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Implication of Net Shift in Population Due to Migration on Intercensal Mortality and Fertility Estimates

Introduction

FOR assessing the problems and formulating plans for health, family welfare, education, social services and many other important functions of government and private organisations, we often need the estimates of mortality and fertility rates being the major demographic components which determine the growth of population. Along with these two demographic characteristics of population, migration is also one of the important factor which not only affects the change in population estimates of but also determines changes in the estimates of mortality and fertility during a specified period.

For the bearing needs of mortality and fertility estimates for many facets of our development plans, we often resort to the quick estimates of these components through the use of standard indirect estimational procedures. In countries with less developed statistical systems where no useable and adequate data on births and deaths are available, generally the indirect methods are used to arrive at the necessary estimates of these vital components of population.

Some of the best methods through which the mortality and fertility estimates can be obtained are described very lucidly in the United Nation's "Manual IV-Methods of Estimating Basic Demographic Measures from Incomplete Data". The elaboration of these methods is, in fact, not the very purpose of this paper, however, necessary references of the techniques used in these methods have been made in this paper to analyse the impacts of migration on the vital rates. Hero

it is pertinent to note that U. N. methods or any other existing indirect methods are applicable only to the population which is closed to migration. However if there exists a significant migration the population is required to be adjusted for any net shift due to migration before the application of these indirect estimational procedures. Estimation of net migration for the specified period therefore becomes an essential part of the procedure to obtain mortality and fertility estimates.

Direct data for estimating net-shifts due to migration are rarely available in countries with less developed statistical systems. For instance in India, the only available source for analysing process of migration is the census data on migrants classified by the place of residence and duration and by other socio-economic characteristics available at decennial intervals. The Census data in India and most of the developing countries, however have the most important limitations of time-lag with regard to their availability and no direct assessment of net-shifts is possible through these data specifically for one individual constituent state.

In absence of any direct evidence for the existence of net-migration, the estimates on mortality and fertility when required on urgent basis for our plan formulation, we sometime surpass the most essential procedural step of adjusting the population for migration with a probable assumption of negligible net-migration during the period for which estimates are desired. Without having any reasonable access to such assumption, the estimates on mortality and fertility rates so obtained may prove to be either reasonable or spurious depending upon the assumption so made happens to be nearer to or far from the facts. The usefulness of estimates on vital rates so obtained therefore should be evaluated with great care with regard to the reasonability of such assumption and the purpose for which these estimates are to made use of,

In the present endeavour therefore an attempt has been made to highlight the implications of net-migration on the estimates of mortality and fertility with simple mathematical analysis with regard to our possible incorrect assumption of negligible net-migration. We have started with an assumption of population which is in fact open to migration and derived the estimate of mortality and fertility with two different propositions viz negligible net-migration and significant net migration. These two sets of estimates are then compared to arrive at certain possible conclusions with regard to the effects of net-migration over these estimates of vital rates.

This analysis is mainly attempted for an intercensal period with a view that any variation in the population of terminal census due to net-shift in population may spuriously inflate or deplete the census survival rates $(x + t/nLx)$ since the

migrants are often concentrated in certain age and sex groups, and as such a substantial volume of net-migration may strongly bias the survival rates and as a result the mortality and fertility rates may also be significantly affected.

Methodology

The main essence of our approach is to obtain mortality and fertility estimates using indirect methods for the population (open to migration) unadjusted and adjusted for migration with two different propositions referred to above and certain other assumptions narrated in the following paragraph.

Assumptions. For application of indirect methods for obtaining the estimates of mortality and fertility rates and net-shift in population, following assumptions with regard to the availability of certain basic data and other literature is made.

- (a) Availability of populations classified by age and sex for atleast two decennial censuses i.e. for initial and terminal censuses covering the period for which estimates are desired.
- (b) Availability of smoothed distribution of populations by age and sex in order to minimise errors due to age-misreporting.
- (c) Availability of a set of Model Life Tables with an assumption that an abridged form of these tables can be logically employed to construct an approximate schedule of mortality.
- (d) Availability of stable population tables, subject to the justification of their applicability.
- (e) Population under consideration is assumed to be open to migration during the period under study.

