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Temporal trends and ethnic variations in amenable mortality in Singapore 1965–1994: the impact of health care in transition

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Background Amenable mortality is used to assess the effects of health care services on gains in mortality outcomes. Possibly differing patterns of trends in amenable mortality may be expected in economically less developed countries, which have undergone rapid epidemiological transition and recent reforms in health care systems, but such studies are scarce. This study was set up to examine the trends in amenable mortality in Singapore from 1965 to 1994; to estimate the relative impact of medical care and primary preventive policy measures in terms of gains in mortality outcomes; to examine ethnic differences in amenable mortality among Chinese, Malays and Indians.

Methods Age-standardized mortality rates were calculated for 16 amenable causes of death in Singapore for six 5-year periods (1965–1969, …, 1990–1994), and for each of the three main ethnic groups for three periods (1989–1991, 1992–1994, 1995–1997). Amenable mortality rates were divided into those which can be reduced by timely therapeutic care for 'treatable' conditions (e.g. asthma and appendicitis), or by primary preventive measures for 'preventable' conditions (e.g. lung cancer and motor vehicle injury).

Results Amenable mortality was higher in males (age-standardized rate 109.7 per 100 000 population) than in females (age-standardized rate 60.7 per 100 000 population). Amenable mortality declined by 1.77% a year in males and 1.72% a year in females. By comparison, the average yearly decline in non-amenable mortality was 0.91% in males and 1.17% in females. The decline in amenable mortality was largely due to 'treatable' causes rather than a decline in mortality due to 'preventable' causes of death. Amenable mortality was lowest for Chinese and highest for Malays. Over the recent 9-year period from 1989 to 1997, amenable mortality declined more in Chinese than in Malays and Indians. However, Indian females showed by far the sharpest decline, whereas Indian males, by contrast, showed an increase in amenable mortality, due to both treatable and preventable causes.

Conclusions In line with findings from European countries, amenable mortality in Singapore declined more than non-amenable mortality. There were more significant gains in mortality outcomes from medical care interventions than from primary preventive policy measures. Gender and ethnic differences in amenable mortality were also observed, highlighting issues of socioeconomic equities to be addressed in the financing and delivery of health care.

Keywords Outcome measures, quality of care

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The concept of studying amenable mortality as a method of measuring the quality of health care was first introduced by the American Working Group on Preventable and Manageable Diseases in 1976.[1] The method is based on the premise that the effectiveness of health care can be evaluated from mortality due to certain conditions which are wholly or substantially avoidable by timely and appropriate medical care interventions. In the 1980s and 1990s, the validity and applicability of using

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amenable mortality as outcome indicators of health care were demonstrated in various studies conducted in the UK, other Western European countries in the European Community, as well as Scandinavian countries such as Sweden and Finland.[2–8] These studies adopted 16 amenable causes of death, developed by an EC working group, for which there is evidence that mortality rates can be reduced by timely therapeutic care for 'treatable' conditions (e.g. as asthma and appendicitis), or by primary preventive measures for 'preventable' conditions (e.g. lung cancer and motor vehicle injury).[8–10] These amenable causes of death were used respectively as indicators of outcome of medical care, and as indicators of outcome of national health policy.

Time trend analyses in these studies have in general shown that amenable mortality has declined faster over the past decades than most other causes of death or overall mortality.[5–7,11] Socioeconomic factors, as well as environmental exposures and nutrition, are likely to contribute to such declines in mortality, especially for non-amenable causes of death, but health care service is also responsible for part of the decline.[12] The impact of health services, estimated by the differential in rates of mortality decline from amenable and non-amenable causes, has been reported to account for 50% of the total decline in mortality from amenable causes.[7]

Geographical variations in amenable mortality at national and international level,[2–5] as well as among different social classes have also tested the application of amenable mortality studies in the evaluation of socioeconomic equity of the health care system.[13–17] There are, however, no studies that have examined ethnic variations in amenable mortality, although such studies are common in other areas of health care research.

Subsequent studies have been conducted in less economically developed countries, such as Eastern Europe and former Soviet republics.[18–20] These studies are of interest in shedding light on possible differing patterns of amenable mortality trends between countries with differing levels of economic development and health care systems. There are, however, virtually no studies in less economically developed countries in Asia which are characterized by rapid epidemiological transition and reforms in systems of health care financing and delivery.

Over the past four decades, the small island republic of Singapore (population about 3 million) has experienced rapid and significant economic development and improvement in health status. Having undergone a rapid epidemiological transition to a disease pattern that is now dominated by chronic degenerative conditions,[21] it is uncertain how much health gains have been achieved through recent measures aimed at primary disease prevention. Health care reform policies since the 1980s have focused on making health care cost-effective and affordable;[22] however, outcome data on medical care quality are largely lacking. Among the multi-ethnic population of Singapore (75% Chinese, 14% Malay and 7% Indian), previous studies have highlighted significant ethnic differences in health status. There are reasons to believe that, apart from intrinsic genetic and socioeconomic factors, much of these differences arise from environmental, behavioural and lifestyle factors that are amenable to primary preventive measures, and from medical care factors that are amenable to measures aimed at improving the delivery of quality medical care.

