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The Pattern of Mortality in India: An Overview

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ABSTRACT

Mortality data indicate numbers of deaths by place, time and cause. WHO's mortality data reflect deaths registered by national civil registration systems of deaths, with the underlying cause of death coded by the national authority. In accordance with the rules of the International Classification of Diseases, the majority of deaths are caused by infectious and chronic diseases. It is noted at end that hunger and poor nutrition directly or as an underlying cause are responsible for the fatal diseases and thus resulting in the mortality.

Keywords: Mortality, Causes of death, Nutrition and public health, Metro cities, India

Introduction

For morbidity, mortality and disability a concrete strategy needs to be evolved in Indian health sector. The majority of the Indians mortality lays on the unavailability of health services in time and proximity of the health services are also matters. Mortality is linked with the various socio-economic background characteristics. Education is linked to the socio-economic status of the family, which itself is a determinant of morbidity and mortality among Indians. Moreover, the poor adherence is a major factor contributing to both the emergence of morbidity and mortality among the poor. Multiple reasons for defaulting are given. The rationale is often based on misconception or lack of financial means to treat their diseases. Without treatment, mortality rates are high. In studies of the natural history of the mortality, the reasons are numerous and answerable. Not only are they more vulnerable to the disease because of their living and working conditions, they are also plunged deeper into poverty as a consequence of morbidity. A heavier burden of poverty and comparatively lower socio-economic status of poor make them more vulnerable to adverse social and environmental conditions. Ultimately, these people are landing high mortality.

The mortality rate provides a historical measure for each age group and gender which, when put together, becomes the mortality table. Mortality is the risk of dying in a given year, measured by the death rate-the number of deaths occurring per 100,000 people in a population. A mortality rate is the number of deaths in a given time period divided by the number of person-years lived in that time period by those at risk for death. For cause-specific rates, the deaths are restricted to those in which a particular condition or disease is listed as the *underlying* causes of death on the death certificate. Many developing countries experienced various phases in the process of modernization, totally changing the cause-specific mortality profile: acute and infectious diseases progressively disappeared while chronic and degenerative diseases as well as cancers became more and more predominant. The recent era is characterized by a shift towards older ages at death from degenerative diseases and a decline in mortality from these diseases and some types of cancer, because of early diagnosis, more healthy behaviours, and more efficient treatments.

Deaths by cause, the WHO considers three broad categories of causes of death (WHO, 2008): *Group-I* encompass communicable diseases as well as maternal, perinatal and nutritional conditions; *Group-II* includes non-communicable diseases; and *Group-III* comprises causes of death resulting from external sources, namely injuries, including both intentional and unintentional injuries. Of the estimated 56.9 million deaths worldwide during 2008, 36.1 million (63.5%) were caused by *Group-II* NCDs, especially cardiovascular diseases, cancers, diabetes and chronic respiratory diseases. *Group-I* health conditions caused 15.6 million deaths (27.5%) worldwide in 2008, with lower respiratory infections (pneumonia), perinatal conditions and diarrhoeal diseases as the leading causes of *Group-I* mortality. The injuries classified in

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Group-III caused the remaining 5.1 million deaths (9.0%) in 2008, with road traffic accidents, suicides and homicides accounting for the largest share of deaths in this cause group. The aim of the paper is to study trends and differentials in cause-specific mortality, during the 21 century, exploiting a new simple but powerful tool: the surface by age and time of leading causes of death. Classic mortality surfaces usually represent mortality rates over age and time (Arthur and Vaupel, 1984). Information on death events recorded in SRS is used to estimate mortality indicators. The various measures of mortality are Crude Death Rate (CDR), Under-five Mortality Rate (U5MR), Infant Mortality Rate (IMR) and its components, Age Specific Mortality Rates (ASMR), Still Birth Rate (SBR) and Peri-Natal Mortality Rate (PMR).

