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Contributions of mortality changes by age group and selected causes of death to the increase in Japanese life expectancy at birth from 1950 to 2000

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Abstract. The purpose of this study is to analyze contributions of mortality change by age group and selected causes of death to the increase in life expectancy at birth from 1950 to 2000 in Japan, which has the longest longevity in the world. Using mortality data from Japanese vital statistics from 1950 to 2000, we analyzed contributions of mortality change by age group and selected causes of death to the increase in life expectancy at birth by the method of decomposition of changes and calculated age-adjusted death rates for selected causes of death. Gastroenteritis, tuberculosis and pneumonia largely contributed to an increase in life expectancy in childhood and in the young in the 1950s and 1960s. The largest contributing disease changed from tuberculosis and pneumonia in earlier decades to cerebrovascular diseases in the 1970s. The largest contributing age group also shifted to older age groups. Age-adjusted death rate for cerebrovascular diseases in 2000 was one fifth of the 1965 level. Cerebrovascular diseases contributed to an increase in life expectancy at birth of 2.9 years in males and 3.1 years in females from 1970 to 2000. In the 1990s, the largest contributing age group, both among males and among females, was the 75–84 age group. Of the selected causes of death, heart diseases other than ischemic heart disease became the largest contributor to the increase in life expectancy at birth. Unlike cerebrovascular diseases, cancer and ischemic heart disease contributed little to change in life expectancy at birth over the past 50 years. In conclusion, although mortality from ischemic heart disease has not increased since 1970 and remained low compared with levels in western countries, mortality from cerebrovascular diseases has dramatically decreased since the mid-1960s in Japan. This gave Japan the longest life expectancy at birth in the world. It is necessary to study future trends in life expectancy at birth in Japan.

Key words: Epidemiology, Life expectancy at birth, Life table, Selected causes of death

Introduction

Since the World War II, life expectancy at birth has increased in many countries [1, 2]. Japan experienced a remarkable increase in life expectancy at birth after the World War II, caught up with the levels of the developed countries in the 1960s, and showed the longest life expectancy at birth in the world in the early 1980s [2–4]. Since the early 1980, Japanese females have continued to set new records for the longest life expectancy at birth (see Appendix) [2], and in 2000 their life expectancy at birth reached 84.6, so close to 85 that further increases were thought impossible [5, 6].

There have been great changes in mortality from selected causes of death in different age group since the Second World War. Over the past 50 years, mortality patterns in Japan have changed greatly from infectious diseases to cancer and cardiovascular diseases over the past 50 years, the major contribution of age groups to increased life expectancy at birth has moved from younger age groups to older age groups [3].

The purpose of this study is to analyze the relationship between the increase in life expectancy at birth and mortality change by age and selected cause of death, and discuss factors relevant to these changes in the light of medical and social developments from 1950 to 2000.

Materials and methods

Mortality data

We used mortality data for selected cause of death by sex and age (5-year intervals) from 1950 to 2000 in the Vital Statistics of Japan published by the Ministry of Health, Labour and Welfare [7].

The causes of death were classified into 10 groups; gastroenteritis, tuberculosis, cancer, ischemic heart disease, other heart diseases, cerebrovascular diseases,

pneumonia, accidents, suicide, and other causes according to the classification used by Shigematsu et al. [3, 4] and Hisanaga [8]. In this study period, the international classification of diseases (ICD) changed four times: ICD6, ICD7, ICD8, ICD9 and ICD10. Table 1 shows codes for selected causes of death in different ICD revisions. Although hepatic diseases and renal diseases are both major causes of death, repeated ICD revisions meant that it was impossible to produce data allowing meaningful comparisons over the study period, and both categories therefore had to be included in the category of other causes.

Age-Adjusted Death Rates (AADR) for selected causes of death

We calculated AADR for 10 selected causes of death, using Japanese death rates for each group of causes by 5-year age groups from 1950 to 2000 [7], and the Japanese model population based on 1985 Japanese population as standard [9].

Contributions of mortality change by age group and cause of death to the increase in life expectancy at birth

For life tables, the complete life table (Ministry of Health, Labour and Welfare) from 1950 to 2000 at 5-year intervals was used. Population data were taken from the census reports (Bureau of Statistics of the Prime Minister's Office) from 1950 to 2000 at 5-year intervals [10–12].

