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Sex differential in life expectancy in Japan and Scotland: age and causes of death.

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Abstract

The contribution of age groups and causes of death to the sex difference in life expectancy (SDLE) at birth in Japan and Scotland was estimated for the period 1965-1990. The purpose was to determine the particular age groups and causes of death responsible for the opposite trend of SDLE in the two countries. SDLE has been widening and narrowing in Japan and Scotland, respectively. The availability of complete and reliable data for these two developed countries facilitated the study. A method of decomposing the total SDLE into age and cause of death components was employed. About 40-60% contribution to SDLE was observed for ages after 65 years. Marked increase in the contribution of the 75+ age group and marked decrease in the contribution of ages 45-64 for Japan and Scotland, respectively, had a major effect on the widening and narrowing of SDLE in the two countries, respectively. The contribution of diseases of the circulatory system was the maximum until 1980 in Japan (< or = 1.8 years or 33.6%; cerebrovascular disease alone < or = 23.4%) and until 1990 in Scotland (< or = 3.1 years or 47.0%; ischemic heart disease alone < or = 42.0%). In Japan, the contribution of malignancy had a marked increased from 0.7 year (12.3%) to 2.0 years (32.6%), particularly for the trachea, bronchus and lung, while there was only a small increase in Scotland from 1.0 year (16.6%) to 1.2 years (19.8%) with an increase in the negative contribution of female breast malignancy. In Japan, the contribution of diseases of the respiratory system increased considerably from 0.5 year (8.5%) to 1.1 years (18.1%) while it decreased in Scotland from 1.0 year (16.5%) to 0.6 year (10.7%). About 60-75% of SDLE is due to the above three groups of causes of death. Malignancy and diseases of the respiratory system had a persistently increased contribution in Japan with resultant widening of SDLE by 0.9 year. Diseases of the circulatory system have always had a high contribution. On the contrary, in Scotland the contribution of diseases of the circulatory system and malignancy was practically unchanged and diseases of the respiratory system had a decrease with a consequent narrowing of SDLE by 0.4 year. Further epidemiological study is necessary to detect and analyze in detail the internal gradients (environmental and genetic-biological) of major contributor diseases to SDLE in Japan and Scotland.

KEYWORDS: contribution to sex difference in life expectancy, japan and Scotland, age, cause of death

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Sex Differential in Life Expectancy in Japan and Scotland: Age and Causes of Death

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The contribution of age groups and causes of death to the sex difference in life expectancy (SDLE) at birth in Japan and Scotland was estimated for the period 1965-1990. The purpose was to determine the particular age groups and causes of death responsible for the opposite trend of SDLE in the two countries. SDLE has been widening and narrowing in Japan and Scotland, respectively. The availability of complete and reliable data for these two developed countries facilitated the study. A method of decomposing the total SDLE into age and cause of death components was employed. About 40-60 % contribution to SDLE was observed for ages after 65 years. Marked increase in the contribution of the 75^{+} age group and marked decrease in the contribution of ages 45-64 for Japan and Scotland, respectively, had a major effect on the widening and narrowing of SDLE in the two countries, respectively. The contribution of diseases of the circulatory system was the maximum until 1980 in Japan ($\leqq$ 1.8 years or 33.6%; cerebrovascular disease alone $\leqq$ 23.4%) and until 1990 in Scotland ($\leqq$ 3.1 years or 47.0%; ischemic heart disease alone $\leqq$ 42.0%). In Japan, the contribution of malignancy had a marked increase from 0.7 year (12.3%) to 2.0 years (32.6%), particularly for the trachea, bronchus and lung, while there was only a small increase in Scotland from 1.0 year (16.6%) to 1.2 years (19.8%) with an increase in the negative contribution of female breast malignancy. In Japan, the contribution of diseases of the respiratory system increased considerably from 0.5 year (8.5%) to 1.1 years (18.1%) while it decreased in Scotland from 1.0 year (16.5%) to 0.6 year (10.7%). About 60-75% of SDLE is due to the above three groups of causes of death. Malignancy and diseases of the respiratory system had a persistently increased contribution in Japan with resultant widening of SDLE by 0.9 year. Diseases of the circulatory system have always had a high contribution. On the contrary, in Scotland the contribution of diseases of the circulatory system and malignancy was practically unchanged and diseases of the respiratory system had a decrease with a consequent narrowing of SDLE by 0.4 year. Further epidemiological study is necessary to detect and analyze in detail the internal gradients (environmental and genetic-biological) of major contributor diseases to SDLE in Japan and Scotland.

Key words: contribution to sex difference in life expectancy, Japan and Scotland, age, causes of death

The sex difference in mortality and morbidity is a subject of scientific curiosity and has been a public health concern for over 300 years. The developed countries experienced an increasing sex difference in mortality in favor of females in recent years with a resultant longer life expectancy than for males (1). The sex difference in life expectancy (SDLE) had been widening in all the developed countries until recently, when it started narrowing in countries such as Canada, USA and Scotland. Conversely, the SDLE continued to widen in Japan and other developed countries (2-6). This opposite trend of SDLE in the developed countries encouraged the authors to carry out the present study. The reasons for selecting Scotland for comparison with Japan are as follows: a) the magnitude of SDLE is almost equal in Japan and Scotland (6.0 ± 0.2 years), whereas, it was much higher in Canada and USA (7.0 ± 0.2 years) in 1990 (4-6); b) the sex ratio of age-standardized death rates for all causes in 1990 is 1.2 in both Japan and Scotland and around 1.7

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in Canada and USA (6); c) the proportion of deaths assigned to the category of senility and ill-defined conditions (which is regarded as a rough indicator of the quality of cause of death data) is less than 5 % and 1 % in Japan and Scotland, respectively, and is around 10 % in the other countries (7-9). Accessibility to the complete and reliable data for Scotland was added to the above factors. Even though SDLE in Japan and Scotland was almost equal in 1990, when traced back to 1920, SDLE in Scotland was almost twice that of Japan. The doubling time of SDLE at birth was 30 years and 55 years in Japan and Scotland, respectively (10-12). Even though the overall change of SDLE with time is known for these two countries, the extent to which a particular age group or cause of death is responsible for the change has not been determined.