Material and Methods

The present study is based on the secondary sources of data consulted from the statistics of *SRS, Ministry of Home Affairs, Government of India.* Apart from all India scenario data on mortality indicators and death rate and infant mortality rate over the last decade for four metro cities like Chennai (Tamil Nadu), New Delhi (Delhi), Kolkata (West Bengal) and Mumbai (Maharashtra).

Mortality Rates in India

Crude Death Rate (Table 1) at national level for 2009 is 7.3% per thousand populations and it varies from 7.8% in rural areas to 5.8% in urban areas. Among the metro cities state, it varies from 4.4% in Delhi to 7.6% in Tamil Nadu.

Table 2 shows the percentage change in the level of crude death rate between the period 1999 and 2009 for India and for metro city states. During this period crude death rate in India has declined by 15.9 %. Among the four metro city states decline in crude death rate varies from 16.2 % in West Bengal, to 4.9% in Tamil Nadu.

Table 1: Crude death rate in India and four metro city states

India & State	Total	Rural	Urban
India	7.3	7.8	5.8
Delhi	4.4	4.8	4.3
Maharashtra	6.7	7.6	5.5
Tamil Nadu	7.6	8.5	6.6
West Bengal	6.2	6.1	6.4

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

Table 3: Crude death rate by sex, India and four metro city states

India & State	Total	Male	Female
India	7.3	7.8	6.7
Delhi	4.4	4.7	4.0
Maharashtra	6.7	7.5	5.8
Tamil Nadu	7.6	8.5	6.8
West Bengal	6.2	6.7	5.6

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

Crude death rate for males and females in the four metro city states are shown in Table 3. It observed that male death rate exceeds female death rate in all four metro city states.

Table 4 given provides the percent distribution of deaths by age groups for India and four metro city states. At the national level, 15.6% of the deaths are of infants deaths (0-1 year), whereas 29.1 % of deaths pertain to persons aged 60 years and above. The group (1–4 years) accounts for 4.1% of the deaths. The percentage of infant deaths to total deaths varies from a low 5.9% in Kerala to a high of 13.5% in Delhi. Percentage contribution of deaths from persons 60 years and above varies from 59.8% in Tamil Nadu to 44.9% in Delhi.

Table 2: Percentage change in average crude death rate in India and four metro city states

India & State	Total			Rural			Urban		
	1999	2009	% Change	1999	2009	% Change	1999	2009	% Change
India	8.8	7.4	-15.9	9.6	7.9	-17.7	6.5	5.9	-9.2
Maharashtra	7.5	6.6	-12.0	8.7	7.4	-14.9	5.6	5.6	0.0
Tamil Nadu	8.2	7.8	-4.9	8.9	8.2	-7.9	6.7	6.4	-4.5
West Bengal	7.4	6.2	-16.2	7.6	6.2	-18.4	7.0	6.5	-7.1

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

Table 4: Percent distribution of deaths by age groups in India and four metro city states

India & State	Age Group					
	<1	1–4	0–4	5-14	15-59	60+
India	15.6	4.1	19.7	2.6	29.1	48.6
Delhi	13.5	2.0	15.5	2.4	37.3	44.9
Maharashtra	8.0	1.5	9.5	1.6	31.3	57.6
Tamil Nadu	5.9	1.0	6.9	0.8	32.4	59.8
West Bengal	9.2	2.1	11.3	2.1	30.4	56.2

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

Table 5 given presents IMR by sex and residence for the year 2009 for India and for metro city states. Infant Mortality Rate (IMR) is defined as the infant deaths (less than one year) per thousands live births. At the national level, IMR is reported to be 50 and varies from 55 in rural areas to 34 in urban areas. Among the four metro city states, it varies from 28 in Tamil Nadu to 33 in Delhi and West Bengal where it is equal. Female infants experienced a higher mortality than male infants in all three metro city states except West Bengal where it is equal. On account of limited deaths there can be some distortion in gender infant

mortality rates. Distribution of four metro city states by level of IMR in rural and urban areas is shown in details table 5.

