

Myocardial Infarction in Singapore: A Nationwide 10-year Study of Multiethnic Differences in Incidence and Mortality

A T H Tan,*^{FAMS, M Med, FRACP}, S C Emmanuel,**^{FAMS, MBBS, MSc}, B Y Tan,***^{MSc}, W S Teo,****^{FAMS, M Med, FRCP},
T S J Chua,[†]^{FAMS, M Med, MRCP}, B H Tan,[‡]^{BA}

Abstract

Introduction and Methods: Cardiovascular diseases have progressively increased in importance as a major contributor of morbidity and mortality in Asia. However, many countries in Asia do not have nationwide systematically-collected and standardised data on myocardial infarction (MI). To accurately document the extent of atherosclerotic coronary heart disease in Singapore, a nationwide myocardial infarct registry was established in the mid-1986. Possible myocardial infarct events were identified through daily national lists of cardiac enzymes, hospital discharge codes, mortuary records and the national death registry. Data obtained from clinical history, cardiac enzymes and 12-lead electrocardiogram Minnesota codes were entered into an algorithm based on the WHO MONICA study. Cases identified as "definite" MI were included in the decade's review for this study. **Results:** From 1988 to 1997, 13,048 myocardial infarct events were diagnosed with 3367 deaths. There was a 39.1% decline in mortality, with an average decline of 6.5% per year [95% confidence intervals (CI), -3.9% to -9.1%]. However, the decline in incidence was only 20.8% with an average decline of 2.4% per year (95% CI, -6.6% to -1.2%). The highest incidence and mortality rates for both genders were seen in the Indians, followed by the Malays and the Chinese. **Conclusion:** Over 10 years, from 1988 to 1997, we documented a significant fall in mortality from MI in Singapore. There was a smaller decline in the incidence of infarction. Singapore implemented a National Healthy Lifestyle Programme in 1992 as a 10-year effort. The disparity in the incidence and mortality may suggest that a more dramatic and immediate impact has taken place in mortality through therapeutic programmes; primary preventive programmes would be more difficult to evaluate and have a more gradual impact. Only with continual accurate data collection through the whole country, over a much longer period, can the relative value of preventive and therapeutic programmes in coronary heart disease be assessed.

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Key words: Decline, Mortality, Lifestyles programme, SMIR, Therapeutic programme, WHO MONICA Study

Introduction

Rapid urbanisation and increasing affluence have improved the socioeconomic status of Asians. This, however, has brought with it new socioeconomic and medical problems resulting from the urbanised lifestyles entrenched in these newly industrialised economies. Major causes of mortality and morbidity in the past, such as infections and tuberculosis, have been gradually replaced by degenerative diseases of atherosclerosis and cancers. Undoubtedly, changed lifestyles, such as cigarette smoking, increased intake of saturated fats, sedentary lifestyles and stressful environments, have contributed to the growing epidemic of atherosclerosis in Asia.¹

In the United States, Australia and Western Europe, age-standardised death rates from atherosclerotic heart disease have declined²⁻⁶ significantly. In contrast, statistics from the World Health Organisation (WHO) show that the death rates from atherosclerotic heart disease in Singapore increased from 1970 to 1980.⁷ The WHO mortality statistics are obtained from national mortality databases. Though indicative of trends, mortality data will, in varying degrees, have with it problems of non-standardised definitions, accuracy and validation.⁸⁻¹¹

Furthermore, declining mortality trends from national mortality registries cannot differentiate whether the improved survival has been due to a reduced incidence of

* Consultant Cardiologist
Gleneagles Medical Centre

** Chief Executive Officer

*** Senior Manager
Health Information Management Department
National Healthcare Group Polyclinics

**** Senior Consultant

† Senior Consultant and Head
Department of Cardiology, National Heart Centre

‡ Senior Biostatistical and Research Executive
Epidemiology and Disease Control Department, Ministry of Health, Singapore

Address for Reprints: Dr S C Emmanuel, National Healthcare Group Polyclinics, 11 Jalan Tan Tock Seng, Level 6, Singapore 308433.

myocardial infarction (MI) or improved therapy for the condition.¹¹⁻¹³ Such differentiation is crucial for the planning and allocation of resources, for evaluating the effectiveness of interventions implemented to reduce the load of infarctions in the country and for research tailored towards preventive and therapeutic programmes.

Recognising the deficiencies in surveillance using national mortality records, the WHO established the multinational MONItoring of trends and determinants of CARdiovascular diseases (MONICA) study¹⁴ to standardise the collection of incidence data of atherosclerotic heart disease in different countries. The aims of the study were to enable accurate and comparative analysis of information, to monitor trends and to evaluate the effectiveness of interventions implemented.

