Studies
in
Population and Development

No. 05-03
Age and Sex Distribution of Population of Madhya Pradesh, India

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February 2005

Introduction

The synergies between demographic growth, age distribution and population momentum, on one hand, and economic growth and development on the other, have long been debated amongst policy makers and the research community. The focus of this debate has been on how does high fertility affect poverty and how does poverty affect high fertility, what policies should be in place to promote development and ease population growth and what is the impact of population stability on economic growth and development. In 1986, a comprehensive review by the United States National Academy of Science concluded that "slower population growth is beneficial to economic development for most developing countries" (National Research Council, 1986). Current research identifies new evidence that results in a debate between three alternative positions: does population growth restrict, promote, or is it independent of economic growth (Bloom, Canning and Sevilla, 2001). Each position has the evidence to support their case. However, each of these explanations focus on population size and growth and under-emphasize perhaps the most critical issue: the age distribution of the population. The age distribution (the way in which the population is distributed across different age groups) can dramatically change as the population grows or shrinks. Notwithstanding these controversies, a significant consensus has emerged around the idea that rapid population growth exerts severe constraints on countries and regions at low levels of socioeconomic development (May, *forthcoming*; Birdsall and Sinding, 2001).

People's economic behavior changes at different stages of life. Therefore, changes in a country's age structure can have significant effects on its economic performance (Bloom, Canning and Sevilla, 2001). In developing countries that have not yet gone through a demographic transition, high fertility and mortality indicates high child-dependency ratios and low old-age dependency ratios As the demographic transition begins to take place, mortality begins to decline causing an increase in the proportion of children in the population, which increases the dependency ratio. Fertility then begins to decline, which initiates a period of declining child-dependency ratios and declining total dependency ratios. Finally, the elderly population begins to increase and old-age dependency ratios and total dependency ratios rise. At the end of the demographic transition, often the dependency ratio equals that what it was prior to the transition. However, the age composition of the population at the end of the demographic transition is enormously different than the age composition of the population at the beginning of the transition (Chu and Lee, 2000). In the middle of the demographic transition, a high proportion of a country's population falls within the working age group resulting in a low

dependency ratio. In this demographic situation, the added productivity of the working group can produce a window of economic opportunity. This may also lead to higher savings rate which could contribute to economic growth and increasing life expectancy can add to this effect (Chu and Lee, 2000). The size of this window, or demographic bonus or dividend as it has become characterized, depends on the duration and pace of fertility decline and, to a lesser extent, the way in which mortality decline affects infants and children (Merrick, 2004). The recent analysis of economic change in East Asian countries has shed light on the impact of sharp fertility declines on economic performance (May, *forthcoming).* The experience of the East Asian countries suggest that countries or populations undergoing their demographic transition have an opportunity to capitalize on the demographic bonus. However, changes in the age structure can only be exploited when they are accompanied by adequate investments and sound public policies. Further, the demographic bonus is not a permanent state, but rather an opportunity that must be seized over a relatively short period of time before population aging sets in (Bloom, Canning and Sevilla, 2001). This phenomena has shown, for the first time, that demographic conditions could also be favourable to economic growth in the developing societies (Bloom and Williamson, 1998; Cutler et al. 1990; Kelley and Schmidt, 1995, 2001; Mason and Lee, 2004).

In this paper, we analyse the age distribution of the population of Madhya Pradesh, as it exists today, in the context of economic growth and development. The state of Madhya Pradesh came into existence for the first time in 1956 as the result of the reorganisation of Indian states on the linguistic basis. In the year 2000, the then state of Madhya Pradesh was divided into the states of Chhattisgarh and existing Madhya Pradesh. It is one of the least developed states of India and the process of demographic transition in the state appears to have started only recently. The average annual population growth rate in the state still continues to be more than 2 per cent per year but the state has recorded a sharp decrease in this rate during the decade 1991-2001 as the data available from the 2001 population census reveal (Ranjan, 2004). Although, Madhya Pradesh is a poor state in terms of both demography and development, yet there has been little systematic investigation of the age distribution of the population of the state in terms of the implications of the age structure on demographic transition as well as in terms of social and economic development. In the context of possible demographic dividend, it is important that the key features of the age structure of the population are analysed and taken into consideration during the social and economic development planning process.

Age distribution of the population has important implications to both demographic transition and social and economic development. Age distribution of the population is vitally important to understanding the fertility, mortality and migration processes. At the same time, the age and sex distribution and changes in this distribution over time have important implications for marriage patterns, labour force participation and gender relations (South and Trent, 1988; Poston et al. 1997; Hobbs 2003). As a basic demographic variable, age structure is intertwined with all other demographic variables. It affects and is affected by the levels and trends in fertility, mortality and patterns of migration. Births, deaths and migration are not age independent. The risk of death varies sharply with age. Similarly, migration is highly age and sex selective and births are concentrated to women of child bearing ages only. Consequently, the number of births and deaths in any population and the level of in- and out-migration are determined not only by the its overall size and levels of fertility, mortality and migration but also by its age and sex composition.

Given the linkages between the age and sex distribution of the population and economic growth, the age and sex structure of the population enters into the decision-making process at each stage of the development planning (Mukherjee, 1976). Development planning is a step-by-step process. It first involves a statement of goals and objectives to be achieved. The next step in the development planning process is the formulation of a strategy to achieve the stated goals and objectives. Finally, the last step in the development planning process is the preparation of the plan for the implementation programmes, projects and activities to achieve the development goals and objectives in the light of the strategy formulated. In a country like India, one of the cherished goals of the developing planning process is the elimination of the abject poverty. One of the elements of the poverty eradication programme is the expansion of employment opportunities. The expansion of the employment opportunities is also necessary for both the purpose of wiping off the unemployment backlog and to provide employment to new entrants into the labour force. Obviously, the knowledge of the age and sex composition of the population is essential for making estimates of existing unemployment and the present and future size of the labour force for which employment generation opportunities need to be created in the economic and social production systems. Maximization of productivity and maximization of employment per unit of capital are often incompatible and conflicting goals. The size of the labour force, depending on the age and sex composition of the population, is one of the criteria which can help in judging the relative merits of the two goals.

Data and Methodology

The analysis presented here is based on the age and sex data available through the decennial population census in India. India has the distinction of having unbroken series of decennial population census beginning from 1881. The unbroken series of population census in India provide and extraordinary valuable storehouse of information for demographic analyses and for analysing the demographic impact of social and economic development processes. A very useful information available from different population census is the information related to the age and sex composition of the population. The present analysis uses the age and sex data available from different population census beginning from 1961 population census through the latest 2001 population census for the analysis of the age and sex composition of the population of Madhya Pradesh as it exists today and the changes that have taken place in this composition during the 40 years under reference. As discussed earlier, the 1961 population census was conducted after the formation of the state of Madhya Pradesh, for the first time, in 1956 while the 2001 population census was conducted immediately after the bifurcation of Madhya Pradesh into the states of Chhattisgarh and existing Madhya Pradesh. The present analysis is confined to the Madhya Pradesh as it exists today (excluding Chhattisgarh).

The analysis concentrates on three aspects of the age and sex composition of the population of Madhya Pradesh: understanding the age and sex composition of the population; analysing the changes in the age and sex composition of the population that have taken place in the state in the forty years between 1961 and 2001; and projecting the changes in the age distribution of the population in the first 50 years of the present century - between 2001 and 2051. For understanding the age and sex composition of the population, the analysis presented here employs indexes and methods described by Spiegelman (1969) Shryock and Siegel (1976) and Arriaga (1994) that are designed to described age and sex composition, to evaluate age and sex data and to entertain demography related reasons for their differences. These indexes have also been used to project the changes in the age and sex distribution of the population in the next fifty years. On the other hand, the Lorenz curve (Hainsworth, 1964) and associated indexes of dissimilarity have been used for analysing changes in the age and sex composition of the population that have taken place in the forty years between 1961 and 2001. Finally, based on the findings of the analysis, the paper also discusses key social and economic implications of the transition over time in the age and sex composition of the population.

The Population Pyramid

The age and sex composition of the population may be analysed in a number of ways. One way is to analyse separately the age data and the sex data. The other way is to cross-tabulate the age data by sex. The population pyramid is the most popular method for the analysis of the age data cross tabulated by sex.

The population pyramid for the existing Madhya Pradesh generated from the age and sex data available from 1961 through 2001 population census are shown in figure 1. In 1961, the population of the state was very young; more than 41 per cent of the state population was below than 15 years of age. In 1971, the state population turned even more young; more than 44 per cent of the state population was below 15 years of age probably because of the increase in the levels of fertility between 1961 and 1971. However, after 1971, the state population turned older albeit very slowly. In between 1971 and 2001, the proportion of population below 15 years of age decreased by about 5 points but in reference to 1961, this decrease was just about 2.5 absolute points from 41.26 per cent in 1961 to 38.69 per cent in 2001. In any case, the observed decrease in the proportion of population below 15 years of age after 1971 is a reflection of the decrease in fertility, although the rate of decrease appears to be very slow.

The decrease in the proportion of population below 15 years of age has resulted in an increase in the proportion of population of other age groups. Thus the elderly population - population with age 60 years and above - increased from around 5 per cent in 1961 to more than 7 per cent in 2001 whereas the proportion of population in the working age group, age group 15-59 increased by more than 4 points between 1971 and 2001 but by less than 0.5 points between 1961 and 2001. Among the working age population, the increase in the proportion was more rapid in the young working ages - age group 15-29 years - as compared to old working ages - age group 30-59 years.

In terms of absolute numbers, the population below 15 years of age increased by more than 13.66 million or by 2.4 times from 9.59 million in 1961 to 23.25 million in 2001. Similarly, population in the age group 15-29 years increased by about 9.60 million or by 2.62 times from 5.92 million in 1961 to 15.52 million in 2001. A similar situation prevailed in the age group 30-59 years in which the population increased by more than 10 million from 6.57 million in 1961 to 17.13 million in 2001. The most rapid increase has however been recorded in the old age group where the population increased from just about 1 million in 1961 to more than 4 million in the year 2001. In other words, between 1961 and 2001, the population of the state increased by around 37

million. Nearly 37 per cent of this increase was accounted by the increase in the age group 0-14 years whereas the age group 15-59 years accounted for almost 55 per cent of this increase. By contrast, the increase in the population with at least 60 years of age accounted for only about 8 per cent of the total increase in population.