In the present study, we examined the trends in amenable mortality in Singapore from 1965 to 1994, with a view to assessing the effects of health care services on gains in mortality outcomes. We also sought to estimate the relative impact of medical care and primary preventive policy measures in terms of their actual reductions in mortality outcome. Finally we examined variations in amenable mortality among the three ethnic groups.

Methodology

Data on deaths and population for the period 1965–1994 were obtained from the Registry of Births, Death and Marriage and the Department of Statistics, Singapore.[23,24] The register is based on the death certificate issued by doctors following the death of a Singaporean citizen or permanent resident. The certificate states the underlying cause of death according to the International Classification of Diseases (ICD-6, 8 and 9). Although there is some variability in the codes between ICD revisions, the changes are not considered significant enough to affect comparability of the data from different years (Table 1).

Data analyses covering the period 1965–1994 were restricted to those aged between 5 and 64 years, because most of the potentially amenable mortality occurs in this group. After the age of 65 years, the declines in mortality from the selected conditions are generally considered much less obvious.[6] We adopted the European Community list of amenable causes of death, divided into treatable and preventable causes, which reflect the outcome of medical care (medical care indicators) and the effect of national health policy (health policy indicators), respectively. The list of amenable causes of death was selected with due consideration to sufficient number of deaths in each age group to allow for meaningful analysis, which meant omitting very infrequent causes of death. Data on perinatal and maternal death were therefore excluded. In order to obtain a sufficient number of deaths, some causes were grouped together, namely, appendicitis and hernia, pneumonia and influenza, a number of infectious and parasitic diseases, malignant neoplasm of colon, rectum and recto-sigmoid junction, and malignant neoplasm of trachea, bronchus and lung.

The trends in age-standardized mortality by amenable, non-amenable, and all causes were analysed for consecutive 5-year periods (1965–1969, …, 1990–1994). Ethnic differences in mortality rates were analysed for three periods (1989–1991, 1992–1994, 1995–1997), the years when routine statistics by ethnic groups were available. Direct standardization for age and sex was done using the 1990 census population as the standard population. The relative rates of decline in amenable and non-amenable mortality were compared by the standardized mortality ratios (SMR), using a base of 100 for the 1990 general population rates. Linear regression analysis with the year of death as independent variable and the logarithm of the standardized mortality ratio (SMR) as dependent variable was also done. The significance of the yearly change or the trend was then tested using the two-tailed t-test. The best model of the linear trends was based on R^2 values (coefficient of determination). All statistical analyses were done using the SPSS statistical software.

In the absence of any direct effect of health care services on mortality, the rate of decline in amenable mortality may be assumed to be the same as that of non-amenable mortality.[7] We

Table 1 Amenable causes of death in Singapore, 1965–1994

Cause of death	1965–1968 ICD[a]-6	1969–1978 ICD-8	1979–1994 ICD-9	No. of deaths	
				Male	Female
Treatable				17 504	10 653
Tuberculosis	001–019	010–019	010–018	3582	1011
Other infectious and parasitic diseases	b	c	d	1767	1156
Peptic ulcer	540–541	531–533	531–533	782	253
Appendicitis, intestinal obstruction and hernia	550–553, 560–561, 570	540–543, 550–553, 560	540–543	166	103
Chronic rheumatic heart disease	410–416	393–398	393–398	730	1036
Hypertensive diseases	440–447	400–404	401–405	2228	1505
Diabetes mellitus	260	250	250	1742	1903
Pneumonia and influenza	480–483, 490–493	470–474, 480–486	480–486, 487	4652	2617
Bronchitis, emphysema, asthma	500–502	490–493	490–493	1855	1069
Preventable				26 514	12 910
Malignant neoplasm					
Colon, rectum and recto-sigmoid junction	153–154	153–154	153–154	1950	1619
Liver and intra-hepatic biliary duct	155–156	155, 197	155	3794	958
Trachea, bronchus, lung	162–163	162	162	5489	1767
Cervix uteri	171	180	180		1560
Cerebrovascular disease	330–334	430–438	430–438	7561	5385
Chronic liver disease and cirrhosis	581	571	571	2149	466
Motor vehicle accidents	E810-E835	E810-E823	E810-E819	5571	1156
Amenable				44 018	23 563
Non-amenable				58 414	30 480
All causes				102 432	54 043

[a] International Classification of Disease.

[b] Codes 020–029, 030–074, 080–096, 100–108, 110–117, 120–138.

[c] Codes 000–009, 020–046, 050–136.

[d] Codes 001–009, 033, 036–038, 050, 055, 084.

