CHAPTER - 3

FACTORS INFLUENCING SEMA-NATAL MORTALITY.

3.1 Introduction:

Amongst animals the birth or death is not as significant as it is amongst human beings. A human life is more precious in many ways and here a birth is all the more precious because its sustainance leads to the progress of humanity. In this circumstance, it is important to take every care to see that the mortality rate particularly amongst children goes down considerably. Therefore it is advisable to have healthy children in few numbers rather than having illnourished and undernourished children in large numbers.

When infant mortality is considered by its components it has been observed that approximately 45 percent of deaths to infants occur in the neo-natal period, and that even within neo-natal period, more than 50 percent of
deaths to infants occur in the semi-natal (0-7 days of life) period. Some of the earlier studies (Woodbury (1928), Yerushalm (1936), Leob (1958), Heady et.al. (1955), M.M. Gandotra (1974)) indicate that babies of mother below 20 and above 35 have higher risk of mortality in comparison to those with mothers in the age group 20-34, and the risk of death is higher among first and higher order births as compared to the intervening births.

In this chapter, an attempt has been made to examine the crude impact of the factors: Birth weight, Maternal Age, Gravida and Sex on semi-natal mortality, on one hand, and the relative effect of each of these factors individually, in the absence of the influence of other factors, on other hand.

For this study, data are collected from the case card records of mothers registered for delivery, during the period 1978-80 in Anand Municipal Hospital, AMAND (India). 3050 single live births are reported to have been recorded with complete information as per performa. And out of these live births, 99 are found to have ended into deaths within seven days of their birth.
3.2 Methodology:

To study the influence of each of the factors under investigation on semi-natal mortality, a binary variable multiple regression method described by Feldstein (1966) and later used by Shah (1971) is adopted. This method is helpful in simultaneous adjustment of large number of variables and uses directly the classificatory data. Another major advantage of this technique is that qualitative variables could also be analysed with it. However the use of some continuous variables like maternal age and infant birth weight, as discrete variables may weaken the analysis slightly.

In this study, semi-natal mortality is assumed to have the impact of the following four factors:
(1) Maternal Age  (2) Birth weight  (3) Gravida
(4) Sex of the infant. Each factor is then divided into subclasses.

(1) Maternal Age:

Mothers included in this study are divided into 
$r_1 = 5$ subgroups with regard to their age. (1) Less 
than 20 years  (2) 20-24 years  (3) 25-29 years
(4) 30–34 years and (5) 35 years and above. Four binary variables $X_1, X_2, X_3, X_4$ are used to denote these subclasses. $(0, 0, 0, 0)$ means that mothers belong to the class (5) i.e., they are of age 35 years and above.

(2) Birth weight:

Live births are categorised into $r_2 = 3$ subgroups with regard to their weight. (1) Below 1500 grams (2) 1500–2000 grams. (3) Above 2000 grams. Two binary variables $X_5, X_6$ are used to denote these subclasses. $(0, 0)$ means that live birth belongs to the class (3) i.e., the live birth has weight above 2000 grams.

(3) Gravida:

It determines the order of present pregnancy. $r_3 = 4$ categories are made: (1) First order (2) Second order (3) 3–5 order (4) 6 and higher order pregnancies. Three binary variables $X_7, X_8, X_9$ are used to denote these subclasses. $(0, 0, 0)$ means that the order of present pregnancy of mother belongs to the class (4) i.e., the order of present pregnancy of mother is 6 and above.
(4) **Sex:**

Live births are divided into \( r = 2 \) categories according to their sex: (1) Male (2) Female. One binary variable \( X_{10} \) is used to denote these subclasses. (0) means that the live birth is female.

For the purpose of multiple regression analysis, all the variables are considered as binary variables taking the value 0 or 1. And each subclass of the variable is considered here as a separate regressor, (Feldstein (1966)). The regression equation between the perinatal deaths and the independent variables mentioned above is given as follows:

\[
y = \beta_0 X_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \epsilon_t
\]

where \( y = 1 \) if a birth results in death within 7 days. 
\( = 0 \) if a birth survives for more than 7 days. 
\( X_0 = 1 \) Dummy variable (always).

