: 1560.2

Number of Fisher Scoring iterations: 7
```

Observations:

● The increasing age of the woman has a negative relationship on the chance of the woman seeking out prenatal care. With an increase in age, confidence in their ability to avoid or tide over potential problems could increase, resulting in this relationship.

● Interestingly enough, being a Muslim/Christian woman reduces the chance of seeking out prenatal care compared to a Hindu woman, with being a Christian reducing the chance more. This could reflect the religious beliefs and culture that prioritise keeping these matters private.

● The standard of living has a positive marginal effect on the chances of women getting prenatal care. This could be because, with improvement in living standards, one can easily access and afford good medical treatment and other necessary amenities. These results match those seen in the research paper.

● Women with primary education and with secondary education have higher chances of going for prenatal care, as compared to an uneducated woman, which could be attributed to greater knowledge about the available medical utilities and their benefits, which comes from exposure to education.

● There are some other predictor variables also included in the model but they are not significant and hence we ignore providing any interpretations for the same.

ii)Hospital Delivery

Regression Coefficients using Probit:

```
> summary(HD_probit)

Call:
glm(formula = HD ~ Residence_urban + motherAge + ReligionMuslim +
    ReligionChristian + ReligionOther + LivingStdMed + LivingStdHigh +
    PartnerOcc_manual + PartnerOcc_agri_household_domes + PartnerOcc_prof_cler_sales_service +
    allowedtogo + hasmoneyforownuse + pregcomplication + MotherEduPrimary +
    MotherEduSecondary + PartnerEduPrimary + PartnerEduSecondary +
    PartnerEduHigh + PC, family = binomial(link = "probit"),
    data = dataset)
```

```
Deviance Residuals:
     Min        1Q    Median        3Q       Max
-2.84653  -0.65289   0.05134   0.63590   2.65357

Coefficients:
                                   Estimate Std. Error z value Pr(>|z|)
(Intercept)                        -0.53685    0.91278  -0.588 0.556430
Residence_urban                     1.04502    0.09976  10.475  < 2e-16 ***
motherAge                          -0.01327    0.00779  -1.703 0.088599 .
ReligionMuslim                     -0.67364    0.08287  -8.129 4.34e-16 ***
ReligionChristian                  -0.39161    0.51980  -0.753 0.451218
ReligionOther                      -0.54669    0.77774  -0.703 0.482107
LivingStdMed                       -0.04386    0.09144  -0.480 0.631458
LivingStdHigh                       0.54585    0.12302   4.437 9.12e-06 ***
PartnerOcc_manual                   0.46723    0.43914   1.064 0.287347
PartnerOcc_agri_household_domes     0.42261    0.44221   0.956 0.339231
PartnerOcc_prof_cler_sales_service  0.57209    0.44049   1.299 0.194023
allowedtogo                         0.10254    0.08062   1.272 0.203435
hasmoneyforownuse                  -0.06167    0.08469  -0.728 0.466547
pregcomplication                    0.05982    0.09593   0.624 0.532888
MotherEduPrimary                    0.45125    0.09169   4.922 8.58e-07 ***
MotherEduSecondary                  1.62524    0.43523   3.734 0.000188 ***
PartnerEduPrimary                   0.15252    0.10597   1.439 0.150067
PartnerEduSecondary                 0.18311    0.10633   1.722 0.085037 .
PartnerEduHigh                      0.64686    0.26056   2.483 0.013045 *
PC                                  0.62332    0.08782   7.098 1.27e-12 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 2315.7  on 1698  degrees of freedom
Residual deviance: 1388.6  on 1679  degrees of freedom
AIC: 1428.6
```

Observations:

We have made interpretations for the coefficients which have at most a significance level of 10%.

- As can be seen from the coefficients and a very low level of significance, the probability of choosing hospital delivery rises significantly in the urbanities.
- It can also be observed that Muslim women have a significantly lower chance of going for hospital delivery which could be attributed to their religious and cultural orientation of not exposing their private lives.

- As expected, mothers with high primary and secondary education have a higher probability of opting for hospital delivery. This could be due to the increased freedom to go outdoors that they get upon receiving education, making them better placed to seek medical help whenever necessary.

- Women whose partners have higher education have higher chances of seeking hospital delivery.A husband's education can influence his understanding of healthcare options and the importance of professional medical assistance during childbirth.

- The women who took prenatal care have a higher probability of going for hospital delivery which may be due to their increased awareness about the importance of seeking medical help.

iii) Child Mortality

Regression Coefficients using Probit:

