CHAPTER: III

Under One Mortality in Assam

3.1 Introduction

Infant Mortality is the most sensitive index to measure socio-economic development and the quality of life. It is commonly used for monitoring and evaluation of population and health programmes and policies. Infant and child mortality form a large fraction of the deaths of all ages. In India one out of every fifth death is of infant and a total of about 1.8 million infants are dying annually (based on Infant Mortality Rate of 2000) as compared to 2.6 million in 1971 (National Workshop on IMR, 11-12 April 2002, Organized by ORGI in collaboration with UNICEF, UNPF, MH&FW and NCP). Most social scientists as on today view infant mortality rate as an excellent indicator of socio-economic development. The issue has prejudiced international as well as national governments/organization to intensify their efforts to reduce the IMR and to enhance the level of child survival. But there is surprisingly little evidence to suggest that people in the rural area throughout the less developed countries have realized the seriousness of the problem. Countries which are committed to reducing the rate of growth of population through vigorous programmes of family planning, have
realized that the reduction of infant and child mortality rates to a low level is an urgent necessary precursor for achieving rapid reduction in fertility. With increasing emphasis at local area planning in the field of population in areas such as family planning, maternal & child health and immunization programmed, the need for data at district level has been realized. The present study has attempted to find district level estimates for all the district of Assam by direct as well as indirect method.

3.2 Review of literature

The main source of data for estimation of infant and child mortality at the district level for post 1991 period was 1991 census fertility tables F-15, F-16, F-17 & F-18 which present data on marriage, children ever born, children surviving and births during last year classified by the age of mother. Studies on infant and child mortality reveal that certain demographic factors of mother such as age at marriage, age at first delivery, numbers of live births, closed birth intervals age at death of the babies have a definite impact in explaining the trends, differential and determinates of impact mortality. Infant mortality tends to be relatively higher for children born to younger mothers particularly those under twenty and thirty years of age, and lower for children born to mothers aged between 20 and 29 (Population report, 1984). Several studies on
infant mortality conducted in different parts of the world showed or U or a shallow U or a reverse J shaped curve in its relationship with birth order (Wyon and Gorden, 1962; Ommran and standely, 1976; Morris and Heady, 1955; Shah and Abbey, 1971; New Combe, 1965; Palloni, 1981; Mahadeven, et al., 1986; Stockel and chouwdhury, 1976). The level of infant mortality is quite high at first and second orders of birth and lower for third order of birth and again high for fourth higher orders of births. Birth interval is also a factor which is negatively associated with infant mortality (Park, 1985; Kabir, 1984). While comparing the data for 25 developing countries Huffman (1984) illustrates substantial impact of spacing on child mortality. It states that "If all births were spaced at least 2 years a part, infant mortality can be reduced by 10 per cent and child mortality (ages <5 years) by 16 per cent."

An analysis of the situation of children in India by UNICEF (1984) states that cultural traditions of intra – family distribution of food rooted in rural areas compel women to eat least both in quality and quantity. This inadequate diet can not meet the demands of the pregnancy and lactation and thereby depletes her health leading to entrenched deficiencies and ill-health. This is the root cause of nutritional deficiency of infant and their deaths in several contexts are resulting out of the
mother (Vankatacharaya, 1985). Probably more relevant to the contexts of the developing counties is a carefully controlled study in Guatemala which demonstrated that a good diet in pregnancy could increase birth weights and directly contribute to a significantly lower infant mortality rate (Habicht, et al., 1977).

In a historical review of the importance of breast-feeding in Europe and North America, (Wray, 1978) noted that for every disease category studied, breast-fed babies had lower morbidity rate than bottle fed babies. The findings of Bhat and Kheterpal (1983) reveal that most of the mothers are ignorant about the nutritive value of colostrum which is particularly rich in anti-infective factors and nutrients such as vitamin-A. Infant mortality, which is more widespread among children who are not breast-fed, is a major cause of a short inter birth interval (Mondot, 1981). In India the mean duration of breastfeeding was 21 months and it did not very much across different communities. The duration of breastfeeding is negatively associated with infant mortality (Mahadevan, et al., 1983) according to several studies conducted reveal that breast-fed are less likely to develop gastrointestinal disease and viral respiratory infections (Cunningham, 1979; Ellestad, et al., 1979; Hildes, et al., 1973;
Schaefer, 1971; and WHO, 1979). Birth weight of an infant is a major determinant of the infant mortality in several developing countries.

The weight of the mother during pregnancy has a relationship with birth weight of the baby. Similarly, the height of the mother also has the relationship with the birth of the infants (NINDS, 1972). A number of investigations have clearly demonstrated that the risk of neonatal mortality increases exponentially as the birth weight declines below 2500 grams, reaching virtually 100 percent at 1000 grams (National Centre for Health Statistics, 1972; Federici and Terrenato, 1980).

Public health measures naturally play an important role in reducing mortality in poorer developing countries, where infectious diseases (microbial and parasitic) which still account for most morbidity and mortality (Mahler, 1984). Therefore, availability of such facilities to the public is more important in bringing down the level of IMR (UN, 1982). Studies of Flegg (1982) found that the health facilities play a greater role in bringing down the level of IMR in less developed countries. But in India, mainly the rural people do not utilize the medical facilities properly, particularly when they have their own belief of illness among the children. They usually prefer traditional treatments for these diseases to allopathic treatment (Sarma et al., 1987). There is evidence that the
infant and child mortalities in rural areas, as well as urban areas are lower when deliveries are attended to by trained medical personal as compared with those attended by untrained ones (UNICEF, 1984). In India, the local midwife or traditional birth attendant is the most important source of support in pregnancy, child birth or child care (UNICEF, 1985; Mahadevan, et al., 1986). Children from developing countries have an unexceptionally high risk of dying under age 5 years due to six major killer disease-measles, pertussis, neonatal tetanus, polio, tuberculosis and diphtheria. Under this situation the immunization against the most common and deadly infancy and childhood diseases saves the lives of some one million children in developing countries per year.