Table 2 Number of deaths by cause and age group, 1965–1994

Cause of death	5–9		10–19		20–29		30–39		40–49		50–59		60–64	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
All causes	1457	1164	4886	2673	9155	4227	9598	5654	16 633	9055	34 776	17 711	25 927	13 559
Non-amenable	957	719	3111	1795	5952	3038	6285	3829	9667	5182	18 915	9090	13 526	6828
Amenable	500	445	1775	878	3203	1189	3313	1825	6966	3873	15 861	8621	12 401	6731
Preventable	187	123	1101	305	2230	467	2031	891	4307	2255	9556	5059	7103	3809
Treatable	313	322	674	573	973	722	1282	934	2659	1618	6305	3562	5298	2922
% Amenable of all causes	34.3	38.2	36.3	32.8	35.0	28.1	34.5	32.3	41.9	42.8	45.6	48.7	47.8	49.6

have therefore used a proxy measure of the direct impact of health care in terms of gains in mortality outcome by calculating the differential percentage decline in amenable mortality after subtracting the percentage decline of non-amenable mortality.

Results

From 1965 to 1994 the number of amenable deaths in those aged 5–64 years (44 018 males and 23 563 females) constituted 42.9% of all male causes and 43.6% of all female causes. 'Treatable' conditions in males and females accounted for 39.8% and 45.2% of amenable deaths, respectively (Table 2). In males, the amenable mortality as a proportion of all-cause mortality increased from 34.3% in the youngest age group (5–14 years) to 47.8% in the oldest age group (60–64 years). In females, this proportion increased from 38.2% in the youngest age group (5–14 years) to 49.6% in the oldest age group (60–64 years). Cerebrovascular disease (12 946 deaths), lung cancer (7256 deaths) and motor vehicle accidents (6727 deaths) accounted for the largest number of amenable deaths, while pneumonia contributed the most to mortality from treatable conditions (7269 deaths) (Table 1). Amenable mortality was higher in males (age-standardized rate 109.7 per 100 000 population in 1990–1994) than in females (age-standardized rate 60.7 per 100 000 population in 1990–1994).

Table 3 Percentage decline of annual mortality rate and the estimated impact of health care by cause between 1990–1994 and 1965–1969

	Male				Female			
Cause of death	ASR[a] 1990–1994	ASR 1965–1969	% Change[b]	% Impact[c]	ASR 1990–1994	ASR 1965–1969	% Change	% Impact
Treatable	33.7	118.8	–78.2	50.8	22.9	65.3	–67.8	32.6
Tuberculosis	2.41	40.24	–108.7	81.3	0.80	12.02	–107.6	72.4
Other infectious and parasitic diseases	4.21	12.13	–68.3	40.9	2.60	7.35	–68.4	33.2
Peptic ulcer	1.12	5.36	–91.3	63.9	0.39	2.13	–95.3	60.1
Appendicitis and hernia	0.12	1.64	–110.4	83.0	0.05	1.20	–114.2	79.0
Chronic rheumatic heart disease	0.90	3.16	–73.5	46.1	1.59	5.72	–72.6	37.4
Hypertensive diseases	3.99	18.37	–86.5	59.1	2.82	12.52	–82.3	47.1
Diabetes mellitus	4.78	5.87	–13.2	–14.2	5.08	5.79	–6.2	–29.0
Pneumonia and influenza	13.40	21.98	–43.0	15.6	7.05	13.48	–51.5	16.3
Bronchitis, emphysema and asthma	2.82	10.05	–81.5	54.1	2.56	5.08	–63.4	28.2
Preventable	75.9	106.2	–28.5	1.1	37.8	55.5	–34.2	–1.0
Malignant neoplasms								
Colon, rectum and recto-sigmoid junction	7.63	5.77	36.0	–63.4	6.30	4.29	38.1	–73.3
Liver intra-hepatic biliary duct	10.69	17.02	–31.4	4.0	2.66	4.85	–42.8	7.6
Trachea, bronchus, lung	17.52	15.25	14.1	–41.5	5.82	6.54	–6.1	–29.1
Cervix uteri					4.39	8.00	–42.1	6.9
Cerebrovascular disease	20.44	32.45	–42.4	15.0	14.40	21.95	–42.4	7.2
Chronic liver disease and cirrhosis	4.81	10.83	–54.3	26.9	1.03	2.57	–58.0	22.8
Motor vehicle accidents	14.85	24.80	–41.8	14.4	3.20	4.78	–42.6	7.4
Amenable	109.7	225.0	–53.1	25.7	60.7	120.8	–51.5	16.3
Non-Amenable	176.6	249.6	–27.4		91.1	148.2	–35.2	
All causes	286.3	474.6	–39.7		151.8	268.9	–42.8	

[a] Age-standardized rate, per 100 000-population per year, was directly age-standardized to the 1990 Census whole population.

[b] Per cent change was based on the best-fitted regression line method using unstandardized predicted values of the first (1965–1969) and the last (1990–1994) periods.

[c] Per cent impact was measured as the net decline of amenable mortality rate after subtracting the decline of non-amenable mortality rate. Positive figures indicate beneficial impact; negative figures indicate no beneficial impact.