```
> summary(CM_probit)

Call:
glm(formula = CM ~ Residence_urban + motherAge + ReligionMuslim +
    ReligionChristian + ReligionOther + LivingStdMed + LivingStdHigh +
    PartnerOcc_manual + PartnerOcc_agri_household_domes + PartnerOcc_prof_cler_sales_service +
    allowedtogo + hasmoneyforownuse + pregcomplication + MotherEduPrimary +
    MotherEduSecondary + PartnerEduPrimary + PartnerEduSecondary +
    PartnerEduHigh + PC + HD, family = binomial(link = "probit"),
    data = dataset)
```

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.1889   0.1317   0.2062   0.2659   0.4792

Coefficients:
                                     Estimate Std. Error z value Pr(>|z|)
(Intercept)                          8.725642 399.489722   0.022   0.9826
Residence_urban                      0.041564   0.176032   0.236   0.8133
motherAge                            0.010070   0.013356   0.754   0.4509
ReligionMuslim                       0.036079   0.148733   0.243   0.8083
ReligionChristian                    3.561009 267.149477   0.013   0.9894
ReligionOther                       -3.505870 312.471446  -0.011   0.9910
LivingStdMed                         0.084027   0.166893   0.503   0.6146
LivingStdHigh                       -0.022626   0.211926  -0.107   0.9150
PartnerOcc_manual                   -3.872555 248.904616  -0.016   0.9876
PartnerOcc_agri_household_domes     -3.293294 248.904653  -0.013   0.9894
PartnerOcc_prof_cler_sales_service  -3.939752 248.904633  -0.016   0.9874
allowedtogo                         -0.201937   0.139652  -1.446   0.1482
hasmoneyforownuse                   -0.089259   0.141525  -0.631   0.5282
pregcomplication                     0.011938   0.169301   0.071   0.9438
MotherEduPrimary                     0.162232   0.176021   0.922   0.3567
MotherEduSecondary                   0.904039   0.462136   1.956   0.0504 .
PartnerEduPrimary                    0.174985   0.193382   0.905   0.3655
PartnerEduSecondary                  0.093670   0.192224   0.487   0.6261
PartnerEduHigh                      -0.091740   0.358412  -0.256   0.7980
PC                                   0.007611   0.167366   0.045   0.9637
HD                                   0.284823   0.177341   1.606   0.1083
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 415.60  on 1698  degrees of freedom
Residual deviance: 388.65  on 1678  degrees of freedom
AIC: 430.65
```

We find that almost all of the coefficients except one are insignificant even for a 10% significance level, thus implying the results of this regression analysis irrelevant.

Regression for Child Mortality in Python

In addition to the above models fitted to the data in R using the base *glm* method, we also ran regression in python for the same dataset. However, the python implementation using the *scikit-learn* library allowed for an increase in the number of iterations that helped mitigate the problems of multicollinearity and allowed the model to converge to a solution. When regression was run on the same dataset, we found the standard errors to be significantly smaller than those estimated using R.

The dataset was split into training and testing data (80:20) and the model was evaluated on the testing data after being fit to the training data.