*Life-affecting variables (LAVs)*

Infant survival and mortality are caused by several factors which have been listed out in a few conceptual models developed by Ruzicka (1982); Chen (1983); and Mahadevan covers comprehensive list of most of the variables that have been identified from the developed and developing countries. It has the advantage of choosing a limited number of homogenous factors out of the 12 sets of 'Life-Affecting Variables (LAVs)' models do not include all the diverse determinants of mortality. They give importance to certain categories of variables only and are not
comprehensive. In addition, all the variables have been conceptualized into a viable model delineating the nature of causal influence, which is valuable for empirical study. A brief account of the components that affects the infant deaths is given below:

_Culture and Infant mortality_

Culture is embedded in the lifestyle of people and reflected in their activity. Cultural factors also have an influence on infant mortality (Benjamin, 1965). "Culture is that complex whole which includes the knowledge, beliefs, morals, law, customs and other habits acquired by man as a member of the society" (Taylor, 1978). Culture as an independent variable has a great role to play on many social and demographic variables viz. proportion of married, age at marriage, value attached to marriage, value of children, sexual taboos, prolonged breastfeeding, traditional and religious beliefs, kinship relation and divorce. These variables in turn, affect infant mortality in different ways.

_Ecological Factors and Infant Mortality_

Studies based on World Fertility Surveys have signaled the importance of the characteristics of households, as distinct from the characteristics of individuals, for the survival of infants. For example the availability of sanitation and electricity in Philippines proved to be
correlated with infant mortality even after controlling things like birth order, maternal age and education (Martin et al. 1993). The Characteristics of mother were found to be among the most important determinants of neonatal mortality, but ecological factors such as housing conditions, type of water supply, and sewage disposal, were found to have an equal importance with the mother's characteristics in determining post-neonatal mortality (Guerra, 1981). Type of toilet facilities available also showed a clear relationship with infant survival in Sri Lanka and Mexico, but in neither country did the availability of pipe water appear to have a bearing on mortality within the first five year of live (Hobcraft, 1982).

**Differential development and mortality**

It is possible to find ample evidence to show that among the different countries of the world socio-economic conditions and survival rates of infant/children are positively related (Adelman, 1963). It has been argued that the poor have consistently had higher probabilities of death than the rich; even if both groups have equal access to education and health services (Antonovskvsky, 1967). In the absence of equal distribution of income, the rich have more access to specialized hospital based medicine, better food and healthy life because it bears directly on
health-related decision-making and actions performed by the parents to protect their children. The net effect of mother's occupation on infant survival prospects cannot be generalized across different cultural settings. Its positive or negative effect depends on the extent to which female economic activity is accompanied by suitable child care arrangements. The net effect may also differ with differences in occupational categories for instance, some occupations like jobs in services and craft industries do not take women outside of their homes full-time, and some agricultural activities are seasonal. There are other female activities which are not compatible with child rearing. In addition, income, occupation, education of parents, especially mother's education; all have an important influence on child survival.

*Demographic Correlates of Mortality*

Several Studies on infant and child mortality reveal that some demographic characteristics of mother have some definite impact on infant and child mortality. These demographic variables are Mother's age at marriage, age at first birth, number of live birth, close birth interval. It is generally observed that infant and child mortality for older (more than 35) and very young women (less than 25) is higher. A good number of studies have indicated that infant mortality is positively
associated with average parity of mother and negatively associated with length of birth intervals. A mother with more frequent births or with shorter birth intervals is more likely to divide her time, resources and emotions among many children than one parity or with longer birth intervals. Omran et al., (1976 have shown that an increase in the birth weight with increase in maternal age. Researchers like Karn and Penrose (1952); Mills and Seng (1953); Basavarajappa et al., (1962) and Puffer (1982) have also confirmed the importance of these variables.

**Nutrition and Mortality**

It's fact that pregnancy is a period of great anabolic activity when growth takes place at a most rapid rate. For along time it was assumed that the foetus develops at the expense of the mother. But later on, this opinion found to be incorrect. Both mothers and infants are likely to suffer if the pre-natal diet is poor. Nutritional needs during pregnancy include the normal requirements of the mother, those of the developing foetus (including the uterus and the placenta) and the building up of the reserves for both labour and lactation (Chandrasekhar, 1972). Nutrition and mortality are interrelated. Indeed, the relatively high mortality rates in the less developed countries compared to the developed countries is
frequently not due to difference in virus virulence, but due to differences in the state of nutrition (Anker and James, 1980).