Estimation Of Net-migration Mortality and Fertility Rates. Due to our assumption of population being open to migration for the intercensal period under consideration, we are required to obtain two sets of estimates of mortality and fertility rates for the populations unadjusted for net migration and adjusted for net-migration.

For obtaining the second set of estimates with population adjusted for net-migration we need at the first instance the estimates of net-migration. Since net-migration takes place at different rates in different age groups, the same may be obtained by age and sex through methods discussed in detail in one of the authors's earlier paper on estimation of Net-Migration in Gujarat, 1951-60 and 1961-70 [4]. For ready reference the necessary equations to obtain these estimates are narrated below :

$${}_nM_x = \frac{1}{2} \Sigma [{}_nP_x (1 + {}_nS'_x) - {}_nP_{x-t}^0 (1 + {}_nS_x)] \quad (\text{A})$$

$${}_nM_{x'} = \frac{1}{4} R_1 \sum_{x=15}^{44} {}_nM_x^{(f)} \quad (\text{B})$$

$$x' \leq 2t/5$$

$$\text{and} \quad {}_nM_{x'}' = \frac{3}{4} R_2 \sum_{x=20}^{49} {}_nM_x^{(f)}. \quad (\text{C})$$

$$t/2 \leq x' \leq 9t/10$$

Where ${}_nM_x$, ${}_nM_{x'}$ and ${}_nM_{x'}'$ represent the estimates of net-migration in the age-group (x , $x - V$ n) for ages 10 years and above, under 5 years and 5 to 9 years of ages respectively. ${}_nM_x^{(s)}$ represents estimate of females net-migration in age-groups (x , $x - f - n$). ${}_nP_x$ and ${}_nP_{x-t}$ are the populations in age-group (x , $x - f$ n) at terminal census and ($-$ years younger at the initial census respectively). ${}_nS_x$ and ${}_nS'_x$ are the census survival and the reverse survival rates derived from the life-table. R_1 and R_2 are the intercensal average child-woman ratios of children aged (0-4) to women aged (15-44) and children (5-9) to women aged (20-49) respectively. Through equation (A) we can obtain the estimates for persons aged above 10 years for each sex separately, while equations (B) and (C) give estimates in age-group (0-4) and (5-9) for total persons, which on applying the sex-ratio of birth can be split by sex. Once the estimates of net-migration are obtained the population can be adjusted for net-migration and two sets of mortality and fertility estimates can be obtained as explained in the next paragraphs.

Unadjusted and Adjusted Estimates of Mortality and Fertility Rates. The underlying rationale of the method for estimation of mortality and fertility rates are based on the United Nations recommended methods and hitherto does not require much emphasis here. However, it is necessary to keep into its conceptual aspects so that the same can be made use of in our present analysis.

In these methods for obtaining indirect estimates of mortality and fertility a set of model life tables along with the records of population growth and its distribution by age. These estimates are generally obtained for one sex and then the estimates for the other sex and total persons are generated using the sex ratio at birth and the mean sex ratio of the total population. In our discussions for computational procedure we will deal in the beginning with one sex say female. The essence of computations is to find a life table (from among the model tables) which may be used to project the population of initial census to produce population of terminal census most constituent with the recorded one.

The appropriate life table may be located by trial and error and using the interpolation techniques. Mathematically the procedural steps are as under :

- Let (i) ${}_n P_{x-t}^0$ and ${}_H P_x$ are the female populations at initial and terminal census respectively in the age-group $(x, x + n)$ aparted by an intercensal period of $(-)$ years.
- (ii) ${}_n P_f$ is the adjusted female population at the terminal census.
- (iii) ${}_n M_x$ is the estimated net-shift in the female population due to migration in the age-group $(x, x + n)$ during t -years.
- (iv) ${}_n Q_x$ and ${}_n Q_x^*$ are mean unadjusted and adjusted populations in age-group $(x, x + M)$ respectively,
- (v) L_m and L_m^* are the unadjusted and adjusted median levels of mortality respectively,
- (vi) ${}_n m_x$ and ${}_n m_x^*$ are the unadjusted and adjusted life table mortality rates implied by the census survival rates in the age-group $(x, x + n)$ based on the median levels of mortality L_m and L_m^* respectively.
- (vii) S_x is the Life table survival rate at mortality level u in the age-group $(x, x + n)$.
- (viii) ${}_n P_{x,t}$ is the Projected population at mortality level w of ages t years and above. Here $t = 10$ years.