In Singapore, we recognised the need for a standardised format for such data collection. With the assistance of the WHO, the national Singapore Myocardial Infarct Registry (SMIR) was established in 1986 conforming to the specifications of the MONICA system, to allow comparison of data on a time-trend basis and internationally, wherever relevant.

We report a 10-year study of data captured by the SMIR covering the period 1988 to 1997.

Materials and Methods

The SMIR is a nationwide Registry based on the specifications of the WHO MONICA Project.

To identify patients with MI, 5 sources of information were utilised, viz cardiac enzyme results, hospital discharge summaries, mortuary records, national registry of deaths data and voluntary notifications of MI by medical practitioners.

Computerised daily listings of all patients who had cardiac enzymes done in Singapore were obtained from all pathology laboratories and hospitals in Singapore. Patients who had elevated creatinine phosphokinase (CPK) results were identified. From the hospital discharge summaries, patients with an International Classification of Disease code of 410 at discharge were selected. From mortuary records, patients with a diagnosis of acute MI were selected. Mortality data from the Singapore Registry of Births and Deaths were obtained regularly, and patients with a death certification of “myocardial infarction” were identified.

In addition, letters were written to all medical practitioners who had certified deaths due to MI, asking them to supply information on relevant parameters required for the MONICA categorisation, such as description of the chest pain experienced by the patient and electrocardiogram (ECG) recordings, to facilitate accurate certification of the diagnosis made.

Once a potential myocardial infarct event was identified from one or more of the notification sources, the Infarct Registry’s research nurses obtained the relevant clinical history, a 12-lead ECG and cardiac enzyme data from the case notes. Minnesota coding of the 12-lead ECG was next done by nurses who had been specially trained in this. The algorithm from the MONICA study was then used. Data from the ECG analysis, cardiac enzymes and clinical history were entered into a computer algorithm, and a classification made as to whether the patient fulfilled the standardised MONICA criteria of “definite myocardial infarction”.

When drawing up the operational framework for the Singapore MONICA Registry, a pilot study¹⁵ was carried out in 1988 on 500 patients with MI to test the potential yield of cases from each notification. The pilot study showed that, for Singapore, the best yield for identification of patients with possible MI was from the cardiac enzymes together with the discharge diagnosis. Very few cases were obtained from the case summaries or voluntary notifications by doctor.

Statistical Analysis

Statistical computations were performed using the SAS version 6.12 (SAS Institute, Cary, N.C.).

Incidence and mortality rates for this study were reported as age-standardised rates per 100,000 population. The age-standardised rates were calculated with direct standardisation for the age groups 20-29, 30-39, 40-49, 50-59 and 60-64, using the World Standard Population.¹⁶ Linear regression on the logarithms of the age-standardised annual rates was used to estimate the changes in incidence and mortality rates over time. The average annual percentage was obtained by exponentiating the gradient, subtracting one and multiplying by 100.¹⁷

Definitions

The diagnosis of acute MI was categorised according to the MONICA criteria. According to the MONICA protocol, suspected coronary events were categorised as:

- 1) definite,
- 2) possible MI or cardiac death,
- 3) ischaemic cardiac arrest with successful resuscitation,
- 4) no MI, and
- 5) fatal unclassifiable events.

Only definite myocardial infarcts, as defined by the MONICA criteria, were included in the analysis for this study.

Results

Of the 30,463 possible acute MI events in patients aged between 20 and 64 years which were screened between

1988 and 1997, 13,048 events fulfilled the criteria of definite MI and were included in the analysis. There were 10,578 males and 2470 females, giving a male to female ratio of 4:1. There were 7950 Chinese (60.9%), 2388 Malays (18.3%) and 2433 Indians (18.6%), demonstrating a definite over-representation of Indians and Malays compared with their distribution in the Singapore population (Chinese, 79.2%; Malay, 12.6%; Indian, 7.1%).¹⁸

Incidence of MI

The peak incidence of MI was 104.3/100,000 seen in 1988, while the lowest incidence was 81.2/100,000 seen in 1995 (Fig. 1). The 10-year average incidence of acute MI