### 3.3 Health Status and Mortality

Health is one of the key factors for the survival and increased life span of human beings in society. It is also important determinant of infant mortality. The reduction of mortality to low levels and the attainment of good health by the entire world's populace is regarded as a pressing goal by government and international organizations. The world population plan of action states that 'it is the goal of this plan of Action to reduce mortality levels, particularly infant and maternal mortality levels, to the maximum extent possible in all regions of the world'. And 'many developing countries consider reduction of mortality, to be one of the most important and urgent goals'. As stated in the declaration of Alam Ata conference on Primary Health Care, held in 1978, 'Health, which is a state of complete physical, mental and social well-being, and not merely the absence of disease and infirmity, is a fundamental human right and the attainment of the highest possible level of health is a most important world-wide social-goal'. The right of enjoyment of good health as a basic human right has also been affirmed by the two united nation symposia on population and human rights (UN,
1984). Recently as a signatory to the Alam Ata declaration of 1978 and charter of health sponsored by WHO in 1980, India has also committed itself to achieving health for all by 2000 A.D., through primary health care approach and as a part of this, has fully recognized her commitment to the reduction in mortality and morbidity among infants and children, in the improvement of women, especially mothers and in reduction of fertility, so as to achieve better health (NIH, 1978). The target set for India for achieving this goal is to bring down infant mortality rate to 60 per thousand live births by 2000 A.D. (Government of India, 1981). Status of the statement is that by 2000, the India’s Infant Mortality has come down to 68 per one thousand live births. In the New Population Policy (NPP) 2000, the Government of India has set up the target of IMR to 30 per 1000 live births by 2010. The possibility of the target stated in NPP 2000 can be assessed from the available data estimated through Sample Registration System (SRS). The last 30 years trend may suggest the approachability of the target. Data presented in Table 3.1 speaks the possibility of the set target.

From the above data it is seen that IMR for the country as a whole has come down from 129 in 1971 to 68 in 2000, thus reducing to half in thirty years. The trend suggests little different from what has been
targeted. With the data, let us draw a graph and see what may happen in 2010. The following chart 3.1 presents India, IMR for the period 1971-2000.


On the data an exponential trend equation \( y = a e^{bx} \) is fitted. The values of \( a \) and \( b \) are estimated by using the Method of Least Squares and these values are obtained as \( a=148.01 \) and \( b=-0.0272 \). The trend equation thus obtained as \( y = 148.01e^{-0.0272x} \). The fitting is supposed to
be the best fitting as the value of $R^2 = 0.9681$. With this trend equation, the estimated value of IMR for the year 2010 is 49.89 per 1000 live births. The trend therefore suggests that IMR may come down to around 50 per 1000 live births until and unless no extra or any special efforts are being made to bring down IMR.

Keeping in view the NPP 2000, if we explore the status of Assam, the pattern may emerge the same. The possibility of the target stated in NPP 2000 can be assessed from the available data estimated through Sample Registration System (SRS) for the state of Assam. The last 30 years trend may suggest the approachability of the target. Data presented in Table 3.2 provides data on the possibility of the set target.

From the above table it is observed that in Assam around 73 out of 1000 live births bid good bye to their parents before completing one year of their life span in the year 2000. Like all India, the state has achieved IMR from 139 in 1971 to 73 in 2000, thus reducing the rate by half during this 30 years period. But it is a big question whether the state will be able to achieve the NPP 2000 target, i.e. IMR of 30 per 1000 live births. The trend suggests little different from what has been targeted. With the data, let us draw a graph and see what may happen in 2010. The following Chart 3.2 presents IMR, Assam for the period 1971-2000.
On the data an exponential trend equation $y = a e^{bx}$ is fitted. The values of $a$ and $b$ are estimated by using the Method of Least Squares and these values are obtained as $a = 142.13$ and $b = -0.024$. The trend equation thus obtained as $y = 142.13 e^{-0.024x}$. The fitting is supposed to be the best fitting as the value of $R^2 = 0.9041$. With this trend equation, the estimated value of IMR for the year 2010 is 54.42 per 1000 live births. The trend therefore suggests that IMR may come down to around
54 per 1000 live births until and unless no extra or any special efforts are being made to bring down IMR.

Issues under consideration

From the above reviews and results, two issues emerge. The first issue is the components on which the IMR depends and second issue is the status of infant based on the policy implications.

Board Classification of the Variables

As discussed above, the variables that IMR depends can be divided into two categories endogenous and exogenous. Endogenous variables are those variables which depend on internal factors. This type of variables may be related to i) culture which include knowledge, beliefs, morals, law, customs and other habits acquired by man as a member of the society or ii) demographic variables are Mother’s age at marriage, age at first birth, number of live birth, close birth interval or iii) socio-economic conditions such as income. All these variables may be controlled if parents are educated or at least mother is literate. Broadly speaking the effect of this endogenous variable could be minimized if education to women gets due importance except, of course, income of the household.
Exogenous variables are those variables which depend on external factors. The variables that correspond to this type may be i) Ecological factor such as housing conditions, type of water supply, toilet facility, sewage disposal etc. ii) Nutrition such as diet during pre- and post-natal period, iii) Primary Health Care of mother and child. All these could be controlled by increasing urbanization and access to medical facilities. Broadly speaking the effect of this exogenous variable could be minimized if the area is properly look into by the Government. Either make it urban or increase the above mentioned facilities.

*Status of Infant*

From the above data it is possible to monitor the IMR for a long period of time in chronological order at all India and state level. The data reflects some clear cut trend. For instance, rural IMR = 2 * urban IMR. Steep decline was observed during seventies, moderate in eighties where as static in nineties. Static situation in nineties compelled the policy planners to search the area responsible for high infant deaths. Further for decentralized health planning, it is necessary to have estimates for each unit of administration. But direct estimates seem to be quite costly as the size of the sample depends on the level on precision and as such, the sample size required for estimation of IMR at
state as well as district level may be same. Keeping in view this constraint, an indirect method has been suggested in UN manual. With this method, district level IMR is estimated using 1981 as well as 1991 census data (Sinha. S.K.1997)

**Indirect Method of Estimation using Census Data 1881 & 1991**


The 1991 census had released Primary Census Abstract (PCA) for each village and town. One of the features of the 1991 census data was the release of population in the age group 0-6 separately for males and
females for each village and town. The population aged 0-6 can be reverse survived to obtain the number of births and the birth rate. The reverse survival method is based on the assumption that the population aged 0-6 is the survivors of the births which occurred during the last 7 years. So, one can have an independent estimate of the probability of survival from birth to age 0-7 during the later half of 1980’s, it would be possible to estimate the number of births that occurred during the period 1st March, 1984 to 1st March, 1991 by using the inverse of survival as a multiplier. In the absence of Civil Registration System, the reverse survival factor \([7l_0 / L(0-6)]\) may be obtained by using the Sample Registration System (SRS) life tables for the period 1986-90.