In the present study, the level and trend of the contribution of different age groups and causes of death to SDLE at birth were analyzed for the period 1965 to 1990 in Japan and Scotland. We also analyzed the role of different ages and causes of death for the unequal widening of SDLE in these two countries.

Materials and Methods

Materials

The data on mortality and population statistics for Japan were collected from the vital statistics report of the Ministry of Health and Welfare for the period 1965 to 1990. For Scotland, data were received on request from the Register General Office for Scotland. Causes of death data were gathered from the World Health Statistics Annual. These data covered the period 1965 to 1990 at 5-years intervals.

Methods

The methodology employed in this paper involves determining the contribution of different age groups and causes of death to the SDLE at birth.

Estimation of contribution of age groups to SDLE at birth. Studying the survivorship in the developed and developing world, the population division of the United Nations introduced a new method of

Table I Contribution of age groups to sex difference in life expectancy (SDLE) at birth for Japan and Scotland, 1965-1990

Age group	1965[a]		1970[a]		1975[a]		1980[a]		1985[a]		1990[a]	
	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot
0	0.3	0.4	0.3	0.4	0.2	0.3	0.1	0.2	0.1	0.1	0.1	0.2
	(6.2)	(5.8)	(5.0)	(6.5)	(3.3)	(4.9)	(2.0)	(3.6)	(1.2)	(1.9)	(1.9)	(2.9)
1-4	0.1	0.1	0.1	0.1	0.1	-0.02	0.1	0.1	0.1	-0.02	0.1	0.1
	(1.3)	(0.8)	(0.9)	(1.1)	(0.9)	(-0.3)	(2.0)	(0.9)	(0.7)	(-0.3)	(0.5)	(0.9)
5-14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.01	0.1	0.1	0.1	0.1
	(2.5)	(1.9)	(2.0)	(1.6)	(1.5)	(2.1)	(1.1)	(-0.2)	(1.0)	(1.0)	(0.7)	(1.0)
15-24	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.3
	(5.1)	(4.0)	(5.6)	(4.0)	(5.0)	(5.2)	(4.0)	(3.8)	(4.8)	(4.4)	(3.7)	(5.9)
25-34	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.3
	(4.5)	(2.7)	(4.6)	(3.2)	(3.5)	(4.3)	(3.3)	(3.4)	(2.9)	(3.4)	(2.9)	(5.9)
35-44	0.3	0.2	0.4	0.2	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2
	(5.7)	(3.7)	(6.9)	(3.7)	(6.5)	(4.2)	(5.3)	(4.2)	(4.5)	(3.9)	(3.7)	(3.8)
45-54	0.5	0.8	0.5	0.7	0.5	0.8	0.8	0.6	0.7	0.7	0.5	0.6
	(9.1)	(12.1)	(9.4)	(10.8)	(10.0)	(11.8)	(14.6)	(9.7)	(12.4)	(11.0)	(8.6)	(9.7)
55-64	1.2	1.5	1.1	1.5	1.0	1.4	0.9	1.3	0.9	1.2	1.1	1.1
	(21.7)	(24.5)	(19.8)	(23.0)	(18.3)	(20.5)	(16.7)	(20.0)	(15.1)	(19.7)	(16.9)	(18.1)
65-74	1.3	1.5	1.4	1.7	1.5	1.8	1.3	2.0	1.2	1.8	1.4	1.5
	(24.5)	(24.4)	(26.5)	(26.5)	(27.2)	(26.8)	(24.2)	(31.7)	(20.7)	(30.0)	(22.1)	(26.4)
75+	1.0	1.2	1.1	1.3	1.3	1.4	1.5	1.5	2.1	1.5	2.5	1.4
	(18.9)	(19.4)	(19.4)	(19.8)	(23.3)	(21.4)	(26.6)	(23.3)	(36.4)	(25.1)	(40.8)	(24.7)
All ages	5.3	6.2	5.4	6.3	5.4	6.6	5.5	6.4	5.8	5.9	6.2	5.8
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

a: The values outside the parentheses represent contribution in years and the value inside represents the percentage contribution. All ages: the total SDLE contributed by all age groups. Jpn: Japan and Scot.: Sotland. SDLE: Sex difference in life expectancy at birth, calculated by deducting the male from the female life expectancy at birth.

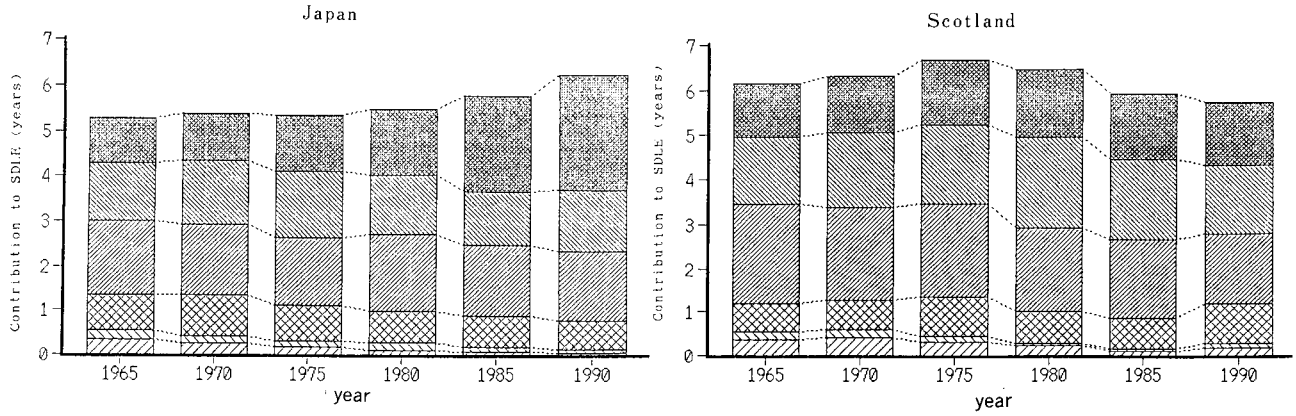

Fig. 1 Contribution of age groups to sex difference in life expectancy (SDLE) at birth for Japan and Scotland for the period 1965 to 1990. Contribution to SDLE (years) represents absolute contribution to SDLE in years (yr) by age group. 0 yr. 1-14 ry. 15-44 yr. 45-64 yr. 65 74 yr. 75+ yr.