Results of Regression:

Confusion Matrix:

```
dataframe = [["CONFUSION MATRIX", "Actual 1", "Actual 0"],["Predicted 1","0" ,"10"],["Predicted 0", "0","330"]]
ddf=pd.DataFrame(dataframe)
ddf
```

	0	1	2
0	CONFUSION MATRIX	Actual 1	Actual 0
1	Predicted 1	0	10
2	Predicted 0	0	330

Next steps: Generate code with ddf | View recommended plots

Testing Parameters:

The model was tested on the following statistics and the following results were obtained:

1. <u>Accuracy</u>
    - This is defined as the ratio of correct predictions to the total number of predictions made by the model.
    - Accuracy = (True positives + True negatives)/Total number of predictions
    - Accuracy provides a straightforward measure of how often the classifier is correct. However, it can be misleading when dealing with imbalanced datasets, where one class is much more frequent than the other, as in our case where more children are alive than not.
2. <u>Precision</u>
    - The ratio of true positive predictions to the total number of positive predictions of the model.
    - Precision = True positives/(True positives + False positives)
    - It measures the accuracy of positive predictions.
3. <u>Recall</u>
    - The ratio of true positive predictions to the total number of positives in the dataset.
    - Recall = True positives/(True positives + False negatives)

- Also known as sensitivity, it describes the model's ability to identify all positive instances.

4. F1 Score
    - The harmonic mean of precision and recall.
    - F1 Score = 2*(Precision * Recall)/(Precision + Recall)
    - It captures the effects of both precision and recall.
    - It reaches its best value at 1 and worst at 0.
    - A good testing parameter when the classes are imbalanced, as in our child mortality case.
    - An F1 score of 0.95 indicates that it is an extremely accurate model.

	Coefficients	Variance	Standard Error
Told about pregnancy complications	0.099568	0.000000e+00	0.000000e+00
Has money for her own use	0.352558	7.888609e-31	8.881784e-16
Age of Mother	-0.004847	1.925930e-32	1.387779e-16
PrenatalCare	0.259869	1.925930e-34	1.387779e-17
Std of Living (Med)	0.171103	4.930381e-32	2.220446e-16
Std of Living (High)	-0.032883	3.774823e-32	1.942890e-16
allowed to go alone	-0.127457	9.321501e-32	3.053113e-16
Religion (Muslim)	0.155934	9.984021e-31	9.992007e-16
Religion (Christian)	0.161070	4.930381e-32	2.220446e-16
Religion (Other)	0.923511	3.081488e-31	5.551115e-16
Partner's Occupation (Agri, household & domestic)	0.738264	7.703720e-34	2.775558e-17
Partner's Occupation (Professional, clerical, sales & service)	0.034288	1.509929e-31	3.885781e-16
Partner's Occupation (Manual)	-0.022556	3.081488e-31	5.551115e-16
Respondent's Occupation (Agri, household & domestic)	-0.057470	3.774823e-32	1.942890e-16
Respondent's Occupation (Professional, clerical, sales & service)	-0.814085	1.232595e-32	1.110223e-16
Respondent's Occupation (Manual)	0.043057	7.523164e-35	8.673617e-18
Place of Residence (Urban)	0.226933	2.773339e-32	1.665335e-16
Mother's Educational level (Primary)	0.110362	1.109336e-31	3.330669e-16
Mother's Educational level (Secondary)	1.092972	4.437343e-31	6.661338e-16
Partner's Educational level (Primary)	-0.017117	7.703720e-34	2.775558e-17
Partner's Educational level (Secondary)	0.110994	6.039716e-31	7.771561e-16
Partner's Education level (High)	0.186758	7.888609e-31	8.881784e-16
Hospital delivery	0.193484	6.933348e-33	8.326673e-17
Intercept	1.140000	0.000000e+00	0.000000e+00

Observations:

- Hospital delivery decreases the probability of child mortality as they are under the supervision of trained medical professionals.

- Prenatal care has also been found to decrease the chances of child mortality as it involves preparing expectant mothers for childbirth and provides guidance on postnatal care for both the mother and the newborn.

- Mother's age has also been found to be negatively correlated with child mortality, as early motherhood can be associated with poor maternal health outcomes that feed through to the child's health.

- Muslim and Christian mothers are less likely to be exposed to the hazards of child mortality as compared to the Hindu mothers.

- Neither educational attainment of mothers nor their partners have any significant impact on child mortality in our analysis.