The Sample Registration System which is an annual sample survey conducted by the Office of the Registrar General, India collects data on the births and deaths by a dual record system. The fertility and mortality rates obtained from SRS are considered as reliable. The probability of survival from birth to 0-6 i.e. \(L(0-6)/7l_0\) and its inverse, the reserve survival ratio may be worked out sex-wise separately for each state. The population aged 0-6 at state level may be reversed survived to estimate the number of birth during 1984-91. The mid point of this period is 1 September, 1987. the population as on this date may be
interpolated from the census population as on 1981 & 1991. The birth rate for the period may be worked out using the interpolated population as denominator.

The birth rate so worked out can be compared with the SRS birth rate for the period 1984-90 at state level. The ratio of the sample registration system birth rate to the birth rate derived by using census data may be considered as an index of the errors in census data due to omission and age distortion. The inflation factor obtained at state level may be used to inflate the birth rate obtained at district level. The estimated birth rates at district level are, therefore, consistent with state level SRS birth rates. This gives birth rate at district level on the assumption that the mortality level of each district is the same as that of state as a whole.

Apart from fertility one other factor which introduces variation in population aged 0-6 at district level is the level of child mortality. The SRS due to the sample size does not provide fertility and mortality levels at levels below the state. Based on the questions on children ever born and children surviving tabulated by the age of mother in 1991 census estimates may be worked out at district level sex-wise. Child mortality estimates that may be available are q(1), q(2), q(3)& q(5) i.e. probability
of dying from birth to age 1, birth to age 2, birth to age 3, and from birth to age 5.

These child mortality estimates can be used as indicators of interdistrict variations in child mortality compared to that of the state level. For this purpose, an index may be constructed as follows. The reverse survival factors from age 5 to birth may be worked out for each district using district-wise q(5) values derived from 1981 census data. Similar reverse survival factor may also be derived at state level. The reverse survival factor at district level to that of the state level may be used as an indicator of the district-wise variations in child mortality. If the child mortality was higher in a particular district than the state, then reverse survival factor for the district would be higher than that of the state and vice-versa. The district wise birth rates obtained in paragraph above may be multiplied by the ratios 'R' to obtain birth rates adjusted for district level variation in mortality.

Other methods that can be tried out to estimate fertility at district level are: 1) Indirect methods of brass type based on comparison of period fertility rates with reported average parities. 2) Reverse survival method to estimate Crude Birth Rate. For each district census publishes population by five year age groups. Based on this, birth rates can be
estimated for the periods 1981-86 & 1986-91 by reverse survival method as explained in previous paragraphs. Age selective omission, age misreporting and migration from other districts and into the district can vitiate the accuracy of the estimates. 3) Rele’s method of using child women ratios to estimate TFR and CBR (Rele 1967). The method originally proposed is affected by age selective omission and age misreporting. When age data from two censuses are available, the estimates can be improved assuming that omission and distortions are of same magnitude in both the censuses. In any case one can get upper and lower limits of birth rates and TFR’s. 4) Palmore’s method and Gunasekharan-Palmore’s regression techniques to estimate TFR. Since the age data and marital status data would be available district-wise, these methods can also be attempted.

Over and above, using information of 1991 census data and UN indirect techniques for Demographic Estimation, Manual X, an estimate has been made for infant and child mortality for all states and union territories along with the districts of India by place of residence and sex (Irudaya Rajan. S and Mohanachandran. P., 1998).

All these above methods provide estimates as and when census data are available. Usually the data that are required for estimation of
infant and child mortality get available after five to six years of census operations and the estimates become available to users when the next decadal primary census data are accessible. It is therefore required that some technique should be evolved to get estimates at desired geographical level. An effort has been made to estimates as and when provisional census results are available. The method derived is based on deflating of available rates at higher geographical levels to lower geographical levels using both census and sample data.

3.4 Deflating of IMR from higher geographical levels to lower geographical levels- A new approach

For decentralized planning and other demographic needs, the requirements of vital rates at lower geographical levels such as district level are very much felt. Due to high cost involved as size of the sample is quite high, either demographic profiles of the district are not considered while deciding the priorities of the district or depends on indirect estimates or rough assessment. As discussed above, there are indirect methods using census data, once in ten year, the vital rates can be estimated. But these methods provide estimates for that particular year only, apart from enumeration problems of eliciting information on children born and children surviving.
We have the balance equation

\[ P_t = B_t - D_t + I_t - O_t \]

Where \( P_t \) is the total population at time \( t \), \( B_t \) is the total births, \( D_t \) is the total number of deaths, \( I_t \) is the number of immigrants added to the population and \( O_t \) is total number of out migrants. Under the assumption that in the growth of population, \( I_t \) and \( O_t \) balance each other i.e. the contribution of the composition of the components \( I_t - O_t \) to population is not significant. In other words, the growth of population is assumed to be due to the difference of births and deaths. Once the death rate is known, birth rate can be worked out by taking difference of growth rate and death rate and from the birth rate it is possible to estimate total number of births in the district. With the available Infant mortality rate of the state, it is possible to find the estimated number of infant deaths in the state. The next thing required will be to inflate these infant deaths of the state among the various district of the state. With the estimated values of the infant deaths and births, it can be arrived at Infant mortality rate of the district. In this process, the following steps needs to be done.