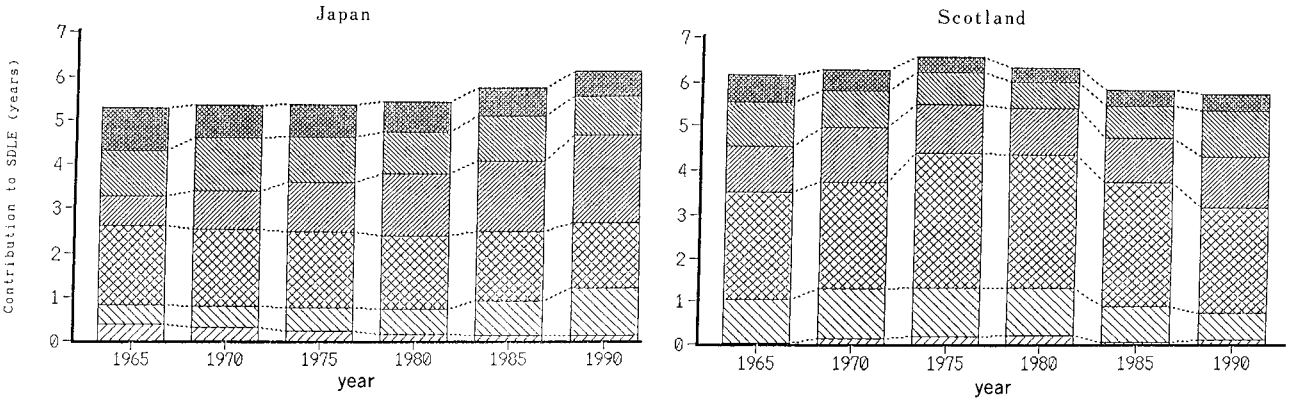

Fig. 2 Contribution of causes of death to SDLE at birth for Japan and Scotland for the period 1965 to 1990. Infectious disease (); disease of the respiratory system (); diseases of the circulatory system (); mlignancy (); accidents and injuries () and other causes of desath (), respectively. SDLE; See Fig. 1.

estimating the contribution of a particular age group to the total SDLE at birth (13). They exploited the fact that the total SDLE can be decomposed into age components. The contribution of individual age groups to SDLE was expressed by estimating the sex difference in total person-years survivorship within an age group in the form of:

$$ {}_{x+n}\Delta_x = [(e^f_x - e^m_x) \cdot (l^f_x + l^m_x)/2] - [(e^f_{x+n} - e^m_{x+n}) \cdot (l^f_{x+n} + l^m_{x+n})/2] \quad \cdots\cdots(I) $$

where ${}_{x+n}\Delta_x$ is the contribution to SDLE at birth of mortality differences within age group $({}_{x,\,x+n})$; n is the length of the age interval; e^f_x (e^m_x) is life expectancy at age x for female (male); l^f_x (l^m_x) measures the life table survivors to age x for females (males) in a life table with a radix of 1 (one). Complete current life tables were constructed for both Japan and Scotland. For each country, equation (I) was estimated for ten age groups: 0, 1-4, 5-14, ····· 65-74, and 75 years and over 75^+. The weighted difference in the contribution of different age groups to SDLE for Japan and Scotland were examined (Table 1 and Fig. 1).

Estimation of contribution of causes of death to SDLE at birth. The contribution of any particular cause of death measures the proportional contri-

Table 2 Contribution of causes of death to SDLE at birth for Japan and Scotland, 1965–1990

Year	Infec. disease[a]		Dis. of Res. system[a]		Dis. of Cir. system[a]		Malignancy[a]		Acc. & injury[a]		Other causes[a]		All causes[a]	
	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot
1965	0.4	0.02	0.5	1.0	1.8	2.5	0.7	1.0	1.1	1.0	1.0	0.6	5.3	6.2
	(7.2)	(0.3)	(8.5)	(16.5)	(33.6)	(40.2)	(12.3)	(16.6)	(20.0)	(16.5)	(19.2)	(11.0)	(100)	(100)
1970	0.3	0.1	0.5	1.2	1.7	2.5	0.9	1.3	1.3	0.8	0.7	0.5	5.4	6.3
	(5.5)	(2.1)	(9.3)	(18.4)	(33.2)	(38.9)	(15.9)	(19.8)	(23.2)	(13.3)	(13.9)	(8.6)	(100)	(100)
1975	0.2	0.2	0.6	1.1	1.7	3.1	1.1	1.1	1.1	0.8	0.8	0.3	5.4	6.6
	(4.3)	(2.7)	(10.2)	(17.1)	(31.7)	(47.0)	(20.6)	(16.7)	(19.4)	(11.4)	(14.1)	(5.5)	(100)	(100)
1980	0.2	0.2	0.6	1.1	1.7	3.1	1.4	1.1	1.0	0.6	0.7	0.3	5.5	6.4
	(2.9)	(3.3)	(10.9)	(17.5)	(30.0)	(48.1)	(25.5)	(16.4)	(17.8)	(9.7)	(13.1)	(5.8)	(100)	(100)
1985	0.1	0.1	0.8	0.8	1.6	2.9	1.6	1.0	1.1	0.8	0.6	0.4	5.8	5.9
	(2.2)	(0.7)	(13.8)	(13.9)	(27.2)	(49.2)	(27.6)	(17.3)	(18.1)	(12.7)	(11.6)	(6.1)	(100)	(100)
1990	0.1	0.1	1.1	0.6	1.5	2.5	2.0	1.2	0.9	1.1	0.6	0.4	6.2	5.8
	(2.1)	(1.9)	(18.1)	(10.7)	(23.6)	(42.8)	(32.6)	(19.8)	(14.7)	(18.1)	(8.9)	(7.1)	(100)	(100)

a: The values outside the parentheses represent contribution in years and the value inside represents the percentage contribution (total SDLE is 100 percent). All causes: the total SDLE contributed by all causes. Infec. disease: infectious diseases. Dis. of Res. system: diseases of respiratory system. Dis. of Cir. system: diseases of circulatory system. Acc. & injury: accident and injury. Jpn.: Japan and Scot.: Sotland. SDLE: See Table 1.