Fitting Heteroskedastic Probit Models

We experimented with the FIML method mentioned in the paper using the *Rchoice* library's *hetprob* model, which gave us the following results:

```
> summary(PC_hetprobit)
------------------------------------------------------------------
Maximum Likelihood estimation of Heteroskedastic Binary model
Newton-Raphson maximisation, 150 iterations
Return code 4: Iteration limit exceeded (iterlim)
Log-Likelihood: -738.1734
37  free parameters

Estimates for the mean:
                                    Estimate Std. error z value Pr(> z)
(Intercept)                         204.2309        Inf       0       1
Residence_urban                     134.5497        Inf       0       1
motherAge                            -1.5896        Inf       0       1
ReligionMuslim                      -18.0943        Inf       0       1
ReligionChristian                   -67.3986        Inf       0       1
ReligionOther                        28.7712        Inf       0       1
LivingStdMed                         26.6144        Inf       0       1
LivingStdHigh                       139.0882        Inf       0       1
PartnerOcc_manual                  -242.4457        Inf       0       1
PartnerOcc_agri_household_domes    -264.3272        Inf       0       1
PartnerOcc_prof_cler_sales_service -205.1539        Inf       0       1
allowedtogo                           5.8608        Inf       0       1
hasmoneyforownuse                   -13.7476        Inf       0       1
pregcomplication                     85.1678        Inf       0       1
MotherEduPrimary                     32.5068        Inf       0       1
MotherEduSecondary                  511.5171        Inf       0       1
PartnerEduPrimary                    26.2376        Inf       0       1
PartnerEduSecondary                  41.6307        Inf       0       1
PartnerEduHigh                      317.4911        Inf       0       1
```

```
Estimates for lnsigma:
                                         Estimate Std. error z value Pr(> z)
het.Residence_urban                     -0.431290        Inf       0       1
het.motherAge                           -0.011666        Inf       0       1
het.ReligionMuslim                       0.080828        Inf       0       1
het.ReligionChristian                  -11.328076        Inf       0       1
het.ReligionOther                        6.328911        Inf       0       1
het.LivingStdMed                         0.258998        Inf       0       1
het.LivingStdHigh                        0.510398        Inf       0       1
het.PartnerOcc_manual                   -0.912248        Inf       0       1
het.PartnerOcc_agri_household_domes     -1.024129        Inf       0       1
het.PartnerOcc_prof_cler_sales_service  -0.566309        Inf       0       1
het.allowedtogo                         -0.264512        Inf       0       1
het.hasmoneyforownuse                   -0.189452        Inf       0       1
het.pregcomplication                     0.592656        Inf       0       1
het.MotherEduPrimary                    -0.325605        Inf       0       1
het.MotherEduSecondary                   0.032723        Inf       0       1
het.PartnerEduPrimary                   -0.023049        Inf       0       1
het.PartnerEduSecondary                  0.092577        Inf       0       1
het.PartnerEduHigh                       0.506593        Inf       0       1

LR test of lnsigma = 0: chi2 45.85 with 18 df. Prob > chi2 =  3e-04
-----------------------------------------------------------------
```