Unadjusted Estimates. The initial population ${}_n P_{x-1}^0$ can be projected to the date of terminal census by applying ${}_n S_{x,u}$ and thereby we get a set of projected values for the terminal census at different levels of mortality as under :

$$\left(P_u = \sum {}_n P_{x,u} = \sum ({}_n P_{x-1}^0 \cdot S_{x,u}) \right)$$

On the basis of set of projected P_u at different levels (u) of mortality level, it is possible to determine at least two mortality levels such that the actual census population $S {}_n P_x (x \geq t)$ can be bracketed between the projected populations P_u at these mortality levels say $it = c$ and $u = d$. Hence the mortality level say L_1 implied by the census survival rate can be obtained by interpolation as under:

$$L_1 = \frac{(d - c) ({}_n P_x - {}_n P_{x,c})}{({}_n P_{x,d} - {}_n P_{x,c})} \quad x \geq t$$

L_1 is determined for population with age 10 years and above, similarly we can determine appropriate levels of mortality for population aged 15 and above, 20

and above and so on and in this manner we get a sequence of mortality levels (sav L_1, L_2, L_3, \dots) for the proportions surviving from the earlier census ${}_n P_{x-t}^0$ to age ten and over, fifteen and over and so on at the later census. The most satisfactory level of mortality to be selected out of the sequence of levels discussed above is the median level of mortality among the first nine levels.

The death rate now can be estimated by applying the age specific mortality rates (${}_n m_x$) in the selected model table at median level of mortality (L_m) to the estimated mid-period population (${}_n Q_x$).

If D is the number of female deaths during the intercensal period, the death rate 'd' per person per year can be estimated as under:

$$d = \frac{D}{\sum {}_n Q_x} = \frac{\sum ({}_n Q_x \cdot {}_n m_x)}{\sum {}_n Q_x} \tag{E}$$

If r is the exponential growth rate of the female population then the female birth rate b can be estimated as under.

$$b = r + d \tag{F}$$

Here the exponential growth rate is considered because of the fact that it takes into account year to year increase in population and therefore is comparatively better than the simple growth rate.

The birth rate for males and total persons can be estimated by using sex ratio at birth and the sex ratio of total mean population.

Adjusted Estimates. For obtaining the adjusted estimates, the main procedure remains the same except that the population of the terminal census requires to be 'adjusted for net-shift in population due to migration during intercensal period.

The adjustment of the terminal population by age and sex can be done with the help of the estimates of net-migration (${}_n M_x$) obtained through equations (A to C) and with an assumption that the rate of net-migration has remained uniform during the intercensal period. The adjustment can therefore be done as under :

$$\begin{aligned} {}_n P_x^* &= {}_n P_x \frac{1}{2} [({}_n P_x + {}_n P_{x-t}) - {}_n M_x] \left[\frac{1}{2} ({}_n P_x + {}_n P_{x-t}) \right]^{-1} \\ \text{or } {}_n P_x^* &= {}_n P_x ({}_n P_x + {}_n P_{x-t})^{-1} [({}_n P_x + {}_n P_{x-t} - {}_n M_x)] \\ \text{or } {}_n P_x^* &= {}_n P_x [1 - {}_n M_x ({}_n P_x + {}_n P_{x-t})^{-1}]. \end{aligned} \tag{G}$$

Examining the inequalities between ${}_n P_x^*$ and ${}_n P_x$ from Equn. (G) we have following set of conditions :

(i) If ${}_nM_x < 0$

then

$${}_nP_x^* > {}_nP_x \quad (a)$$

$${}_nQ_x^* > {}_nQ_x \quad (b)$$

(ii) If ${}_nM_x > 0$

then

$${}_nP_x^* \leq {}_nP_x \quad (a)$$

$${}_nQ_x^* \leq {}_nQ_x \quad (b)$$

Examining the inequalities between ${}_nm_x^*$ and ${}_nm_x$ we have following set of conditions :

(iii) If ${}_nM_x < 0$

$$\text{then } L_m^* > L_m \text{ (due to condition (i)(a))} \quad (a)$$

$$nm_x \leq nM_x \text{ (due to conditions(iii)(a))} \quad (b)$$

The above inequalities can be explained with fact that higher terminal population generates higher level of mortality and higher survival rate, and higher survival rate generates lower life table mortality rate. Therefore, a net-shift in population in negative direction would cause a lower death rate in the population as compared to the death rate estimated on the basis of unadjusted population.