Table 3 Contribution of diseases of the circulatory system to SDLE at birth, 1965–1990

Year	Japan[a]			Sctoland[a]		
	All cir disease	IHD	CVD	All cir disease	IHD	CVD
1965	1.8(33.6)	0.30(6.7)	1.2(23.4)	2.5(40.2)	2.1(33.1)	0.1(1.6)
1970	1.7(32.2)	0.37(6.9)	1.3(23.3)	2.4(38.9)	2.2(34.6)	0.1(1.7)
1975	1.7(31.7)	0.4 (7.2)	1.1(21.1)	3.1(47.0)	2.6(38.6)	0.2(3.6)
1980	1.6(30.0)	0.4 (7.8)	0.9(16.4)	3.0(48.1)	2.6(40.6)	0.2(2.8)
1985	1.5(27.2)	0.4 (6.7)	0.6(10.4)	2.9(49.2)	2.5(42.0)	0.2(2.7)
1990	1.4(23.6)	0.4 (6.3)	0.5(8.2)	2.5(42.8)	2.1(36.2)	0.2(3.1)

a: The values outside the parentheses stand for contribution in years and the value inside represesnts the percentage contribution (total SDLE is 100 percent). All cir. disease: all circulatory disease. IHD: ischemic heart disease. CVD: cerebrovascular disease. SDLE: See Table 1.

bution of that cause in relation to the total contribution by all causes of death in the form of:

$$[(r^{m}{}_{i}-r^{f}{}_{i})/(r^{m}-r^{f})] \cdot {}_{x+n}\Delta_{n} \quad \cdots\cdots\cdots (II)$$

where $r^{m}{}_{i}$ ($r^{f}{}_{i}$) is the male (female) death rate from cause ($_{i}$) at age ($_{x, x+n}$); r^{m} (r^{f}) is the male (female) death rate from all causes at age group ($_{x, x+n}$); ${}_{x+n}\Delta_{x}$ is the contribution of age group ($_{x, x+n}$) to SDLE at birth. Causes of death were grouped into six major categories on the basis of the International Classification of Diseases (ICD) (8th and 9th revision). These are infectious diseases (A1–A44, 01–07), where the first and second symbol within the parentheses belong to 8th and 9th revision of ICD, respectively and the same applies to all of the diseases described below: Diseases of the respiratory system (A89–A96, 31–32); Diseases of the circulatory system (A80–A88, 25–30); Malignancy (A45–A61, 08–17); Accidents and injuries (AE138–AE150, E47–E56); and all other diseases (A62–A79, A97–137; 18–24, 34–46). Direct age-standardized death rates for all causes and sex-age-specific death rates for selected causes were estimated as the basis for computing equation (II) for the assessment of the contribution of those causes of death to SDLE at birth for both countries (Table 2 and

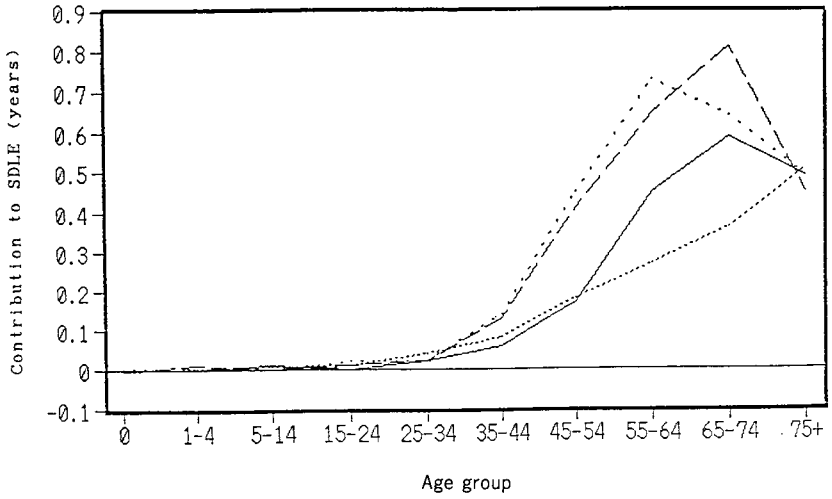

Fig. 3 Age-specific contribution of diseases of the circuratory system to SDLE at birth for Japan and Scotland for the period 1965 and 1990. Contribution of diseases of the circulatory system for Japan (— 1965, ···· 1990) and Scotland (- - - 1965, – – 1990). SDLE: See Fig. 1.

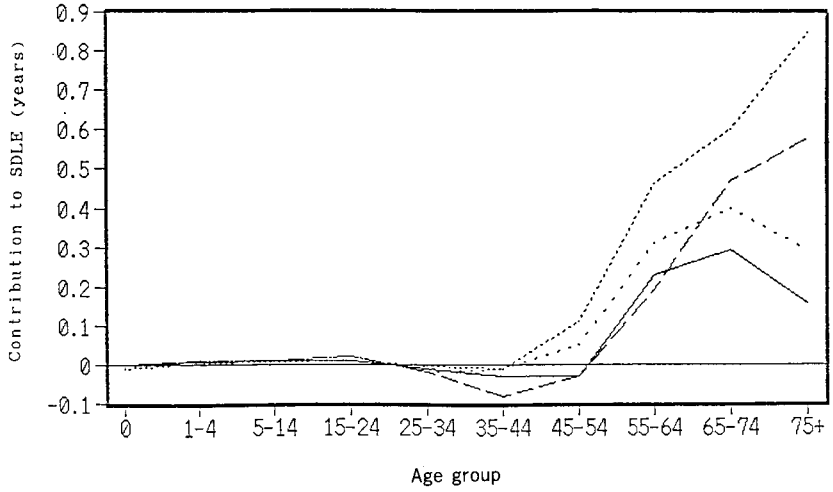

Fig. 4 Age-specific contribution of malignancy to SDLE at birth for Japan and Scotland for the period 1965 and 1990. Contribution of malignancy for Japan (— 1965, ···· 1990) and Scotland (- - - 1965, – – 1990). SDLE: Fig. 1.