The percentage change in the average level of infant mortality between 1999 and 2009 is given in Table 6. During this period, IMR at the national level declined by 25.8%. Among the four metro city states, the decline varies from 40.6% in Tamil Nadu to 31.9% Maharashtra. In rural areas, decline in IMR varies from 41.7% in Tamil Nadu to 31.4% in Maharashtra. The decline in IMR varies from 31.5% in West Bengal to 26.5% in Maharashtra.

Table 7 given presents the neo-natal (less than 29 days) mortality rate and the percentage of neo-natal deaths to infant deaths for the year 2009 both at the National and four metro city state levels. At the national level, the neo-natal mortality rate is 34 and ranges from 21 in urban areas to 38 in rural areas. Among the four metro city states, neo-natal mortality ranges from 25 in West Bengal to 18 in Delhi and Tamil Nadu. The percentage of neo-natal deaths to total infant deaths is 67.9% at the national level and varies from 61% in urban areas to 69.1% in rural areas. Among the four metro city states, Maharashtra (77.4%) registered the highest percentage of neo-natal deaths to infant deaths and lowest in Delhi (53.9%).

Table 5: Infant mortality rates by sex in India and four metro city states

India & State	Total			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
India	50	49	52	55	54	56	34	32	35
Delhi	33	31	34	40	40	39	31	29	33
Maharashtra	31	28	33	37	35	39	22	19	25
Tamil Nadu	28	27	29	30	29	30	26	24	27
West Bengal	33	33	33	34	34	35	27	26	28

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

Table 6: Percent change in average infant mortality rate in India and four metro city states

India & State	Total			Rural			Urban		
	1999	2009	% Change	1999	2009	% Change	1999	2009	% Change
India	71.0	52.7	-25.8	76.3	58.0	-24.0	44.7	35.7	-20.1
Delhi									
Maharashtra	48.0	32.7	-31.9	57.3	39.3	-31.4	31.3	23.0	-26.5
Tamil Nadu	52.7	31.3	-40.6	58.3	34.0	-41.7	39.7	28.3	-28.7
West Bengal	53.3	35.0	-34.3	56.3	36.7	-34.8	41.3	28.3	-31.5

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

The death rates for children below age 5 by rural and urban are given in Table 8 separately for males and females. At the national levels, child mortality rate is estimated at 14.1 and it varies from 15.7 in rural areas to 8.7 in urban areas. Among the four metro states, child death rate varies from 6.7 in Tamil Nadu to 7.9 in West Bengal.

The under-five mortality rates by residence are given in Table 9 separately for males and females. At the national level, under-five mortality rate is estimated at 64 and it varies from 71 in rural areas to 41 in urban areas. Among the four metro city states, it varies from 33 in Tamil Nadu and 40 in West Bengal. All the four metro city states have higher death rates of female children than male children.

Death rates for children in the age group 5–14 are given in Table 10. As revealed by the data, at the national level, the death rate in this age group is estimated to be 0.9. Rural-urban differentials exist with the urban areas registering significantly lower death rates as compared to that in rural areas in all the four metro city states. Among the four metro city states, the lowest death rate in this age group is registered in Tamil Nadu (0.4) and the highest in West Bengal (0.7).

Death rate in the age group 15–59, by sex and rural–urban, are given in Table 11. At the national level, death rate in this age group is estimated to be 3.5 and it varies from 3.7 in rural areas to 3.0 in urban areas. The female

Table 7: Neo-natal mortality rates and percentage share of neo-natal deaths to infant deaths in India and four metro city states

India & State	Neo-natal mortality rate			Percentage of Neo-natal death to infant deaths		
	Total	Rural	Urban	Total	Rural	Urban
India	34	38	21	67.9	69.1	61.0
Delhi	18	17	18	53.9	42.9	56.5
Maharashtra	24	27	19	77.4	73.9	85.7
Tamil Nadu	18	21	14	65.1	71.6	54.8
West Bengal	25	27	19	76.3	77.6	69.7

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

Table 8: Estimated death rates for children aged 0–4 years in India and four metro city states