Now the relationship between the adjusted growth rate r^* and unadjusted growth rate r can be established as under :

The exponential growth rate per person during an interval of t years can be given by the following exponential curves

$$P^* = P_0 e^{r^*t} \quad (H)$$

$$\text{and } P = P_0 e^{rt} \quad (I)$$

Where P^* = Total adjusted terminal population,

P = Total unadjusted terminal population,

and P_0 = Total initial population.

Dividing equation (H) by (I) we have

$$\frac{P^*}{P} = e^{t(r^* - r)}$$

or
$$\overset{*}{r} = r + \frac{1}{t} \log_e \left(\frac{P^*}{P} \right) \quad (J)$$

and
$$\frac{*}{r} = \bar{r} + \log_e \left(\frac{P^*}{P} \right). \quad (K)$$

Where $\frac{*}{r}$ and \bar{r} represent the exponential adjusted and unadjusted growth rates per person for an interval of t years. Now on the basis of condition (i)(a) we have

(iv) If ${}_nM_x \leq 0$

then
$$\frac{*}{r} > \bar{r} \quad (a)$$

$$\frac{*}{r} > r. \quad (b)$$

and condition (ii)(a) implies the following conditions :

(v) If ${}_nM_x \geq 0$

then
$$\frac{*}{r} < \bar{r} \quad (a)$$

$$\frac{*}{r} < r. \quad (b)$$

If $\overset{*}{d}$ and d are the intercensal adjusted and unadjusted death rates per person per annum then

$$\frac{\overset{*}{d}}{d} = \frac{\sum ({}_n\overset{*}{m}_x \cdot {}_n\overset{*}{Q}_x)}{\overset{*}{Q}} \cdot \frac{Q}{\sum ({}_n m_x \cdot {}_n Q_x)}$$

hence

$$\frac{\overset{*}{d}}{d} = d \frac{\sum ({}_n\overset{*}{m}_x \cdot {}_n\overset{*}{Q}_x)}{\sum ({}_n m_x \cdot {}_n Q_x)} \cdot \frac{Q}{\overset{*}{Q}}. \quad (L)$$

Now examining the inequalities between $\overset{*}{d}$ and d , we observe that when ${}_nM_x$ is negative, ${}_n\overset{*}{Q}_x$ is greater than ${}_n Q_x$ according to the condition (i)(b) and ${}_n\overset{*}{m}_x$ is lesser than ${}_n m_x$ according to the condition (iii)(C), so that the denominator on

the right hand side of the equation (L) will either be greater or equal or less than its numerator depending upon values of the product terms $\Sigma ({}_n\dot{m}_x \cdot {}_n\dot{Q}_x)$ and $\Sigma ({}_n\dot{m}_x \cdot {}_nQ_x)$. But since ${}_n\dot{Q}_x$ and ${}_nQ_x$ are the mid values of the terminal and initial population while ${}_n\dot{m}_x$ and ${}_nm_x$ largely depend on the values of the terminal populations, the variation between these adjusted and unadjusted mortality rates will be higher than the variation between ${}_n\dot{Q}_x$ and ${}_nQ_x$. Hence for death rates we have the following set of conditions for

(vi) If ${}_nM_x \leq 0$

then $\dot{d} < d$. (a)

(vii) If ${}_nM_x \geq 0$

then $\dot{d} \geq d$. (a)

The above two conditions show that if there exists a negative or positive net-migration in an area then we will get depleted or inflated estimate of death rate respectively if the population is not adjusted for net-shift in population due to migration.