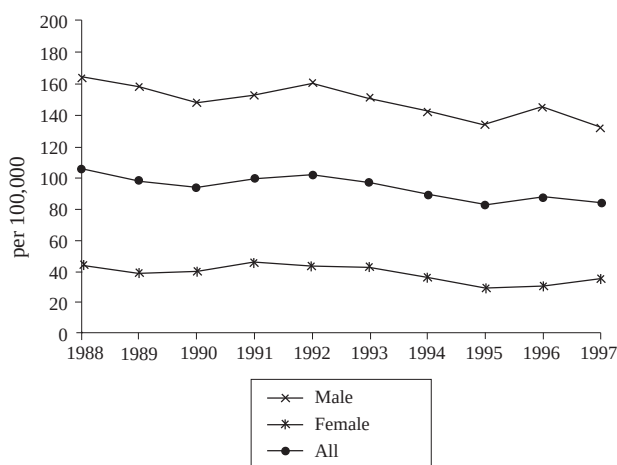


Fig. 1. Trends in age-standardised acute myocardial infarction incidence rates per 100,000 Singaporeans aged 20 to 64 years by gender (1988 to 1997).

was 92.7/100,000, with the incidence being 148.1/100,000 in males and 37.3/100,000 in females; illustrating a 4-fold higher incidence in males (Fig. 1).

During the 10-year review, the average annual incidence of myocardial infarcts in Chinese males was 115.3/100,000, while those in Malay males (234.2/100,000) and Indian males (331.9/100,000) were 2 and 2.9 times higher, respectively, than in Chinese males. Similarly, the 10-year average annual incidence of myocardial infarcts in Chinese females was 28.3/100,000, while the incidence in Malay females (65.0/100,000) and Indian females (102.6/100,000) being 2.3 and 3.6 times higher, respectively, than in Chinese females.

Trends in the Incidence of MI

The incidence of MI fell by 20.8% between 1988 and 1997, falling from 104.3/100,000 to 82.6/100,000 (Fig. 1). The incidence of acute MI in the population during this period showed an average annual decline of 2.4% (Table I). The incidence in females declined by 21.1%, from 43.1/100,000 in 1988 to 34.0/100,000 in 1997. The incidence in males on the other hand declined by 20%, from 164.7/100,000 in 1988 to 131.3/100,000 in 1997. The average annual decline in the incidence of MI was 3.7% for females and 2.1% for males (Table I).

The incidence of MI in males on an annual basis varied between the three races, demonstrating a negative trend in each case (Fig. 2). The average annual decline in incidence of MI was 1.4% for Chinese males, 0.8% for Malay males and 1.6% for Indian males.

TABLE I: AGE-STANDARDISED ACUTE MYOCARDIAL INFARCTION INCIDENCE RATES PER 100,000 SINGAPOREANS AGED 20 TO 64 YEARS BY ETHNIC GROUP AND GENDER (1988 TO 1997)

Year	Per 100,000 resident population											
	Chinese			Malay			Indian			Total		
	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female	All
1988	119.0	33.2	75.2	259.2	85.5	173.0	376.4	96.1	264.8	164.7	43.1	104.3
1989	127.2	28.8	76.8	220.0	63.3	139.8	323.8	106.5	231.5	158.1	38.0	98.2
1990	109.7	28.0	68.2	227.4	77.0	150.6	356.6	113.5	250.2	147.9	39.3	93.7
1991	124.1	36.0	79.3	222.2	66.9	142.2	311.3	117.7	225.1	153.0	45.0	99.0
1992	124.0	30.7	76.7	268.1	71.6	167.0	343.3	142.3	252.9	160.9	42.6	101.7
1993	117.7	31.0	73.9	246.3	73.7	156.9	318.4	119.0	228.5	151.5	41.8	96.6
1994	109.6	24.2	66.5	232.3	63.6	144.7	340.1	121.9	241.1	142.7	35.0	88.8
1995	106.8	22.6	64.4	211.2	53.0	129.2	313.4	61.5	196.9	133.8	28.7	81.2
1996	113.0	23.3	67.9	238.6	48.5	140.3	352.3	82.5	226.6	144.4	29.8	87.0
1997	107.3	27.7	67.3	216.7	53.4	132.7	278.1	79.0	183.6	131.3	34.0	82.6
Average rate per year	115.3	28.3	71.3	234.2	65.0	147.3	331.9	102.6	229.8	148.1	37.3	92.7
Average % change per year	-1.4	-3.2	-1.6	-0.8	-4.8	-1.9	-1.6	-4.0	-2.7	-2.1	-3.7	-2.4
95% confidence intervals for % change	(-2.7, -0.1)	(-6.2, -3.2)	(-3.1, -0.2)	(-2.8, -1.2)	(-7.4, -2.1)	(-3.8, 0.1)	(-3.4, 0.4)	(-9.5, 1.9)	(-4.7, -0.7)	(-3.1, -1.0)	(-6.4, -0.8)	(-6.6, -1.2)