Changes in the age composition of the population of the state since 1961 is well reflected in the changes in the dependency ratio. The dependency ratio is defined as the ratio of the population measured in consuming units to the population measured in producing units (Meade, 1979). Here the population measured in consuming units is the sum of the population in different age and sex groups, each weighed by its relevant specific needs rate. Similarly, the population measured in the producing units is the sum of the population in different age and sex groups, each weighed by its relevant specific work rate. If it is assumed that the specific need rates and specific work rates for different age and sex groups of the population are fixed, regardless the level of standard of living, then the dependency ratio depends solely upon the age and sex composition of the population. In this limited definition of dependency ratio, population below 15 years of age and population 60 years and above are regarded as dependents and the working age population, population in the age group 15-59 years, is regarded as supporters to the dependent population.

In Madhya Pradesh, the dependency ratio increased from 861 dependents (young and old) per 1000 working age population in 1961 to 993 in 1971, primarily because of a very rapid increase in the young dependency ratio from 768 in 1961 to 878 in 1971. The increase in the young dependency ratio between 1961 and 1971 again suggests a substantial increase in fertility in the state between 1961 and 1971. Since 1971, however, the young dependency ratio has shown a declining trend and this ratio, in 2001 was 712 which is well below the level that prevailed in 1961.

In contrast to the young dependency ratio, the old dependency ratio has increased throughout the period 1961 through 2001 which reflects improvements in mortality situation in the state during the 40 years between 1961 and 2001. The net increase in the old dependency ratio since 1971 has however been less than the net decrease in the young dependency ratio with the result that the dependency ratio for the whole population has shown a declining trend.

Figure 1 also reveals differences in the changes in the age composition of male and female populations. In the population below 15 years of age, males outnumber females and the ratio of males to females has increased over time in this age group. A similar situation exists in the young working age group (15-29 years) where the increase in this ratio has been quite rapid since 1961. By

contrast, the ratio of males to females in the age group 30-59 years has decreased over time although males continue to out number females in this age group also. Finally, in the old population (60 years and above), the trend in the ratio of males to females is not monotonous. This ratio increased between 1961 and 1971, remained stagnant between 1971 and 1981, increased sharply between 1981 and 1991 and decreased, again very sharply, between 1991 and 2001.

On the whole, the population pyramid of the state continues to be triangular in shape with a broad base and a thin top despite the fact that some important changes in the age and sex composition of the population have taken place in the 40 years under reference. The means that the population of the state continues to be predominantly very young. Such a population pyramid and the age composition of the population is very conducive to rapid population growth in the years to come despite decrease in the levels of fertility. The momentum generated as the result of the very young age structure of the population of the state will offset, to a significant extent the decrease in fertility levels as far as population growth is concerned. This means that despite reductions in the levels of fertility and mortality, the population of the state will continue to increase rapidly, at least, in the intermediate future primarily because of the momentum for increase generated by the very young age structure of the population.

The projection of the population of the state for the first half of the present century indicates that there is going to be some significant change in the age structure in the next 50 years (Ranjan, 2004). It is projected that the shape of the population pyramid of the state will change from the triangular shape characterised by the broad base and thin top to a rectangular shape in the next fifty years (Figure 2). This projection is based on the assumption that the state will be able to reach the replacement level fertility by the year 2021 and beyond the year 2021, the replacement level fertility will be maintained. Because of the decline in the levels of fertility, the concentration of the population will shift from the younger population (population in the age group 0-14 years) to the working age population (population in the age group 15-59 years). The projection exercise suggests that proportion of the young population in the state will monotonically decrease from around 38 per cent in 2001 to just above 20 per cent by the year 2051 whereas the proportion of old population will monotonically increase from around 6 per cent in 2001 to 16 per cent during the same period. By contrast, the proportion of the working age population will first increase and then decrease during this period. It is project that the proportion of the working age population will increase from around 55 per cent to more than 65 per cent between 2001 and 2031. In the year 2031, two out of every three persons in the state are projected to be

working age persons. Beyond the year 2031, the proportion of working age population is projected to decrease with the result that by the year 2051, the proportion of the working age population will constitute around 63 per cent of the total population of the state. Thus, in contrast to projected changes in the proportion young and old populations of the state, the proportion of the working age population in the state is projected to follow a reverse U trend in the first 50 years of the present century.

The demographic opportunity or dividend resulting out of the transition in the age distribution of the population of the state in the first half of the present century should now be clear. In the first thirty years of the present century, the proportion of the working age population in the state is project to increase by a massive 10 per cent. This means, that in the next 30 years, the prospective labour force in the state is projected to increase at a very rapid rate. If this prospective labour force is put to effective productive utilisation, there is every possibility that the economy of the state will grow at a very rapid rate which will have far reaching implications for poverty eradication and social and economic development. On the other hand, it is also clear that if this prospective labour force is not productively utilised, it is going to be a big demographic liability in terms of social and economic development and the quality of life of the people.

The demographic dividend or opportunity resulting out of the transition in the age structure of the population is very well reflected in the projected trend in the dependency ratio which is the ratio of the dependent population (population in the age group 0-14 years and population in the age group 60+) to the working age population (population in the age group 15-59 years). In the year 2001, the dependency ratio in Madhya Pradesh was estimated to be about 800 dependents for every 1000 working age people. This ratio is projected to decrease rapidly till 1931 to reach an all time low of just 529 dependents for every 1000 working age people. Beyond 1931, the dependency ratio is expected to increase again largely because of some very rapid increase in the old age population to reach the value of 580 by the year 1951. This means, that the resources demand for supporting the dependent population will be at its minimum around the year 1931 with the result that the resources available for productive utilisation will be at their maximum around this time. Obviously, if these resources are astutely utilised in the social and economic production system, significant acceleration in the growth of the economy of the state will be possible. It is also obvious that this demographic opportunity or dividend will start shrinking after 1931 again because of the increase in the dependency ratio as the result of continued transition in the age distribution of the population.

The foregoing analysis reveals that Madhya Pradesh has a unique opportunity in the next 25-30 years to cash on the demographic opportunity resulting out of the transition in the age structure of the population in accelerating economic growth thereby improving the quality of life of the people. There is a need of evolving appropriate policies and programmes for economic and social development in the light of the projected transition in the age distribution of the population presented in this analysis. The most critical issue in this direction is to chalk out strategies and programmes that can lead to the productive utilisation of the working age population that is expected to increase very rapidly in the coming years because of the reduction in the levels of fertility. It is also clear that if this rapidly increasing population is not effectively utilised in the social and economic productive systems, the resultant situation may be catastrophic as the working age population is also the major consumers of the available resources. It is therefore important that development planning in general and economic development planning in particular takes into consideration that transition in the age distribution of the population of the state that is projected in the coming years.

Age Ratios

The age composition of the population may also be examined in terms of age ratios for five-year age groups (United Nations, 1955). An age ratio in any 5-year category is the ratio of the population in that age group to the average population of adjacent (preceding and following) age groups for every hundred population in the reference age group. In the absence of any major fluctuations in fertility and mortality and with insignificant levels of migration, the age ratios should be fairly similar across the age categories (Arriaga, 1994). This means that if there are no violent fluctuations in fertility and mortality or big waves of migration (which is often age-selective), and if the number of persons in successive age-groups gradually deplete through the incidence of mortality, the age ratio for any age group should be approximately 100. By contrast, if there are fluctuations in fertility and mortality or if migration, in as well as out, is significant, age ratio for different age groups may deviate significantly from the normative value of 100. The age ratio may also deviate from 100 if there is misreporting of age or differential omission in enumeration of persons belonging to a given age or both. At the same time, it is well known that the age curve is not linear. Hence, even if the age data are completely accurate, the age ratios may deviate from the normative value of 100.

Figure 4 presents the graph of age ratios for males and females for each of the 5-year age groups from 5-9 through 70-74 for existing Madhya Pradesh for different population census. In general age ratios fluctuate within the

narrow range of 90 to 110 for ages less than 50 years in all population census but fluctuate violently in ages 50 years and above. In 2001, the highest age ratio is 124.8 for males in the age group 60-64 years and 116.2 for females again in the same age group. On the other hand, the lowest age ratio is 79.8 for males in the age group 55-59 years and 82.3 for females in the age group 15-19 years. An age ratio of 82.3 for females in the age group 15-19 years means that there are 17.7 per cent less females in the age group 15-19 years than the average number of females in the two adjacent age groups, i.e. age group 10-14 and age group 20-24. Similarly, the age ratio of 124.8 for males in the age group 60-64 years means that there are almost 25 per more males in the age group 60-64 years than the average number of males in the two adjacent age groups.

Variations in age ratios primarily reflect age misreporting or differential omission of persons of a specific age group at the time of enumeration or both. They may also be the result of significant changes in the levels of mortality and patterns of migration resulting from say war or natural catastrophe. They should however not be taken as valid indicators of error for particular age group (Shryock and Siegel, 1976).

Changes in the Age Composition

The essential similarity of the age composition of the Indian population over time in contrast to the age composition of West European and North American countries is well known (Mukherjee, 1976). The transition in the age composition of population of West European and North American countries is marked by a steep fall in the proportion of population in the younger ages, a remarkable increase in the population of old ages, and a slight increase in the proportion of working age population. This pattern of transition is attributed to the decline in fertility (United Nations, 1958). On the other hand, the near constancy of age distribution in India has been attributed to substantively unchanged fertility over a long period and a secular decline in mortality (Government of India, 1973; Lopez, 1961; Saxena, 1965; Visaria, 1961). In the above context, this section analyses the transition in the age composition of the population of Madhya Pradesh by comparing the age composition of the population in reference to the quasi stability which means a population with a history of constant fertility (both level and pattern) and constant mortality (both level and pattern) up to a certain time and thereafter a changing level of mortality, the pattern of mortality remaining restricted within a family of model life tables (Mukherjee, 1976).

Figure 5 presents the Lorenz curve of the age composition of the population of Madhya Pradesh for the years 1961 and 2001 for males and females respectively. This curve plots the cumulative proportions of one

population against those of another over the same age groups; the age groups are arranged in the ascending order. When the age composition of population at two points of time are exactly similar, the Lorenz curve reduces to the straight diagonal; the larger is the dissimilarity between the two age composition, the more Lorenz curve deviates from the diagonal.

A number of summary measures can be derived from the Lorenz curve to ascertain the nature and the extent of the dissimilarity between two age compositions. These include aggregate dissimilarity, $|D|$; concentration dissimilarity, $|C|$; net concentration dissimilarity, C; partial dissimilarity, D_p and partial concentration dissimilarity, C_p. The method of estimating these indexes and their interpretation is given elsewhere and is not repeated here (Shryock and Siegel, 1976; Mukherjee, 1976). The validity of this approach of analysing the changes in the age composition of the population for a number of developed countries for which fairly reliable age data are available over a long period of time and in which both fertility and mortality are known to have declined over time (United Nations, 1956). Mukherjee (1976) has repeated the exercise for a number of other countries as well as for India and has concluded that distances between age composition in India at two different times are significantly smaller in India than in the developed countries.