Now if $\frac{*}{b}$ and \bar{b} are the adjusted and unadjusted birth rates per person for t -years and $\frac{*}{d}$ and \bar{d} are similar death rates then we have the following equations :

$$\frac{*}{b} = \frac{*}{r} + \frac{*}{d} \quad (M)$$

and

$$\bar{b} = \bar{r} + \bar{d} \quad (N)$$

Substituting the value of $\frac{*}{r}$ from equation (K) in equation (M) we get :

$$\frac{*}{b} = \bar{r} + \log_e \left(\frac{\dot{P}}{P} \right) + \frac{*}{d} \quad (O)$$

Substituting the value of \bar{r} from equation (N) in equation (O) we get :

$$\frac{*}{b} = (\bar{b} - \bar{d}) + \log_e \left(\frac{\dot{P}}{P} \right) + \frac{*}{d}$$

or
$$\left(\frac{*}{b} - \frac{*}{d}\right) = (\bar{b} - \bar{d}) + \log_e \left(\frac{\dot{P}}{P}\right). \quad (P)$$

Hence

$$(\dot{b} - \dot{d}) = (b - d) + \frac{1}{t} \log_e \left(\frac{\dot{P}}{P}\right). \quad (Q)$$

Now equation (Q) provides as the following conditions for birth rate per person per annum.

(viii) If ${}_nM_x \geq 0$

then
$$(\dot{b} - \dot{d}) \leq (b - d) \text{ since } \dot{P} \leq P \quad (a)$$

$$\dot{b} \geq b \text{ since } \dot{r} \geq r \text{ and } \dot{d} \geq d. \quad (b)$$

Hence conditions Viii(a) and viii(b) show that in case of positive net-migration in the population we will get an inflated rate of natural growth and an depleted birth rate if population is not adjusted for net-shift in population due to migration, and in case of a negative net-migration the unadjusted terminal population will give rise to depleted natural growth rate and inflated birth rate.

The above conditions can also be examined in determining the variations between the adjusted and unadjusted general and total fertility rates, gross reproduction rates and the net-reproduction rates and the population.

Since the value of the general fertility rate depends on the total number of births and the female population count in the age-group (15-44), the unadjusted population would give rise to depleted estimate of fertility rate if there is a positive net-shift in the population of both the sex. In case there is an overall positive net-shift in the total population but a negative net-shift in the female population in the set-group (15-44) the extent of inflation or depletion would depend on the extend of net-shifts in both the sex.

The above sets of conditions obtained from various inequalities in respect of mortality rate and birth rate very specifically point cut the implications of net* migration on the vital rates and caution us about the far-reaching and indirect effects in utilising the unadjusted estimates of mortality and fertility without having any proper access to extent of net-shift in population during the period under consideration.

In the succeeding paragraphs we have attempted to analyse such implications for Gujarat during 1961-71 as a case study.

Implications of Net Migration on Mortality and Fertility, Gujarat, 1961-71.

Gujarat is one of the most developed and leading urbanised states of the Indian Union. The fast developing economy of the state can be very well viewed through the growth rate of 11.33 percent of its state domestic product (SDP) at current prices during 1961-62 to 1976-77 as againsts the 10.99 percent growth rate of the net-domestic product of the country as a whole [2]. In view of the percent urban population, Gujarat has ranked third as compared to other states during the last two decades. The percentage of population living in urban areas had increased from 21 to 28 percent during 1961-1971 and during the last decade (1971-81) it marked an increase of 3 percent points. The annual exponential growth rates of urban population have remained in the neighbourhood of 3.6 and 3.5 percent during 1961-71 and 1971-81 respectively. Such a high rate of growth of urban population prompt us to assume that along with the natural growth rate the inflow of net migration might also have contributed to large extent to the growth of state's population which has grown at an annual exponential rate of 2.6 percent during 1961-71 and 2.4 percent during 1971-81. Hitherto, we had attempted to compute the estimates of net-migration in the state during 1951-61 and 1961-71 and according to these estimates the state had an inflow of nearly 3.17 lakhs and 3.52 lakhs of net-migrants during the above two decades respectively. The average rates of net-migration were estimated at 1.7 and 1.5 per 1000 population per year during 1951-61 and 1961-71 respectively. Such a high rate of positive net-migration inspired us to attempt the present case study especially to evaluate the implications on the birth and death rates of the state during 1961-71. We could have extended this analysis for the period 1971-81, but for the want of necessary data on population by age and sex etc. for the 1981 census, which are still under finalisation with the census authorities.

For our analysis we adopted the smoothed distribution of 1961 and 1971 census populations by age and sex. The smoothing was mainly done in order to remove the effects of age mis-reporting. For obtaining the migration-adjusted birth and death rates, the 1971 census population was adjusted using the estimates of net-migration by age and sex.

