Hindawi Publishing Corporation
Advances in Epidemiology
Volume 2014, Article ID 328102, 11 pages
http://dx.doi.org/10.1155/2014/328102

Research Article

Epidemiological Transition in Urban Population of Maharashtra

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Received 23 July 2014; Accepted 14 October 2014; Published 18 November 2014

Academic Editor: Peng Bi

Our objective is to assess epidemiological transition in urban Maharashtra in India in past two decades. We used the medically certified causes of death (MCCD) data from urban areas of Maharashtra, 1990–2006. Cause-specific death rate was estimated, standardized for age groups, and projected by using an exponential linear regression model. The results indicate that the burden of mortality due to noncommunicable conditions increased by 25% between 1990 and 2006 and will add 20% more by 2020. Among specific causes, the "diseases of the circulatory system" were consistently the leading CoD between 1990 and 2006. The "infectious and parasitic disease" and "diseases related to respiratory system" were the second and third leading causes of death, respectively. For children and young population, the leading cause of death was the "certain conditions originating in the prenatal period" and "injury and poisoning," respectively, among both sexes. Among adults, the leading cause of death was "infectious and parasitic diseases." In case of the adult female and elderly population, "diseases of circulatory system" caused the most deaths. Overall the findings foster that socioeconomically developed and demographically advanced urban Maharashtra bears the double burden of disease-specific mortality.

1. Introduction

Omran [1] laid the foundation for the "epidemiological transition theory," which builds upon the demographic transition and the changing patterns in disease prevalence [2]. Epidemiological transition is marked by a shift in the cause of death profile to reflect the predominance of noncommunicable diseases as the mean age of the population advances [1, 3]. This shift from communicable (predominance of infectious and parasitic) to noncommunicable (chronic and degenerative) diseases is classified into four stages: first stage being the stage of pestilence and famine, followed by the stage of receding pandemics; third is the stage of degenerative and man-made disease, and finally, the stage of delayed degenerative diseases [1, 3–5]. Epidemiological transition is expected to progress faster in urban and industrialized areas than in rural areas. Urbanization is associated with improved sanitation, nutrition, and health systems which reduce the burden of infectious diseases and related mortality, particularly among vulnerable populations [6, 7].

During the last decade as a consequence of rapid demographic transition and growing proportion of the adult and older population, the epidemiological profile of low and middle income countries reflects the diseases of adults rather than childhood while retaining high exposure to risk factors associated with infectious diseases, leaving poor rural areas and urban slums with persisting high rates of infections and childhood deaths alongside richer urban areas where adults die prematurely of noncommunicable diseases [2, 4, 5, 8–13]. About 60 million deaths occur worldwide every year, out of which 46 million deaths occur in low and middle income countries [14]. The World Health Organization (WHO) forecasts that, within the next two decades, there will be dramatic changes in health needs of these countries as a result of the epidemiological transition. The mortality resulting from NCDs is expected to double in these countries by 2020. Mortality and morbidity resulting from injuries, both unintentional and intentional, are also gaining importance and by 2020 it could be almost equal to mortality from infectious diseases [13]. Thus, most low and middle income countries are dealing with a dual burden of infectious diseases among children and premature chronic and degenerative diseases among adults, which has made it particularly difficult for policy makers to address the diverse population needs [4, 14, 15].

The human immunodeficiency virus (HIV) epidemic, violence, injury, and civil unrest have added another level of complexity to the epidemiological transition by reversing the gains made in life expectancy in developing countries [4, 11, 16, 17]. The main difference in the patterns of mortality in developed and developing regions is the high proportion of premature deaths due to external causes of death, primarily homicides, suicides, road traffic crashes, and poisoning among youth and adult population. Further, in the context of developing countries, studies also point to multiple causes associated with disease; thus, death is the result of not just one event, but the chain of events [4, 11, 13].

Indian Scenario. India occupies a unique place among developing countries not only because of its population size but also due to compound health problems [17]. India reports about 9.5 million deaths a year, which amount to about one in six of total deaths worldwide [16]. Like other developing countries, India is undergoing rapid epidemiological transition and change in the mortality pattern as a result of its socioeconomic and demographic changes [17, 18]. The crude death rate in India was 12.5 (per 1000) in 1981, which was declined to 7.2 (per 1000) in 2010. During the same period, the crude birth rate fell from 34 to 22 per 1000. Over the last century, life expectancy in India has increased by almost threefold, rising from 23 years in 1901 to 65 years in 2005-06. In urban Maharashtra, life expectancy was only 59 years in 1981 for both males and females; however, it has increased to 66.4 years for males and 69.8 years for females in 2005-06 and is expected to further rise to 70.9 years and 74.7 years, respectively, in 2021 and 2025 [17–21].