Corresponding to five age compositions for the male population and five age compositions for the females population, there are 10 values for each of the indexes $|D|$, $|C|$, C, D_p and C_p so that there are 50 values for the male population and 50 values for the female population of the state. These values are set out in table 3. On the basis of figure 5 and table 3, the following conclusions may be drawn about the change in the age composition of the population of the state between 1961 and 2001:

- The distance measures between the age compositions in the state at two points of time are very small; they are never more than 0.1000. This implies that over the years, there has been only a marginal change in the age composition of the population of the state.
- Although not very clear, the distance measures for successive census years appears to be increasing albeit very slowly irrespective of which year is taken as base.
- The substantial difference between the values of indexes $|C|$ and C for corresponding age compositions indicate that there are substantial errors in the age data available through different population census in the state.

Sex Ratios

It is well known that the probability of a male birth and the probability of a female birth are not same. The ratio of a male to a female birth is

universally assumed to be 106 boys for every 100 females. At the time of conception, however, this ratio is even more favourable to males, around 120 males for every 100 females because the bulk of evidence suggests that males are more fragile than females and the intra-uterine mortality of male foetus is substantially higher than the female foetus (Naeye et al., 1971; Calle et al., 1999). It has also been observed that the mother nature tries hard to compensate for the fragility of male foetus by allowing significantly more boys to be conceived at a time of year when conditions for pregnancy and birth are optimal (Cagnacci et al. 2003).

After birth, the survival probability of a female child is generally higher than that of male child because of a number of factors. The fact that females have two X chromosomes and males one probably confers a survival advantage on females as compared to males (Naeye et al., 1971); greater average level of estrogen in pre-menopausal women almost certainly protect them against the development of coronary heart diseases (Epstein, 1965). Women have also been found to adjust more rapidly to changes in the environmental temperature and they have a physiological advantages (Chaurasia, 1983). On the other hand, tougher living conditions of women including social discrimination against the fair sex and the risk of death associated with the complications of pregnancy and delivery put women at a disadvantage to men in most of the developing countries (Chaurasia, 1983). Similarly, the sex selective migration of the working age population also affects the ratio of male to females in different age groups and is reflected in this ratio for the whole population. The net result of all these factors is that the ratio of males to females in any population, popularly known as the sex ratio varies with age. If the effect of migration is excluded then the sex ratio is very high at very young ages starting at around 105-106 at the age 0. Age-specific sex ratios are then expected to decline with age, attaining a ratio of around 100 for persons in their late 20s, and continue to decline to levels around 50 to 60 in the oldest ages (Poston et al., 2003) because of lower female mortality as compared to male mortality. This normative age pattern of sex ratio is disturbed by extreme forms of a number of man made interventions which include war and conflicts which effect the size of the male population and discrimination against females at individual, family and community levels of which perhaps the most livid example is the female-specific abortion and female infanticide and which effect the size of the female population.

Some idea about the extent to which human interventions have disturbed the above described normative sex ratio pattern as well as to evaluate the quality of the data on sex composition can be made by calculating the sex ratio for each 5-year age group and then calculating the sex ratio difference

which is the difference between the sex ratio of the reference age group and the sex ratio of the immediately preceding age group. The difference so obtained may be summarized for the all age groups by taking the mean of the age-specific sex ratio differences without regard to the sign of the difference.

The age patterns of sex ratio in Madhya Pradesh are presented in figure 6 for different population census between 1961 and 2001. Interestingly, the age pattern of sex ratio is more or less similar across different population census, although there are subtle differences but little extraordinary deviations. Another important observation is that the age pattern of sex ratio in Madhya Pradesh does not conform to the normative age pattern described above. Unlike the normative pattern, the sex ratios in Madhya Pradesh do not decrease monotonically with age. Rather, they first increase in the younger age groups, decrease rather sharply in the young working age groups, gradually increase again to reach very high levels around 50 years of age and then decrease again. Reasons for this fluctuating pattern of age-specific sex ratio lie in both sex-specific age misreporting as well as differential mortality of sexes in different age groups. For example, the increase in the sex ratio in younger ages may be due to higher female as compared to male mortality in these age groups. Similarly, the rapid drop in sex ratio between the age groups 15-19 years and 20-24 years in each census may be due to some very substantial under reporting of females in the age group 15-19 years and consequently some very substantial over reporting of females in the age group 20-24 years. In Madhya Pradesh, female marriage at a young age is very common despite the fact that marriage of females below 18 years of age is legally prohibited. Since marriage, especially of females, has a number of social, cultural and religious dimensions, there may be a tendency in the population to over report the age of married females to avoid the legal implications. This over reporting of females in the age group 20-24 years at the cost of the age group 15-19 years appears to have resulted in the deficiency of females in the age group 15-19 years but their excess in the age group 20-24 years. On the other hand, the increase in the sex ratio after 25 years of age may be attributed to high to very high risk of death associated with the complications of pregnancy and delivery associated with married women only. Even in the old age groups, ages beyond 60 years, the sex ratio has not been found to be as low as is expected according to the normative age pattern. This reflects towards a relatively higher female mortality in the old age as compared to the male mortality with the result that the gap between male and female mortality in the old ages is narrower than expected leading to relatively higher sex ratios. In fact, both age misreporting and differential mortality of sexes appear to be responsible for variations in sex ratio by age.

Quality of Age and Sex Data

The observed variations in the age ratios and sex ratios as discussed above are the result of two groups of factors, the overall quality of the age and sex data and variations and changes in the demographic processes. In the absence of changes and variations in the demographic processes, the 'accurate' age data are rectangularly distributed and the age-specific sex ratios decline over the life cycle in an even manner. Departures from these patterns result inaccurate data patterns.

The overall quality of age and sex data can be judged by the age-Sex Accuracy Index which is the sum of age ratio score for males, age ratio score for females and three times the sex ratio score (Shryock and Siegel, 1976; United Nations, 1955). According to the United Nations, the permissible values of the age ratio scores is 2.6 for males and 2.4 for females. On the other hand, the permissible limit for sex ratio score is 1.5. Combining the three, the permissible limit for Age-Sex Accuracy Index is 9.5.

The age and sex ratio scores and the age-sex accuracy index for Madhya Pradesh for different census years are given in table 1. The age-sex accuracy index for the enumerated population of the state is well above the permissible limit of 9.5 indicating that there are substantial inaccuracies in the age-sex data available from different population census. Perhaps, even more disturbing is the fact that the age-sex accuracy index has worsened since 1981 largely because of the increase in the sex ratio score. The age-sex accuracy index in the 2001 population census was 41 which is well above the permissible value of 9.5 and is almost same as the age-sex accuracy index 40 years earlier, at the time of 1961 population census.

Although, age-sex accuracy index is a very simple summary measure of the accuracy of age and sex data, yet it has a number of limitations. Perhaps, the most serious limitation of the index is that it does not take account the expected decline in the sex ratio with increasing age and the real irregularities in the age composition due to normal fluctuations in births, deaths and patterns of migration. Another problem with the index is that considerable weight is given to sex ratio component in estimating the age-sex accuracy index and the logic of giving this weight is not clear. Because of these limitations, the age and sex accuracy index is useful in making rough comparisons and distinctions between and among populations (Hobbs, 2003). The major function of this index appears to be its ability to flag extreme values in the age and sex data. In general these extreme values are due to under enumeration and misreporting. At the same time, some of inaccuracies in the data captured by the age-sex accuracy index may really be due to fluctuations in demographic processes.

Age-sex Selectivity in Under Enumeration

One of the basic causes of the inaccuracies in the age and sex data is the age selective and sex selective under enumeration. The age and sex selectivity in under enumeration can be examined by calculating survival ratios by sex on the basis of the age and sex data for two consecutive population census. If it is assumed that the population is closed to migration or if population increase or decrease due to migration is negligible as compared to the natural population increase or decrease, then the number of persons in the age group (x+10 to x+14) years in the later census are the survivors of the persons in the age group (x to x+4) years in the population census conducted 10 years earlier. These survival ratios are given in table 4. In general, the survival ratios are very high and do not match to the prevailing levels of mortality. Moreover, in many cases, the survival ratios are found to be greater than 1. For example, in case of males, the survival ratios are always greater than 1, implying that there were more males in the age group 10-14 years in the latter census than those aged 0-4 in the earlier one. In females, a similar situation may be seen in recent census. Clearly, the exceptionally high census survival ratios indicate large under enumeration in age group 0-4 years in the respective census years.

The sex selectivity in under enumeration may be judged by comparing the similar survival ratios for the female population with those for male population. Table 4 suggests that males 0-4 years are consistently under enumerated more than the females. Similar interpretations can also be made for other age groups by comparing male and female survival ratios.

Conclusions

This paper attempts to describe the age and sex composition of the population of Madhya Pradesh and past and future changes in this structure over time. The purpose of analysis has primarily been to high light the importance of considering the patterns and transition in the age and sex structure of the population in the development planning process. The analysis reveals that, in the next 30 years, more and more population of the state will get concentrated in the working ages; it is projected that, by the year 2031, two out of every three persons in the state will be in the age group 15-59 years which are the productive years for any individual. The added productivity of this group can produce a demographic opportunity or dividend for rapid economic growth and eradication of poverty if policies to take advantage of this fact are in place. The fact is that the combined effect of this large working-age population and appropriate health, family, labor, financial, and human development policies can create virtuous cycles of wealth creation in the state

in the years to come thereby improving the quality of life of the people of the state..

The paper has also attempted to analyse the age and sex data from a demographic perspective also along with the accuracy of the age sex data available from the population census. The analysis reveals that there had been very little change in the age structure of the population in the past but in the coming years, significant changes in the age structure are expected which when en-cashed may provide the demographic opportunity or dividend for rapid economic growth. The analysis also reveals that age sex data are not rectangularly distributed and there are large deviations in the age and sex data available through different population census from the predicted trend carried out in the country and these deviations appear to have increased over time. This could be due to both errors in the age and sex data and fluctuations in fertility and mortality levels and patterns of migration.