The population of 1961 census was projected to produce the 1971 population most consistent with the recorded one by applying 10 year cohort survival rates at various levels of mortality and a series of mortality levels were obtained as

discussed earlier. The process was repeated for the adjusted 1971 population also. On the basis of the median levels of mortality for adjusted and unadjusted populations the intercensal female crude death and birth rates were obtained in the manner discussed in preceding pages. Similar rates for males and persons were also obtained on the basis of female death rate and birth rate and the sex ratio at birth and the sex ratio of the total mean population for the period 1961-71.

The adjusted and unadjusted death rates obtained are presented in Table 1.

TABLE 1—AVERAGE ADJUSTED AND UNADJUSTED CRUDE DEATH RATES IN GUJARAT DURING 1961-71 CORRESPONDING TO MEDIAN LEVELS OF MORTALITY IMPLIED BY THE CENSUS SURVIVAL RATES

	<i>Crude death rates, 1961-71</i>		<i>Percent variation</i>
	<i>Adjusted</i>	<i>Unadjusted</i>	
Persons	16.78	15.96	(-) 4.88
Males	16.68	15.84	(-) 5.04
Females	16.90	16.10	(-) 4.73

A depletion in the unadjusted death rates works out to about 5 percent as compared to the adjusted death rates. Since there was a positive net-migration in the state during 1961-71 the unadjusted death rate has been depleted as was shown under the condition vi (a).

The birth rates computed on the basis of death rates obtained above and the corresponding exponential growth rates by sex are presented in Table 2.

TABLE 2—AVERAGE ADJUSTED AND UNADJUSTED BIRTH RATES IN GUJARAT DURING 1961-71 IMPLIED BY THE DEATH RATES AND THE EXPONENTIAL GROWTH RATES

	<i>Crude birth rates, 1951-11</i>		<i>Percent variation</i>
	<i>Adjusted</i>	<i>Unadjusted</i>	
Persons	41.61	41.13	(—) 1.03
Males	41.35	40.87	(—) 1.16
Females	41.90	41.53	() 0.88

A little more than one percent depletion in the unadjusted birth rate for the total population has been observed. It is important to note here that the adjusted estimates of birth and death rates are very much close to the estimates computed by the census actuaries [6], viz. 41.6 and 16.8 respectively for the intercensal period 1961-71.

Such depleted estimates of birth and death rates if considered for long term plan formulations related to health, family welfare and other socio-economic fields, may give rise to spurious targets which ultimately may not enable us to meet our desired goals.

Similar variations of the order of 2 to 3 percent between the adjusted and unadjusted estimates on general fertility, net and gross reproduction rates have also been observed in our present attempt. Due to positive net-migration and depleted mortality rates for the unadjusted population the estimate of expectation of life at birth works out to be an inflated one as shown in Table 3.

TABLE 3—ESTIMATED ADJUSTED AND UNADJUSTED EXPECTATION OF LIFE AT BIRTH (e_0) DURING 1961-71 IMPLIED BY THE MEDIAN LEVELS OF MORTALITY

	<i>Expectation of life at birth (e_0)</i>		
	<i>Adjusted</i>	<i>Unadjusted</i>	<i>Percent variation</i>
Persons	47.92	48.84	(+) 1.92
Males	47.61	48.45	(+) 1.76
Females	48.25	49.25	(+) 2.07

The inflation in the estimates of e_0 works out to about 2 percent. Hence, we have seen that Gujarat being a state of fast developing economy and experiencing a significant rate of positive net-migration in its population since last few decades and as a result its mortality and fertility characteristics getting distorted. It suggests therefore that while making projections for various components of the population the trend of migration component in the State's population must invariably be considered.

Summary and Conclusions

The population of an area with a fast developing economy is generally subject to a net-shift due to net migration during a course of time. Such net-shifts, in

population impute distorted estimates of mortality and fertility rates being the most important characteristics of population required for the formulation of plans and programmes in various important fields of developments if computed without resorting to the necessary adjustments for migration at the appropriate stage of estimational procedures.