We calculated contributions (in years) to the increase in life expectancy at birth, using mortality data for 1950, 1960, 1970, 1980, 1990 and 2000. To avoid the influence of annual fluctuations in mortality, mortality data were taken as the averages of 3 consecutive years. For example, mortality data for 1960 were the averages of those for 1959, 1960 and 1961. However, mortality data for 1950 and for 2000 were the averages of those for 1950 and 1951, and 1999 and 2000 respectively. We applied the method of Pollard [13, 14] to this calculation. In this method, differences between life expectancies at time1 and time2 can be expressed as

$$\begin{aligned}\mathring{e}_0^2 - \mathring{e}_0^1 = {} & \left({}_1m_0^1 - {}_1m_0^2\right)w_0 + 4\left({}_4m_1^1 - {}_4m_1^2\right)w_2 \\ & + 5\left({}_5m_5^1 - {}_5m_5^2\right)w_{7.5} \\ & + 5\left({}_5m_{10}^1 - {}_5m_{10}^2\right)w_{12.5} + \cdots,\end{aligned}$$

with

$$w_t = \frac{1}{2}\left({}_tp_0^2\mathring{e}_t^1 + {}_tp_0^1\mathring{e}_t^2\right),$$

$\mathring{e}_t^1$ and $\mathring{e}_t^2$ represent life expectancy at birth, ${}_tp_x{}^1$ and ${}_tp_x{}^2$ the probability of survival for t years from age x, and ${}_nm_x{}^1$ and ${}_nm_x{}^2$ the central mortality rate at age x at time1 and time 2, respectively.

The central mortality rate m_x is defined:

$${}_nm_x = \frac{{}_nd_x}{{}_nL_x}.$$

In addition, when dealing with mortality rates according to the all causes of death ${}_nD_x$ and the cause of death ${}_nD_x{}^{(i)}$ for cause i,

$${}_nm_x{}^{(i)} = {}_nm_x\left(\frac{{}_nD_x^{(i)}}{{}_nD_x}\right).$$

Table 1. Codes for selected causes of death in different ICD revisions

Causes of death	ICD6 (1950–1957)	ICD7 (1958–1967)	ICD8 (1968–1978)	ICD9 (1979–1994)	ICD10 (1995–2000)
Gastroenteritis	543,571,572 764	543,571,572 764	008,009 535 561–563	008–009 535 555–556 558 562	A04 A08–A09 K29 K50–K52 K57
Tuberculosis	001–008 010–019	001–008 010–019	010–012 013–019	010–012 013–018	A15–A19
Cancer	140–205	140–205	140–209	140–208	C00–C97
Ischemic heart disease	420	420	410–414	410–414	I20–I25
Other heart diseases	410–416 421–422 430–434	410–416 421–422 430–434	393–398 420–429	393–398 415–429	I01–I02.0 I05–I09 I26–I28 I30–I52
Cerebrovascular diseases	330–334	330–334	430–438	430–438	I60–I69
Pneumonia	490–493 763	490–493 763	480–486	480–486	J12–J18
Accidents	E800–E802 E810–E835 E840–E965	E800–E802 E810–E835 E840–E962	E800–E807 E810–E823 E825–E949	E800–E949	V01–X59 Y40–Y86 Y88–Y89
Suicide	E963 E970–E979	E963 E970–E979	E950–E959	E950–E959	X60–X84

Therefore, the difference in life expectancy is

$$\begin{aligned}\overset{\circ}{e}{}_0^2 - \overset{\circ}{e}{}_0^1 = &\sum_i \left({}_1m_0^{(i)1} - {}_1m_0^{(i)2}\right)w_0 \\ &+ 4\sum_i \left({}_4m_1^{(i)1} - {}_4m_1^{(i)2}\right)w_2 \\ &+ 5\sum_i \left({}_5m_5^{(i)1} - {}_5m_5^{(i)2}\right)w_{7.5} \\ &+ 5\sum_i \left({}_5m_{10}^{(i)1} - {}_5m_{10}^{(i)2}\right)w_{12.5} + \cdots\end{aligned}$$

Results

Trends in AADR for selected causes of death from 1950 to 2000

Table 2 shows AADR for selected causes of death at intervals of 5 years from 1950 to 2000 for males and females, respectively.