Mortality changes and impact of health care between 1965–1969 and 1990–1994

Age-adjusted mortality by amenable (preventable and treatable), non-amenable and all causes by sex were examined for six 5-year interval time periods (1965–1969, …, 1990–1994). (Table 3 and Figure 1). Between 1965 and 1994, amenable mortality showed an absolute decline of 53.1% in males and 51.5% in females. The annual trends in amenable mortality were 1.77% in males and 1.72% in females ($P < 0.001$). The decline was, however, steepest in the 1960s and 1970s, and relatively more modest in the 1980s and 1990s (Figure 1).

By comparison, between 1965 and 1994, mortality from non-amenable causes showed a smaller decline of 27.4% in males and 35.2% in females. The yearly trends in non-amenable mortality were 0.91% in males and 1.17% in females ($P < 0.001$).

By evaluating the decline in amenable mortality relative to the decline in non-amenable mortality, it would appear that there was a greater impact of health care on the male population than on the female population (Table 3).

The decline in amenable mortality was contributed to more by the decline in 'treatable' mortality than the decline in 'preventable' mortality. Between the periods from 1965–1969 to 1990–1994, 'treatable' causes of death declined by 78.2% in males and 67.8% in females. By comparison, 'preventable' causes of death declined by only 28.5% in males and 34.2% in females. This is most clearly shown by the relative declines in SMR of treatable and preventable causes of death in Figure 2.

When concomitant declines in non-amenable mortality are taken into account, the actual declines attributable to medical care and public health policy interventions were 50.8% in males and 32.6% in females for 'treatable' causes of death, and only 1.1% (males) for 'preventable' causes of death, respectively. In females, no positive impact for preventable causes was demonstrated (the percentage impact was expressed in negative terms).

The greatest decline in 'treatable' causes of death was observed for tuberculosis (108.7% in males and 107.6% in females) and appendicitis and hernia (110.4% in males and 114.2% in females). For 'preventable' causes of death, the lack of a substantial decline was mainly explained by actual increases in death rates from colo-rectal cancers (36.0% in men and 38.1% in women) and lung cancer (14.1% in men).

Ethnic differences

Among the three ethnic groups in the population, Chinese had the lowest all cause mortality rate, whereas Indians had a slightly higher rate than Malays (Table 4). However, when amenable mortality was examined, Malays had the highest rates of mortality, followed by Indians, especially for treatable causes. For preventable causes, Indians had similar rates of mortality compared to Chinese.

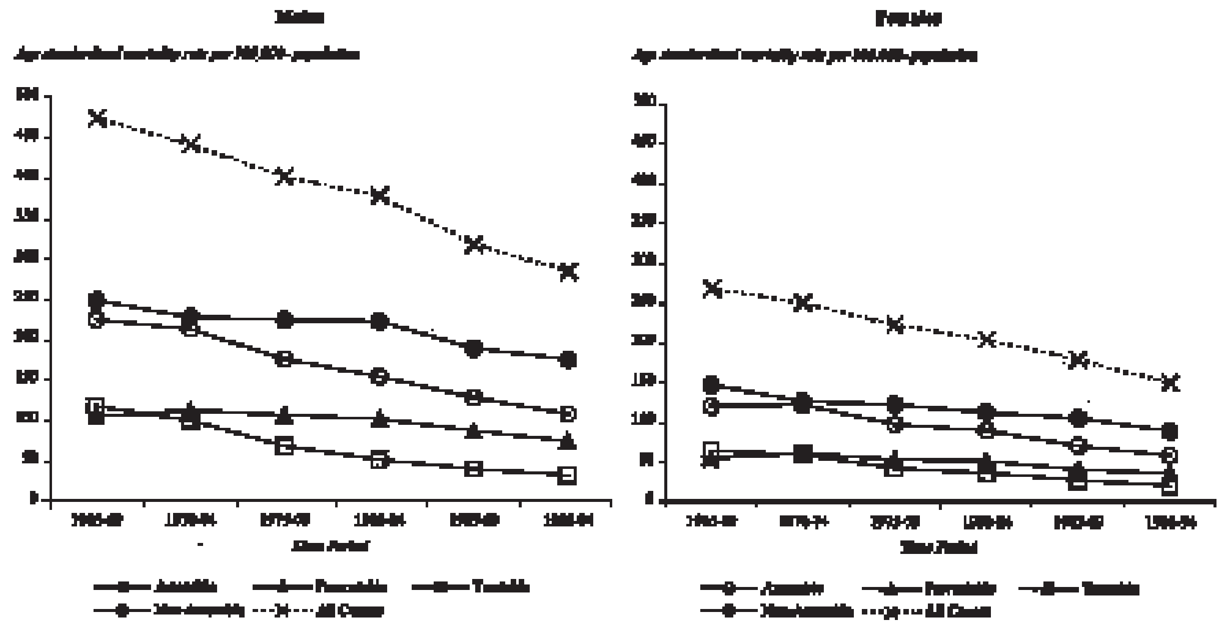
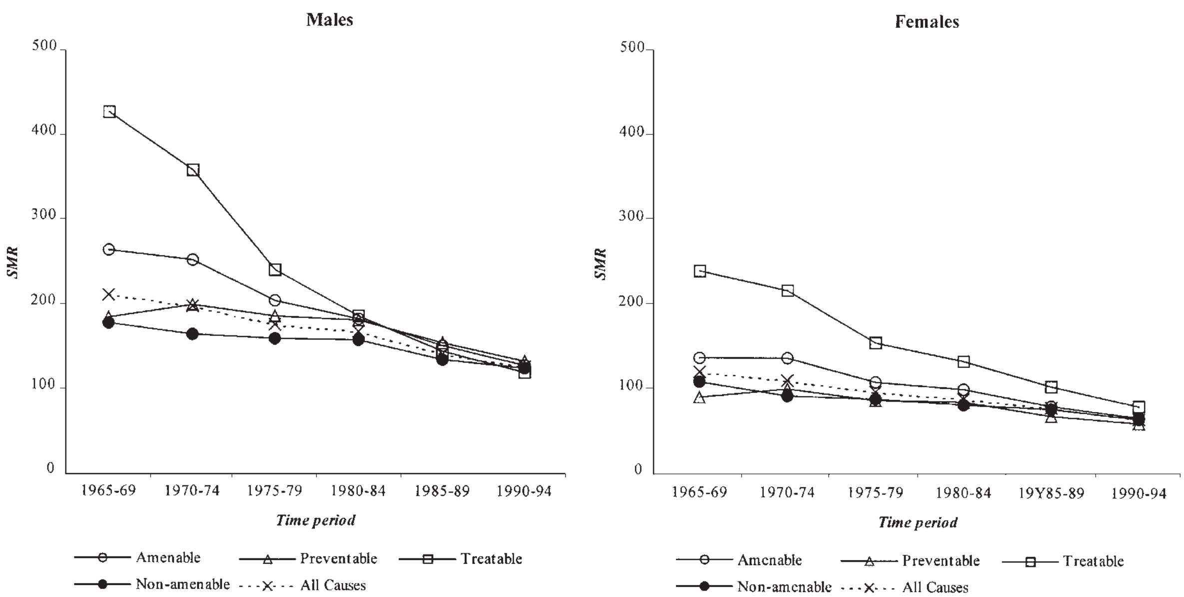