\( (X_1, X_2, X_3, X_4) = (1, 0, 0, 0) \) if the birth belongs to mother with age less than 20 years.
= (0, 1, 0, 0) if the birth belongs to mother with age 20-24 years.
= (0, 0, 1, 0) if the birth belongs to mother with age 25-29 years.
= (0, 0, 0, 1) if the birth belongs to mother with age 30-34 years.
= (0, 0, 0, 0) if the birth belongs to mother with age 35 years and above.

\[ (x_5, x_6) = (1, 0) \]
if the live birth has weight below 1500 grams.
\[ = (0, 1) \]
if the live birth has weight 1500-2000 grams.
\[ = (0, 0) \]
if the live birth has weight above 2000 grams.

\[ (x_7, x_8, x_9) = (1, 0, 0) \]
if the order of present pregnancy of mother is one.
\[ = (0, 1, 0) \]
if the order of present pregnancy of mother is two.
\[ = (0, 0, 1) \]
if the order of present pregnancy of mother is 3-5.
If the order of present pregnancy is 6 and above.

If the live birth is male.

If the live birth if female.

Error component such that $E(\varepsilon_t) = 0$ and $E(X_{it}, \varepsilon_t + \varepsilon) = 0$ for all $i$, $t$ and $\theta$.

Since the interest in this study is to measure the average effect of each factor on the perinatal mortality rather than its prediction, we have not assumed interactions between the effects of the four different factors in the above model.

The above regression model can be rewritten as follows:

\[(3.2.2) \quad E(y) = X \beta\]

where $y$ is the vector of $N$ observations, $X$ is the $N \times 11$ matrix $(X_0, X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10})$ of zeros and ones and $\beta$ is $11 \times 1$ vector of regression coefficients, $(\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10})$. Using the standard procedure, the
least square estimates of regression coefficients are obtained as

\( (3.2.3) \quad \hat{\beta} = (X'X)^{-1} X'Y \)

one can easily verify that

\( (3.2.4) \quad XX = \)

\[
\begin{bmatrix}
N & n_1 & n_2 & n_3 & n_4 & n_5 & n_6 & n_7 & n_8 & n_9 & n_{10} \\
n_1 & n_1 & 0 & 0 & 0 & n_{15} & n_{16} & n_{17} & n_{18} & n_{19} & n_{110} \\
n_2 & 0 & n_2 & 0 & 0 & n_{25} & n_{26} & n_{27} & n_{28} & n_{29} & n_{210} \\
n_3 & 0 & 0 & n_3 & 0 & n_{35} & n_{36} & n_{37} & n_{38} & n_{39} & n_{310} \\
n_4 & 0 & 0 & 0 & n_4 & n_{45} & n_{46} & n_{47} & n_{48} & n_{49} & n_{410} \\
n_5 & n_{15} & n_{25} & n_{35} & n_{45} & n_5 & 0 & n_{57} & n_{58} & n_{59} & n_{510} \\
n_6 & n_{16} & n_{26} & n_{36} & n_{46} & 0 & n_6 & n_{67} & n_{68} & n_{69} & n_{610} \\
n_7 & n_{17} & n_{27} & n_{37} & n_{47} & n_7 & 0 & 0 & n_{710} \\
n_8 & n_{18} & n_{28} & n_{38} & n_{48} & n_8 & 0 & 0 & n_{810} \\
n_9 & n_{19} & n_{29} & n_{39} & n_{49} & n_9 & 0 & 0 & n_{910} \\
n_{10} & n_{110} & n_{210} & n_{310} & n_{410} & n_{510} & n_{610} & n_{710} & n_{810} & n_{910} & n_{10}
\end{bmatrix}
\]
\( n_{ij} = \) The number of live births in the sample who are both in subclass \( i \) and subclass \( j \).

\( n_i = \) The number of live births in the subclass \( i \).

\( N = \sum n_{ij} = \) Total number of live births.

\[
(3.2.5) \quad X'y = \begin{bmatrix}
D_0 \\
D_1 \\
D_2 \\
\vdots \\
D_{10}
\end{bmatrix}
\]

where \( D_i = \) Number of semi-natal deaths in the class \( i \).

\( i = 1, 2, 3, \ldots, 10. \)

\[
D_o = \sum_{i=1}^{10} D_i = \text{Total number of semi-natal deaths.}
\]

The estimated regression equation is given by

\[
(3.2.6) \quad \hat{y} = X \hat{\beta}
\]

Let \( \bar{y} = \frac{D_0}{N} \times 1000 = \) observed semi-natal mortality rate defined as the number of deaths to children born alive with in 7 days per 1000 live births in a year.
\( \bar{Y} \) = semi-natal mortality rate in the population.

Then, the estimated \( \bar{Y} \) is given by

\[
(3.2.7) \quad \bar{Y} = 1000 \times \frac{\hat{Y}}{N}
\]

\[
= 1000 \times (\hat{\beta}_0 + \frac{1}{N} \sum_{i=1}^{10} \hat{\beta}_i n_i)
\]

The deviation from the average risk of dying within 7 days associated with being in a particular subclass of a variable is estimated by

\[
(3.2.8) \quad d_i = \hat{\beta}_i - \frac{1}{N} \sum_{j=1}^{r-1} \hat{\beta}_j n_j, \quad i = 1, 2, \ldots, r-1
\]

where \( \hat{\beta}_j \) = estimate of regression coefficient for the subclass \( j \) of a variable.