1) To inflate death rate from state to district

2) Using the equation, Birth rate = Growth rate - death rate, the birth rate for each district could be estimated.
3) Estimate the number of births in the district using population of the district

4) Estimate total number of infant deaths in the state

5) Inflate infant deaths at the district level

6) Calculate Infant death rate at the district level

In this process, we are calculating, all three important vital indicators such as birth rate, death rate and infant mortality rate of the district.

3.5 Inflating Process for Death Rate

After repeated experiments on death rates for a number of years, it has been observed that the death rate at district level by residence may follow the following model. It has been assumed in the model that death rates have a significant variation on residence of the deceased. The empirical model therefore can be written as under.

\[
\text{Total: } dR(i, t) = \Delta p(i, r)\frac{dR}{dp}D_r + \Delta p(i, u)\frac{dR}{dp}D_u + D_t
\]

Where \( dR(i, t) = \) Death rate for ith district for combined areas of rural and urban,

\[\Delta p(i, r) = P_r - P_{ir},\]

\( P_r = \) Total population proportion of rural area of the state

\( P_{ir} = \) Population proportion of the ith district of rural area
\[
\frac{dR}{dp} = \text{Relative deviation of death rates with respect to change in population proportion between rural and urban.}
\]

\(D_r, D_u, D_t\) are the death rates of total, rural and urban areas respectively of the state.

\[\Delta p(i, u) = P_u - P_{iu}\]

\(P_u = \text{Total population proportion of urban area of the state}\)

\(P_{iu} = \text{Population proportion of the i}_{th} \text{ district of urban area.}\)

For rural areas, the model is slightly changed and is given below:

Rural:
\[dR(i, r) = \Delta p(i, r) \times \frac{dR}{dp} \times D_r + \Delta p(i, u) \times \frac{dR}{dp} \times D_u + Dr\]

And for urban areas

Urban:
\[dR(i, u) = \Delta p(i, r) \times \frac{dR}{dp} \times D_r + \Delta p(i, u) \times \frac{dR}{dp} \times D_u + Du\]

**Algorithm**

**Step 1:** Calculation of \(\Delta p(i, r) = P_{ir} - P_r\)

This component is to be calculated from the Census data. \(P_r\) is the proportion of rural population of the state. \(P_{ir}\) is the rural population proportion of the \(i^{th}\) district. So the difference between the proportion of rural population of the state and the district will give the value of \(\Delta p(i, r)\).
Similarly the $\Delta p(i, u)$ is the difference of proportion of the urban population of the state and the district.

Step 2: Calculation of $\Delta p(i, u) = P_{iu} - P_u$

This component is to be calculated from the Census data. $P_u$ is the proportion of urban population of the state. $P_{iu}$ is the urban population proportion of the $i^{th}$ district. The $\Delta p(i, u)$ is the difference of proportion of the urban population of the state and the district. This can be calculated similar to rural.

Step 3: Calculation of $\frac{dR}{dp}$

This value is the critical value for calculation of death rate. This is to be calculated from Census as well as the Sample Registration System (SRS) data. The rural-urban differential for population is calculated from Census data, whereas the state level death rates are taken from SRS estimates. The ratio of the deviation of death rate to the deviation of population proportion will provide the value of $\frac{dR}{dp}$.
Step 4: Calculation of Dr, Du, Dt

These values are estimated from SRS data.

The district wise death rates have been estimated using this new formula for various districts of Assam, which are given in Table 3.3:

3.6 Inflating Process for Birth Rate

Under the assumptions stated that growth independent of migrations, the birth rates can be calculated using the following equations

\[ bR(i, t) = gR(i, t) + dR(i, t) \]
\[ bR(i, r) = gR(i, r) + dR(i, r) \]
\[ bR(i, u) = gR(i, u) + dR(i, u) \]

To find the number of births in different districts, we may find the probability of births in the district and multiply the total births of the state to obtain the total number of births in the district. Baye's Theorem of probability would be used as given below:

\[ P(i/b) = \frac{P(i) * P(b/i)}{\sum_{i=1}^{n} P(i) * P(b/i)} \]

Where \( P(i/b) \) = The probability of selection of \( i^{th} \) district subject to the condition that birth has already taken place in the district

\[ P(i) = \text{Probability of selection of } i^{th} \text{ district.} \]
\[ P(b / i) = \text{Probability of occurrence of a birth in the district } i. \]

If \( B \) is the total number of birth in the state, then the total number of birth \( B_i \) in the district is given by

\[ B_i = B \times P(i / b) \]

**Algorithm**

Step 1: Calculation of \( bR(i, t) = gR(i, t) + dR(i, t) \)

\( gR(i, t) \) is to be calculated from Census data. Using the death rates for total areas (rural urban combined) for different districts as calculated by the new approach, \( gR(i, t) - dR(i, t) \) is to be calculated.

Step 2: Calculation of \( P(i) \):

Under the assumption that each district has equal probability of occurrence, \( P(i) = 1/n \), where \( n \) is the total number of districts in the state.

Step 3: Calculation of \( P(b/i) \):

This is to be calculated from the birth rates of the \( i^{th} \) district.

Step 4: Calculation of \( P(i/b) \):

This is to be calculated using \( P(i) \) and \( P(b/i) \).

Using this new approach, birth rates and the estimated number of births in each district are given in Table 3.4.
3.7 Deflating Infant Mortality Rates

Study of last thirty years data on rural-urban differential of Infant Mortality from various states suggests that for most of the backward states, the infant mortality in rural areas is more or less twice the infant mortality in urban areas i.e. Urban: Rural = 1:2, whereas there are states of middle order where the infant mortality of rural to urban are also of the same order. But the states with highly advanced demographic profile states where this is of the order of 4:5. Let us take up the examples of the states of Assam, Maharashtra and Kerala. The state of Assam comes under the category of backward state, Maharashtra in advance and Kerala in highly advanced states so far as the demographic parameters are concerned. The rural – urban differentials for these states are given in the table 3.5.