The findings of the present analysis therefore suggest that one should not possibly ignore the possibilities of net-shifts in the population due to migration without any valid reason while estimating the vital rates even for a smaller area like sub-region or sub-division specifically where long term health or family welfare programmes are required to be planned. The practical exercise in our case study for Gujarat has also suggested that state like Gujarat would definitely experience such inflation or depletion in the mortality and fertility rates if based on an un-adjusted population under consideration. Similar analysis if attempted by selecting two groups of states viz.: (i) More developed, and (ii) comparatively less developed in respect of industrialisation and urbanisation may throw very interesting results and give more justification to the present analysis.

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APPENDIX

TABLE 1— MALE POPULATION OF 1961 AND 1971 CENSUS, ESTIMATED MALE NET-MIGRATION DURING 1961-71 BY AGE-GROUP AND MIGRATION ADJUSTED POPULATION OF 1971, GUJARAT

Age	Census population*		Male net-migration (thousands)	Adjustment factor for migration	Migration adjusted population 1971 (thousands)
	1961 Census	1971 Census			
1	2	3	4	5	6
0-4	1900	2336	11	.9974	2380
5-9	1330	1747	23	.9926	1734
10-14	1306	1694	<-)34	1.0115	1713
15-19	1016	1439	195	.9264	1333
20-24	954	1272	45	.9802	1247
25-29	820	973	21	.9884	962
30-34	716	894	4	.9975	892
35-39	607	754	(-)9	1.0067	759
40-44	521	642	(-)20	1,0175	653
45-49	423	550	—	1.0000	550
50-54	369	455	3	.9964	453
55-59	248	353	3	.9950	351
60-64	169	281	(-)13	1.0297	289
65-69	118	184	2	.9934	183
70+	136	178	10	.9691	173
Total	10633	13802	241	—	13672

*Smoothed male population,

†Estimated by authors.

TABLE 2—FEMALE POPULATION OF 1961 AND 1971 CENSUS, ESTIMATED NET-MIGRATION DURING 1961-71 BY AGE-GROUP AND MIGRATION ADJUSTED POPULATION OF 1971, GUJARAT

Age	Census population* 1961/1971 (thousands)		Female net- migration^ (thousands)	Adjustment factor for migration	Migration adjusted population, 1971 (thousands)
(1)	(2)	(3)	(4)	(5)	(6)
0-4	1809	2255	11	0.9973	2249
5-9	1255	1636	21	0.9929	1624
10-14	1208	1557	(-66)	1.0245	1595
15-19	958	1248	65	0.9714	1212
20-24	900	1200	37	0.9827	1179
25-29	773	931	4	0.9977	929
30-34	677	857	(-2)	1.0013	858
35-39	559	707	(-2)	1.0016	708
40-44	474	600	4	0.9963	598
45-49	402	525	45	0.9537	501
50-54	337	420	19	0.9755	410
55-59	225	320	(-19)	1.0361	332
60-64	160	265	(-12)	1.0291	273
65-69	122	190	17	0.9483	180
70+	141	184	(-10)	1.0317	190
All Ages	10000	12895	112	—	12838

•Smoothed female population.
Estimated by the authors.

TABLE 3—MEAN ESTIMATED POPULATION ADJUSTED AND UNADJUSTED
FOR NET-MIGRATION BY AGE-GROUP, GUJARAT, 1961-71

(000)

Age	Mean unadjusted population (1961-71)			Mean adjusted population (1961-71)		
	Males	Females	Persons	Males	Females	Persons
(1)	(3)	(3)	(4)	(5)	(6)	(7)
0-4	2143	2032	4175	2140	2029	4169
5-9	1539	1446	2985	1532	1440	2972
10-14	1500	1383	2883	1510	1402	2912
15-19	1228	1103	2331	1175	1085	2260
20-24	1113	1050	2163	1101	1040	2141
25-29	897	852	1749	891	851	1742
30-34	805	767	1572	804	768	1572
35-39	681	633	1314	683	634	1317
40-44	582	537	1119	587	536	1123
45-49	487	464	951	487	452	939
50-54	412	379	791	411	374	785
55-59	301	273	574	300	279	579
60-64	225	212	437	229	217	446
65-69	151	156	307	151	151	302
70+	157	163	320	155	166	321
All Ages	12221	11450	23671	12156	11424	23580