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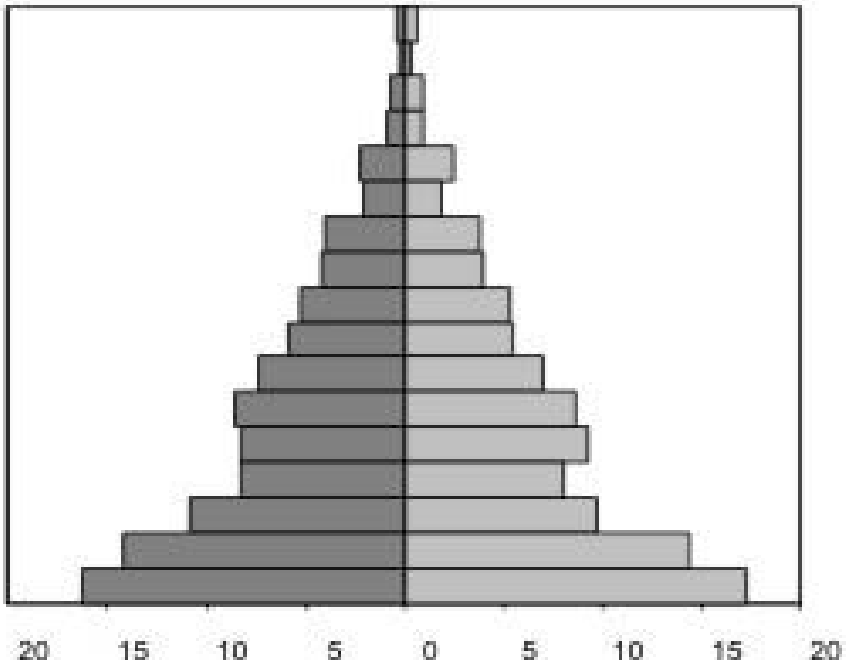
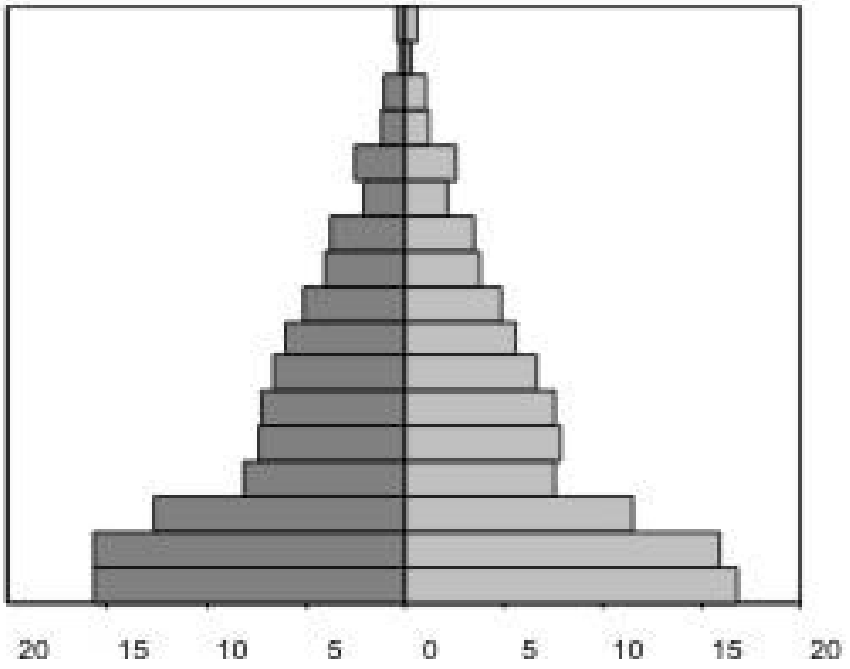
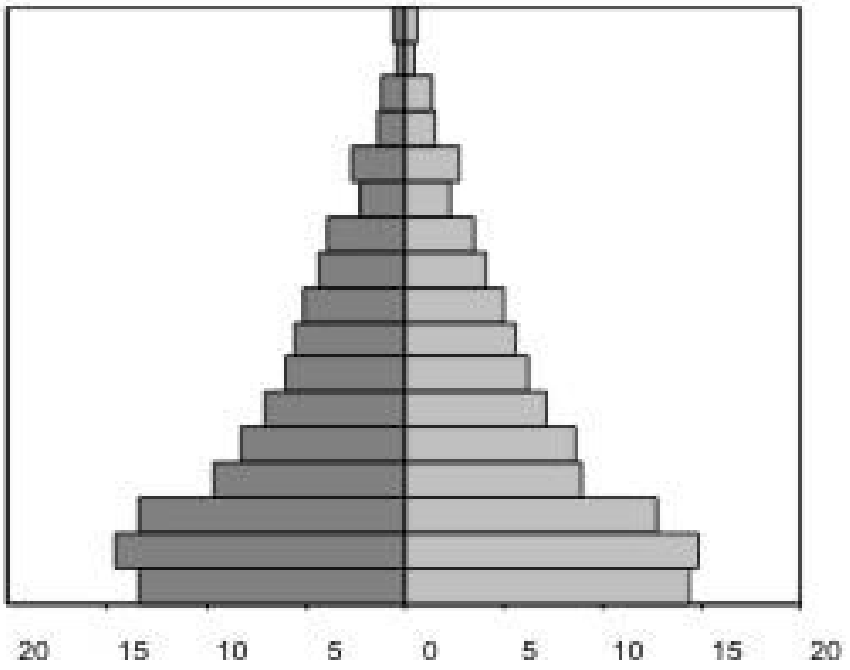
Figure 1
Population Pyramid, 1961



Population Pyramid 1971



Population Pyramid, 1981



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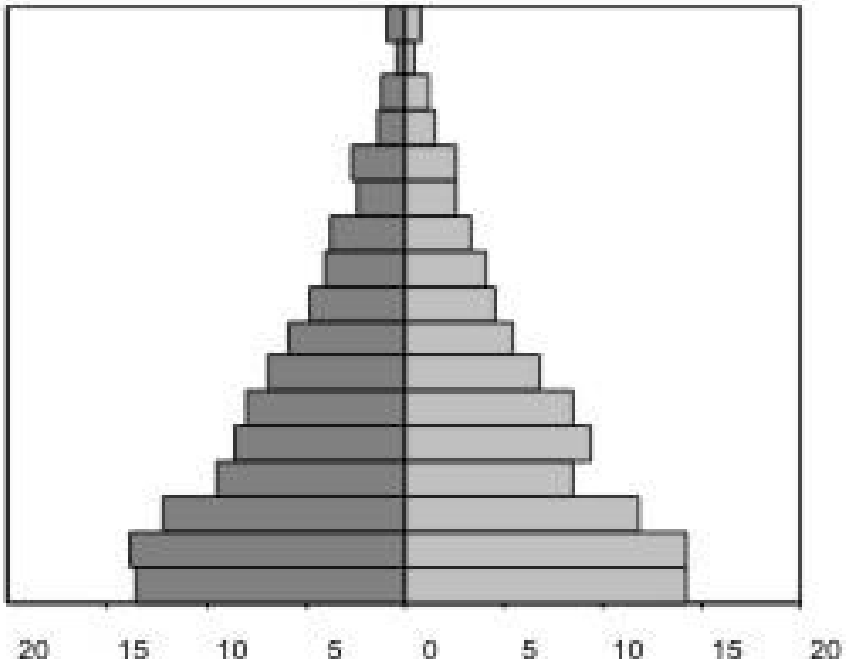


Population Pyramid 2001

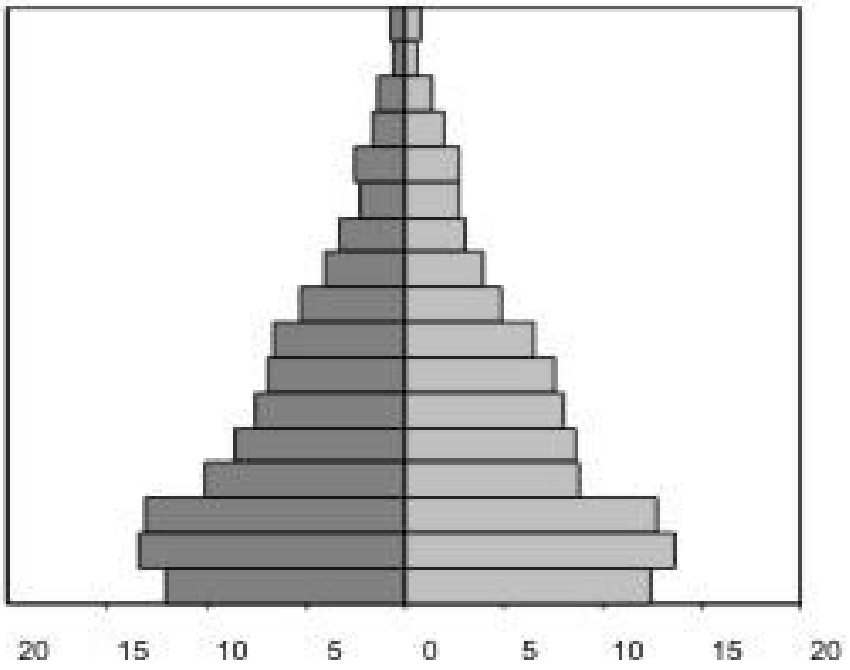
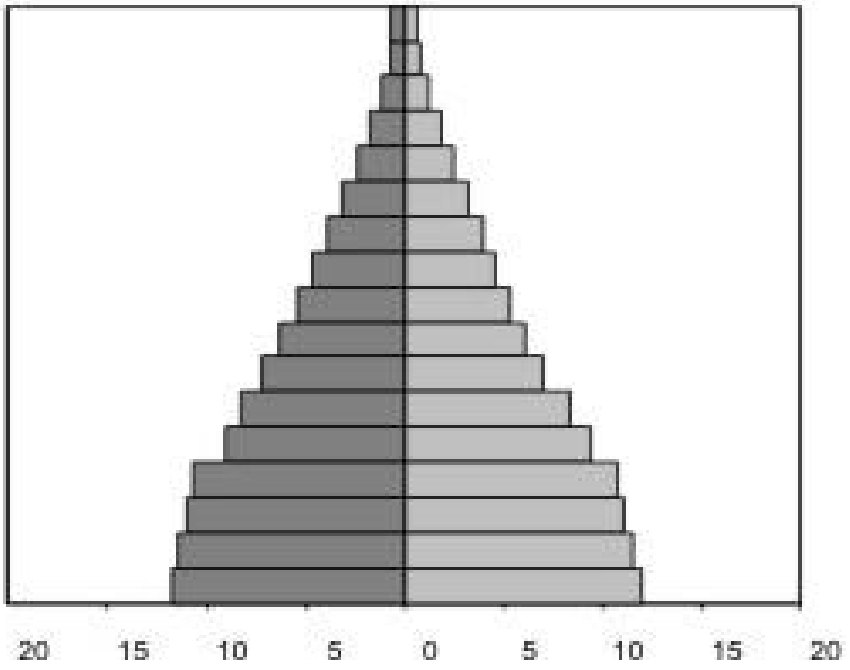
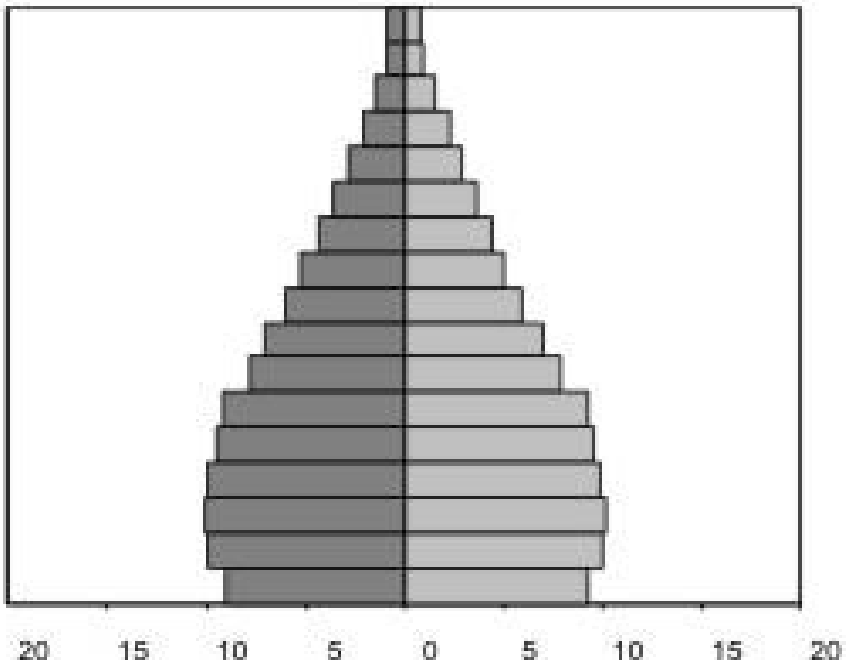