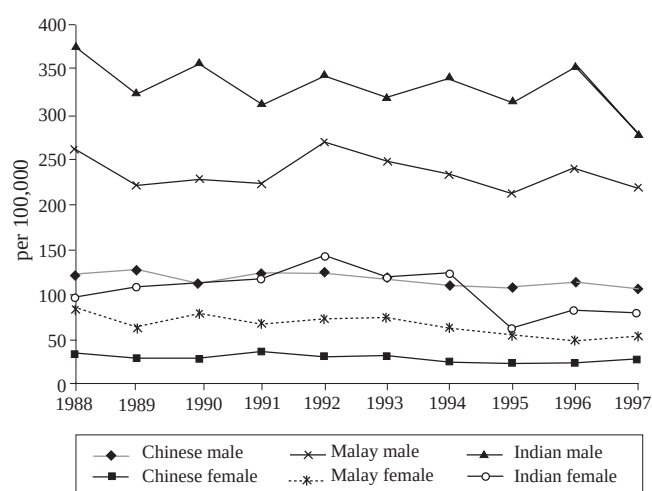


Fig. 2. Trends in age-standardised acute myocardial infarction incidence rates per 100,000 Singaporeans aged 20 to 64 years by gender and ethnic group (1988 to 1997).

For females, the incidence of MI also showed negative trends among the 3 ethnic groups. The average annual decline in incidence of MI was 3.2% for Chinese females, 4.8% for Malay females and 4.0% for Indian females.

On examining the age-specific incidence rates in MI, it was observed that the peak ages for the disease condition

were those in the 60 to 64 years age band for both males and females. The incidence rate in females in this age group was, however, half that of males (238.7 per 100,000 population versus 536.9 for males). Males in the 50 to 59 years age band had a relatively higher rate (340.7 per 100,000) compared with females in this age band who would have entered their menopausal years (76.5 per 100,000) (Table II).

Mortality from MI

Between 1988 and 1997, there were 3367 deaths from MI in Singapore (2606 males and 761 females, with a male to female ratio of 3.4:1) in the 20 to 64 years age group. The highest mortality from MI in the 10-year period reviewed was in 1989 at 32/100,000 persons and the minimum mortality was in 1995 at 17.2/100,000 persons (Fig. 3).

The 10-year average annual mortality from MI in Singapore during this period was 24.8/100,000, with the average annual mortality being 38.0/100,000 in males and 11.6/100,000 in females, reflecting a 3.3-fold gender difference (Table III).

The average annual mortality in Chinese males during this period was 29.5/100,000; Malay and Indian males had significantly higher average annual mortality rates at 63.7/100,000 (2.2-fold difference) and 78.3/100,000 (2.7-fold difference), respectively. Similarly, the average age-

TABLE II: AGE-SPECIFIC INCIDENCE RATES OF ACUTE MYOCARDIAL INFARCTION EVENTS FOR PATIENTS AGED 20 TO 64 YEARS (1988 TO 1997)

Age group (y)	Per 100,000 resident population									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
All										
20 - 29	3.0	1.5	1.7	0.8	2.6	0.2	0.6	1.2	1.6	0.8
30 - 39	17.9	11.2	13.0	14.7	16.1	14.8	17.7	10.8	15.3	12.1
40 - 49	82.5	78.1	84.2	72.2	82.2	82.6	70.6	79.9	78.1	66.6
50 - 59	256.0	254.7	236.1	245.6	243.8	233.0	226.8	213.9	212.7	208.4
60 - 64	492.7	454.7	411.8	494.7	493.7	463.2	399.3	317.8	387.0	386.1
20 - 64	76.0	72.6	71.6	75.9	79.1	75.5	70.9	66.1	71.5	68.3
Male										
20 - 29	5.5	3.0	2.3	1.5	3.9	0.4	1.2	2.4	2.5	1.6
30 - 39	32.5	20.9	23.4	26.5	30.0	26.8	32.8	20.0	29.6	22.5
40 - 49	139.3	139.1	149.8	123.8	146.4	139.7	125.6	143.6	141.3	119.7
50 - 59	411.1	418.7	378.6	394.7	389.1	367.7	359.3	346.1	347.8	340.7
60 - 64	720.1	661.3	578.9	681.7	711.9	678.9	602.2	493.5	608.1	539.6
20 - 64	120.7	117.1	113.2	117.6	125.8	119.0	115.0	109.8	119.9	110.7
Female										
20 - 29	0.4	0.0	1.2	0.0	1.2	0.0	0.0	0.0	0.8	0.0
30 - 39	2.8	1.2	2.2	2.5	1.8	2.4	2.4	1.3	0.7	1.6
40 - 49	25.1	16.1	17.1	19.2	16.3	23.8	13.8	14.1	12.8	11.6
50 - 59	98.7	89.7	93.1	97.0	99.2	98.6	94.4	81.6	77.9	76.5
60 - 64	263.9	250.2	248.4	312.5	281.8	252.8	202.6	150.8	175.9	238.7
20 - 64	30.2	27.0	28.9	33.2	31.5	31.4	26.3	21.9	22.6	25.8