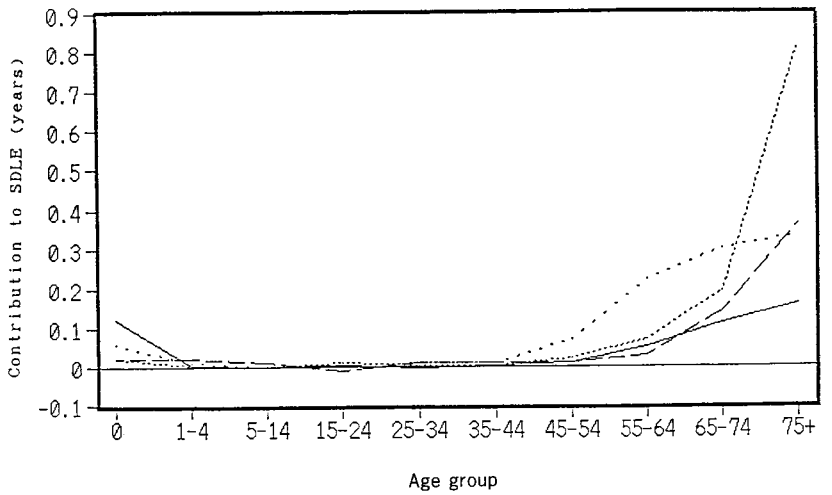

Fig. 5 Age-specific contribution of diseases of the respiratory system to SDLE at birth for Japan and Scotland for the period 1965 and 1990. Contribution of diseases of the respiratory system for Japan (— 1965, ···· 1990) and Scotland (- - - 1965, – – 1990). SDLE: See Fig. 1.

Table 4 Contribution of malignancy of selected sites to SDLE at birth for Japan and Scotland, 1965–1990

Year	All malig[a]		Malig. of trac., bronc. & lung[a]		Malig. of stomach[a]		Malig. of male gen. organ[a]		Malig. of female gen. organ[a]		Malig. of female breast[a]	
	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot	Jpn	Scot
1965	0.7	1.0	0.1	0.9	0.5	0.2	0.03	0.2	-0.2	-0.2	-0.1	-0.4
	(12.9)	(16.6)	(2.5)	(15.3)	(10.2)	(2.6)	(0.6)	(3.2)	(-4.5)	(-2.7)	(-1.3)	(-5.9)
1970	0.9	1.3	0.2	1.0	0.5	0.1	0.03	0.2	-0.2	-0.1	-0.1	-0.4
	(15.9)	(19.8)	(3.5)	(16.1)	(9.4)	(1.8)	(0.6)	(3.0)	(-3.9)	(-2.2)	(-1.7)	(-6.7)
1975	1.1	1.1	0.3	1.1	0.6	0.2	0.1	0.2	-0.5	-0.2	-0.1	-0.5
	(20.6)	(16.7)	(5.6)	(16.7)	(10.9)	(2.4)	(0.9)	(2.6)	(-8.3)	(-2.4)	(-2.0)	(-7.1)
1980	1.4	1.1	0.4	1.1	0.6	0.2	0.1	0.2	-0.2	-0.1	-0.1	-0.6
	(25.5)	(16.4)	(7.1)	(16.9)	(10.2)	(2.3)	(1.1)	(3.3)	(-2.9)	(-2.1)	(-2.4)	(-8.6)
1985	1.6	1.0	0.5	1.0	0.5	0.1	0.1	0.3	-0.1	-0.1	-0.1	-0.5
	(27.6)	(17.3)	(9.0)	(17.3)	(9.1)	(2.4)	(1.7)	(4.2)	(-2.4)	(-2.4)	(-2.4)	(-9.2)
1990	2.0	1.2	0.7	0.8	0.6	0.1	0.1	0.3	-0.1	-00.1	-0.2	-0.6
	(32.6)	(19.8)	(10.8)	(14.1)	(8.9)	(2.4)	(2.1)	(5.3)	(-1.9)	(-2.4)	(-2.7)	(-9.8)

a: The values outside the parentheses stand for contribution in years and the value inside represents the percentage contribution (total SDLE is 100 percent). All malig.: malignancy of all sites. Malig. of trac., bronc. & lung: malignancy of trachea, bronchus and lung. Malig. of male gen.: malignancy of male genital organs. Malig. of female gen.: malignancy of female genital organs. Jpn.: Japan and Scot.: Scotland. SDLE: See Table 1.

Fig. 2). The time trends of the contribution of causes of death to SDLE were observed and compared between Japan and Scotland (Figs. 3–5). Diseases of the circulatory system was simplified into ischemic heart disease (A83, 27) and cerebrovascular disease (A85, 29). Malignancy was decomposed into malignancy of the trachea, bronchus and lung (A51, 101); malignancy of the stomach (A47, 091); malignancy of the female breast (A54, 113); malignancy of the female genital organs (A55–A56, 120–123); and malignancy of the male genital organs (A57, 124–125). Individual contribution of these causes were estimated for both countries (Tables 3 and 4). Accidents and injuries were not analyzed in detail because of the diversity of this group of "cause of death" and its associated factors from others considered in this study.