In 1950, the combined AADR for gastroenteritis and tuberculosis was 277 for males and 245 for females, which accounted for a large proportion of the total deaths: 17% for males and 15% for females. However, the AADR continued to decrease by about 50% every 10 years, falling to 2.7 for males and 1.4 for females in 2000, which accounted for less than 1% of the total deaths.

The AADR for pneumonia decreased by about a half up to 1980: from 66 to 39 in males and from 58 to 30 in females, since then, however, it has leveled off.

The AADR for cerebrovascular diseases increased up to the mid-1960s in both males and females, and was the leading cause of death from 1950 to 1981. Since the mid-1960s, the AADR for cerebrovascular diseases has dramatically decreased and in 2000 it amounted to only 20% of the peak level reached in the mid-1960s. In recent year, cerebrovascular diseases have ranked as the second or third leading cause of death.

The AADR for ischemic heart disease slightly increased up to 1970, and since then, has tended to decrease in both males and females, despite a temporary increase in 1995. The AADR for other heart diseases has declined since 1950, though with minor fluctuations. The declining trend was much steeper from 1990 to 2000.

The AADR for cancer in males increased from 134 in 1950 to 194 in 1995, but fell slightly in 2000. In females, after a temporary increase in the 1950s, the AADR for cancer has gradually decreased since 1960, falling from 144 to 116. Cancer has ranked as the leading cause of death since 1981.

The AADR for accidents has decreased from 61 to 31 in males, but in females has, with minor fluctuations, remained around 20. The AADR for suicide decreased from 33 to around 20 in the 1970s and 1980s, but then increased to 30 in 1990s in males. In females, the AADR for suicide has gradually decreased from 22 to 11.

Contributions of age groups and selected causes of death to changes in life expectancy at birth

Tables 3 and 4 show years of contribution to the increase in life expectancy at birth by age groups and 10-year periods, and by selected causes of death and 10-year periods, respectively.

Life expectancy at birth increased by 6.0 years in males and 7.5 years in females in the 1950s. It continued to increase in each subsequent decade, though in each decade the increase was smaller; 4.2, 4.3, 2.6 and 1.8 years in males and 4.6, 4.1, 3.1 and 2.7 years in females in the 1960s, 1970s, 1980s and 1990s, respectively.

In the 1950s and 1960s, a large contribution to the increase in life expectancy at birth was observed in children aged 0–4 and the young aged 15–34. As shown in Table 5, increasing life expectancy at birth in the former resulted from dramatically decreased mortality from gastroenteritis and pneumonia. In the latter, it was due to a reduction in mortality from tuberculosis. Between 1950 and 2000, these three diseases contributed to an increase in life expectancy at birth of 5.7 years in males and 5.8 years in females, though the contribution attributable to changes in mortality in childhood and the young clearly decreased after 1970.

In the 1970s and 1980s, the largest contributing disease changed from infectious diseases to cerebrovascular diseases. The largest contributing age group also shifted to older age groups; the 65–74 age group in the 1970s. In females, the largest contributing age group shifted from the 65–74 age group in the 1970s to the 75–84 age group in the 1980s. Cerebrovascular diseases largely contributed to the increase in life expectancy in those aged 65–84 in the 1970s and 1980s, as shown in Table 6. Between 1970 and 2000, cerebrovascular diseases contributed to an increase in life expectancy at birth of 2.9 years in males and 3.1 years in females because the AADR for cerebrovascular disease in 2000 was only about one fifth of the mid-1960s level.

Although the contribution of other heart diseases to life expectancy at birth was much smaller than that of cerebrovascular diseases in the 1970s and 1980s, it then became the largest contributor, particularly in those aged 65 or over, as shown in Table 7. In the 1990s, other heart diseases contributed to an increase in life expectancy at birth of 0.72 years in males and 0.89 years in females.

The contribution of ischemic heart disease to life expectancy at birth was negative in 1950s and 1960s, and positive in the 1970s and 1980s. In the 1990s, ischemic heart disease made little contribution to life expectancy at birth; negative in males and positive in females. Consequently, ischemic heart disease has made a minor contribution to life expectancy at birth in males and females over the past 50 years.