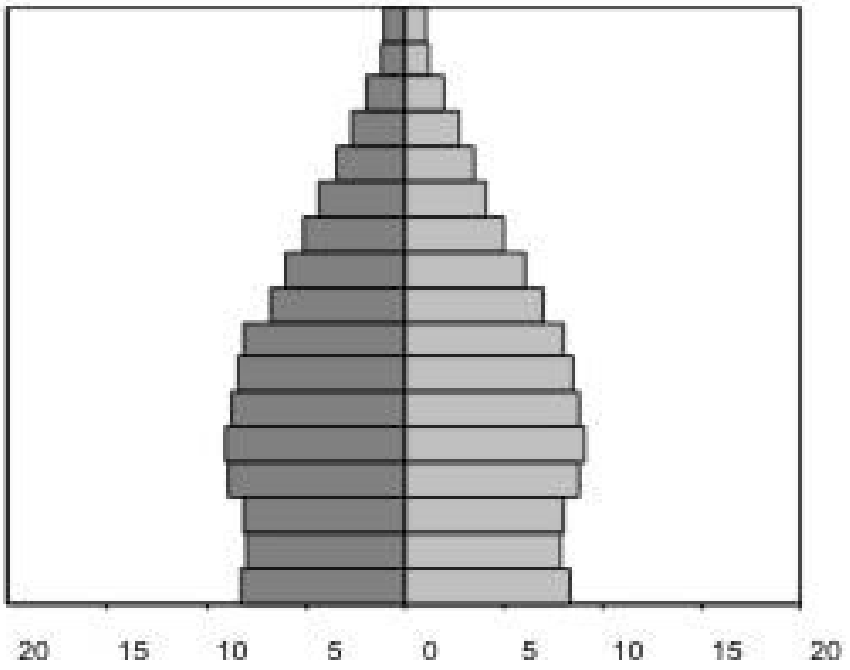
Figure 2
Project Population Pyramid 2011