India & State	Total			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
India	14.1	13.4	14.9	15.7	14.9	16.6	8.7	8.3	9.2
Delhi	7.1	7.0	7.2	7.9	8.8	6.8	7.0	6.7	7.3
Maharashtra	6.8	6.3	7.4	8.0	7.8	8.2	5.0	4.0	6.2
Tamil Nadu	6.7	6.5	7.0	7.3	7.0	7.6	5.9	5.8	6.1
West Bengal	7.9	7.9	8.0	8.6	8.6	8.5	5.5	5.2	5.9

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

Table 9: Under-five Mortality Rates (U5MR) in India and four metro city states

India & State	Total			Rural			Urban		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
India	64	60	69	71	66	76	41	39	44
Delhi	37	36	38	42	45	39	36	34	38
Maharashtra	36	32	40	43	40	46	26	20	31
Tamil Nadu	33	31	34	35	33	38	28	27	30
West Bengal	40	39	41	42	42	43	30	28	32

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

Table 13: Percentage distribution of deaths by type of medical attention received before death in India and four metro city states

India & State	Govt. Hospital			Private Hospital			Qualified Professional			Untrained functionary & others		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
India	17.17	14.8	28.2	12.3	10.3	19.5	37.9	38.6	35.1	32.1	36.3	17.3
Delhi	40.0	17.3	44.3	11.2	6.3	12.1	28.9	49.3	25.0	20.0	27.1	18.6
Maharashtra	23.4	19.6	30.3	15.3	12.2	20.9	42.2	45.1	36.9	19.1	23.1	11.9
Tamil Nadu	17.1	13.2	23.7	14.9	10.4	22.6	22.2	20.2	25.6	45.9	56.2	28.1
West Bengal	23.4	18.5	35.9	6.4	3.8	13.0	46.2	47.0	44.0	24.1	30.7	7.1

Source: SRS, Ministry of Home Affairs, Govt. of India, New Delhi, 2009

urban areas. The infant mortality rate, which plays an important role in health planning, has shown a considerable decline from 129 live births in 1971 to 50 in 2009. The child mortality rate has depicted a perceptible decline from 51.9% in 1971 to 14.1% in 2009. In 2009, 30% of the deaths were institutional and 70% received medical attention other than institution.

Causes of Death

The cause of death information in our country is poor particularly in the rural areas. Due to continuing paucity of medical personnel and facilities in rural areas, where three-fourth of the population of the country lives, it is not feasible to build up statistics of mortality causes based on 'Medical certification of the cause of Death'. As per Department of Health Statistics and Informatics World Health Organization, Geneva, April 2011 given a list the cause of death categories and their definitions in terms of the International Classification of Diseases which are given as in the following:

I. Communicable, maternal, perinatal and nutritional conditions
A. Infectious and parasitic diseases- 1. Tuberculosis 2. Sexually transmitted diseases excluding HIV (Syphilis, Chlamydia, Gonorrhoea other STDs), 3. HIV/AIDS 4. Diarrhoeal diseases 5. Childhood-cluster diseases (Pertussis, Poliomyelitis, Diphtheria, Measles, Tetanus), 6. Meningitis 7. Hepatitis B, Hepatitis C 8. Malaria 9. Tropical-cluster diseases (Trypanosomiasis, Chagas disease, Schistosomiasis, Leishmaniasis, Lymphatic filariasis, Onchocerciasis), 10. Leprosy, 11. Dengue, 12. Japanese encephalitis, 13. Trachoma 14. Intestinal nematode infections (Ascariasis, Trichuriasis, Hookworm disease (ancylostomiasis and