\( r \) = number of subclasses of the variable.

\( n_j \) = number of births in the subclass \( j \).

The above equation (3.2.8) can also be written as

\[
d_i = \hat{\beta}_i (1 - \frac{n_i}{N}) - \frac{1}{N} \sum_{j \neq i} \hat{\beta}_j n_j
\]

\[
= w_i \hat{\beta}
\]
where \( w_i \) is a row vector

\[
\left[ -\frac{n_1}{N}, -\frac{n_2}{N}, \ldots, (1 - \frac{n_1}{N}), \ldots, -\frac{n_{r-1}}{N} \right]
\]

and

\[
\hat{\beta} = (\hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3, \ldots, \hat{\beta}_{r-1}).
\]

The second term on the right hand side of the equation (3.2.8) estimates the average risk of dying for the variable under consideration. The percentage deviation from average risk of dying is estimated by \( \frac{d_i}{Y} \times 100 \).

Now

\[
\text{var} (d_i) = \text{var} (w_i \hat{\beta})
\]

\[
= w_i \text{var} (\hat{\beta}) w_i
\]

\[
= w_i \sigma^2 V w_i
\]

(3.2.9)

\[
= \sigma^2 w_i^2 V w_i
\]

where \( V \) is the relevant submatrix of \((x'x)^{-1}\).

Now \( \sigma^2 \) is estimated by

(3.2.10) \[
\hat{\sigma}^2 = s^2 = \frac{x'x - \hat{\beta}I}{h - 1}, \quad h = \sum_{j=1}^{m} (r_j - 1)
\]

\[
D_0 = \sum_{i=0}^{10} \hat{\beta}_1 D_i
\]

\[
= \frac{D_0 - \sum_{i=0}^{10} \hat{\beta}_1 D_i}{N - 11}
\]
\[ \text{S.E.} \left(\frac{d_i}{Y} \times 100\right) = \frac{100}{Y} \times \text{SE}(d_i), \] which is estimated by

\[ (3.2.11) \quad \frac{100}{Y} \times \text{SV}(w_i' \lor w_i) \]

If the estimated percentage deviation from average risk associated with being in a particular subclass of a variable is less than two times the standard error, it implies that the particular subclass of variable has little or no impact on semi-natal mortality. If the estimated percentage deviation from average risk associated with being in a particular subclass of a variable is more than two times the standard error, the impact of the subclass of the variable is taken as significant.

The estimated percentage deviation from average risk associated with being in a particular subclass of a variable with plus sign is interpreted as the higher risk of dying than that of the average. The estimated percentage deviation from average risk associated with being in a particular subclass of a variable with negative sign indicates the lower risk of dying than that of the average.
3.3 Results and Discussion:

The sema-natal mortality rate in the population of Anand Municipal Hospital is found to be 32.0 per thousand live births. The unadjusted percentage deviation from the average risk of dying is estimated for each variable, (i.e. Sex, Weight, Age of mother and Gravida) in the absence of the effects of all other variables. The adjusted percentage deviation from the average risk of dying is estimated in the presence of the effects of all variables.

The regression equation when the effects of all variables are to be considered is obtained as follows:

\[(3.3.1) \quad y = .0437 - .0139 X_1 - .0092 X_2 - .0204 X_3 \\
- .0164 X_4 + .0972 X_5 + .1152 X_6 - .0288 X_7 \\
- .0248 X_8 - .0280 X_9 + .0095 X_{10}.\]

3.3.1 Maternal Age:

The regression equation of sema-natal death on maternal age is obtained as follows:
Table 3.1 indicates the percentage deviations from average sema-natal mortality by maternal age.

<table>
<thead>
<tr>
<th>Age Group (in years)</th>
<th>Unadjusted</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \nu_i )</td>
<td>Deviations</td>
</tr>
<tr>
<td>&lt; 20</td>
<td>9</td>
<td>51.4494</td>
</tr>
<tr>
<td>20 - 24</td>
<td>42</td>
<td>1.2323</td>
</tr>
<tr>
<td>30 - 34</td>
<td>14</td>
<td>3.0806</td>
</tr>
<tr>
<td>35 and above</td>
<td>14</td>
<td>77.3260</td>
</tr>
</tbody>
</table>

\( \nu_i \) = number of sema-natal deaths in subclass \( i \).