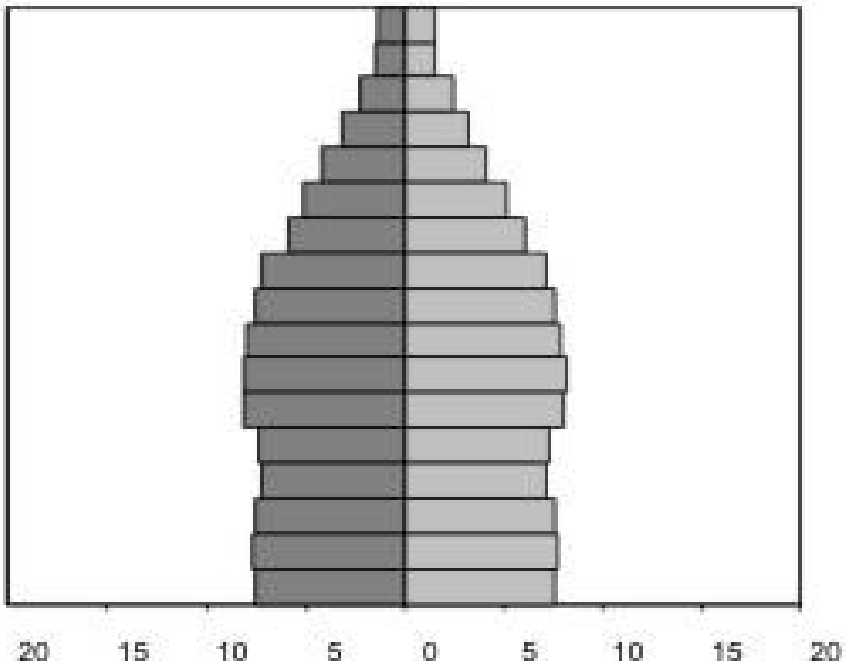
Projected Population Pyramid 2021



Projected Population Pyramid 2031



Projected Population Pyramid 2041



Projected Population Pyramid 2051

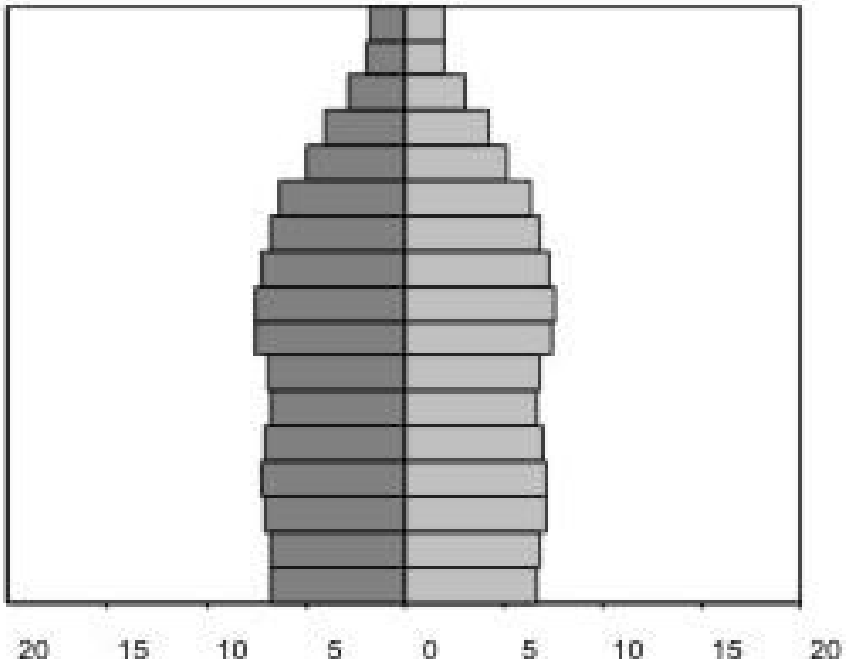


Figure 3
The demographic dividend

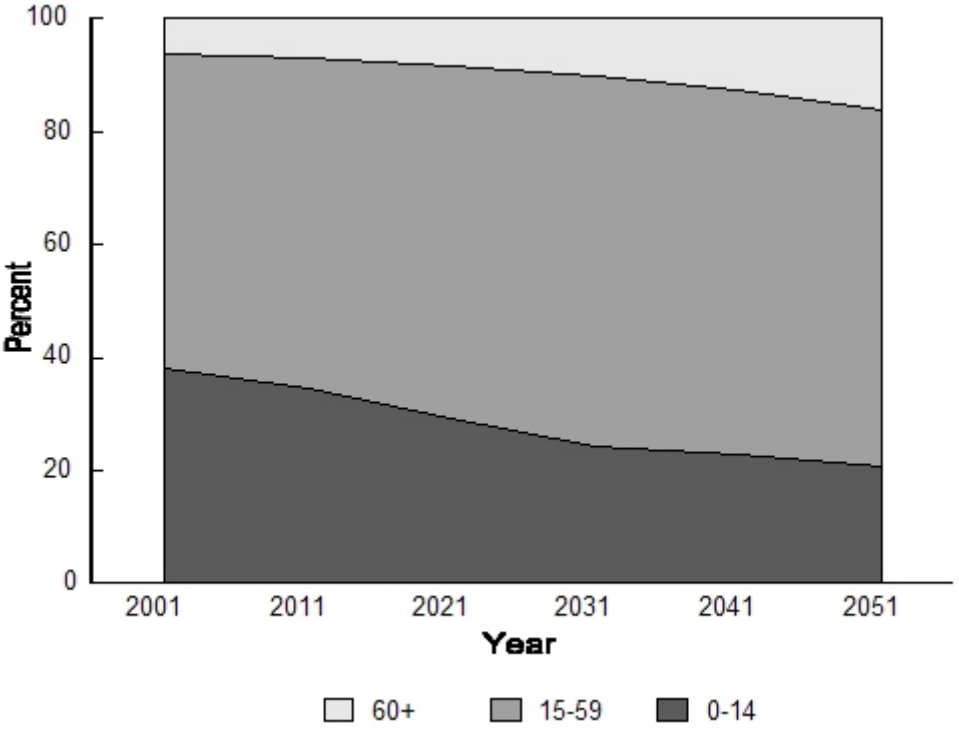
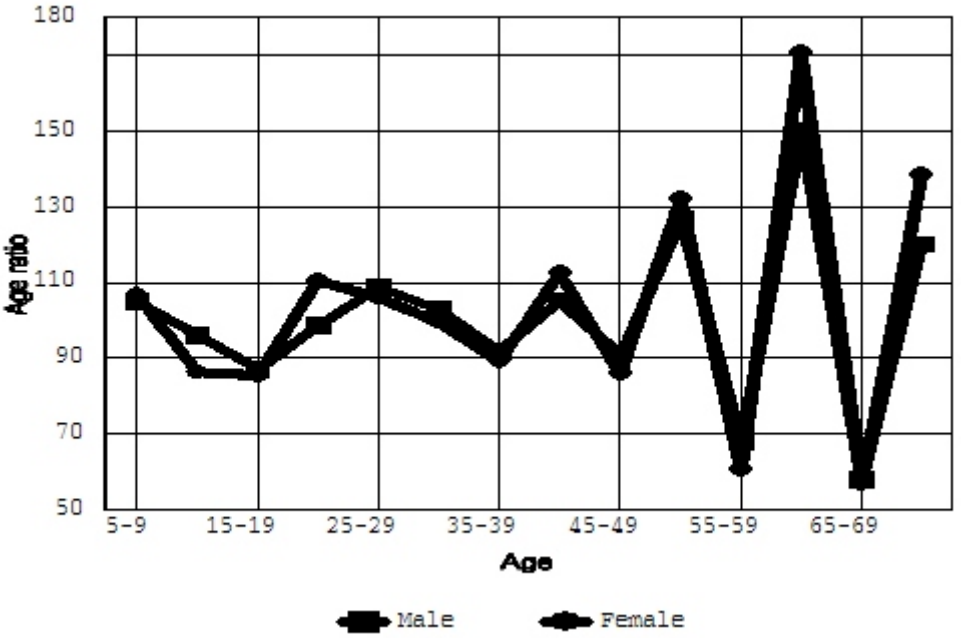
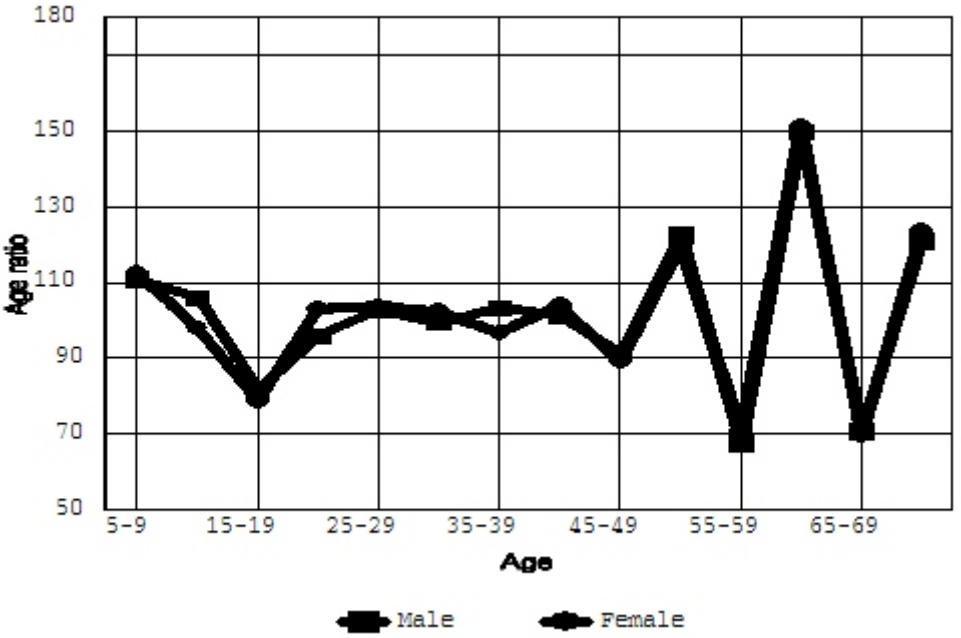