To identify and monitor the rapidly changing disease and mortality patterns and accomplish the health system needs, studying and reporting updated information on causes of death (CoD) is essential. The information on trends and patterns of CoD is important in order to caution against potential future health policy challenges. There are not many studies in India which address this important issue. The lack of reliable database on the causes of deaths at the national level is the key hindrance for not conducting regular studies on this subject. Though MCCD scheme is an important mechanism for obtaining authentic and scientific information regarding causes of mortality worldwide [9], researchers in developing regions studying CoD often experience a dearth of reliable and accurate information regarding the causes of mortality [4]. The vital registration system and MCCD are expected to provide a reliable database for generating mortality statistics but they have not taken roots to the extent desired. Thus, it is not able to produce representative and reliable statistics on mortality as part of the vital statistics system [20, 22, 23]. Since early 1970, sample registration system is a reliable source of counting births and deaths but does not provide information on the causes. To overcome this, in early 2004-05, India had decided to undertake a Special Survey of Deaths using an advanced form of Verbal Autopsy (the baseline survey of the Million Death Study) [23]. The first report of this survey was published in 2009. They have also published articles on some specialised themes which are reported elsewhere [22, 24–26]. The recent Global Burden of Disease (GBD) gives some information on the national level analysis of the cause of deaths in India as part of global country study, but the study did not address national or subnational level findings in detail [4]. Therefore, in this study, we have a twofold objective: (1) to measure the trends in mortality by different CoD between 1990 and 2006 and their relative contributions among different age groups stratified by sex; (2) to project the leading causes of death through 2020.

2. Methods

2.1. Data Source. The data used for this study is based on the records of MCCD scheme in urban areas of Maharashtra for the period 1996–2006. The MCCD scheme was introduced in India under the provisions of the Registration of Births and Deaths (RBD) Act, 1969 Section 10 (2) and Section 10 (3), for certification of causes of death by a medical practitioner with the responsibility of Registrar General of India (RGI) to ensure that all deaths had a medical certificate stating the CoD. Though RGI is responsible for the collection, compilation, and publication of CoD statistics, information about MCCD is generated as a part of the Civil Registration System (CRS) wherein the registration of the CoD attended by medical personnel is mandatory. The ethical approval for the collection and compilation of such registration of births and deaths statistics was taken from the World Health Organization (WHO) and Indian Council for Medical Research (ICMR) by the Office of RGI under RBD Act, 1969. However, at the national level, the reliability and quality of this information is a major issue. Incompleteness of registration and lack of correct stratification of CoD are main hindrance in determining the mortality trends and current stage of epidemiological transition in India [27, 28]. Nevertheless, the quality of MCCD data is much better in the urban areas of the Maharashtra. The reported MCCD coverage is almost 78% for urban deaths which is reasonably good quality data compared to the rest of India [20]. Therefore, this study used MCCD based CoD information of urban Maharashtra. The state of Maharashtra also represents a significant portion of Indian population in terms of size and socioeconomic, demographic, and health transition [17]. Maharashtra is the second largest state in India and accounts for almost half of the total population that lives in urban areas. Moreover, three big cities including Mumbai, Pune, and Nagpur in the state have huge migrant populations from a number of states in India. Therefore, findings based on this population can roughly be generalized to India [27–29].

Another important reason for selecting the MCCD urban Maharashtra data during 1996–2006 is to overcome the reclassifying of CoD from previous ICD to new ICD and the lack of bridge-coding which is the main hindrance in the long term CoD analyses. WHO has given the ICD X revision in 1998 and it was implemented from 1999 so the reclassification of deaths classified in ICD IX to ICD X was a challenging task. However, in case of MCCD urban Maharashtra data, we could manage to collect already reclassified data on CoD based on ICD X for the entire period from 1996 to 2006. MCCD data from urban Maharashtra are quite useful in understanding the trend and pattern in causes of death, share of deaths due to communicable and noncommunicable diseases in the context of urban Maharashtra in particular and India in general [20, 27, 28]. Apart from MCCD data, we have also used age-sex wise distribution of the population for the same period from the sample registration system (SRS). The projected age-sex wise distribution of the population was taken from the expert committee population projection reports available from the office of Registrar General of India and Census Commissioner of India. The SRS and expert committee population projection reports are considered to be the most reliable source of demographic statistics in India [28, 29].

2.2. Data Collection. MCCD in Maharashtra has adopted an improved registration system since the mid-1970s. Since 1976, the MCCD system in urban Maharashtra is working on a well-built mechanism. In 2006, MCCD data were available for about 209,515 deaths out of 293,432 deaths in urban Maharashtra (Table 1). During this period, through the World Bank's Maharashtra Health System Development Project (MHSDP), special training programs were conducted to improve the manner in which MCCD data were collected. Everyone from the civil surgeons to medical officers at Primary Health Centers (PHCs) was invited to undergo this MCCD certificate registration training. As per standard operating procedure, MCCD certificates from all hospitals and private medical practitioners are collected at the office of the local registrars and from there they are sent to the offices of the Deputy Chief Registrar of births and deaths and the Deputy Director of Health Services (DDHS) at the state level. The standard formats prescribed by the World Health Organization for institutional and noninstitutional deaths are used for recording MCCD. The data is collected in the prescribed forms (Form 4 for Hospital deaths and Form 4A for noninstitutional deaths). Submission of the MCCD forms to the local registrar is legally mandated under the Maharashtra Registration of Births and Deaths Rules legislation in 2000. By the fifth day of every month, the forms are sent to the local municipal authorities for onward submission. After the receipt of certificates the cause of death is coded using the latest ICD classification and cross-tabulated by age, sex, and cause of death at Data Processing Unit State Bureau of Health Intelligence & Vital Statistics (SBHI & VS), Pune [20, 27].

2.3. Statistical Analysis

2.3.1. Compilation of COD. In order to meet the objectives of this study, the CoD data have been recompiled from reports of MCCD for urban Maharashtra to incorporate the international classification of diseases [20, 27, 28]. MCCD data by age and sex segregation are clubbed into ICD codes

Table 1: Percentage of medically certified deaths to total registered and registered urban deaths in Maharashtra, 1993–2006.