From this, it is clear that rural-urban differential of Assam and Maharashtra are of more or less equal weight but Kerala is of weight more than 4:5. While preparing composite index for calculation of probability of infant death, the probability that an infant death occurs in a rural area can be taken as 2/3, whereas for urban areas it can be taken as 1/3 for the state of Assam. But for Kerala, the same may be taken as
4/5 and 1. As discussed above, this rural-urban differential takes into account the exogenous variables responsible for infant deaths.

Studies of infant deaths by female literacy from different sources such as National Family Health Survey and primary data of SRS suggest that illiterate mothers are responsible for about 3/4th of infant deaths and 1/4th pertains to literate women. This female literacy controls most of the endogenous variables which are discussed above. Based on these issues, the composite index attributable to infant deaths may be made as follows:

$$\theta_y = P(r_y)P(m_y/\alpha_y)P(u_y)P(m_y/\alpha_y) + P(\beta_y)P(m_y/\beta_y)$$

Where $\theta_y$ is the composite index of probability of death of $j^{th}$ infant in the $i^{th}$ district. The index may lie between 0 and 4.

- $P(r_y)$ is the probability of $j^{th}$ infant living in rural area of $i^{th}$ district.
- $P(m_y/r_y)$ is the probability of death of $j^{th}$ infant living in rural area of $i^{th}$ district.
- $P(u_y)$ is the probability of $j^{th}$ infant living in urban area of $i^{th}$ district.
- $P(m_y/u_y)$ is the probability of death of $j^{th}$ infant living in urban area of $i^{th}$ district.
- $P(\alpha_y)$ is the probability that mother of $j^{th}$ infant of $i^{th}$ district is literate.
- $P(m_y/\alpha_y)$ is the probability of death of $j^{th}$ infant of $i^{th}$ district subject to the
condition that mother of j\textsuperscript{th} infant of i\textsuperscript{th} district is literate

\( P(\beta_j) \) is the probability that mother of j\textsuperscript{th} infant of i\textsuperscript{th} district is illiterate

\( P(m_j/\beta_j) \) is the probability of death of j\textsuperscript{th} infant of i\textsuperscript{th} district subject to the condition that mother of j\textsuperscript{th} infant of i\textsuperscript{th} district is illiterate.

With the help of this index and using the conditional probability, it is possible to find the probability of an infant death of i\textsuperscript{th} district using the following formula

\[
\rho_{ij} = \frac{\theta_j}{\sum_{j=1}^{k} \theta_j}
\]

Where \( \rho_{ij} \) if the probability of j\textsuperscript{th} infant death in the i\textsuperscript{th} district.

Total number of infant deaths may be estimated from the Infant mortality rate of the state

Let B be the estimated births in the state, total number of infant deaths in the state is obtained by

\[ \£ = B \times I/1000 \]

\( \£ \) = total number of infant deaths in the state

\( I \) = infant death rate for the state.

So, using \( \rho_{ij} \) one can find the total number of infant deaths in the i\textsuperscript{th} district as follows:

\[ \£_i = \rho_{ij} \times \£ \]
\( e_i = \) number of infant deaths in the \( i^{th} \) district.

Thus the Infant Mortality Rate in the \( i^{th} \) is given by

\[ l_i = \left( \frac{e_i}{B_i} \right) \times 1000. \]

**Algorithms**

**Step 1:** Calculate \( P(r_{ij}) \) that gives the probability of \( j^{th} \) infant living in rural area of \( i^{th} \) district. It gives the proportion of rural population of the district.

**Step 2:** Calculate \( P(u_{ij}) \) that gives the probability of \( j^{th} \) infant living in urban area of \( i^{th} \) district. It gives the proportion of urban population of the district.

**Step 3:** Calculate \( P(\alpha_{ij}) \) that the probability that mother of \( j^{th} \) infant of \( i^{th} \) district is literate. It gives the proportion of female literates in the district.

**Step 4:** Calculate \( P(\beta_{ij}) \) that the probability that mother of \( j^{th} \) infant of \( i^{th} \) district is illiterate. It gives the proportion of female illiterates in the district.

**Step 5:** Calculate \( P(m_{ij}/r_{ij}) \) that the probability of death of \( j^{th} \) infant living in rural area of \( i^{th} \) district. This value is assumed as 0.667 (reason stated above).

**Step 6:** Calculate \( P(m_{ij}/u_{ij}) \) that the probability of death of \( j^{th} \) infant living in urban area of \( i^{th} \) district. This value is assumed as 0.333 (reason
stated above).

Step 7: Calculate \( P(m_{ij}/a_{ij}) \) that the probability of death of \( j^{th} \) infant of \( i^{th} \) district subject to the condition that mother of \( j^{th} \) infant of \( i^{th} \) district is literate. This value is assumed as 0.250 (reason stated above).

Step 8: Calculate \( P(m_{ij}/\beta_{ij}) \) that the probability of death of \( j^{th} \) infant of \( i^{th} \) district subject to the condition that mother of \( j^{th} \) infant of \( i^{th} \) district is illiterate. This value is assumed as 0.750 (reason stated above).

Step 9: Calculate \( \theta_{i} \) using the formula stated above.

Step 10: Calculate \( \rho_{ij} \) the Baye's theorem based formula stated above.

Step 11: Calculate \( \xi \), total number of infant deaths in the state by using \( B^*I/1000 \).

Step 12: Calculate \( \xi_{i} \) using \( \rho_{ij} \times \xi \) i.e. district wise number of infant deaths.