Figure 1 Trends in amenable and non-amenable mortality, Singapore, 1965–1994



Using 1990 general population rates as a base of 100

Figure 2 Trends in amenable and non-amenable standardized mortality ratios, Singapore, 1965–1994

Over the recent 9-year period from 1989 to 1997, Chinese showed the steepest decline in amenable mortality (13.6%), followed by Malays (7.6%) and Indians (4.9%) (Table 5). However, in Indians, female amenable mortality showed a remarkably steep decline (28.4%), in contrast to males who showed in fact an increase of 10.3% (due to both treatable and preventable causes).

Discussion

A principal finding of this study is that mortality due to amenable causes dropped more than mortality from non-amenable causes for both sexes. This pattern is similar to those observed in economically developed countries.[6–8,11] Most of the decline in amenable mortality was attributable to treatable causes, not preventable ones. Amenable mortality from treatable causes declined at more than twice the rate of decline due to preventable causes. The gains in mortality outcome has, however, been most pronounced in the first two decades, and moderated in more recent periods.

Although preventable mortality declined over a 30-year study period by nearly 30% for both sexes, this was, however, not very different from the decline in non-amenable mortality, suggesting that the impact of primary preventive health care

Table 4 Ethnic variations in amenable (preventable and treatable), non-amenable and all-cause mortality by gender, 1989–1997