It is clear from the unadjusted deviations shown in Table 3.1, that the risk of death to infants within a week of its birth is higher than average for those babies whose mothers are very young (<24 years) and whose
mothers are of age 30 years and above. Thus the trend of unadjusted percentage deviations follow a U shaped curve of semi-natal mortality by age of mother.

It is clear from the adjusted deviations shown in Table 3.1 that the babies whose mothers are of age 25-29 years and 35 years and above have higher risk of dying than the average. The babies whose mothers are of age less than 24 years and in age group 30 - 34 years have lower risk of dying than the average. When adjustments are made by considering the effects of all variables, this pattern seems to deviate from U shaped trend observed when adjustments were not made. This is obvious from figure 1.

As the unadjusted percentage deviations, are greater than two times the standard error, the risk of death from average for the maternal age < 20 years, 25 - 29 years and 35 years and above is found to be statistically significant. This means that these groups have more impact on semi-natal mortality, while other groups of age i.e., 20 - 24, 30 - 34 years have no impact on semi-natal mortality. Since the adjusted percentage deviations are greater than two times the standard error for
maternal age < 20 years, the risk of death from the average for the maternal age < 20 years is found to be statistically significant. This means that this group has more impact on semi-natal mortality in the presence of all variables. (i.e., Weight, Gravida, Sex).

3.3.2 Weight:

The regression equation of semi-natal death on weight is obtained as follows:

\[ (3.3.3) \quad y = 0.0096 + 0.6959 X_1 + 0.1151 X_2 \]

Table 3.2 indicates the percentage deviations from average semi-natal mortality by weight.

<table>
<thead>
<tr>
<th>Weight (Grams)</th>
<th>( y_1 )</th>
<th>Unadjusted Deviations Standard Error</th>
<th>Adjusted Deviations Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1500</td>
<td>36</td>
<td>2076.46 62.84</td>
<td>2080.46 66.24</td>
</tr>
<tr>
<td>1500-2000</td>
<td>31</td>
<td>287.13 79.48</td>
<td>247.44 79.18</td>
</tr>
<tr>
<td>above 2000</td>
<td>32</td>
<td>-67.47 2.46</td>
<td>-67.47 2.68</td>
</tr>
</tbody>
</table>

* \( y_1 \) = number of semi-natal deaths in subclass i.
It is clear from the unadjusted deviations shown in Table 3.2, that low birth weight babies (whose weight is less than 1500 grams) had higher risk of dying i.e., 2076 percent above the average. While the babies whose weight is above 2000 grams have pretty high chances of survival with unadjusted percentage deviation 67 percent below the average sema-natal mortality. The adjusted percentage deviations are found to have similar pattern. The comparison of unadjusted and adjusted percentage deviation indicates that the influence of birth weight on sema-natal mortality is independent of the influence of the remaining three variables. Birth weight of a baby is therefore an important factor in influencing sema-natal mortality. This supports the findings of five other studies (Shah, et. al. (1971), Shapiro, et.al. (1954), Chase (1962), Rosen Waik et.al. (1967), Gandotra (1974)).

The unadjusted and adjusted percentage deviations, are more than two times the standard error, hence the risk of death from average, for babies (whose weight is less than 1500 grams, 1500 - 2000 grams, above 2000 grams) is found to be statistically significant. This implies that the birth weight has great impact on
3.3.3 *Gravida*:

The regression equation of sema-natal death on gravida is obtained as follows:

\[(3.3.4) \quad y = 0.0569 - 0.0205 x_1 - 0.0267 x_2 - 0.0324 x_3\]

Table 3.3 indicates the percentage deviations from average sema-natal mortality by gravida.

**Table 3.3**

PERCENTAGE DEVIATIONS FROM AVERAGE SEMA-NATAL MORTALITY BY GRAVIDA.

<table>
<thead>
<tr>
<th>Gravida</th>
<th><em>y_i</em></th>
<th>Unadjusted</th>
<th></th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Deviations</td>
<td>Standard error</td>
<td>Deviations</td>
</tr>
<tr>
<td>1</td>
<td>34</td>
<td>14.4779</td>
<td>15.4965</td>
<td>2.1565</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>-4.6212</td>
<td>17.2836</td>
<td>-7.2020</td>
</tr>
<tr>
<td>3 - 5</td>
<td>27</td>
<td>-22.1818</td>
<td>13.8636</td>
<td>-10.1667</td>
</tr>
<tr>
<td>6 and above</td>
<td>17</td>
<td>77.6362</td>
<td>67.1616</td>
<td>78.5656</td>
</tr>
</tbody>
</table>

*\[y_i\] = number of sema-natal deaths in subclass i.*
It is clear from the unadjusted deviations shown in Table 3.3, that babies of mothers of lowest gravida one and highest gravida 6 and above have higher risk of dying than the average. And the babies of mothers of intermediate gravida 2 to 5 have lower risk of dying than the average. The trend of unadjusted deviations from average perinatal mortality by gravida seems to follow a U shaped pattern. This trend persists with slight modification even after the adjustment is being made. This is obvious from Figure 2.