Step 13: Copy \( B_{ij} \), the district wise number of births.

Step 14: Calculate \( I_{i} \), the district wise infant Mortality Rates by using the formula \( (\xi_{i} / B_{ij}) \times 1000 \).

3.8 Estimation from SRS

Using the SRS primary data for the years 1995-2000, it has been attempted to calculate the birth rates, death rates and infant mortality rates for various districts of Assam, to see how far the new approach is
close to the SRS rates (unpublished). For calculation of rates and their standard errors, the following formulas have been used.

**ESTIMATION PROCEDURE OF SRS RATES AND VARIANCES**

**RURAL AREAS**

\[ i = \text{subscript for village/segments} \]
\[ j = \text{subscript for stratum} \]
\[ k = \text{subscript for natural division} \]
\[ n_{jk} = \text{No. of sample villages/segments in the } j^{th} \text{ stratum of } k^{th} \text{ natural division.} \]
\[ N_{jk} = \text{Total no. of villages in the } j^{th} \text{ stratum of } k^{th} \text{ natural division.} \]
\[ J_k = \text{No. of stratums in } k^{th} \text{ natural division.} \]
\[ K = \text{No. of natural division in the state.} \]
\[ p_{ijk} = \text{Sample population of } i^{th} \text{ village of } j^{th} \text{ stratum in } k^{th} \text{ natural division.} \]
\[ b_{ijk} = \text{No. of live births in } i^{th} \text{ village of } j^{th} \text{ stratum in } k^{th} \text{ natural division.} \]
\[ d_{ijk} = \text{No. of deaths in } i^{th} \text{ village of } j^{th} \text{ stratum in } k^{th} \text{ natural division.} \]
\[ d'_{jk} = \text{No. of infant deaths in } i^{th} \text{ village of } j^{th} \text{ stratum in } k^{th} \text{ natural division.} \]

**ESTIMATION OF POPULATION, BIRTHS, DEATHS AND INFANT DEATHS**

The estimates at stratum level are given below:

\[
\hat{P}_{jk} = \frac{N_{jk}}{n_{jk}} \sum_{i=1}^{n_{jk}} \hat{p}_{ijk}
\]

\[
\hat{B}_{jk} = \frac{N_{jk}}{n_{jk}} \sum_{i=1}^{n_{jk}} \hat{b}_{ijk}
\]

\[
\hat{D}_{jk} = \frac{N_{jk}}{n_{jk}} \sum_{i=1}^{n_{jk}} \hat{d}_{ijk}
\]

\[
\hat{D}'_{jk} = \frac{N_{jk}}{n_{jk}} \sum_{i=1}^{n_{jk}} \hat{d}'_{ijk}
\]
The estimates at District level are as under:

\[
\hat{P}_k = \sum_{i=1}^{j} \hat{P}_{ik} \quad \hat{B}_k = \sum_{i=1}^{j} \hat{B}_{ik}
\]

\[
\hat{D}_k = \sum_{i=1}^{j} \hat{D}_{ik} \quad \hat{D}'_k = \sum_{i=1}^{j} \hat{D}'_{ik}
\]

The estimates of birth, death and infant mortality rates at State level are calculated as under:

\[
B.R = \frac{\hat{B}}{\hat{P}} \times 1000 = s \times 1000
\]

\[
D.R = \frac{\hat{D}}{\hat{P}} \times 1000 = r \times 1000
\]

\[
I.M.R = \frac{\hat{D}}{\hat{B}} \times 1000 = r' \times 1000
\]

Variances and Covariance's of Population, Births, Deaths and Infant Deaths:

\[
\hat{V}(P) = \sum_{k} \sum_{j} \left[ \frac{N_{jk}(N_{jk} - n_{jk})}{n_{jk}(n_{jk} - 1)} (\sum p_{jk}^2 - (\sum p_{jk})^2 / n_{jk}) \right]
\]

\[
\hat{V}(B) = \sum_{k} \sum_{j} \left[ \frac{N_{jk}(N_{jk} - n_{jk})}{n_{jk}(n_{jk} - 1)} (\sum b_{jk}^2 - (\sum b_{jk})^2 / n_{jk}) \right]
\]

\[
\hat{V}(D) = \sum_{k} \sum_{j} \left[ \frac{N_{jk}(N_{jk} - n_{jk})}{n_{jk}(n_{jk} - 1)} (\sum d_{jk}^2 - (\sum d_{jk})^2 / n_{jk}) \right]
\]

\[
\hat{V}(D') = \sum_{k} \sum_{j} \left[ \frac{N_{jk}(N_{jk} - n_{jk})}{n_{jk}(n_{jk} - 1)} (\sum d'^{2}_{jk} - (\sum d'^{2}_{jk})^2 / n_{jk}) \right]
\]
Covariance's

\[
\hat{C}(P, B) = \sum_{k, j} \left[ N_{jk}(N_{jk} - n_{jk})/n_{jk}(n_{jk} - 1)(\sum p_{yk} b_{yk} - \sum p_{yk} b_{yk} / n_{jk}) \right]
\]

\[
\hat{C}(P, D) = \sum_{k, j} \left[ N_{jk}(N_{jk} - n_{jk})/n_{jk}(n_{jk} - 1)(\sum p_{yk} d_{yk} - \sum p_{yk} d_{yk} / n_{jk}) \right]
\]

\[
\hat{C}(B, D') = \sum_{k, j} \left[ N_{jk}(N_{jk} - n_{jk})/n_{jk}(n_{jk} - 1)(\sum p_{yk} d_{yk}' - \sum p_{yk} d_{yk}' / n_{jk}) \right]
\]