			Male			Female			All		
Cause of death	**No.**	**% of all causes**	ASR[a]	RR[b]	(95% CI)	ASR	RR	(95% CI)	ASR	RR	(95% CI)
Amenable											
Chinese	13 679	(41.0%)	33.7	1.00		17.0	1.00		25.3	1.00	
Malay	3179	(42.3%)	44.7	1.33	(1.26–1.40)	35.3	2.07	(1.93–2.22)	40.0	1.58	(1.49–1.68)
Indian	1573	(31.1%)	41.0	1.22	(1.15–1.28)	21.8	1.28	(1.19–1.38)	31.8	1.26	(1.18–1.34)
Preventable											
Chinese	9782	(29.3%)	24.6	1.00		11.7	1.00		18.0	1.00	
Malay	1732	(23.0%)	26.9	1.09	(1.02–1.17)	16.7	1.43	(1.31–1.56)	21.7	1.21	(1.12–1.30)
Indian	865	(17.1%)	24.7	1.00	(0.94– 1.07)	9.6	0.82	(0.74–0.91)	17.6	0.97	(0.90–1.05)
Treatable											
Chinese	3897	(11.6%)	9.1	1.00		5.4	1.00		7.2	1.00	
Malay	1447	(19.2%)	17.8	1.96	(1.78–2.16)	18.6	3.45	(3.08–3.87)	18.2	2.53	(2.28–2.81)
Indian	708	(14.0%)	16.3	1.80	(1.63–1.99)	12.2	2.26	(2.00–2.55)	14.3	1.98	(1.78–2.21)
Non-amenable											
Chinese	19 719	(59.0%)	46.7	1.00		26.5	1.00		36.5	1.00	
Malay	4344	(57.7%)	64.2	1.37	(1.31–1.44)	43.8	1.66	(1.56–1.75)	53.8	1.47	(1.40–1.55)
Indian	3491	(68.9%)	94.8	2.03	(1.95–2.12)	44.2	1.67	(1.58–1.77)	70.9	1.94	(1.85–2.04)
All causes											
Chinese	33 398		80.4	1.00		43.5	1.00		61.8	1.00	
Malay	7523		108.9	1.35	(1.31–1.40)	79.1	1.82	(1.74–1.90)	93.7	1.52	(1.46–1.58)
Indian	5064		135.8	1.69	(1.63–1.75)	66.0	1.52	(1.45–1.59)	102.7	1.66	(1.60–1.73)

[a] Age-standardized rate, per 100 000-population per year, was directly age-standardized to the 1990 Census whole population.

[b] Relative risk with Chinese subgroup as reference.

Table 5 Age-standardized mortality rates per 100 000 persons-year in 3-year periods 1989–1997 by ethnic groups

	Amenable causes			**Preventable causes**			**Treatable causes**			**Non-amenable causes**			**All causes**		
	Chinese	Malay	Indian	Chinese	Malay	Indian	Chinese	Malay	Indian	Chinese	Malay	Indian	Chinese	Malay	Indian
Males															
1989–1991	36.6	46.8	38.9	27.5	29.9	22.7	9.1	16.9	16.2	51.1	65.5	91.5	87.7	112.2	130.4
1992–1994	33.6	42.1	41.1	24.0	25.6	26.3	9.6	16.5	14.8	45.4	65.1	89.9	79.0	107.1	131.0
1995–1997	31.4	42.6	42.9	22.9	24.1	24.6	8.6	18.5	18.3	44.4	58.4	100.3	75.8	101.0	143.2
% Change[a] (1995–1997 – 1989–1991)	–14.3	–9.1	10.3	–17.0	–19.7	8.1	–5.3	9.7	13.7	–13.3	–10.7	9.8	–13.7	–10.0	10.0
% Impact[b]	1.0	–1.5	–0.4	3.7	9.0	1.8	–8.0	–20.4	–3.8						
Females															
1989–1991	18.2	34.8	26.1	12.0	17.2	12.9	6.2	17.6	13.2	30.2	43.4	53.1	48.3	78.2	79.2
1992–1994	17.5	36.7	21.2	12.1	16.8	8.9	5.4	19.9	12.3	25.4	44.0	44.8	42.9	80.6	66.0
1995–1997	15.7	33.2	18.8	10.9	15.6	7.6	4.7	17.6	11.2	24.2	43.6	35.9	39.9	76.7	54.7
% Change (1995–97 – 1989–91)	–13.6	–4.5	–28.4	–9.0	–9.2	–42.6	–24.3	0.0	–15.1	–20.3	0.5	–32.3	–17.5	–1.9	–31.1
% Impact	–6.7	4.9	–3.9	–11.3	9.7	10.2	4.0	0.5	–17.2						
All															
1989–1991	27.2	40.9	32.9	19.6	23.5	18.1	7.6	17.4	14.8	40.4	54.4	74.3	67.6	95.2	107.2
1992–1994	25.4	39.5	31.6	18.0	21.2	18.2	7.4	18.3	13.4	35.3	54.3	68.6	60.7	93.8	100.2
1995–1997	23.5	37.8	31.3	16.9	19.7	16.4	6.6	18.1	14.9	34.3	50.8	69.3	57.8	88.6	100.7
% Change (1995–97 – 1989–91)	–13.6	–7.6	–4.9	–13.8	–16.3	–9.2	–13.0	4.0	0.7	–15.4	–6.5	–6.8	–14.6	–6.9	–6.1
% Impact	–1.8	1.0	–1.9	–1.5	9.7	2.4	–2.4	–10.5	–7.5						

[a] Per cent change was based on the best-fitted regression line method using unstandardized predicted values of the first (1989–1991) and the last (1995–1997) periods.