Results

Sex differential in Life Expectancy at Birth in Japan and Scotland

In Japan, SDLE at birth was 3.5 years in 1950, and then it steadily increased without any decline to reach its maximum of 6.2 years in 1990 (Table 5). On the other hand, SDLE in Scotland at birth was 4.0 years in 1950, after which it increased gradually to reach the peak value of 6.6 years in 1975. Later, it declined continuously and became 5.8 years in 1990 (Table 5). In Japan, SDLE increased by 0.9 year while in Scotland it decreased by 0.4 years between 1965 and 1990. Even though the time period considered in this study was from 1965 to 1990,

Table 5 Trend in SDLE at birth for Japan and Scotland, 1950–1990

Year	Japan			Scotland		
	Life expec. at birth[a]		SDLE[a]	Life expec. at birth[a]		SDLE[a]
	Male	Female		Male	Female	
1950	59.6	63.1	3.5	64.2	68.2	4.0
1955	61.2	65.6	4.4	65.8	70.8	5.1
1960	64.1	69.2	5.1	66.3	72.1	5.8
1965	68.2	73.5	5.3	66.6	72.8	6.2
1970	69.6	75.0	5.4	67.1	73.4	6.3
1975	72.2	77.6	5.4	67.9	74.5	6.6
1980	72.9	78.4	5.5	69.0	75.4	6.4
1985	75.6	81.4	5.8	70.1	76.0	5.9
1990	76.1	82.3	6.2	71.2	77.0	5.8

a: Each value stands for the absolute contribution in years. SDLE: Sex difference in life expectancy at birth, calculated by deducting the male from the female life expectancy at birth. Life expec. at birth: life expectancy at birth.

the trend in the change of SDLE was considered from 1950 to facilitate a better comparison.

Contribution of Different Age Groups to SDLE at Birth

The contribution to SDLE was the minimum in age group 1-4 in both countries and the maximum in age group 65-74 throughout the time period considered in Scotland and until 1980 in Japan (later by 75^+ age group). About 40-60 % of total SDLE was contributed by the 65-74 and 75^+ age groups in both countries (Table 1 and Fig. 1). In Japan, the contribution of all ages except 75^+ decreased from 4.3 years (81.1 %) to 3.7 years (60.2 %) between 1965 and 1990. Conversely, the contribution of the 75^+ age group increased from 1.0 year (18.7 %) to 2.5 years (40.8 %) over the same time period. In Scotland, the contribution of ages 15-44 increased from 0.7 year (10.4 %) to 0.8 year (15.6 %) and of age groups 65-74 and 75^+ from 2.7 years (43.8 %) to 2.9 years (51.1 %). The rest of the age groups had a decrease in their contribution from 2.8 years (44.3 %) to 2.0 years (31.7 %) with the maximum decrease in ages 45-64 (Table 1 and Fig. 1).

Contribution of "Causes of Death" to SDLE at Birth

Of all the causes, three major groups of causes of death (diseases of the circulatory system, malignancy and diseases of the respiratory system) account for about 60-75 % of the total contribution to SDLE at birth in both Japan and Scotland (Table 2 and Fig. 2).

Contribution of diseases of the circulatory system to SDLE at birth. Diseases of the circulatory system had the maximum contribution throughout the time period considered in Scotland ($\leqq$ 3.1 year or 47.0 %) and until 1980 in Japan ($\leqq$ 1.8 years or 33.6 %). In Scotland, it was practically unchanged but decreased in Japan between 1965 and 1990 (Table 2 and Fig. 2). In Japan, the contribution by this cause decreased from 1.8 years (33.6 %) to 1.4 years (23.6 %) between 1965 and 1990. The contribution of ischemic heart disease (IHD) was practically unchanged (0.4 year in all the years) and that of cerebrovascular disease (CVD) decreased from 1.2 years (23.7 %) to 0.5 years (8.2 %) (Table 3). In Scotland, the contribution of diseases of the circulatory system was 2.5 years (40.2 %) in 1965 and 2.5 years (42.8 %) in 1990. The contribution of ischemic heart disease (IHD) also remained the same at 2.1 years in 1965 and in 1990. The contribution of CVD increased a little from 0.1 years (1.6 %) to 0.2 years (3.1 %) (Table 3). The contribution of ages below 45 was very small in both countries; it decreased considerably in Japan in ages 55-74 and increased in Scotland in ages 65-74 (Fig. 3).

Contribution of malignancy to SDLE at birth. The contribution of malignancy increased from 0.7 year (12.3 %) to 2.0 years (32.6 %) in Japan and from 1.0 year (16.6 %) to 1.2 years (19.8 %) in Scotland between 1965 and 1990 (Table 4). In 1990, malignancy alone contributed to about one-third of the total SDLE in Japan. The contribution in ages below 45 was minimum and ages 15-44 had a negative contribution in both countries (Fig. 4). In Japan, a marked increase in contribution was observed in most of the age groups and the maximum was in the age group 75^+. In Scotland, the contribution increased only in the 65-74 and the 75^+ age groups and the magnitude was not as high as in Japan (Fig. 4). The simplification of malignancy into several subgroups is shown in Table 4. The contribution of malignancy of the trachea, bronchus and lung to SDLE was markedly less in Japan as compared to Scotland in 1965, and after that it increased continuously to 0.7 year (10.8 %) in 1990. In Scotland, it decreased a little to 0.8 year (14.1 %). The contribution of malignancy of the stomach to SDLE increased a little in Japan to 0.6 year (8.9%) in 1990. In Scotland, it decreased further to 0.1 year (2.4 %) and was always lower than Japan (Table 4).

The contribution (negative) of malignancy of the female breast to SDLE increased markedly in Scotland (-0.6 year or -9.8 %) as compared to Japan (-0.2 year or -2.7 %) in 1990. The contribution of malignancy of the female genital organs decreased almost to the same extent in both countries (-0.2 year to -0.1 year) between 1965 and 1990 (Table 4).

Contribution of diseases of the respiratory system to SDLE at birth. The contribution of diseases of the respiratory system to SDLE at birth increased markedly and continuously in Japan from 0.5 year (8.5 %) to 1.1 years (18.1 %) between 1965 and 1990 (Table 2). Ages before 45 had a very small contribution, whereas ages after 45 had an increasing contribution with the maximum increase in age group 75^+ (Fig. 5). In Scotland, a decrease in the contribution was observed from 1.0 year (16.5 %) to 0.6 year (10.7 %). The contribution declined in all age groups.