Year	Registered deaths		MCCD received	Percentage of MCCD received to reg. deaths	
	Total	Urban		Total	Urban
1993	445569	209531	129512	29.1	61.8
1994	425999	207571	135132	31.7	65.1
1995	436146	208890	145704	33.4	69.8
1996	453940	222237	148313	32.7	66.7
1997	412066	218461	151541	36.8	69.4
1998	512649	255158	172494	33.6	67.6
1999	510291	247561	170406	33.4	68.8
2000	512330	265149	172714	33.7	65.1
2001	512241	254227	173026	33.7	68.6
2002	564485	276901	172995	30.7	62.5
2003	602711	290326	182910	30.4	63
2004	518533	251810	181294	35	72
2005	554633	279627	191586	34.5	68.5
2006	565892	269432	209515	37	77.8

also called blocks. Further, these ICD codes were grouped into 19 chapters of CoD as indicated in ICD-10 classification. At the last stage, these 19 chapters of CoD are regrouped into three broad groups based on their nature of the occurrence and prevalence: communicable diseases, noncommunicable diseases, and other causes of death. However, chapter of Endocrine, Nutritional and Metabolic Diseases usually comprises both communicable and noncommunicable diseases [23]. Thus, we kept chapter-2 in both communicable and noncommunicable diseases and indicated as part-1 and part-2 of chapter-2, respectively. The part-1 blocks include E00–E02, E40–E46, and E50 (largely related to nutritional deficiencies) and part-2 blocks include E03–E07, E10–E16, E20–E34, and E51–E89 (largely related to Endocrine and Metabolic diseases) [23]. Further, diseases like respiratory origin and pregnancy complications, and so forth, can be included either in communicable or noncommunicable diseases, but MCCD of Maharashtra included them in noncommunicable diseases [27] (see Table 2).

2.3.2. Death Rate. The death rate is calculated by the standard procedure as described in

$$\text{Death rate} = \left(\frac{\text{Number of deaths}}{\text{Total population exposed to the risk}}\right) * 100000. \quad (1)$$

2.3.3. Age-Standardisation Death Rate. Age-standardisation death rate is calculated as expressed in

$$\text{Age-standardised death rate} = \frac{\sum (P_k m_k)}{\sum P_k}, \quad (2)$$

where P_k = standard population in age/sex group k, m_k = observed mortality rate (death rates per 100,000 persons) in

Table 2: Classification of CoD in urban Maharashtra based on ICD-10.

Cause group	Chapters: titles	ICD-10 codes (blocks)
Group I Communicable disease	(1) Infectious and parasitic diseases (2) Endocrine, nutritional and metabolic diseases [Part 1] (3) Complications of pregnancy (4) Certain conditions originating in the peri-natal period	A00–B99, G00–G04, N70–N73, J00–J06, J10–J18, J20–J22, H65-H66, O00–O99, P00–P96, E00–E02, E40–E46, E50, D50–D64
Group II Noncommunicable disease	(2) Endocrine, nutritional and metabolic diseases [Part 2] (5) Neoplasm (6) Disease of blood and blood forming organs (7) Mental disorders (8) Disease of nervous system and sense organs (9) Disease of circulatory system (10) Disease of respiratory system (11) Disease of digestive system (12) Disease of genitourinary system (13) Disease of skin and subcutaneous tissue (14) Disease of musculoskeletal system and connective tissue (15) Congenital anomalies (16) Disease of the eye and adnexa (17) Disease of the ear mastoid process	C00–C97, D00–D48, D65–D89, E03–E07, E10–E16, E20–E34, E51–E89, F01–F99, G06–G99, H00–H61, H68–H95, I00–I99, J30–J99, K00–K92, N00–N64, N75–N99, L00–L99, M00–M99, Q00–Q99
Group III Other diseases	(18) Symptoms, signs and ill-defined conditions (19) Injury and poisoning	R00–R99 V01–Y98

the age group/sex, k = age/sex group 0-1, 1–4, 5–9, 70 + years and older.

Standard age-structure of population of Maharashtra is taken from expert committee projected population (1996–2026) by age and sex based on Censuses 1991 and 2001 from the Office of the Registrar General of India [29].

2.3.4. Projection of Age-Standardised Death Rate. The exponential regression model is used for projecting trends of the major causes of death. The mathematical form of this model is

$$f(x) = y = ae^{bx}. \tag{3}$$

In order to estimate the parameters of the above exponential model, the following linear regression model is fitted using the estimated age-standardized mortality rates for selected causes of death over 1990–2006:

$$\text{In}(y) = \text{In}(a) + bx. \tag{4}$$

The parameter estimates including standard errors and test of significance were obtained using Microsoft Excel data analysis and solver tool packs [30, 31].

3. Findings

3.1. Age-Sex Profile of Study Population. Assessment of the age-sex profile of the population is important to understand the changing pattern of CoD in a population. For this reason, we assessed the age-sex transition of population in urban Maharashtra between 1990 and 2006. Table 3 presents the age-sex composition of the population of urban Maharashtra during 1990 to 2006. The results reveal that there was an increase in the percentage share of adults and older population, but a decrease in percentage share of the child population of age 0–4 years during the study period. By sex, the results indicate that the proportion of younger age and the working ages was more or less similar for both the males and females during 1990 to 2006, although the absolute percentage share has increased over the period for both groups. However, in 2006, the proportion of older females (7.3%) was higher as compared to males (6.8%). This can be attributed to the increasing life expectancy for the females in the past decade.