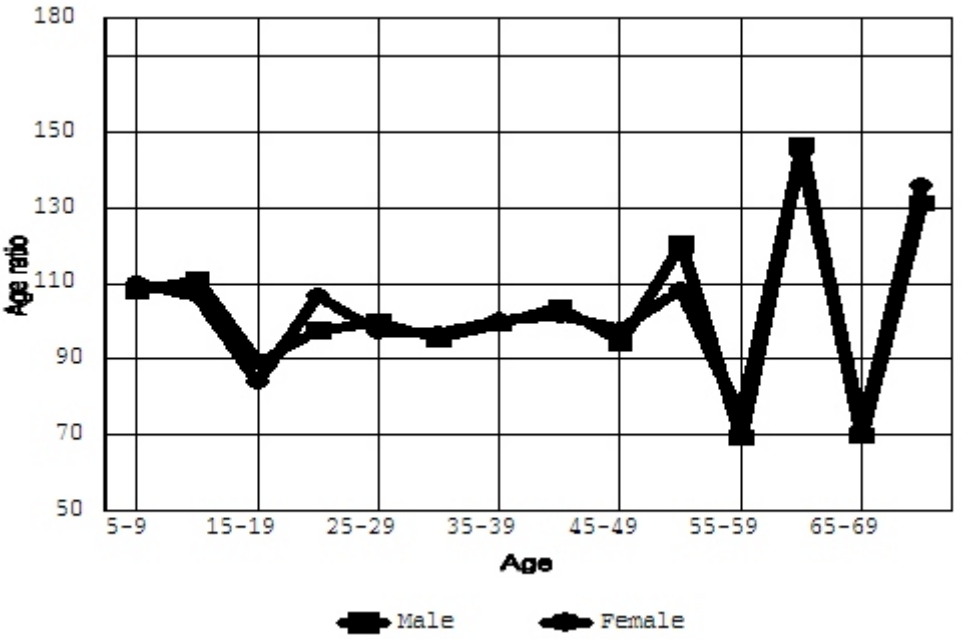
Figure 4
Age ratios 1961



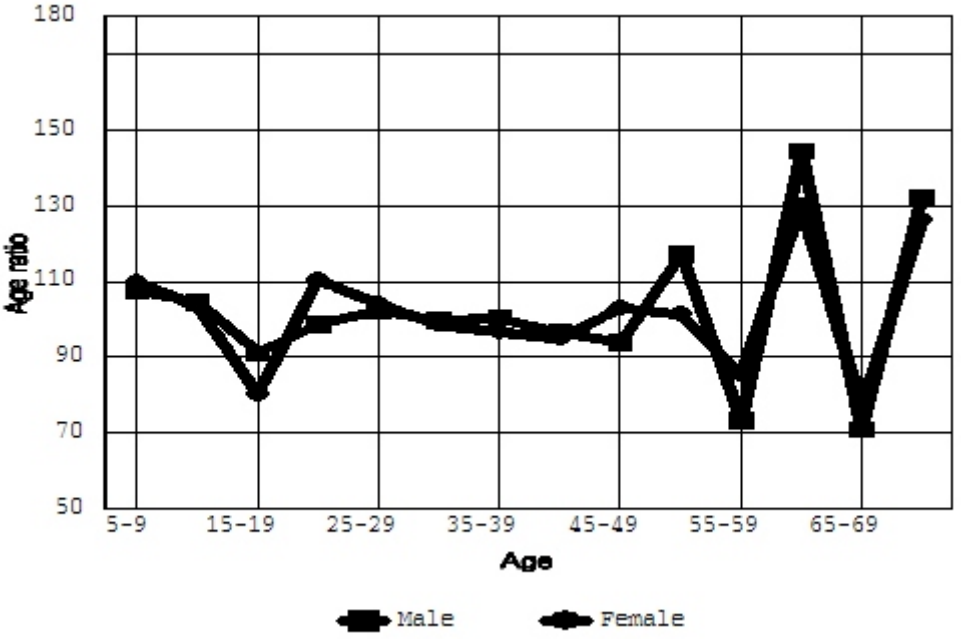
Age ratios, 1971



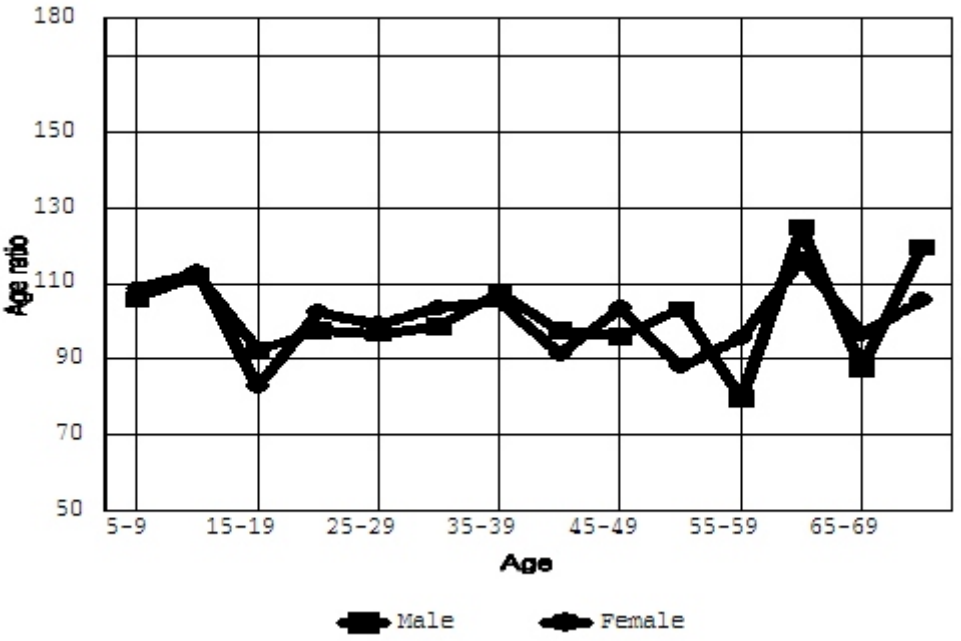
Age ratios 1981



Age ratios 1991



Age ratios 2001



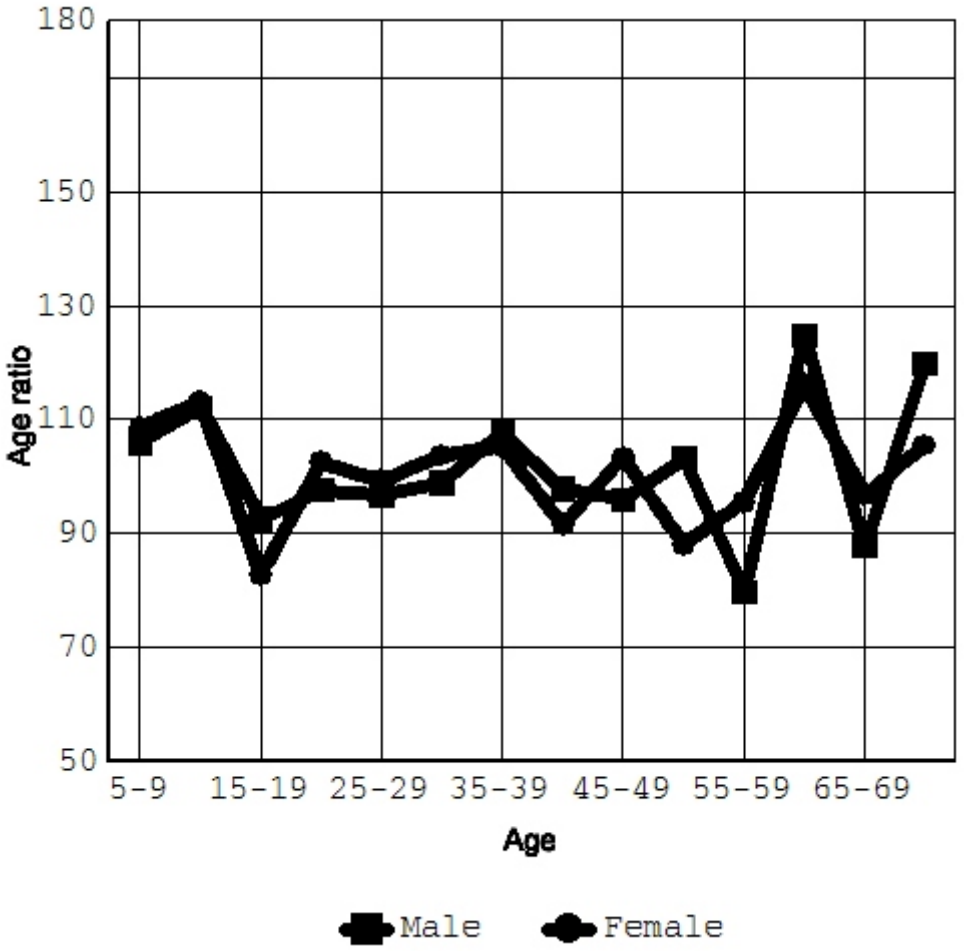

180
150
130
110
90
70
50
Age ratio
5-9
15-19
25-29
35-39
45-49
55-59
65-69
Age
Male
Female

Figure 6
Age pattern of sex ratio

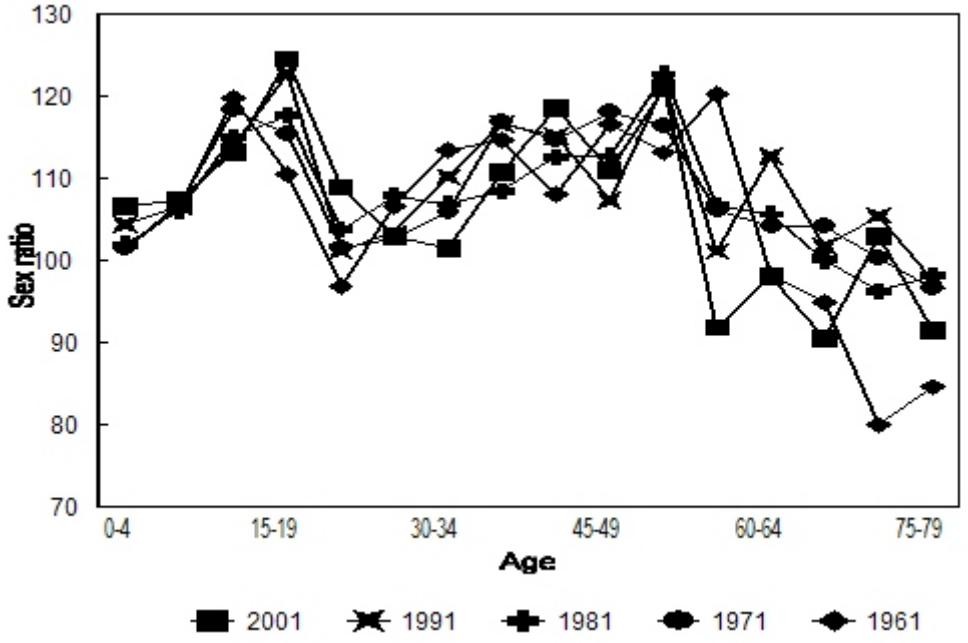


Table 1: Enumerated population of Madhya Pradesh: 1961-2001

Age	2001			1991			1981			1971			1961		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
0-4	7368736	3801712	3567024	6651176	3397526	3253650	5293645	2672139	2621506	4851352	2441654	2409698	3890633	1959777	1930856
5-9	8114671	4198430	3916241	6738739	3474692	3264047	5614874	2889903	2724971	4738304	2447050	2291254	3319307	1709923	1609384
10-14	7769009	4123794	3645215	5755267	3063850	2691417	4995471	2671490	2323981	3629963	1967725	1662238	2384558	1299317	1085241
15-19	5690617	3155715	2534902	4322524	2381171	1941353	3563038	1925784	1637254	2369824	1268922	1100902	1903780	998785	904995
20-24	5168016	2693698	2474318	4304777	2163643	2141134	3208363	1633588	1574775	2270916	1143833	1127083	2029345	997573	1031772
25-29	4664502	2364315	2300187	3936104	1999688	1936416	2731836	1417310	1314526	2205397	1116894	1088503	1989557	1025956	963601
30-34	4348461	2189149	2159312	3318433	1738838	1579595	2337534	1206770	1130764	1997454	1026939	970515	1676462	890908	785554
35-39	3927208	2062808	1864400	2746590	1478387	1268203	2124648	1105104	1019544	1755826	946320	809506	1318909	704401	614508
40-44	3016434	1635980	1380454	2244171	1200920	1043251	1917405	1015305	902100	1507634	805125	702509	1233767	640592	593175
45-49	2437191	1281601	1155590	1935105	1001788	933317	1606048	850964	755084	1182204	640215	541989	952847	512876	439971
50-54	1890978	1035226	855752	1704324	934931	769393	1425270	785035	640235	1111795	597700	514095	918065	487092	430973
55-59	1511753	723319	788434	1176762	591391	585371	880665	454408	426257	652501	335716	316785	469416	256231	213185
60-64	1572796	778022	794774	1281894	679085	602809	1025924	526843	499081	774867	395375	379492	542728	268987	273741
65-69	1102622	523430	579192	691210	348505	342705	529538	264778	264760	377026	192339	184687	209166	101836	107330
70-74	816977	414281	402696	589668	302566	287102	473245	232015	241230	298066	149118	148948	184887	82065	102822
75-79	352761	168501	184260	221776	109420	112356	179362	88826	90536	111317	54691	56626	106036	34727	41129
80+	435768	207559	228209	422175	227429	194746	238771	112761	126010	160758	69713	91045	121610	50729	70881

Table 2: Age distribution of population of Madhya Pradesh: 1961-2001.

Age	2001			1991			1981			1971			1961		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
0-4	12.24	12.12	12.37	13.84	13.54	14.18	13.88	13.46	14.33	16.17	15.65	16.74	16.73	16.30	17.24
5-9	13.48	13.39	13.58	14.03	13.85	14.22	14.72	14.56	14.90	15.80	15.69	15.92	14.28	14.22	14.37
10-14	12.91	13.15	12.64	11.98	12.21	11.73	13.10	13.46	12.70	12.10	12.61	11.55	10.26	10.81	9.69
15-19	9.45	10.06	8.79	9.00	9.49	8.46	9.34	9.70	8.95	7.90	8.13	7.65	8.19	8.31	8.08
20-24	8.59	8.59	8.58	8.96	8.62	9.33	8.41	8.23	8.61	7.57	7.33	7.83	8.73	8.30	9.21
25-29	7.75	7.54	7.98	8.19	7.97	8.44	7.16	7.14	7.19	7.35	7.16	7.56	8.56	8.53	8.60
30-34	7.22	6.98	7.49	6.91	6.93	6.88	6.13	6.08	6.18	6.66	6.58	6.74	7.21	7.41	7.01
35-39	6.52	6.58	6.47	5.72	5.89	5.53	5.57	5.57	5.57	5.85	6.07	5.62	5.67	5.86	5.49
40-44	5.01	5.22	4.79	4.67	4.79	4.55	5.03	5.11	4.93	5.03	5.16	4.88	5.31	5.33	5.30
45-49	4.05	4.09	4.01	4.03	3.99	4.07	4.21	4.29	4.13	3.94	4.10	3.76	4.10	4.27	3.93
50-54	3.14	3.30	2.97	3.55	3.73	3.35	3.74	3.95	3.50	3.71	3.83	3.57	3.95	4.05	3.85
55-59	2.51	2.31	2.73	2.45	2.36	2.55	2.31	2.29	2.33	2.18	2.15	2.20	2.02	2.13	1.90
60-64	2.61	2.48	2.76	2.67	2.71	2.63	2.69	2.65	2.73	2.58	2.53	2.64	2.33	2.24	2.44
65-69	1.83	1.67	2.01	1.44	1.39	1.49	1.39	1.33	1.45	1.26	1.23	1.28	0.90	0.85	0.96
70-74	1.36	1.32	1.40	1.23	1.21	1.25	1.24	1.17	1.32	0.99	0.96	1.03	0.80	0.68	0.92
75-79	0.59	0.54	0.64	0.46	0.44	0.49	0.47	0.45	0.49	0.37	0.35	0.39	0.46	0.29	0.37
80+	0.72	0.66	0.79	0.88	0.91	0.85	0.63	0.57	0.69	0.54	0.45	0.63	0.52	0.42	0.63