Variances of Vital rates

\[
V (B . R ) = 10^{-6} \times \hat{V} (B / P)
\]

\[
= 10^{-6} \times 1 / P \left[ \hat{V} (B) + s^2 \hat{V} (P) - 2 s \hat{C} (P, B) \right]
\]

\[
V (D . R ) = 10^{-6} \times \hat{V} (D / P)
\]

\[
= 10^{-6} \times 1 / P \left[ \hat{V} (D) + r^2 \hat{V} (P) - 2 r \hat{C} (P, D) \right]
\]

\[
V (I . M . R ) = 10^{-6} \times \hat{V} (D' / B)
\]

\[
= 10^{-6} \times 1 / B \left[ \hat{V} (D') + r'^2 \hat{V} (B) - 2 r' \hat{C} (B, D') \right]
\]

The standard errors of births, deaths and infant deaths rates are obtained as the square root of the respective variance.
URBAN AREAS

\[ i = \text{subscript for enumeration block.} \]
\[ j = \text{subscript for stratum} \]
\[ n_j = \text{No. of sample enumeration blocks in the } j^{\text{th}} \text{ stratum.} \]
\[ N_j = \text{Total no. of enumeration block in the } j^{\text{th}} \text{ stratum.} \]
\[ J = \text{No. of stratums.} \]

Estimates of population, births, deaths and infant deaths and their variances are calculated as done for rural areas.

Using these formulas, the Birth Rates, Death Rates and Infant Mortality Rates along with their respective standard errors and percentage relative standard errors for two natural divisions of Assam have been calculated for 1995-99 and provided in the tables 3.7 to 3.13.

Based on the above data, the levels of vital rates for rural areas of various districts of Assam can be approximated as given in the Table 3.14.

3.9 Data Analysis

The following table provides the estimates based on the new approach and the estimates based on the data collected through SRS. It
has also been attempted to test the Chi-square statistic for goodness of fit. The value of \( \chi^2 = \sum (O - E)^2 / E \) at 22 degrees of freedom at 95 percent level of significance is 12.338. There are some problem in the data set for two districts viz. Kamrup and North Cachar Hill District. Otherwise, the hypothesis of equality of death rates by two methods holds good i.e. the hypothesis equality is accepted. Similar is the case for birth rates. In case of Birth rates, excluding two districts viz. Bongaigaon and Dibrugarh, the hypothesis of equality is acceptable, whereas in case of Infant Mortality Rates, there seems to be problems in the data set for as many as six districts viz. Bongaigaon Dibrugarh, Goalpara Karimganj Marigaon and Nagaon. Table 3.15 provides the data of death rates, birth rates and infant mortality rates and their values of chi-squares for acceptability of the estimates at 65 per cent level of significance.

The Value of \( \chi^2 \) excluding Kamrup and North Cachar Hills is 2.68 for Death rates. The Value of \( \chi^2 \) excluding Bongaigaon and Dibrugarh is 9.52 for Birth rates. The Value of \( \chi^2 \) excluding Bongaigaon Dibrugarh, Goalpara Karimganj Marigaon and Nagaon is 11.56 for Infant Mortality rates.
We have another source of data, which has been estimated based on 1991 census data by indirect method. From this source, it is very clear that there are some problems with the data set for the districts of Dhemaji and Karbi Anglong, where IMRs are quite far off from the values estimated by other two methods. Other than these two districts, remaining twenty one districts are in more or less conformity with the estimates of other two methods.

It is interesting to note that the highest IMR is recorded in the district of Bongaigaon by the new method, whereas the highest IMR is estimated in district of Dhubri by Census 1991. By the sample of SRS indicates the highest IMR in the district of Cachar, though it is not the case in other two methods. Geographically the two districts namely Bongaigaon and Dhubri are close to each other. Moreover IMR of Bongaigaon as per 1991 Census data is of high order of 122. So the highest IMR of Bongaigaon by the new method may be accepted. The estimate obtained through SRS, 1995-2000 suggest that the highest IMR lies in the district of Cachar followed by Karimganj, which have a sort of homogeneity as both the district lie in the same geographical location, whereas other two method suggest a moderate level of IMR. Instead of comparing individual IMR, if we compare in a particular
intervals, it can be seen that there are seven districts namely Bongaigaon, Dibrugarh, Nalbari, Kokrajhar, Golaghat, Darrang and Kamrup, whose IMR is 80 or more. The IMRs of Jorhat, Sonitpur, Barpeta, Sibsagar, Tinsukia, Cachar, Dhemaji and Lakhimpur lie in the range of 70-80 and the remaining districts have IMR less than 70. The remaining districts viz. Hailakandi, Dhubri, Karbi Anglong, Marigaon, North Cachar Hills, Nagaon, Goalpara and Karimganj have IMR less than 70.

The graph given below depicts variation of IMR among three different methods. It may be noted that data given in table 3.16 belong to three different periods. The IMR based on Census pertain to 1991, SRS pertains to 1997-98 and IMR based on the new method pertains to 2000. So there are obvious reasons to differ. However, it is expected that the IMR in the new method will be slightly lower than other two. It can be seen from the graph that IMR obtained by at least two methods for as many as sixteen districts are comparable. One can take decision based on these estimates. For better health condition facilities must be improved in the first and second categories of districts so that infant deaths can be minimized. The method developed in this chapter also includes methods for estimation of birth rates and death rates also. The
data pertaining to birth rates and death rates are not being analyzed as we are discussing health status in Assam.

Chart 3.3: Infant Mortality Rates for Assam by three different method.
It can be seen from the graph that during last ten years IMR has come down in different districts with some exception in the estimates. There needs to be done something more as the status of Assam not comparable with other advanced states like Kerala, Maharashtra, Punjab and others.

Tables pertaining to the chapter III are given in Annexure II.