Table 2. Age-adjusted death rates for selected causes of death by year in Japan (per 100,000)

Year	All causes	Gastroenteritis	Tuberculosis	Cancer	Ischemic heart disease	Other heart diseases	Cerebrovascular diseases	Pneumonia	Accidents	Suicide	Others
Males											
1950	1639	86	191	134	22	90	255	66	61	33	703
1955	1298	41	81	151	24	85	260	49	61	37	509
1960	1278	29	61	169	42	88	292	60	72	28	437
1965	1174	18	43	174	53	78	306	49	71	20	361
1970	1053	11	29	176	64	71	280	42	71	19	291
1975	882	6	17	175	59	66	220	40	49	23	228
1980	783	3	9	185	55	76	167	39	39	23	187
1985	689	2	6	187	45	76	110	43	36	26	158
1990	633	1	4	188	38	76	81	53	34	19	139
1995	605	1	3	194	47	36	81	47	39	21	136
2000	535	1	2	184	38	35	61	41	31	30	114
Females											
1950	1608	106	139	130	14	102	269	58	21	22	747
1955	1241	54	53	136	17	93	256	43	20	23	546
1960	1192	41	33	144	30	99	280	52	24	21	468
1965	1075	26	21	142	41	90	284	43	24	15	389
1970	951	16	13	139	51	84	261	37	25	15	310
1975	798	10	7	133	51	76	217	36	18	16	233
1980	677	5	3	131	45	80	168	30	15	14	185
1985	563	2	2	126	37	76	114	32	14	13	147
1990	492	1	1	121	31	75	82	37	14	11	119
1995	443	1	1	121	36	35	76	34	21	10	108
2000	369	1	1	116	26	33	54	27	14	11	87

Note: Using the Japanese model population based on 1985 Japanese population as standard.

Table 3. Years of contribution to the increase in life expectancy at birth by age groups and 10-year periods

	Age group										
Year	0	1–4	5–14	15–24	25–34	35–44	45–54	55–64	65–74	75–84	85–94	95+	Total
Males													
1950–1960	1.576	1.343	0.388	0.489	0.715	0.543	0.436	0.356	0.208	–0.042	–0.001	0.000	6.010
1960–1970	1.330	0.396	0.192	0.259	0.308	0.159	0.357	0.503	0.395	0.271	0.011	0.000	4.180
1970–1980	0.482	0.125	0.129	0.207	0.253	0.321	0.269	0.743	0.967	0.689	0.074	0.003	4.262
1980–1990	0.252	0.062	0.061	0.049	0.087	0.183	0.337	0.212	0.664	0.551	0.115	0.003	2.574
1990–2000	0.117	0.055	0.035	0.085	0.006	0.029	0.068	0.310	0.294	0.550	0.225	0.016	1.792
Females													
1950–1960	1.593	1.522	0.470	0.725	0.921	0.681	0.535	0.553	0.407	0.075	0.039	0.001	7.521
1960–1970	1.213	0.386	0.189	0.275	0.331	0.305	0.402	0.483	0.601	0.339	0.033	0.005	4.561
1970–1980	0.386	0.101	0.088	0.135	0.182	0.240	0.362	0.648	0.974	0.831	0.179	0.001	4.128
1980–1990	0.196	0.057	0.033	0.028	0.073	0.099	0.193	0.358	0.738	0.968	0.363	0.022	3.128
1990–2000	0.100	0.036	0.028	0.027	0.012	0.040	0.060	0.196	0.470	0.930	0.677	0.095	2.672

Cancer had even less impact on life expectancy at birth than cardiovascular diseases. The contribution to the increase in life expectancy at birth varied between the different age groups and 10-year periods observed; positive in some age group and 10-year periods and negative in others. On the whole, cancer contributed negatively to the increase in life expectancy at birth until 1980 in males and until 1960 in females, and thereafter, it made a small positive contribution.

Since the 1960s, accidents have made a positive, though small, contribution to the increase in life expectancy at birth in both males and females because mortality from motor accidents has decreased. Suicides contributed positively to the increase in life expectancy at birth in some age groups and 10-year periods, and negatively in others. In the 1990s, suicide was a negative contributor to life expectancy at birth, contributing more strongly in males.