[b] Per cent impact was measured as the net decline of amenable mortality rate after subtracting the decline of non-amenable mortality rate. Positive figures indicate beneficial impact; negative figures indicate no beneficial impact.

policy measures was rather limited. Individually, two causes of death in the preventable group, namely, malignant neoplasm of colon, rectum and recto-sigmoid junction and malignant neoplasm of trachea, bronchus and lung contributed most to the unfavourable trend in preventable mortality. Apart from these two conditions, mortality from preventable causes decreased more than non-amenable mortality for both sexes. Smoking and dietary habits that contributed to increases in these conditions during the 30-year period did not receive much attention until the late 1980s. The emphasis in public health from the 1950s to the 1970s was on environmental sanitation and the control of communicable diseases. Public health measures aimed at chronic disease prevention and promotion of healthy lifestyles were largely implemented in the 1980s. Since then, they have appeared to produce some results in reducing the prevalence and levels of behavioural risk factors in the population, but it will be probably another decade before their impact on reducing the incidence and mortality from cancer and chronic lifestyle-related diseases can begin to be apparent.

It is also worth noting that even though the percentage decline in amenable mortality was similar for both sexes, it would appear that health care had a more favourable impact on males than in females. Although *pari passu*, it is expected that health care should be of the quality that the impact is the same irrespective of gender differences, the percentage decline in death from some diseases was less in females than in males, a finding which parallels that in several previous studies on gender differences.[7,8] The study in Sweden[8] even showed an upward trend of mortality for this group of causes, especially asthma, among the female population.

We found important differences among the ethnic groups in mortality outcomes of primary preventive and curative health care interventions. To the best of our knowledge, this has not been studied by previous investigators. The best outcomes were seen for Chinese, in whom both the levels and rates of declines in amenable causes of death (both preventable and treatable) were most favourable. Although Malays had a higher level of amenable mortality compared to Indians, the rate of decline was in fact more favourable. Given that the recent period from 1989 to 1997 witnessed more moderate mortality declines, amenable mortality dropped faster than non-amenable mortality in this group, suggesting that Malays are currently achieving more gains from health care interventions than Chinese and Indians. Among Indians, amenable mortality from both preventable and treatable causes in fact increased in males. On the other hand, Indian females appeared to show extraordinary gains from health care interventions. Some data are available of the known determinants of health status differences among the three ethnic groups which explain the observed differences in the levels of amenable mortality. Apart from genetic factors which obviously contribute, socioeconomic status, smoking, alcohol consumption, diet, physical activity, obesity, accident risk, and health-seeking behaviour, including health care utilization, are known to be different among the ethnic groups in Singapore.[25] The Chinese are the most affluent and educated ethnic population group in the country, and almost certainly have more access to better quality health care. The levels of smoking, obesity, cholesterol, alcohol, exercise, and dietary patterns are generally all unfavourable in Malays and Indians.[25] We believe that health beliefs and cultural differences in health-seeking behaviour are most likely to explain why there are such disparities.

As in previous studies, empirical dichotomies of ‘amenable’ and ‘non-amenable’ causes of death, and of ‘preventable’ and ‘treatable’ causes of death were employed in this study. This allowed us to examine the impact of health care in its broadest sense, as well as through its component strategies of medical treatment and primary prevention. The strategies apply to causes of death which are amenable through curative measures, as well as by appropriate primary preventive measures for diseases, which are known to be not definitely curable through current medical interventions. The spontaneous decline in incidence of ‘non-amenable’ causes is considered to be mostly attributable to the impact of general socioeconomic factors outside the health care system.

The selection of specific conditions into the rubric of amenable causes of death deserves to be reviewed. It may be justified to include coronary heart disease in this group in view of recent evidence about the effectiveness of thrombolytic therapy and other interventions. However, we were also aware that our evaluation dated back to 1965. The introduction of medical care technologies for coronary heart disease care including thrombolytic therapy, coronary artery bypass graft (CABG) and percutaneous transluminal coronary angioplasty (PTCA), and the evidence of their effectiveness, are of more recent origin. The selection of conditions was therefore based on the best evidence available at the time that an appropriate intervention would be effective in preventing death. Furthermore, we were interested in comparing amenable mortality outcome information with that already available in many Western countries. To make the comparison as valid as possible we therefore decided on having the same fixed selection of amenable causes of death.

There were changes in coding practice (from ICD-6 to ICD-9) over the period of study, however, previous other studies have shown that revisions are unlikely to be responsible for the observed trends.[6] The accuracy of diagnostic labelling and coding could be possible causes of such overall variation in death rates for different time periods, but the effect of these causes was negligible (Table 1). In the present study, data based on yearly trends are subject to the effects of random fluctuations, and the change in mortality rate may also be non-linear. In assessing the statistical significance of trends, mortality trends were modelled by linear regression of the logarithm of the age-standardized mortality rates on calendar year. The use of logarithmic transformation improves the linear correlation. In most instances, the linear model was appropriate, and the use of non-linear (quadratic) modelling did not improve the fit significantly. This is evidenced by the trends in mortality rates across successive 5-year periods as presented in the Figures.