3.2. Trends in Death Rates by Causes. Figure 1 presents the age-standardized death rates from communicable, noncommunicable, and other causes during 1990 to 2006. The rate of deaths resulting from noncommunicable diseases was around 200 per hundred thousand populations in 1990, but it increased to 250 per hundred thousand populations by 2006, thus recording a 25% increase in death rate due to noncommunicable diseases. On the other hand, the death rate due to communicable diseases was around 102 per hundred thousand populations in 1990 then followed a decreasing trend until 2001 but again slightly moved up and settled at initial levels of 102 per hundred thousand populations in 2006. The rate of deaths due to other causes was at 150 per hundred thousand populations in 1990 but continuously declined thereafter, declined at 100 per hundred thousand populations in 2006. The abnormal and sharp rise in the mortality rate due to noncommunicable diseases and comparative decline in deaths due to communicable diseases in the year 2001 are attributed to changes in the international classification of diseases.

Table 3: Population share (in percentage) among children (0–4 years), working age population (15–59 years), and old age (60 and above), in urban Maharashtra, 1990–2006.

Year	Male				Female				Total			
	0–4	5–14	15–59	60 and above	0–4	5–14	15–59	60 and above	0–4	5–14	15–59	60 and above
1990	11.0	21.4	63.1	4.5	11.0	21.5	63.1	4.5	11.3	21.5	62.1	5.1
1991	10.8	21.3	63.1	4.8	10.8	21.2	63.1	4.8	11.0	21.4	62.3	5.3
1992	10.4	21.1	63.5	5.0	10.4	21.4	63.5	5.0	10.6	21.2	62.7	5.5
1993	10.7	22.5	61.4	5.4	10.7	23.0	61.4	5.4	10.9	22.8	60.5	5.8
1994	10.3	22.4	62.1	5.2	10.3	22.8	62.1	5.2	10.5	22.2	62.1	5.2
1996	9.9	21.5	63.1	5.5	9.9	22.0	63.1	5.5	10.0	21.6	62.3	6.1
1997	9.8	21.1	63.6	5.5	9.8	21.1	63.6	5.5	9.9	21.0	63.0	6.1
1998	10.1	20.0	63.7	6.2	10.1	20.2	63.7	6.2	10.0	20.3	63.2	6.5
1999	10.2	20.0	63.4	6.4	10.2	19.8	63.4	6.4	10.0	19.9	63.2	6.9
2000	9.9	19.4	64.4	6.3	9.9	19.7	64.4	6.3	9.7	19.4	64.1	6.8
2001	10.2	20.0	63.7	6.1	10.2	19.8	63.7	6.1	9.9	19.7	63.5	6.9
2002	9.6	19.1	65.0	6.3	9.6	19.3	65.0	6.3	9.4	19.0	64.5	7.1
2003	9.3	18.9	65.1	6.7	9.3	18.4	65.1	6.7	10.3	16.4	65.8	7.5
2004	9.3	18.7	65.6	6.4	9.3	18.7	65.6	6.4	9.6	18.4	65.2	6.8
2005	9.1	18.6	65.8	6.5	9.1	18.3	65.8	6.5	9.0	18.5	65.5	7.0
2006	8.9	18.4	65.9	6.8	8.9	17.8	65.9	6.8	8.8	18.0	66.1	7.1

Trends in age-standardized death rates of communicable, noncommunicable, and other causes among male and female are also presented in Figure 1. The results reveal that, except for the period of one year, between 1999 and 2000, the rate of deaths due to noncommunicable diseases consistently increases in males and females. Though for both male and female population there can be seen almost same slight increase in non-communicable death rate but in initial years the death rate due to non-communicable disease was much higher in male (202 per 100000) compared to female (150 per 100000). This indicates that females experienced greater increases (33%) in noncommunicable deaths compared to males (20%). In case of death rate due to communicable and other causes, the results show a steady decline till early 2000 and slight rise thereafter and settled down more or less near to initial levels. Overall, male population experienced higher age-standardized death rate in all three groups of causes of mortality compared to female populations.

3.3. Noncommunicable to Communicable Death Rates. The trends in the ratio of noncommunicable to communicable death rates vis-a-vis percentage share of the older population in the total population are presented in Figure 2. The results reveal that the ratio of deaths due to noncommunicable disease to communicable diseases was increased with the increase in percentage share of the older population in the total population. In 1990, the ratio of deaths due to noncommunicable disease to communicable diseases was 1.83 (37253/19884) which increased to 2.23 (70781/32742) in 2006. The increase in the ratio of 0.40 might not look a major shift, but in terms of absolute number of deaths its shows rise of 20,670 more noncommunicable deaths compared to communicable deaths. Figure 2 also presents the ratio of noncommunicable to communicable death rates vis-a-vis proportion of the older population in total population for males and females separately. For both male and female populations, the figure shows rise and fall of trends during 1990 to 2006 but overall the ratio of deaths due to noncommunicable to communicable disease increased with increase in proportion of the older population in the total population. In case of males, this ratio increased from 1.87 in 1990 to 2.16 in 2006 while, for females, the ratio increased by more than 30% from 1.77 in 1990 to 2.34 in 2006. Overall, the results indicate that there were an increasing proportion of deaths due to noncommunicable diseases with the increase in the share of the older population in the total population and the effect differs by gender.