necatoriasis) other intestinal infections, other infectious diseases),
B. Respiratory infections- 1. Lower respiratory infections, 2. Upper respiratory infections, 3. Otitis media,
C. Maternal conditions- 1. Maternal haemorrhage, 2. Maternal sepsis, 3. Hypertensive disorders of pregnancy, 4. Obstructed labour, 5. Abortion other maternal conditions,
D. Conditions arising during the perinatal period- 1. Prematurity and low birth weight. 2. Birth asphyxia and birth trauma Neonatal infections and other conditions,
E. Nutritional deficiencies- 1.Protein-energy malnutrition, 2. Iodine deficiency, 3. Vitamin A deficiency, 4. Iron-deficiency anaemia other nutritional disorders.
II. Non-communicable disease
A. Malignant neoplasm- 1. Mouth and oropharynx cancer, 2. Oesophagus cancer, 3. Stomach cancer, 4. Colon and rectum cancer, 5. Liver cancer, 6. Pancreas cancer, 7. Trachea, bronchus and lung cancer, 8. Melanoma and other skin cancer, 9. Breast cancer, 10. Cervix uteri cancer, 11. Corpus uteri cancer, 12. Ovary cancer, 13. Prostate cancer, 14. Bladder cancer, 15. Lymphomas and multiple myeloma, 16. Leukaemia and other malignant neoplasm,
B. Other neoplasms,
C. Diabetes mellitus,
D. Endocrine disorders,
E. Neuropsychiatric conditions- 1. Unipolar depressive disorders, 2. Bipolar affective disorder, 3. Schizophrenia, 4. Epilepsy, 5. Alcohol use disorders, 6. Alzheimer and other dementias, 7. Parkinson's disease, 8. Multiple sclerosis, 9. Drug use disorders, 10. Post-traumatic stress disorder, 11. Obsessive-

compulsive disorder, 12. Panic disorder, 13. Insomnia (primary) 14. Migraine,

F. Sense organ diseases- 1. Glaucoma 2. Cataracts 3. Refractive errors 4. Hearing loss, adult onset Macular degeneration and other

G   Cardiovascular diseases- 1. Rheumatic heart disease 2. Hypertensive heart disease 3. Ischaemic heart disease 4. Cerebrovascular disease 5. Inflammatory heart diseases other cardiovascular diseases

H. Respiratory diseases- 1. Chronic obstructive pulmonary disease, 2. Asthma other respiratory diseases

I. Digestive diseases- 1. Peptic ulcer disease 2. Cirrhosis of the liver 3. Appendicitis other digestive diseases

J. Genitourinary diseases- 1. Nephritis and nephrosis 2. Benign prostatic hypertrophy other genitourinary system diseases

K. Skin diseases

L. Musculoskeletal diseases- 1. Rheumatoid arthritis 2. Osteoarthritis 3. Gout 4. Low back pain other musculoskeletal disorders

M. Congenital anomalies- 1. Abdominal wall defect 2. Anencephaly 3. Anorectal atresia 4. Cleft lip 5. Cleft palate 6. Oesophageal atresia 7. Renal agenesis 8. Down syndrome 9. Congenital heart anomalies 10. Spina bifida other congenital anomalies

N. Oral conditions - 1. Dental caries 2. Periodontal disease 3. Edentulism- other oral diseases

III. Injuries

A. Unintentional injuries- 1. Road traffic accidents, 2. Poisonings 3. Falls 4. Fires 5. Drowning, 6. Other unintentional injuries

B. Intentional injuries- 1. Self-inflicted injuries 2. Violence 3. War and conflict other intentional injuries

Factors Affecting Death

1. There is a strong association between chronological age and the risk of death. This is most evident in the area of cancer. Among men, the strongest association between age and cancer is found for prostatic cancer, less so for cancer of the colon and rectum. With increasing age, the extent of the difference becomes less pronounced.

2. It is well known that women live longer than men (Hazard, 1986; 1989). Today, a woman has an excellent chance of surviving well into her 80s and among women who survive to age 85, they can expect to live another 6 years on average. At each point in the life course, females have a greater life expectancy than men. The extent of gender difference varies globally. Newman and Brach (2001) report that gender differences in longevity are related to the stage of economic and social development. As noted earlier, the relatively high maternal mortality rate limits life expectancy among women in developing countries. With improvements in maternal and infant mortality, often used as a health indicator of economic development, life expectancy improves significantly, especially for women. Newman and Brach (2001, p. 343) hypothesized that in the latest stage of development, 'Life expectancy for women is so high that it may be near its maximum.' Moreover, subsequent improvements are found for elderly men, even though the percentage of older woman still far exceeds the percentage of older men (Newman and Brach, 2001).