Discussion

The life expectancy at birth increased tremendously in the 1950s and 1960s, and then gradually caught up with western levels [2]. This increase in life expectancy at birth was mainly attributable to a reduction of mortality from gastroenteritis and pneumonia in infants and from tuberculosis in the young. Health centers were reestablished in Japan after the Second World War. The health centers vigorously worked to improve the environment and prevent communicable diseases [3, 4, 15, 16]. Consequently, most acute infectious diseases of the digestive tract, excluding dysentery, had been controlled by the 1950s [4]. The health centers also actively carried out well-organized tuberculosis prevention programs; BCG vaccination, mass screening, patient registration and supervision of detected tuberculosis patients [4, 15]. In Japan, tuberculosis was the leading cause of death until 1950 and the mortality rate was the highest among those aged 20–29 [4]. Antibiotics such as penicillin and streptomycin became available in Japan after the Second World War and widely used after 1950 [4]. These developments in public health services and medical practices contributed to an increase in life expectancy at birth, especially in infants, children and the young in the 1950s and 1960s [15, 16].

In the 1950s, mortality pattern in Japan showed a markedly shift from infectious diseases to cancer and cardiovascular disease. Cancer, heart diseases and cerebrovascular diseases have been the three leading causes of death since the mid-1950s [2]. In cardiovascular diseases, western countries had higher mortality from myocardial infarction than from cerebrovascular diseases; Japan, on the other hand, had lower mortality from the former than from the latter [17, 18].

Table 4. Years of contribution to the increase in life expectancy at birth by selected causes of death and 10-year periods

	Year				
Causes of death	1950–1960	1960–1970	1970–1980	1980–1990	1990–2000
Males					
All causes	6.010	4.180	4.262	2.574	1.792
Gastroenteritis	0.990	0.324	0.120	0.033	0.001
Tuberculosis	2.179	0.537	0.278	0.088	0.031
Cancer	−0.348	−0.049	−0.002	0.061	0.186
Ischemic heart disease	−0.143	−0.164	0.151	0.238	−0.025
Other heart diseases	0.178	0.202	−0.087	−0.004	0.724
Cerebrovascular diseases	−0.400	0.309	1.447	1.195	0.302
Pneumonia	0.353	0.607	0.151	−0.132	0.156
Accidents	−0.336	0.232	0.721	0.143	0.159
Suicide	−0.061	0.222	−0.093	0.107	−0.242
Others	3.596	1.960	1.577	0.844	0.499
Females					
All causes	7.521	4.561	4.128	3.128	2.672
Gastroenteritis	1.127	0.384	0.144	0.055	0.008
Tuberculosis	2.153	0.447	0.161	0.039	0.012
Cancer	−0.158	0.102	0.260	0.284	0.187
Ischemic heart disease	−0.106	−0.136	0.113	0.219	0.089
Other heart diseases	0.269	0.284	0.073	0.087	0.890
Cerebrovascular diseases	−0.052	0.436	1.213	1.290	0.563
Pneumonia	0.415	0.593	0.189	−0.051	0.144
Accidents	−0.073	0.119	0.235	0.039	0.027
Suicide	−0.088	0.173	0.036	0.067	−0.007
Others	4.035	2.159	1.703	1.099	0.758

Table 5. Years of contribution of gastroenteritis, tuberculosis and pneumonia to the increase in life expectancy at birth by age groups in 1950–1960 and 1960–1970