Upon trying to run the heteroskedastic FIML estimation for prenatal care regression, we found that the gradient descent/parameter optimization algorithm failed to converge to a solution within the given number of iterations (150), hence implying that either it needs more time or a better cost function to be defined.

```
> summary(HD_hetprobit)
-----------------------------------------------------------------
Maximum Likelihood estimation of Heteroskedastic Binary model
Newton-Raphson maximisation, 37 iterations
Return code 8: successive function values within relative tolerance limit (reltol)
Log-Likelihood: -687.0315
39  free parameters

Estimates for the mean:
                                  Estimate Std. error z value Pr(> z)
(Intercept)                      -5.507979  38.023011 -0.1449  0.8848
Residence_urban                   6.156865  22.883942  0.2690  0.7879
motherAge                        -0.083575   0.313777 -0.2664  0.7900
ReligionMuslim                   -3.917980  14.560090 -0.2691  0.7879
ReligionChristian                -3.198065  12.505621 -0.2557  0.7982
ReligionOther                    -1.224263  32.092939 -0.0381  0.9696
LivingStdMed                     -0.107129   0.704376 -0.1521  0.8791
LivingStdHigh                     2.118348   7.912542  0.2677  0.7889
PartnerOcc_manual                 2.732324  10.550089  0.2590  0.7956
PartnerOcc_agri_household_domes   2.454446   9.572107  0.2564  0.7976
PartnerOcc_prof_cler_sales_service 3.104787  11.886136  0.2612  0.7939
allowedtogo                       0.642595   2.440601  0.2633  0.7923
hasmoneyforownuse                -0.407079   1.594172 -0.2554  0.7984
pregcomplication                  0.425732   1.706407  0.2495  0.8030
MotherEduPrimary                  2.441317   9.082984  0.2688  0.7881
MotherEduSecondary                8.501223  32.468342  0.2618  0.7935
PartnerEduPrimary                 0.886717   3.360702  0.2638  0.7919
PartnerEduSecondary               1.222736   4.586203  0.2666  0.7898
PartnerEduHigh                    2.777889  10.514071  0.2642  0.7916
PC                                4.294969  15.965934  0.2690  0.7879
```

```
Estimates for lnsigma:
                                       Estimate Std. error z value Pr(> z)
het.Residence_urban                   0.1631007  0.2418564  0.6744  0.5001
het.motherAge                         0.0056706  0.0093157  0.6087  0.5427
het.ReligionMuslim                   -0.1756349  0.1219257 -1.4405  0.1497
het.ReligionChristian                 0.2620197  0.6396841  0.4096  0.6821
het.ReligionOther                     2.0756746  3.7409950  0.5548  0.5790
het.LivingStdMed                     -0.1934202  0.1233569 -1.5680  0.1169
het.LivingStdHigh                    -0.3874176  0.1730806 -2.2384  0.0252 *
het.PartnerOcc_manual                -0.1292968  0.4814531 -0.2686  0.7883
het.PartnerOcc_agri_household_domes  -0.1630966  0.4893118 -0.3333  0.7389
het.PartnerOcc_prof_cler_sales_service -0.2317119  0.4815038 -0.4812  0.6304
het.allowedtogo                      -0.0211007  0.0990935 -0.2129  0.8314
het.hasmoneyforownuse                -0.0756735  0.1039308 -0.7281  0.4665
het.pregcomplication                  0.0660567  0.1343210  0.4918  0.6229
het.MotherEduPrimary                  0.1241329  0.1355303  0.9159  0.3597
het.MotherEduSecondary                0.0438570  0.7992200  0.0549  0.9562
het.PartnerEduPrimary                 0.0810085  0.1536429  0.5273  0.5980
het.PartnerEduSecondary              -0.0444436  0.1558770 -0.2851  0.7756
het.PartnerEduHigh                   -0.1277447  0.4064286 -0.3143  0.7533
het.PC                               -0.2789938  0.1949925 -1.4308  0.1525
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

LR test of lnsigma = 0: chi2 14.59 with 19 df. Prob > chi2 =  0.7486
--------------------------------------------------------------------
```