Table 3: Projected population of Madhya Pradesh: 2011-2051

Age	2011			2021			2031			2041			2051		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
0-4	8625711	4454085	4171626	7588803	3922820	3665983	7652606	3949510	3703096	7613354	3924761	3688593	7151119	3682041	3469078
5-9	8307205	4302275	4004930	8225910	4261311	3964599	7277074	3765520	3511554	7711321	3980188	3731133	7214869	3718353	3496516
10-14	8008424	4149700	3858724	8398182	4351071	4047111	7450894	3859971	3590923	7548569	3899892	3648677	7534370	3885810	3648560
15-19	7757385	4019670	3737715	8202707	4249220	3953487	8151487	4222138	3929349	7227363	3737969	3489394	7669910	3956183	3713727
20-24	6694657	3433251	3261406	7885100	4083637	3801463	8304320	4298577	4005743	7386984	3822208	3564776	7497493	3868281	3629212
25-29	6016627	3117729	2898898	7599063	3934776	3664287	8080311	4180861	3899450	8057895	4166980	3890915	7161432	3697273	3464159
30-34	5179338	2728774	2450564	6526147	3346104	3180043	7738270	4004279	3733991	8184653	4230614	3954039	7301498	3771528	3529970
35-39	4503106	2382639	2120467	5830103	3022076	2808027	7421753	3841476	3580277	7931670	4099263	3832407	7937372	4098295	3839077
40-44	3917666	2054551	1863115	4974666	2620946	2353720	6326240	3241666	3084574	7545886	3899242	3646644	8016235	4135903	3880332
45-49	3362623	1758197	1604426	4268872	2255331	2013541	5587048	2890772	2696276	7164185	3698668	3465517	7697705	3966479	3731226
50-54	2815528	1466458	1349070	3639913	1901082	1738831	4682760	2456896	2225864	6009348	3063758	2945590	7215942	3708489	3507453
55-59	2294120	1192072	1102048	3026013	1570679	1455334	3904573	2047580	1856993	5169949	2651495	2518454	6690899	3422191	3268708
60-64	1756962	917678	839284	2408640	1242057	1166583	3180275	1643199	1537076	4153953	2151822	2002131	5400122	2714425	2685697
65-69	1303774	680345	623429	1813053	931114	881939	2454153	1254636	1199517	3228385	1661198	1567187	4355971	2189070	2166901
70-74	896953	465820	431133	1236656	638118	598538	1749817	884709	865108	2365659	1188775	1176884	3171534	1596451	1575083
75-79	557455	288704	268751	765887	394637	371250	1111181	559988	551193	1550551	770715	779836	2100681	1046814	1053867
80+	511628	263923	247705	680198	349251	330947	969553	493174	476379	1425992	706999	718993	2032298	991479	1040819

Table 4: Projected age distribution of population of Madhya Pradesh: 2011-2051.

Age	2011			2021			2031			2041			2051		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
0-4	11.90	11.82	11.98	9.14	9.11	9.17	8.31	8.30	8.33	7.59	7.60	7.59	6.74	6.76	6.71
5-9	11.46	11.42	11.50	9.90	9.89	9.91	7.91	7.91	7.90	7.69	7.71	7.67	6.80	6.83	6.76
10-14	11.04	11.01	11.08	10.11	10.10	10.12	8.10	8.11	8.08	7.53	7.55	7.50	7.10	7.14	7.06
15-19	10.70	10.67	10.73	9.87	9.86	9.88	8.86	8.87	8.84	7.21	7.24	7.18	7.23	7.27	7.18
20-24	9.23	9.11	9.36	9.49	9.48	9.50	9.02	9.03	9.01	7.37	7.40	7.33	7.06	7.10	7.02
25-29	8.30	8.28	8.32	9.15	9.13	9.16	8.78	8.78	8.77	8.04	8.07	8.00	6.75	6.79	6.70
30-34	7.14	7.24	7.04	7.86	7.77	7.95	8.41	8.41	8.40	8.16	8.19	8.13	6.88	6.93	6.83
35-39	6.21	6.32	6.09	7.02	7.02	7.02	8.06	8.07	8.06	7.91	7.94	7.88	7.48	7.53	7.43
40-44	5.40	5.45	5.35	5.99	6.08	5.88	6.87	6.81	6.94	7.53	7.55	7.50	7.55	7.60	7.51
45-49	4.64	4.67	4.61	5.14	5.24	5.03	6.07	6.07	6.07	7.14	7.16	7.13	7.25	7.28	7.22
50-54	3.88	3.89	3.87	4.38	4.41	4.35	5.09	5.16	5.01	5.99	5.93	6.06	6.80	6.81	6.78
55-59	3.16	3.16	3.16	3.64	3.65	3.64	4.24	4.30	4.18	5.16	5.13	5.18	6.30	6.29	6.32
60-64	2.42	2.44	2.41	2.90	2.88	2.92	3.46	3.45	3.46	4.14	4.17	4.12	5.09	4.99	5.19
65-69	1.80	1.81	1.79	2.18	2.16	2.21	2.67	2.64	2.70	3.22	3.22	3.22	4.10	4.02	4.19
70-74	1.24	1.24	1.24	1.49	1.48	1.50	1.90	1.86	1.95	2.36	2.30	2.42	2.99	2.93	3.05
75-79	0.77	0.77	0.77	0.92	0.92	0.93	1.21	1.18	1.24	1.55	1.49	1.60	1.98	1.92	2.04
80+	0.71	0.70	0.71	0.82	0.81	0.83	1.05	1.04	1.07	1.42	1.37	1.48	1.91	1.82	2.01

Table 5: Age ratios in Madhya Pradesh: 1961-2001

Age	2001		1991		1981		1971		1961	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4										
5-9	105.9	108.6	107.6	109.8	108.2	110.2	111.0	112.5	104.9	106.7
10-14	112.1	113.0	104.6	103.4	110.9	106.6	105.9	98.0	95.9	86.3
15-19	92.6	82.8	91.1	80.3	89.5	84.0	81.6	78.9	87.0	85.5
20-24	97.6	102.3	98.8	110.4	97.7	106.7	95.9	103.0	98.5	110.4
25-29	96.8	99.3	102.5	104.1	99.8	97.2	102.9	103.8	108.7	106.0
30-34	98.9	103.7	100.0	98.6	95.7	96.9	99.5	102.3	103.0	99.6
35-39	107.9	105.3	100.6	96.7	99.5	100.3	103.3	96.8	92.0	89.1
40-44	97.8	91.4	96.8	94.8	103.8	101.7	101.5	104.0	105.2	112.5
45-49	96.0	103.4	93.8	103.0	94.5	97.9	91.3	89.1	91.0	85.9
50-54	103.3	88.0	117.4	101.3	120.3	108.4	122.5	119.7	126.7	132.0
55-59	79.8	95.5	73.3	85.3	69.3	74.8	67.6	70.9	67.8	60.5
60-64	124.8	116.2	144.5	129.9	146.5	144.4	149.7	151.4	150.2	170.8
65-69	87.8	96.7	71.0	77.0	69.8	71.5	70.6	69.9	58.0	57.0
70-74	119.7	105.5	132.1	126.2	131.2	135.8	120.7	123.4	120.2	138.5
75-79										
80+										

Table 6: Dissimilarity indexes for Madhya Pradesh 1961-2001: Male

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Index	Year of latter census			
	1971	1981	1991	2001
|D|	0.0454	0.0624	0.0553	0.0748
		0.0400	0.0513	0.0643
			0.0303	0.0383
				0.0328
Dp	-0.0005	-0.0003	0.0040	0.0081
		0.0002	0.0045	0.0086
			0.0043	0.0084
				0.0041
C	-0.0088	-0.0087	-0.0086	-0.0086
		-0.0014	-0.0020	-0.0028
			-0.0007	-0.0014
				-0.0007
Cp	-0.0505	-0.0501	-0.0490	-0.0488
		-0.0096	-0.0158	-0.0202
			-0.0066	-0.0109
				-0.0041
|C|	0.0893	0.0885	0.0872	0.0874
		0.0206	0.0249	0.0321
			0.0180	0.0232
				0.0179

Table 7: Dissimilarity indexes for Madhya Pradesh 1961-2001: Female.

Index	Year of latter census			
	1971	1981	1991	2001
|D|	0.0449	0.0648	0.0475	0.0830
		0.0448	0.0491	0.0739
			0.0310	0.0431
				0.0416
Dp	-0.0002	0.0026	0.0042	0.0162
		0.0028	0.0044	0.0164
			0.0016	0.0136
				0.0121
C	-0.0087	-0.0086	-0.0085	-0.0007
		-0.0008	-0.0014	-0.0036
			-0.0007	-0.0007
				-0.0015
Cp	-0.0531	-0.0523	-0.0516	-0.0048
		0.0008	-0.0070	-0.0218
			-0.0081	-0.0089
				-0.0060
|C|	0.0939	0.0929	0.0921	0.0357
		0.0311	0.0239	0.0404
			0.0167	0.0168
				0.0222

Table 8: Sex ratios in Madhya Pradesh: 1961-2001

Age	2001	1991	1981	1971	1961
0-4	106.6	104.4	101.9	101.3	101.5
5-9	107.2	106.5	106.1	106.8	106.2
10-14	113.1	113.8	115.0	118.4	119.7
15-19	124.5	122.7	117.6	115.3	110.4
20-24	108.9	101.1	103.7	101.5	96.7
25-29	102.8	103.3	107.8	102.6	106.5
30-34	101.4	110.1	106.7	105.8	113.4
35-39	110.6	116.6	108.4	116.9	114.6
40-44	118.5	115.1	112.5	114.6	108.0
45-49	110.9	107.3	112.7	118.1	116.6
50-54	121.0	121.5	122.6	116.3	113.0
55-59	91.7	101.0	106.6	106.0	120.2
60-64	97.9	112.7	105.6	104.2	98.3
65-69	90.4	101.7	100.0	104.1	94.9
70-74	102.9	105.4	96.2	100.1	79.8
75-79	91.4	97.4	98.1	96.6	84.4

Table 9: Age-sex accuracy indexes in Madhya Pradesh: 1961-2001

Year	Age ratio score		Age accuracy index	Sex ratio score	Age-sex accuracy index
	Male	Female			
2001	9.0	7.4	8.2	9.5	44.9
1991	13.2	11.1	12.2	8.9	51.0
1981	14.7	13.7	14.2	5.3	44.3
1971	15.1	15.5	15.3	5.1	45.9
1961	16.3	22.4	19.4	8.7	64.8

Table 10: Age-sex selectivity in under enumeration.

Age at earlier census	Age at later census	Year of later census			
		1971	1981	1991	2001
Male					
0-4	10-14	1.0041	1.0941	1.1466	1.2138
5-9	15-19	0.7421	0.7870	0.8240	0.9082
10-14	20-24	0.8803	0.8302	0.8099	0.8792
15-19	25-29	1.1183	1.1169	1.0384	0.9929
Female					
0-4	10-14	0.8609	0.9644	1.0267	1.1203
5-9	15-19	0.6841	0.7146	0.7124	0.7766
10-14	20-24	1.0386	0.9474	0.9213	0.9193
15-19	25-29	1.2028	1.1940	1.1827	1.1848