Discussion

The sex differential in life expectancy is the result of

increased and/or decreased mortality advantage of one sex over another. In the developed countries, females have a longer life expectancy than males (13). Although epidemiological studies have provided a wealth of information on relative morbidity and mortality between the sexes, the causes of the differences are poorly understood. The interest in this field of study has grown recently because, for a long time, sex differences were expected and unquestioned in all areas of life including longivity (14). The sex differential in mortality and life expectancy is influenced by two broad groups of factors: genetic-biological and environmental (behavioral, economic and cultural) (1). The mode of interaction of environmental with genetic-biological factors in different situations determines the outcome of SDLE. This may explain the different trend of SDLE in the developed countries in recent years including Japan and Scotland. The ultimate effect of the interaction between different factors is reflected through the change in the pattern of causes of death and as such it was analyzed in this study. The variation of SDLE with time is related to the well known fact that different causes of death assume quite different importance at different age ranges and between the sexes, and there has been a shift in the proportions of death from particular causes (2). It is noteworthy that all ages are not involved equally in the changes of SDLE. This is confirmed by the present study by decomposing the total SDLE into age and cause of death components, as the magnitude of contribution to SDLE by age groups and causes of death shifted with time (Tables 1 and 2). In Japan, the marked increase of contribution to SDLE in age group 75^{+} was due to the increased contribution of the major contributor diseases in this age group which led to the widening of SDLE. Conversely, in Scotland the marked decrease of the major contributor diseases in ages 45–64 mainly caused the narrowing of SDLE.

Diseases of the circulatory system, malignancy and diseases of the respiratory system contributed in chronological order in Japan in 1965. In 1990, the order changed to malignancy, diseases of the circulatory system and diseases of the respiratory system. In Scotland, the chronological order remained unchanged as diseases of the circulatory system, malignancy and diseases of the respiratory system in all the years (Table 2 and Fig. 2). These three groups of causes of death account for about two-thirds of the total SDLE in recent years in both countries. In Japan, the decreased contribution to SDLE by diseases of the circulatory system was mainly due to the reduction of CVD because IHD was practically unchanged (Table 3). The decrease in the contribution of CVD was due to lowering of male CVD mortality, possibly as a result of effective control of hypertension and a decline in the prevalence of male smokers (15, 16). Conversely, in Scotland the practicallyunchanged and high contribution of diseases of the circulatory system was because of the persistently high contribution of IHD. The contribution of IHD in Scotland was always 5 to 6 times higher than in Japan (Table 3) due to a persistent high mortality from IHD in Scotland.

Evidence from different studies suggests that smoking is the major factor for the sex differences in cardiovascular mortality (17–19), but other factors must also contribute as male cardiovascular mortality is higher even among non-smokers (20, 21). In Japan, sex difference in smoking habit has been decreasing due to a decline in the prevalence of male smokers from 80 % in 1965 to 61 % in 1988. The smoking rate has been quite steady among females since the 1950s and was only 13 % in 1988 (15). This decline in the sex difference in smoking habits in Japan may explain the declining contribution of diseases of the circulatory system to SDLE. Conversely, sex difference in smoking habits is very small in Scotland (38 % and 36 % of men and women, respectively, were smokers in 1988) which does not explain the marked contribution of diseases of the circulatory system to SDLE (22). Some other factors may be involved. It has been proposed that female sex hormones have a protective effect against coronary heart disease and there is evidence that heart disease mortality for female smokers is considerably lower than male smokers (23, 24). The other important factor is suggested to be the Type A behavior pattern which is more common among males than females, a hard-driving style of life characterized by aggressiveness, competitiveness, hostility, impatience, a chronic sense of time urgency, and a strong drive to achieve (25, 26). A higher male cardiovascular mortality in Scotland is also suggested to be associated with unemployment (27).

The marked increase (about 3 times) in the contribution of malignancy played a major role in further widening of SDLE in Japan. Among all the subgroups, the contribution of malignancy of the trachea, bronchus and lung had a marked increase and that of malignancy of the stomach was as high as always. Conversely, in Scotland the contribution of malignancy of the trachea, bronchus and lung remained as high as alway as, and that of malignancy of the stomach as low as always (Table 4).

The considerable increase in negative contribution of malignancy of the female breast added further to the narrowing of SDLE in Scotland. The sex difference in mortality from different malignant diseases which affect SDLE varies over time between and within countries. Evidence from different studies suggests that a major cause of men's higher cancer mortality which affect their life expectancy is the sex difference in smoking habit (18, 21). Studies have found that for adults who had never smoked regularly there was little or no sex difference in cancer mortality (28, 29). In Japan, the substantial sex difference in smoking habit may explain the marked contribution of malignancy to SDLE but it does not explain the figures for Scotland as the sex difference in smoking habit is quite small. This indicates the involvement of some other factors. Studies suggest the association of men's higher cancer mortality with occupational exposure to carcinogens, alcohol intake, dietary habits (intake of salty meat or fish, lack of fresh vegetables, milk and dairy products), and genetic factors (30-33). Sex differential in reproductive anatomy and the effect of sex hormones contribute to higher mortality for women, particularly for breast cancer (33, 34). The inter-country variation between Japan and Scotland may be, as evidenced, due to a different socioeconomic status, high fat and alcohol intake, and low level of motivation in Scotland (32, 35-37).

The effect of contribution of the respiratory system to SDLE was opposite in Japan and Scotland. In Japan, it helped widen SDLE by becoming almost double with time. In Scotland, it had a narrowing effect by decreasing to about half of the previous contribution over the same time period (Table 2). These findings reflect the diversity of factors responsible for the sex difference in mortality from diseases of the respiratory system in these two countries which in turn affect the SDLE. The factors, suggested in different studies, are smoking, occupational exposure to polluted air, alcohol intake, old age and genetic factors (38-41).

It can be concluded that the persistent widening of SDLE at birth in Japan is a consequence of the marked increase in the contribution of malignancy and diseases of the respiratory system. Continued high (though reduced with time) contribution of diseases of the circulatory system also had an important role. On the other hand, in Scotland the narrowing of SDLE at birth is a consequence of the fact that the maximum contributor, diseases of the circulatory system, was practically unchanged and diseases of the respiratory system decreased markedly. Malignancy had a little increase in contribution but was balanced by the decrease in other causes. In Japan, age group 75^{+} alone had a considerable increase thus contributing to the widening of SDLE. In contrast, in Scotland ages 45-64 had a marked decrease in the contribution to cause narrowing of SDLE.