3.4. Major Causes of Deaths by Age Groups. The leading CoD by different age groups was calculated and presented in Table 4 to Table 8. Tables 4 and 5 present the main causes of infant and child deaths in urban Maharashtra during 1990 to 2006. The results reveal that "certain conditions originating in the prenatal period" contributed to 44% share of infant deaths in 1990 which rose to 50% in 2006. The second most common cause of infant deaths in urban Maharashtra was "disease of respiratory system" which contributed to 13% in 1990 and rose to 16% in 2006. In the case of children, again "certain conditions originating in the perinatal period" contributed to 28% in 1990 and increased to 34% in 2006. Though "infectious and parasitic disease" was the second leading cause of death with a 18% contribution among children in 1990, it has slipped to third place with 15% in 2006. With a 17% contribution, the "disease of respiratory system" emerged as the second commonest cause of childhood deaths in 2006.

Table 6 shows the percentage contributions of the main CoD among the youth population of urban Maharashtra. Among youth, the leading cause of death was "injury

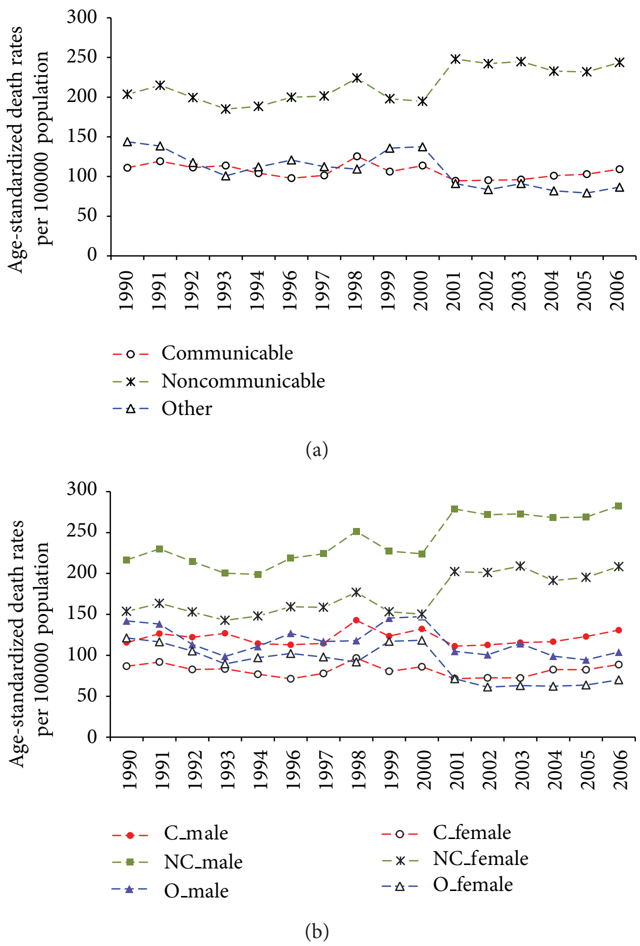

Figure 1: Age-standardized death rates of communicable, noncommunicable, and other causes overall in urban Maharashtra and for male and female, 1990–2006.

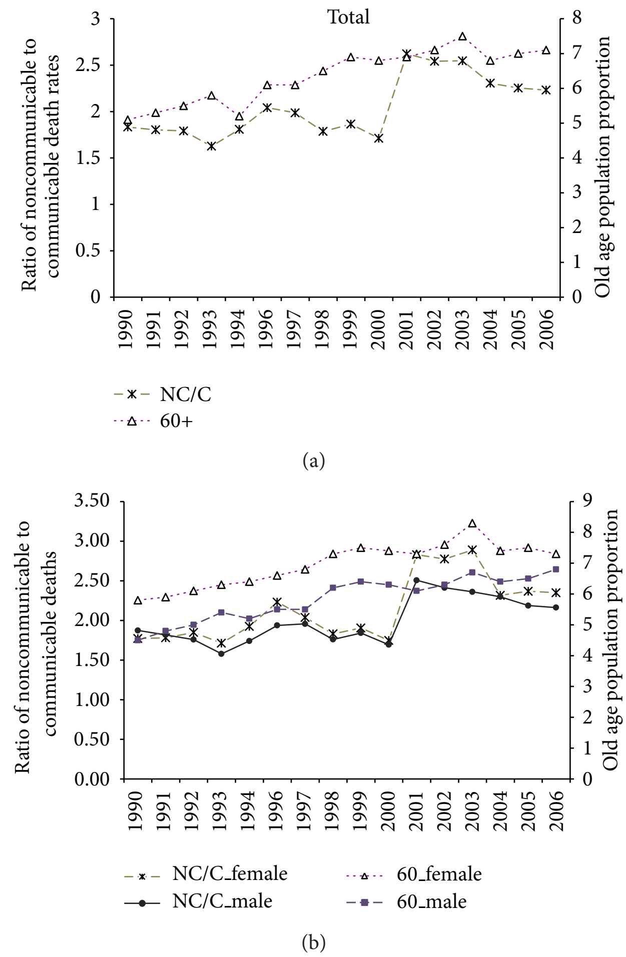

Figure 2: Ratio of noncommunicable to communicable death rates and proportion of old age population overall in urban Maharashtra and for male and female, 1990–2006.