3. Racial and ethnic minorities have poorer survival than non-Hispanic whites, across the life course. Most research has focused on differences between non-Hispanic whites, African–Americans, and Hispanic whites. Considerably less attention has been directed to the different Asian-American groups, one of the fastest growing populations in the United States. In general, African-American males have poorer life expectancy than Asian-American, Hispanic white, or non-Hispanic white males. Although the racial and ethnic differences in longevity are also evident for females, it is much less pronounced. Not only are racial and ethnic minorities at elevated risk for acute and chronic conditions, but also they tend to be diagnosed at a more advanced stage and have less access to care and rehabilitation services. These factors contribute significantly to an elevated risk of death. It is interesting to note, however, that the extent of that racial difference is considerably reduced among those aged 75 years and older (Hummer *et al.*, 2004).

4. Various studies have shown that states with relatively harsh climatic conditions and cold winters show less winter excess mortality than states with warm or moderate climate. It is argued that people in colder regions are better able to protect themselves against adverse environmental conditions. One disadvantage of previous studies was that these results were based on cross four metro city states analyses. The data from the states provide an excellent framework to analyze seasonal mortality in different climatic regions

within one metro city state. For our regional analysis we followed the state groupings given to resemble different climatic regions. In some cases, however, the regional classification does not describe states with similar meteorological conditions. We refer to the actual 'state of occurrence', i.e., the state/region where the death has happened. 'State of residence' is given in the data as well. More than 98% of all deaths happened in the same region as the place of residence of the deceased.

5. Socio-economic status may affect health in several ways. Medical technology is expensive, and income increases have been instrumental in financing that care. Further, socio-economic status is associated with better behaviors. Education has a slightly stronger relationship to smoking than income. Richer people may demand better health, just as there is income elasticity to many goods. The link between behaviour and education suggests such an effect. The decline in suicide among the elderly is coincident with the large absolute increase in income for the elderly stemming from transfer programs such as social security and the programs that preceded it. It is less clear that the rise in youth suicide reflects falling income, although it may be due to other social pressures that are influencing youths (Cutler *et al.*, 2001). Finally, income may affect health in other, indirect ways.

6. Environmental factors include both chemical and toxic exposures as well as characteristics of the built environment. There is evidence that environmental exposures such as air pollution and lead exposures elevate the risk of illness and death across the life course (Committee on Chemical Toxicity and Aging, 1987). As noted earlier, there is a recent initiative to examine effects of environmental exposure on health and longevity of older people. Segments of the older population may be at elevated risk because of combinations of exposures over the life course, coupled with reduced immunological resistance later in life. There is also evidence that characteristics of the built environment, e.g., land use patterns, are associated with mortality. It was determined that environmental area characteristics in the place of residence was associated with survival (Takano *et al.*, 2002). Specifically, it was determined that those who live in areas with walk-able streets and spaces had better survival than those who did not, after

adjustment of the residents' age, sex, marital status, and socio economic status. There are also a number of studies that have examined the association between residential characteristics and the risk of accidental death in older populations. There are also studies of older people at risk for heat-related deaths. Kilbourne *et al.* (1982) reported that those most likely to die of heatstroke were those who were elderly, ill, poor, and socially isolated. Smoyer (1998) conducted a study in which it was also determined that health-related deaths were more likely to occur in the 'warmer, less stable, and most socio-economically disadvantaged areas'.

7. It is often reported that social capital refers to the quality of social relationships and community life. Following from research and commentary in sociology and political science (Coleman, 1988; Putnam, 1995), social capital has been defined in terms of social and community relationships characterized by trust and reciprocity (Kawachi and Kennedy, 1997; Lochner *et al.*, 2001, 2003). It is important to emphasize again that social capital is a term used to characterize populations and communities rather than individuals. Research indicates that communities (both at the level of the state and the neighborhood) characterized by high social capital have lower rates of mortality than communities with lower levels of social capital, following adjustment for individual and population characteristics (Kawachi *et al.*, 1997; Lochner *et al.*, 2003).