		Age group								
Year	Causes of death	0	1–4	5–14	15–24	25–34	35–44	45–54	55+	Total
Males										
1950–1960	Gastroenteritis	0.314	0.402	0.043	0.013	0.013	0.014	0.025	0.166	0.990
	Tuberculosis	0.024	0.120	0.105	0.515	0.688	0.393	0.233	0.100	2.179
	Pneumonia	0.106	0.154	0.025	0.011	0.009	0.010	0.016	0.022	0.353
1960–1970	Gastroenteritis	0.137	0.060	0.017	0.004	0.004	0.004	0.006	0.093	0.324
	Tuberculosis	0.004	0.012	0.008	0.034	0.110	0.129	0.109	0.131	0.537
	Pneumonia	0.475	0.066	0.012	0.006	0.007	0.005	0.006	0.031	0.607
Females										
1950–1960	Gastroenteritis	0.309	0.430	0.052	0.018	0.022	0.023	0.034	0.238	1.127
	Tuberculosis	0.025	0.135	0.152	0.614	0.642	0.307	0.172	0.106	2.153
	Pneumonia	0.122	0.192	0.032	0.012	0.017	0.015	0.013	0.011	0.415
1960–1970	Gastroenteritis	0.122	0.066	0.021	0.004	0.006	0.007	0.010	0.147	0.384
	Tuberculosis	0.004	0.014	0.011	0.046	0.121	0.104	0.066	0.082	0.447
	Pneumonia	0.439	0.071	0.014	0.012	0.012	0.008	0.005	0.031	0.593

In 1950, cerebrovascular diseases replaced tuberculosis as the leading cause of death. The mortality from cerebrovascular diseases peaked in 1965, and has declined since then. The AADR in 2000 had diminished to one-fifth of the 1965 level. Kubo et al. [19], who conducted an autopsy-based population study in Japan, showed that mortality from cerebrovascular diseases in 1988–2000 had declined to one-sixth of that in 1961–1973. The control of hypertension and improvement in dietary habits have been mainly responsibly for this reduction of mortality from cerebrovascular diseases [18, 20–22]. The traditional Japanese diet was high in salt and low in animal protein and fat [20]. This appears to increase the risk of hypertension and eventually of cerebrovascular diseases. Salt intake has decreased from

Table 6. Years of contribution of cerebrovascular diseases to the increase in life expectancy at birth by age groups in 1970–1980 and 1980–1990

	Age group								
Year	0–34	35–44	45–54	55–64	65–74	75–84	85–94	95+	Total
Males									
1970–1980	0.015	0.051	0.100	0.342	0.529	0.389	0.019	0.000	1.447
1980–1990	0.011	0.040	0.102	0.164	0.402	0.394	0.080	0.002	1.195
Females									
1970–1980	0.012	0.016	0.076	0.249	0.477	0.360	0.024	−0.001	1.213
1980–1990	0.008	0.016	0.055	0.136	0.369	0.538	0.163	0.005	1.290

Table 7. Years of contribution of other heart diseases to the increase in life expectancy at birth by age groups in 1990–2000

	Age group								
Sex	0–34	35–44	45–54	55–64	65–74	75–84	85–94	95+	Total
Males	0.032	0.029	0.057	0.094	0.147	0.234	0.122	0.010	0.724
Females	0.021	0.011	0.026	0.057	0.144	0.320	0.269	0.043	0.890

14.5 g/day in 1972 to 12.3 g/day in 2000 [22]. Animal protein and fat intake has increased from 28.5 g/day and 11.1 g/day in 1965 to 41.7 g/day and 23.0 g/day in 2000 respectively [23]. Despite this increase, the Japanese diet still contains much less fat than western diets. Tanaka et al. [20] suggested that an appropriate animal protein and fat intake (no excessive) might prevent cerebrovascular diseases.

In the 1960s, health centers shifted the priority of their activity from the prevention of tuberculosis to cerebrovascular diseases. National-wide mass screening for hypertension began in the 1960s [20] and accelerated with the Health Act for the elderly in 1987. Furthermore, Japan started a universal health insurance system in 1961, giving people easy access to medical treatment at relatively low costs [21–22]. The percentage of hypertensives taking antihypertensive drugs has shown several sharp increases since the 1960s [21].

Japanese life expectancy has increased steadily even for older age groups, though Nusselder et al. [24] reported that life expectancy stagnated and declined in advanced ages in the 1980s and 1990s in the Netherlands, which is a country with long life expectancy at birth.

In females, the age group making the greatest contribution to the increase in life expectancy changed from those aged 65–74 to those aged 75–84 in the 1980s. In males, the same change took place in the 1990s. In the 1990s, the contribution of groups aged 75 or over accounted for 44.1% of the increase in life expectancy at birth among males, and 63.7% among females. In females, life expectancy at birth in 2000 reached 84.6, close to the level of 85 that is regarded as an upper limit to life expectancy at birth.