In conclusion, the present study indicates that health care interventions in Singapore over 30 years have had a significant impact in mortality outcomes. The gain in terms of mortality reduction from medical care appears to be greater than that from primary prevention. This has to be understood in the context of the rapid epidemiological and health care transition that has taken place. The gain from primary prevention was mostly offset by trends in lung cancer and colo-rectal cancer, which have yet to be reversed by recent initiatives in primary prevention. The study also highlights important gender and ethnic differences in the outcomes of health care that call attention to issues of socioeconomic equity in health care which would need to be addressed in the financing and delivery of health care.

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Commentary: Evaluating avoidable mortality in developing countries—an important issue for public health

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In the late 1970s, an American working group chaired by David D Rutstein introduced a method for measuring the quality of medical care.[1] It was based on the tradition of using potentially avoidable mortality such as perinatal and maternal mortality as negative indicators of health and as a starting point for the evaluation of health care. Studies of the maternal and infant mortality rate have been useful. These rates, however, have the limitation that they only apply to mothers and infants. With

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the help of specialists in many fields of medicine 80 causes of death were defined as 'unnecessary untimely deaths'. The list was based on judgements as to whether the conditions were amenable to preventive and/or therapeutic measures. An agglomeration of deaths from these causes would be warning signals indicating that the quality of medical care may need to be improved.

The list was designed for international use, not only for use in more economically developed countries. However, most of the studies applying the method have mainly been published from western industrialized countries.

There was a break-through for the concept in 1986 when Charlton and Velez showed that mortality from avoidable causes of death had decreased to a greater degree than total mortality in several industrial countries during the period 1950–1980.[2] These trends have been confirmed in later studies from several countries.[3] For many avoidable causes of death, mortality has also been shown to decline faster after the introduction of new technologies in health care, such as primary care programmes for the management of hypertension for preventing mortality from cerebrovascular disease and cervix cancer screening.

A large number of deaths in the American working group list were relatively rare in developed countries. In Sweden a limited number of causes of death accounted for most of the deaths covered by the Rutstein list.[4] For a majority of the remaining causes there were few cases and for several causes, no deaths at all during a 12-year period.

In the 1980s a European Community (EC) working group was set up to prepare an atlas of avoidable mortality in the EC.[5] Seventeen disease groups were agreed as avoidable death indicators, mainly selected from the Rutstein list. The general principle was that each disease has identifiable effective interventions and providers of health care intervention. Three of the conditions were considered to be indicators of the national health policy for primary prevention, usually outside the direct control of the health services. Fourteen conditions were defined as medical care indicators. These would reflect different aspects of medical care delivered by health administrative authorities, mainly curative and secondary preventive measures. Strict age limits were set for each condition to increase the validity of the outcome indicators. Several studies on the variations in avoidable death between different countries and different health administrative areas have been published using the EC working group criteria.[3]

In the 1990s some studies of avoidable mortality in Eastern European countries were published. Comparisons between Eastern and Western European countries have also been performed. For instance, in Lithuania death rates for avoidable death indicators were between 2 and 36 times higher than in Sweden during the years 1971–1990.[6] For several avoidable causes of death, such as tuberculosis, appendicitis and hypertensive and cerebrovascular disease the gap was widening. The study pointed out potential fields for improvement of the health care system in Lithuania.

A study on avoidable mortality in Singapore 1965 to 1994 has been published in this issue of *International Journal of Epidemiology*, extending the application of the method further.[7] In this study, the temporal trends in avoidable mortality have been analysed in an economically less developed country. The EC working group list of indicators was used. For ages 5–64 years, more than 40% of the deaths was covered by the list of avoidable causes of death. The corresponding figures for the EC countries varied between 10% and 30%. Thus, there seems to be potential to reduce mortality in Singapore considerably by health care intervention. A promising reduction in avoidable death rates was also found when compared to other causes of death. Thus, the general pattern of decreasing avoidable death rates previously found in industrialized countries seems to be valid also in developing countries.

The EC working group indicators were chosen in order to make comparisons possible with European countries. However, the original American working group list was much broader including about 80 causes of death. Many of these causes of death have been rare in industrialized countries but they may be useful as indicators in developing countries. Thus, when extending the application of the avoidable mortality method to developing countries it would be useful to make a revision of the choice of indicators.

In later avoidable mortality studies there has been concern also about the equity in outcome of health care. For instance, several studies have shown socioeconomic differences in avoidable mortality.[8] Ethnic differences have also been found between white and blacks in the US.[9] The Singapore study illustrates the usefulness of studying the equity in avoidable mortality also in Asian countries. Both ethnic and gender differences were found. Evaluating the equity in mortality outcome should be a major concern for further studies of avoidable mortality.

According to the original idea, an agglomeration of avoidable deaths is a warning signal motivating in-depth studies of the quality of care. Several audits of avoidable factors influencing death have been published from a variety of countries, both industrialized and developing countries. However, there is a need to define the evaluation criteria further.[10] For instance, the avoidable factors examined should be explicitly classified and the sources of information and people responsible for the judgements presented.

To sum up, the avoidable mortality concept originally was developed for international use. So far, there has however been a lack of studies from developing countries. The Singapore study shows the feasibility of applying the concept also in economically developing countries.

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