For the hospital delivery regression, the gradient descent/parameter algorithm did converge to a solution, however, it was not a good solution as almost all of the parameters were insignificant.

```
> summary(CM_hetprobit)
--------------------------------------------------------------------
Maximum Likelihood estimation of Heteroskedastic Binary model
Newton-Raphson maximisation, 20 iterations
Return code 8: successive function values within relative tolerance limit (reltol)
Log-Likelihood: -173.415
41  free parameters

Estimates for the mean:
                                    Estimate  Std. error z value Pr(> z)
(Intercept)                       35.5040352         Inf       0       1
Residence_urban                   -0.0134284         Inf       0       1
motherAge                          0.0043998         Inf       0       1
ReligionMuslim                     0.0959795         Inf       0       1
ReligionChristian                  1.1799594         Inf       0       1
ReligionOther                    -20.3607819         Inf       0       1
LivingStdMed                       0.4870012         Inf       0       1
LivingStdHigh                     -0.1910931         Inf       0       1
PartnerOcc_manual                -14.5015445         Inf       0       1
PartnerOcc_agri_household_domes  -14.3002125         Inf       0       1
PartnerOcc_prof_cler_sales_service -14.4850352       Inf       0       1
allowedtogo                        0.0466532         Inf       0       1
hasmoneyforownuse                  0.0113836         Inf       0       1
pregcomplication                   5.6040421         Inf       0       1
MotherEduPrimary                  -0.0379434         Inf       0       1
MotherEduSecondary                 8.2432228         Inf       0       1
PartnerEduPrimary                  0.0592515         Inf       0       1
PartnerEduSecondary                0.0599556         Inf       0       1
PartnerEduHigh                     0.2437306         Inf       0       1
PC                                -0.0311669         Inf       0       1
HD                                -0.4900659         Inf       0       1
```

```
Estimates for lnsigma:
                                     Estimate Std. error z value Pr(> z)
het.Residence_urban                 -0.0142233        Inf       0       1
het.motherAge                        0.0044770        Inf       0       1
het.ReligionMuslim                   0.2232000        Inf       0       1
het.ReligionChristian               -1.7204262        Inf       0       1
het.ReligionOther                   -0.1251462        Inf       0       1
het.LivingStdMed                     0.5742606        Inf       0       1
het.LivingStdHigh                   -1.0365715        Inf       0       1
het.PartnerOcc_manual               -0.9293199        Inf       0       1
het.PartnerOcc_agri_household_domes -1.0438437        Inf       0       1
het.PartnerOcc_prof_cler_sales_service -0.7811381     Inf       0       1
het.allowedtogo                      0.3121671        Inf       0       1
het.hasmoneyforownuse                0.0971718        Inf       0       1
het.pregcomplication                 2.1015729        Inf       0       1
het.MotherEduPrimary                -0.2404814        Inf       0       1
het.MotherEduSecondary               1.5014126        Inf       0       1
het.PartnerEduPrimary                0.0041494        Inf       0       1
het.PartnerEduSecondary             -0.0385602        Inf       0       1
het.PartnerEduHigh                   0.6870922        Inf       0       1
het.PC                              -0.1355109        Inf       0       1
het.HD                              -0.8667732        Inf       0       1

LR test of lnsigma = 0: chi2 41.82 with 20 df. Prob > chi2 =  0.0029
-------------------------------------------------------------------
```

For the child mortality heteroskedastic model, the function returned code 8, implying successful convergence within tolerance limits. However, we still see that this is not the case as the std errors are shown to be infinite. As in the prenatal care model, a better cost function needs to be defined to approach a solution. However, compared to the prenatal care model, this one achieved convergence to a solution within 20 iterations, further implying that the algorithm (Newton-Raphson) cannot find a satisfactory solution given its cost function.

CONCLUSION

The conclusions that we have reached from our analysis are comparable to those in the original research paper in spite of the different techniques that we have used to run our regression.
We looked into the important socio-economic and socio-demographic factors that possibly impact the demand for maternal inputs - prenatal health care and hospital delivery for the child. The results are promising and not too far removed from one's expectations.

Our results show that urban women tend to have a higher demand for maternal inputs as compared to rural women. Also the chances of seeking out prenatal care and an institutionalised child delivery increases when the woman in question is educated and comes from a more well to do family.
Our results also include the effects that the age of the woman and the birth order of the child may have on them seeking out maternal inputs.

On the other hand, child mortality generally decreases in women who receive prenatal care and opt for hospital delivery. There are other characteristics that reduce the likelihood of child mortality, such as a higher standard of living and a greater education for women.

In summary, it's evident that maternal inputs such as prenatal care and leveraging institutional support for child labour play crucial roles in significantly reducing child mortality rates. The findings of this study underscore the importance of these factors and cannot be overlooked. Therefore, it's imperative for the government to proactively formulate policies aimed at stimulating demand for maternal inputs, ultimately leading to a decline in child mortality rates.

A few policies that the government can implement to promote women's education could be to enact laws that require compulsory education for girls up to a certain age, providing scholarships and grants specifically targeted towards women and invest in infrastructure development especially in areas where access to education for girls is limited.. The government could also institutionalise laws such that families are forced to resort to the institutional child delivery mechanism rather than relying on traditional methods, as it would go a long way in reducing child mortality.