This study highlighted the salient features of the current situation regarding the role of different ages and causes of death for a different trend in SDLE at birth in Japan and Scotland. Further epidemiological studies remain to be done and it is necessary to identify and analyze in detail the internal gradients (environmental and genetic-biological) of the major contributor diseases to SDLE in either country. Research into the interaction of those gradients will enhance our knowledge of and ability to improve the health of both men and women.

References

1. Lopez AD: Sex differentials in mortality. WHO Chron (1984) **38**, 217-224.
2. United Nations. Department of International Economic and Social Affairs: Level and Trend of Mortality Since 1950. New York (1982) pp 7, 69-82.
3. World Health Statistics Annual 1985: Geneva (1985) pp 30-35.
4. World Health Statistics Annual 1991. Geneva (1991) pp 80-85.
5. World Health Statistics Annual 1992. Geneva (1992) pp C-8, C-9.
6. World Health Statistics Annual 1993. Geneva (1993) pp D-432, D-440, D-444.
7. Hansluwka H: New Developements in the Analysis of Mortality and Causes of Death. Amarian Press, Bangkok (1986) pp 1-7.
8. Ueda K: Recent Trends of Mortality in Asian countries. SEAMIC Publication No. 34, Tokyo (1984) pp 100-119.
9. Hansluka H: Cancer mortality in Europe. World Health Stat Q (1978) **31**, 159-194.
10. Nanzo Z and Kobayashi K: Cohort Life Tables Based on Annual Life Tables for the Japanese Nationals Covering the Years 1891-1982, NUPRI Research Paper Series No. 23, Tokyo (1985) pp 130-190.
11. Coale AJ and Demeny P: Regional Model Life Tables and Stable Populations, Princeton University, Princeton (1966) pp 73-91.
12. Davis T: The expectation of life in England and Wales. Popul Trend (1990) **60**, 23-24.
13. United Nations: Survivorship in Developed and Developing Countries, Department of International Economic and Social Affairs, New York (1982) pp 10-19.
14. Holden C: Why do women live longer than men? Science (1987) **238**, 158-160.
15. Shimamoto T, Komachi Y, Inada H and Kojima S: Trends of coronary heart disease and stroke and their risk factors in Japan. Circulation (1989) **79**, 503-515.
16. Tanaka H, Ueda Y, Kato T and Detels R: Incidence of stroke in Shibata, Japan, 1976-1678. Stroke (1981) **12**, 460-466.
17. Waldron I: Sex differential in heart disease risk. Lancet (1981) **ii**, 368.
18. Waldron I: The contribution of smoking to sex differences in mortality.

Public HeaHh Rep (1986) **101**.
19. Johnson A: Sex differential in coronary heart disease: The explanatory role of primary risk factors. J Health Soc Behav (1977) **18**, 46-54.
20. Shurtleff D: Some characteristics related to the incidence of cardiovascular disease and death: Framingham study, 18-year follow up; in The Framingham Study, Kannel WB and Gordon T eds, United States Department of Health, Education and Welfare, Washington, D. C (1974).
21. Doll R: Mortality in relation to smoking. Br Med J (1980) **280**, 967 971.
22. Townsend P: Deprivation. J Social Policy (1987) **16**, 125-146.
23. Johanson and Sales W: Myocardial infarction in women. Epidemiol Rev (1983) **5**, 67-95.
24. Waldron I: Sex differences in human mortality: The role of genetic factors. Soc Sci Med (1983) **17**, 1107-1123.
25. Wingard DL: The sex difference in morbidity, mortality and life style. Ann Rev Public Health (1984) **5**, 433-458.
26. Waldron I: Sex differences in the coronary-prone behaviour pattern; in Coronary Prone Behaviour, Dembroski TM ed, Springer-Verlag, New York (1978) pp 199-205.
27. Crombie IK and Tunstell-Pedoe HD: Unemployment, socioeconomic factors, and coronary heart disease in Scotland. Br Heart J (1989) **61**, 172-177.
28. Enstorm JE and Godley FH: Cancer mortality among a representative sample of non-smokers in the United States during 1966-1968. J Natl Cancer Inst (1980) **65**, 1175-1183.
29. Hammond EC and Seidman H: Smoking and cancer in the United States. Prev Med (1980) **9**, 169-173.
30. Higginson J and Muir CS: Environmental carcinogenesis. J Natl Cancer Inst (1979) **63**, 1291-1298.
31. Carstairs V, Morris R: Deprivation and Health in Scotland. Abardeen University Press, Abardeen (1991) pp 102-106.
32. Armstrong B and Doll R: Environmental factors and cancer incidence and mortality in different countries with special reference to dietary practices. Int J Cancer (1975) **15**, 617-631.
33. Waldron I: Why do women live longer than men? Soc Sci Med (1976) **10**, 349-362.
34. Ramey ER and Ramwell P: The relationship of sex hormones to female and male longivity; in The Changing Risk of Disease in Women, Ellen BG ed, Collamore Press, Lexington (1984) pp 25-36.
35. Skegg DCG: Alcohol, coffee, fat and breast cancer. Br Med J (1987) **295**, 1011-1012.
36. Morimoto T, Tanaka T and Monden Y: Breast cancer detected by mass screening using physical examination alone. Jpn J Surg (1987) **17**, 377-381.
37. Roberts MM, Alexander FE and Prescott RJ: Edinburgh trial of screening for breast cancer, mortality at seven years. Lancet (1990) **335**, 241-246.
38. Waldron I: What do we know about causes of sex differences in mortality?: A review of literature. Popul Bull United Nations (1985) **18**, 59-76.
39. Araki S and Murata K: Social life factors affecting the mortality of total Japanese population. Soc Sci Med (1986) **23**, 1163-1169.
40. Walker AM: Projections of Asbestos-related disease 1980-2009. J Occup Med (1983) **25**, 409-425.
41. Lacroix Az, Lipson S and White L: Prospective study of pneumonia, hospitalization and mortality of older people: The role of chronic condition, health behaviours and nutritional status. Public Health Rep (1989) **104**, 350-360.

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