and poisoning" which leads to 43% deaths in 1990. However, there was a decline of 10% in absolute contribution of "injury and poisoning" to deaths among youth population of urban Maharashtra by 2006. Table 6 also provides the details about the leading cause of death among males and females, separately. The results show a similar pattern of contribution from major CoD by gender. "Injury and poisoning" was a leading cause of death, followed by "infectious and parasitic disease" for both male and female youth populations. Table 7 illustrates the main CoD among adults in urban Maharashtra during 1990 to 2006. The results indicate a shifting pattern of the leading cause of death among adult population of urban Maharashtra in the period of 16 years. In 1990, the "injury and poisoning" contributed 23% adult deaths, but it dropped to third position (16%) in 2006. On the other hand, "infectious and parasitic disease" which was in third position with 17% share of deaths in 1990 climbed up to the first position in 2006 by contributing to 22% share of deaths. The disaggregated estimates for CoD for adult males and females indicate that the leading cause of death among adult male was "infectious and parasitic disease" (23%) while for adult females it was "disease of the circulatory system" (22%) in the year 2006.

Table 8 provides data on leading CoD among older population in urban Maharashtra. For the older population, the results show that the leading CoD were "disease of the circulatory system" (37%) followed by "symptoms, signs and ill-defined conditions" (30%) in 1990. Similarly, in 2006, "disease of the circulatory system" (44%) retained the position of the top killer among the older age population, followed by "disease of respiratory system" (17%), which moved up one step from its third position in 1990. Among the older male population of urban Maharashtra "disease of the circulatory system" continued to be the top killer from 1990 to 2006. The resulting deaths from this condition climbed from 35% in 1990 to 40% in 2006. Similarly, among the older female population, "disease of the circulatory system" remained the major killer during the study period.

3.5. Projected Death Rate by Causes. Assuming that there will be no major changes or disruption in the existing mortality trends in the future, the parameter estimate for fitted exponential regression models from Table 9 were used for projecting scenarios for broad groups of causes of death. The R^2 values presented in the Table 9 show that all models

Table 4: Percentage contribution of main causes of death among the children in age group 0-1, in urban Maharashtra, 1990–2006.

Causes of death	Infant deaths				Male infant deaths				Female infant deaths			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Certain conditions originating in the perinatal period	41.1	45.9	43.0	45.4	39.2	44.3	40.5	43.2	34.9	37.2	36.8	38.6
Infectious and parasitic diseases	15.3	8.8	7.7	9.8	13.7	8.2	7.2	9.1	14.1	7.5	6.7	8.7
Diseases of the respiratory system	14.6	13.4	12.6	13.9	12.5	11.4	10.9	12.1	14.2	12.8	12.0	13.2
Congenital anomalies	2.3	2.0	15.3	4.6	2.3	1.7	14.5	4.4	1.8	1.8	12.9	3.9
Diseases of the circulatory system	1.9	2.1	0.6	3.0	1.8	1.9	0.6	3.0	1.6	1.9	0.6	2.3
Symptoms, signs and ill-defined conditions	9.2	12.9	3.7	6.1	8.6	11.2	3.2	5.3	8.1	12.0	3.6	5.9

Table 5: Percentage contribution of top five causes of death among the children in age group 1–14, in urban Maharashtra, 1990–2006.

Causes of death	Child deaths				Male child deaths				Female child deaths			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Infectious and parasitic diseases	26.8	17.3	18.1	20.0	23.6	14.7	14.2	16.2	23.4	14.5	16.0	17.4
Diseases of the respiratory system	16.8	15.8	15.1	15.9	14.2	12.2	12.1	13.3	15.3	14.5	13.1	13.5
Injury and poisoning	7.2	10.3	14.1	10.2	6.3	8.8	13.9	9.4	6.3	8.4	9.2	7.7
Diseases of the nervous system and sense organs	5.3	7.4	4.0	7.1	5.2	6.6	3.6	6.2	4.1	5.8	2.9	5.8
Diseases of the circulatory system	3.6	4.5	10.7	8.7	3.4	3.9	8.6	7.6	2.9	3.6	9.1	6.9
Symptoms, signs and ill-defined conditions	15.1	13.8	7.9	6.8	12.7	13.5	6.6	5.7	13.8	9.5	6.5	5.7

Table 6: Percentage contribution of main causes of death among the Youth in age group 15–24, in urban Maharashtra, 1990–2006.

Cause of death	Youth deaths				Male youth deaths				Female youth deaths			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Injury and poisoning	42.9	36.1	38.5	33.7	40.8	30.8	38.7	35	45.1	41.4	38.3	31.7
Infectious and parasitic diseases	17.6	19.2	19.5	23.7	18.5	20.5	17.9	22.4	16.7	17.8	21.4	25.5
Diseases of the circulatory system	7.1	5.5	11.5	8.1	8.1	5.8	12.1	7.9	6.2	5.2	10.9	8.3
Diseases of the respiratory system	4.5	4.3	8.7	7.5	4.7	4.7	10	8.2	4.3	3.9	7.1	6.6
Complication of pregnancy	—	—	—	—	—	—	—	—	8.4	4.9	4.9	2.3
Symptoms, signs and ill-defined conditions	11.1	19.4	9.8	13.1	14.2	23.9	10.5	13.7	7.9	14.8	8.9	12.4