TABLE 4—FEMALE POPULATION UNADJUSTED FOR MIGRATION OF GUJARAT AT AGE X AND OVER IN 1971 AS REPORTED BY CENSUS 1971 AND AS PROJECTED FROM 1961 ASSUMING VARIOUS LEVELS OF MORTALITY IN "WEST" FEMALE MODEL LIFE TABLES

Age (X and over)	1971 Census population (thousands)	Projected population assuming various mortality levels				e_0
		Level-11	Level-13	Level-15	Level (h)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
10	9004	8857	9031	—	12.7	49.25
15	7447	—	7354	7467	14.6	54.00
20	6199	—	6147	6248	14.0	52.50
25	4999	—	4993	5082	13.1	50.25
30	4068	3992	4088	—	12.6	49.00
35	3211	3164	3246	—	21.1	47.75
40	2504	2460	2529	—	12.3	48.25
45	1904	1850	1907	—	12.9	49.75
50	1379	1353	1399	—	12.1	47.75

TABLE 5—MIGRATION ADJUSTED FEMALE POPULATION OF GUJARAT AT AGE X AND OVER IN 1971 AND AS PROJECTED FROM 1961 ASSUMING VARIOUS LEVELS OF MORTALITY IN "WEST" FEMALE MODEL LIFE TABLES

Age (X and over)	1977 census population (thousands)	Projected population assuming various mortality levels				e_0
		Level-11	Level-13	Level-15	Level(h)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
10	8965	8857	9031	—	12.2	48-75
15	7370	—	7354	7467	13.3	53.25
20	6158	—	6147	6248	13.2	53.00
25	4979	4884	4993	—	12.7	49.25
30	4050	3992	4088	—	12.2	48.00
35	3192	3164	3246	—	11.7	46.75
40	2484	2460	2529	—	11.7	46.75
45	1886	1850	1907	—	12.3	48.25
50	1385	1353	1399	—	12.4	48.50

TABLE 6-CALCULATION OF THE AVERAGE (UNADJUSTED FOR MIGRATION)
FEMALE CRUDE DEATH RATE IN GUJARAT 1961-71 CORRESPONDING
TO THE MEDIAN LEVEL OF MORTALITY IMPLIED BY CENSUS
SURVIVAL RATES

<i>Age X</i>	<i>Mean population (1961-71) (thousands)</i>	<i>Death rates per thousand at age X' in median life table level 12.7</i>	<i>Average annual deaths at age X (thousands) (Col. 2 x Col. 3)</i>
(1)	(2)	(3)	(4)
0-4	2032	44.3	90018
5-9	1446	4.5	6507
10-14	1383	3.5	4841
15-19	1103	4.8	5294
20-24	1050	6.1	6405
25-29	852	6.9	5879
30-34	767	7.9	6059
35-39	633	8.8	5570
40-44	537	9.8	5263
45-49	464	11.4	5290
50-54	379	15.3	5799
55-59	273	20.5	5597
60-64	212	30.8	6530
65-69	156	44.7	6973
70 +	163	112.2	18289
All Ages	11450	516.10*	184314

* (Sum of Col. 4)/(Sum of Col. 2).

TABLE 7—CALCULATION OF THE AVERAGE (ADJUSTED FOR MIGRATION)
FEMALE CRUDE DEATH RATE IN GUJARAT 1961-71 CORRESPONDING
 TO THE MEDIAN LEVEL OF MORTALITY IMPLIED BY CENSUS
 SURVIVAL RATES

<i>Age X</i>	<i>Mean population (1961-71) (thousands)</i>	<i>Death rates per thousand at age X in median life table level 12.3</i>	<i>Average annual deaths at age X (thousands) (Col. 2 x Col. 3)</i>
<i>0)</i>	<i>(2)</i>	<i>(3)</i>	<i>(4)</i>
0-4	2029	46.8	94957
5-9	1440	4.7	6768
10-14	1402	3.7	5187
15-19	1085	5.0	5425
20-24	1040	6.4	6656
25-29	851	7.2	6127
30-34	768	8.2	6298
35-39	634	9.2	5833
40-44	536	10.2	5467
45-49	452	11.8	5334
50-54	374	15.8	5909
55-59	279	21.1	5887
60-64	217	31.7	6879
65-69	151	45.9	6931
70 +	166	113.4	18824
All Ages	11424	16.9*	192482

*(Sum of Col. 4)/(Sum of Col. 2).