Goldberg et al. [25] reported that hypertension and smoking were negatively associated with survival to 75 years of age in the middle-aged. Japanese blood pressure levels have declined in every age group since the mid-1960s [22]. Therefore, it seems that in the 1990s the beneficial effects of this decline on life expectancy have extended to older age groups.

In a Japanese autopsy-based population study [26], the accuracy of diagnosis on death certificates was found to be high for cerebrovascular diseases and malignant neoplasm, and relatively low for ischemic heart disease and other heart diseases. Japanese physicians are disposed to diagnose heart failure as an underlying cause of death in the elderly [26, 27]. Saito et al. [27] suggested that other heart disease deaths might include many cases of ischemic heart diseases. Actually, mortality from other heart diseases fell and that from ischemic heart diseases rose after the tenth ICD revision in 1995 because the Japanese Ministry of Health and Welfare required physicians to diagnose heart failure more accurately. In 1990s, other heart disease made the largest contribution to the increase in life expectancy in both males and females, especially in older age groups. Although the substantial decrease in mortality from other heart disease in the 1990s may be partly attributable to declining blood pressure and smoking rates in males, it probably also results partly from physicians trying to make more accurate diagnoses.

Our study found that mortality from ischemic heart disease had declined since 1970 in both males and females, despite a temporary increase in 1995. Hasuo et al. [26] reported uncertainty as to whether the decline was due to a real fall in mortality, or merely to changing fashions in diagnosis. Kubo et al.

[19] found, in an autopsy-based population study, that mortality from ischemic heart disease was unchanged from 1961 to 2000, despite increasing Japanese cholesterol level during this period. Saito et al. [27] reported similar results. While it remains uncertain whether there has been a genuine decline, these studies, together with our results, indicate that Japanese mortality from ischemic heart disease have not increased at least since 1970, and remained at lower level than in western countries.

Cancer had even less impact on life expectancy at birth than cardiovascular diseases. Cancer contributed negatively until the 1970s in males and the 1950s in females, and thereafter changed to making small positive contributions. Trends in AADR for selected sites of cancer showed that stomach cancer decreased remarkably: in males, from 98.5 in 1960 to 45.5 in 1995, and in females, from 51.8 to 21.6 over the same period [9]. Also, uterine cancer decreased from 21.3 in 1960 to 5.4 in 1995 [9]. On the other hand, there have been increases in ADDR for lung cancer, colon cancer, and liver cancer among both males and females, and breast cancer among females [9].

In males, AADR for all sites of cancer has leveled off since 1980 because the decrease in mortality from stomach cancer has been offset by a roughly equal increase in mortality from lung cancer, colon cancer and liver cancer. In females, AADR has gradually decreased since 1960 because the decrease in mortality from stomach cancer and uterine cancer exceeded the increase in mortality from lung cancer, colon cancer, liver cancer and breast cancer.

From a social viewpoint, the success of the Japanese economy must be considered a factor in the rapid improvement in life expectancy at birth [4, 16]. Japanese economic growth made it possible to deliver the public health services and medical services mentioned earlier [4]. In addition to these public health services and medical services, a policy giving the aged free access to physicians was introduced in 1973 [2]. This may have led to better control of chronic diseases such as hypertension and diabetes mellitus. Moreover, the ten-year strategy for the promotion of health and welfare services started, and was intended to improve home care and nursing home care for the disabled elderly [2]. It may have helped to improve their quality of life and decrease mortality.

One study [28] expects further gains in life expectancy at birth, predicting that it will reach 79.76 years for males and 87.52 for females in 2025. However, the long economic recession in Japan might be an obstacle to further extension of life. The number of suicides increased by about 11,000 in the 1990s, particularly in middle-aged men who are victims of the long economic recession.

It is possible that medical and nursing services for the elderly will be restricted because of limited financial resources. Because of all these factors, it is necessary to monitor future trends in life expectancy at birth in Japan.

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Appendix

Life expectancy at birth by year in Japan [2]

Year	Males	Females
1950	59.57	62.97
1955	63.60	67.75
1960	65.32	70.19
1965	67.74	72.92
1970	69.31	74.66
1975	71.73	76.89
1980	73.35	78.76
1985	74.78	80.48
1990	75.92	81.90
1995	76.46	82.96
2000	77.72	84.60

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