fall in best fit or reasonably well fit. Moreover, all the models are statistically significant at $P < 0.001$. By using the parameters presented in Table 9, the age standardized mortality rate for broad groups of CoD was projected and presented in Table 10. The results indicate that while the deaths due to communicable and other diseases will decrease, deaths due to noncommunicable diseases will increase during 2006 to 2020 (from 243 per 100000 in 2006 to 290 per 100000 in 2020) which counts for 20% rise from initial levels. A similar trend is also evident in the case of the male population. However, in case of female population, all three major groups of causes of death will decrease during 2006 to 2016 followed by a rise in noncommunicable deaths. The female population is expected to experience a remarkable decrease in other causes of deaths which include maternal deaths related to childbirth.

Table 7: Percentage contribution of main causes of death among adults population in age group (25–64), in urban Maharashtra, 1990–2006.

Causes of death	Adult deaths				Male adult deaths				Female adult deaths			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Infectious and parasitic diseases	17.5	19.3	20.5	22.3	19.4	21.2	21.7	23.0	13.5	15.1	17.7	20.7
Diseases of the circulatory system	24.3	23.2	28.8	23.9	25.5	23.7	28.5	23.7	21.8	22.2	29.7	24.3
Injury and poisoning	20.8	16.1	15.0	13.9	18.4	14.3	15.1	14.4	25.7	20.2	14.6	12.6
Diseases of the respiratory system	6.6	6.0	11.1	9.9	6.8	6.0	10.8	9.6	6.4	6.0	12.1	10.7
Diseases of the digestive system	6.1	6.8	5.7	6.6	7.3	8.1	6.8	8.0	3.8	4.0	2.8	3.4
Symptoms, signs and ill-defined conditions	10.6	15.7	7.6	7.5	10.7	15.9	8.0	8.0	10.2	15.1	6.6	6.3

Table 8: Percentage contribution of main causes of death among older population in age group 65+, in urban Maharashtra, 1990–2006.

Cause of death	Old age deaths				Male old age deaths				Female old age deaths			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Diseases of the circulatory system	37.2	41.8	49	44.8	35.1	38.7	45.4	39.3	35.7	41.1	48.6	45.2
Diseases of the respiratory system	13.9	13.8	17	16.8	12.6	12.6	15.3	15.5	14.1	13.9	17.4	15.8
Infectious and parasitic diseases	7.7	8.1	7.7	12.2	8.6	8.6	8.2	11.7	5.6	6.6	6.3	10.8
Neoplasms	5	4	4.2	6.5	5.1	3.8	4.2	5.8	4.3	3.8	3.8	6.5
Endocrine, nutritional and metabolic diseases and immunity disorders	3.4	4.2	3.2	5	2.8	3.9	2.8	4.4	3.7	4.2	3.3	5.1
Symptoms, signs and ill-defined conditions	29.4	23.2	16	14	25	19.7	13.4	11.1	31.9	25.1	17.6	15.7

Table 9: Parameter estimate of fitted exponential regression models on age standardized death rates of selected causes of death, urban Maharashtra, 1990–2006.

Causes of death	Intercept (a)[1]	Beta (b)	SE (b)	P value	R^2 (Percent)
Male					
Communicable	20878	0.0224	0.02364	0.00	89.6
Noncommunicable	35129	0.0419	0.02006	0.00	97.7
Others	22411	0.0085	0.04102	0.00	29.1
Female					
Communicable	12615	0.0183	0.02999	0.00	78.1
Noncommunicable	21684	0.0434	0.026	0.00	96.4
Others	18224	−0.017	0.05208	0.00	50.5
Urban Maharashtra					
Communicable	33497	0.0209	0.0252	0.00	86.8
Noncommunicable	56808	0.0425	0.02198	0.00	97.3
Others	40085	0.0001	0.04346	0.00	0.01

The Intercept (a) superscript shows the constant in the regression equation and the R squared is the coefficient of determination value of equation.

4. Discussion

This study is one of the most systematic and comprehensive efforts to perform analyses of CoD in India in recent times. The analysis of the MCCD data of urban Maharashtra provided key insights in terms of epidemiological transition in India. Since 1990, noncommunicable diseases have taken the largest toll of human life in urban Maharashtra. Deaths due to noncommunicable diseases accounted for an average of 50% of total MCCD from 1990 to 2006. Noncommunicable diseases were more common among males as compared to females. Deaths due to "certain conditions originating in

Table 10: Actual and projected death rates due to communicable and noncommunicable deaths, urban Maharashtra, 1990–2020.