8. A history of cigarette smoking is associated with the risk of death from all of the leading causes of death, including coronary heart disease, stroke, chronic obstructive lung disease, and a number of different forms of cancer, such as cancers of the lung and bronchus, head and neck, stomach, and esophagus, as well as infections (Arcavi and Benowitz, 2004; Burns, 2000; Rivara *et al.*, 2004). The quantity of tobacco consumed and length of time one has smoked are associated with the subsequent risk of death. As Burns (2000) writes, 'Disease consequences of smoking occurs disproportionately among the elderly because of long duration of cumulative injury or change that underlies the bulk of tobacco-caused disease.' There is also evidence that older smokers are more likely than younger smokers to develop lung cancer, a cancer with a relatively long latency. On the other hand, younger smokers are at elevated risk for the development of cardiovascular disease.

9. Heavy and sustained consumption of alcohol is associated with an elevated risk of death (Camacho *et al.*, 1987). Unlike tobacco exposure, there is evidence that moderate consumption of alcohol may be associated with reduced risk of coronary heart disease. Heavy consumption, however, is associated with an elevated risk of death associated with conditions such as cancer of the head and neck, liver cancer, cirrhosis and deaths due to accidents and injuries. An elevated risk of death is also associated with alcohol consumption, even moderate consumption, in combination with multiple medications and comorbidities (Reid *et al.*, 2002).

10. There is considerable research indicating that older people who engage in physical activity have a reduced risk of death. In contrast, those who are sedentary are at elevated risk for many of the leading causes of death, including coronary heart disease, stroke and specific forms of cancer, most notably colorectal cancer (Rakowski and Mor, 1992; Rosengren and Wilhelmsen, 1997). A reduction of risk is noted for people who engage in a variety of forms of physical activity, both weight-bearing exercises as well as aerobic forms of activity. The reasons for this reduction of risk include increased lung capacity, increased lean muscle mass and increase in antioxidant activity.

11. Research also indicates that diet and nutrition are associated with a reduction in the risk of premature mortality (Pirlich and Lochs, 2001; Meyyazhagan and Palmer, 2002). Although there is considerable debate about the types of foods that should be consumed, there is general consensus that moderate consumption of food is healthful. In terms of specific foods, there is general agreement that a low-fat diet coupled with consumption of fruits and vegetables are associated with reduced risk of premature death. Ironically, the twin problems facing older populations that are associated with diet and nutrition are obesity on the one hand and under-nutrition on the other. Obesity is associated with increased intake of food, coupled with sedentary activity. Under-nutrition is associated with inadequate consumption of nutritious foods, a condition that many researchers consider to be the primary source of nutrition-related mortality in older populations. This may be associated with poor oral health, reduction in sense of smell and olfaction, as well as co-morbid conditions of cognitive dysfunction and depression.

Conclusion

Mortality has declined continuously over the course of the 21st century. Mortality rates declined every decade. But the constancy of mortality reductions masks significant heterogeneity by age, cause, and source. Early in the 21st century, mortality declines resulted from public health and economic measures that improved peoples' ability to withstand disease. Formal medical care was unimportant for longer life. Because nutrition and public health were more important for the young than the old, mortality reductions were concentrated at younger ages. By midcentury, medical care became more significant and other factors less so. Penicillin and sulfa drugs brought the first mortality reductions at older ages, which were coupled with continuing improvements in health at younger ages. The pattern of mortality reduction was relatively equal by age. Cardiovascular disease mortality was prevented in significant part through medical intervention. Traditional killers such as pneumonia in the young continued to decline, but mortality from these causes was already so low that further improvements did not add greatly to overall longevity. Rather, infant mortality declined because medical advances kept alive infants born of low birth weight. Still, there was a significant shift in the nature of longevity improvements away from improvements at younger ages and toward improvements at older ages. In addition to nutrition and public health, health insurance programs, income changes and social policies more generally have all contributed to longer life.

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