After considering the effect of all other variables, it is clear from the adjusted deviations that babies of mothers of lowest gravida one and higher gravida 6 and above have higher risk of dying than the average. The comparison of unadjusted and adjusted percentage deviations indicates that the influence of gravida on perinatal mortality is reduced to some extent.

As the unadjusted percentage deviations are less than two times the standard error, the risk of death from average for gravida (1, 2, 3–5, 6 and above) is found to be statistically insignificant. This implies that gravida in the absence of other variables has no impact.
on sema-natal mortality. Similarly, the adjusted percentage deviations are less than two times the standard error except in the case of gravida 6 and above. So the risk of death from average for gravida 1, 2, 3 - 5 is found to be statistically insignificant, while it is found to be statistically significant in the case of gravida 6 and above. This implies that gravida 6 and above has more impact on sema-natal mortality in the presence of all variables (i.e. Maternal age, Weight, Sex).

3.3.4 Sex:

The regression equation of sema-natal death on sex is obtained as follows:

\[ y = 0.0282 + 0.0065 x_1. \]

Table 3.4 indicates the percentage deviations from average sema-natal mortality by sex.
TABLE 3.4
PERCENTAGE DEVIATIONS FROM AVERAGE SEMA-NATAL MORTALITY BY SEX.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Unadjusted</th>
<th></th>
<th>Adjusted</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$y_1$</td>
<td>Deviations</td>
<td>Standard</td>
<td>Deviations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>error</td>
<td></td>
<td>error</td>
</tr>
<tr>
<td>Female</td>
<td>42</td>
<td>-10.7828</td>
<td>10.4747</td>
<td>-15.7121</td>
</tr>
</tbody>
</table>

$y_1$ = number of sema-natal deaths in subclass 1.

It is clear from the unadjusted deviations shown in Table 3.4, that male babies have risk of dying 9.24 percentage above the average. After considering the effect of all other variables, it is clear from the adjusted deviations, that the risk of death in the case of males increased to 13.55 percentage above the average. Similarly, from the unadjusted deviations shown in the Table 3.4, it is clear that female babies have risk of death 10.7 percentage below the average. After considering the effect of all other variables, the risk of death decreased to 15.71 percentage below the average.
The unadjusted percentage deviations are less than two times the standard error, hence the risk of death from average for males and females is not found to be statistically significant. This implies that sex in absence of other variables has no impact on sema-natal mortality. Since the adjusted percentage deviations, are more than two times the standard error, the risk of death from average, for males and females is found to be statistically significant. This implies that sex has more impact on sema-natal mortality in the presence of other variables. This supports the findings of other studies (United Nations (1953)) that biologically male babies are more prone to the risk of death than female babies. The other study made by Gandotra (1974) also supports the above findings.

3.4 Conclusions:

(1) From the above discussion it is very clear that birth weight is the important factor in influencing sema-natal mortality.

(2) The variable maternal age ranks second in order of importance. The risk of death to infants within a week of its birth is higher than the average for those
babies whose mothers are very young (< 20 years) and whose mothers are of age 66 years and above. Maternal age affects fetal mortality through other variables such as maternal condition and gravida which are closely linked with the age of the mother.

(3) The babies of mothers of lowest gravida one and highest gravida 6 and above have higher risk of dying than that of average.

(4) Male babies are more prone to the risk of death than female babies.

3.5 Suggestions:

(1) If the interval between the two pregnancies is very small, then the mother's body becomes nutritionally deficient and the weight of a live birth is below normal. Hence the fetal mortality will be high due to low weight of a live birth. Therefore there must be some proper interval between the two births.

(2) Improve the gross nutritional deficiencies and physical conditions of the expectant mothers, through providing effective pre-natal care.

(3) Enforce small family size norms by way of effective family planning.
Figure 1: PERCENT DEVIATIONS FROM AVERAGE SEMI-NATAL MORTALITY BY AGE OF THE MOTHER
Figure 2: PERCENT DEVIATIONS FROM AVERAGE SEBAA--MORTALITY BY GRAVIDA

--- Unadjusted deviations
--- Adjusted deviations