Causes of death	Age-standardized mortality rate						
	1990	1996	2001	2006	2011	2016	2020
Total							
Communicable	111.1	97.9	94.6	109.2	**95.6**	**92.1**	**89.5**
Noncommunicable	203.6	199.9	248.0	243.7	**255.2**	**274.0**	**290.0**
Others	143.9	120.8	91.1	86.6	**74.3**	**64.5**	**57.6**
Male							
Year	1990	1996	2001	2006	**2011**	**2016**	**2020**
Communicable	115.6	112.9	111.2	130.8	**105.0**	**105.2**	**105.3**
Noncommunicable	216.6	218.7	278.7	282.7	**266.2**	**293.9**	**318.2**
Others	142.0	126.9	104.8	103.9	**84.2**	**78.7**	**74.5**
Female							
Communicable	86.7	71.4	71.5	88.7	**58.4**	**57.3**	**56.5**
Noncommunicable	153.7	159.3	202.2	208.4	**170.0**	**189.2**	**206.1**
Others	121.2	102.2	71.4	70.0	**40.1**	**33.0**	**28.3**

Note: bolded figures are projected age-standardized death rates.

the perinatal period" were the main cause of infant and childhood deaths. Among youth, the leading cause of death was "injury and poisoning" from 1990 to 2006 for both males and females. In the adult age groups, overall leading cause of death was "infectious and parasitic disease." However, among adult females, "disease of the circulatory system" was leading cause of death. For the older population, "disease of the circulatory system" was the leading cause of death for both males and females. Among all the diseases that cause death, "diseases of the circulatory system" were the most common causes of death for the population of urban Maharashtra from 1990 to 2006.

The estimates of CoD trends during 1996 to 2006 and projected estimates up to 2020 indicate that the deaths due to noncommunicable diseases increased by 20%. This increase in mortality related to noncommunicable diseases reflects the impact of the diseases related to adult and older population and changes in lifestyle in urban Maharashtra. Further, the projected estimates suggest that the future increase in noncommunicable deaths is more evident for male population compared to the female population. The analysis of the cause of death for all age group populations suggest that urban Maharashtra is approximately experiencing the onset of the third stage of epidemiological transition but disaggregated analyses by age-groups possibly differ with this. The unique feature of epidemiological transition in urban Maharashtra is that though communicable disease deaths are decreasing over time, they are still predominant among infants, children, youth, and adult populations. Considering the magnitude of absolute number of infants and children and youth population in the state, it accounts for a large number of deaths in these populations. Other disease categories like accidents, injury, and "Symptoms, Signs and Ill Defined Conditions" are also responsible for a large proportion of deaths in urban Maharashtra. Even though urban Maharashtra is socioeconomically and demographically a more developed state in India, it bears the double burden of disease reflected by the mortality pattern which is difficult to explain by the simple four-stage sequence demonstrated by Omran. Therefore, the results of this study challenge the applicability of sequence of classical epidemiological transition on the mortality transition in India. Our results in this study also align with the findings of other studies in developing countries [2, 4, 5, 8].

The comparison of findings of our study with the global burden of disease study and million death studies foster that our study has a unique contribution to the literature on epidemiological transition in India. Both global burden of disease studies and million death studies have contributed in a different aspect. The global burden of study completely focused on multicountry comparison; thus, the importance was not specific to India. Therefore, the scope for detailed discussion on the aspects of epidemiological transition of India in their study is very limited [2]. The million death study has brought out a comprehensive report on CoD in 2009 based on the data collected between 2001 and 2003, but, thereafter, their focus was limited to specific issues (maternal and child deaths, diarrheal, pneumonia, and infectious, unintentional, and injury deaths) [22–26]. On the other hand, we made a comprehensive assessment of trends in communicable and noncommunicable diseases in order to predict current stages of epidemiological transition in India with the evidence from urban Maharashtra MCCD information. Thus, our study evidently fills a critical gap in terms of knowledge on epidemiological transition in India and its future patterns. Though the results from urban Maharashtra may not be generalized to India, but in the absence of quality cause of death data at the national level, these results can become inputs for predicting current and future health care needs and possible changes in national health policy agenda and strengthening existing health system.

Our study has some limitations: first, the lack of reliable national level MCCD data restricted scope of analyses to only urban Maharashtra. Second, even in the setting of urban Maharashtra, the coverage of MCCD has ranged from 61% in 1993 to 78% of total deaths in 2006. Thus, individual errors in medical certification cannot be ignored completely. The missing deaths or deaths that physicians were unable to code cannot be ignored but given their low proportion it is safe to assume that they did not affect the general pattern of CoD trend. In case of these missing values, as per MCCD policy, they were classified under symptoms, signs, and ill-defined conditions of cause group. Third, the cause of death profile of a population is dependent on changes in the health system, socioeconomic and cultural factors, and political commitments which are not addressed completely through this study.

Keeping in the view limitations of our study and other relevant studies in this field [2, 25, 26], we advocate for necessity of reliable and timely information on the leading CoD and relevant changes in trends of CoD which are crucial to priority setting in health policy. We argue that cause-specific mortality is arguably one of the most fundamental metrics of population health. The assessment of trends in mortality and its major causes provides important information about whether society is making progress in reducing the burden of premature mortality and where renewed efforts are needed. Routine registration of births, recording deaths by age, sex, and cause, and calculating mortality levels and differentials are fundamental to evidence-based health policy, monitoring, and evaluation. Although the validity of routinely monitored health data by health system employees has been continuously questioned, if it is handled well like the one in urban Maharashtra, it will be a permanent solution to the problem. Though sample vital registration, when applied in conjunction with validated verbal autopsy procedures and medical record review, represents an affordable and cost-effective method, it is only a short- and medium-term solution to this problem [32, 33]. Therefore, better systems for reporting, surveillance and monitoring of mortality and CoD will be sustainable only if developed keeping in mind the existing monitoring protocol at the national, state and district levels. Therefore, our study will rejuvenate the plan of increasing efforts to revive vital registration system and MCCD at a national level with an inspiration of reasonably good quality registration evident in MCCD of urban Maharashtra.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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