Source: Singapore Myocardial Infarct Registry

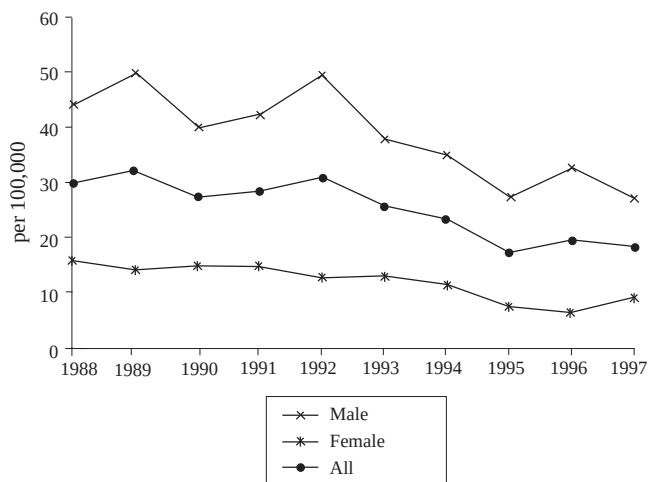


Fig. 3. Trends in age-standardised acute myocardial infarction mortality rates per 100,000 Singaporeans aged 20 to 64 years by gender (1988 to 1997).

standardised mortality in Chinese females was 8.4/100,000, with Malay and Indian females having significantly higher mortality rates at 24.4/100,000 (2.9-fold difference) and 29.8/100,000 (3.5-fold difference), respectively.

Trends in Mortality from MI

The mortality from MI for the population between the ages of 20 and 64 years fell from 29.9/100,000 in 1988 to 18.2/100,000 in 1997. This was a 39.1% fall (Fig. 3). The average annual reduction in mortality was 6.5% (Table III).

Mortality rates in both genders fell between 1988 and

1997, with a larger fall seen in females compared with males (Fig. 3). The mortality in females fell from 15.8/100,000 in 1988 to 9.2/100,000 in 1997, a fall of 41.8%. In contrast, mortality rates in males fell by 38.0% from 43.9/100,000 in 1988 to 27.2/100,000 in 1997.

The average annual decline in mortality was 8.6% for females and 5.9% for males (Table III).

During this period, however, mortality in males fluctuated from year to year, though showing an overall downward trend. This decline was experienced by all males in the 3 ethnic groups, with an average annual decline of 4.9% seen in Chinese males, 5.0% in Malay males and 5.8% in Indian males (Fig. 4).

In each ethnic group, females showed a more definite declining trend if their age-standardised mortality rates were compared with their male counterparts (Fig. 4). The average annual decline in the age-standardised mortality rates were 8.3% in Chinese females, 8.4% in Malay females and 9.2% in Indian females.

Discussion

Singapore is currently assessed to have achieved a “developed nation” economic status. With an ageing population and urbanised lifestyles in the population typified by sedentary lifestyles, increased dietary saturated fat intake, smoking, a high prevalence of diabetes and blood cholesterol levels approximating that of Western developed countries,¹⁹ there has been an increasing incidence and death rate from coronary artery disease.⁷ To effectively monitor this disease, and to evaluate the preventive and

TABLE III: AGE-STANDARDISED ACUTE MYOCARDIAL INFARCTION MORTALITY RATES PER 100,000 SINGAPOREANS AGED 20 TO 64 YEARS BY GENDER AND ETHNIC GROUP (1988 TO 1997)

Year	Chinese			Malay			Indian			Total		
	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female	All
1988	30.2	11.0	20.3	79.7	42.4	61.6	95.3	29.5	68.9	43.9	15.8	29.9
1989	41.0	11.1	25.6	67.9	19.6	43.6	89.7	40.5	67.2	49.9	14.0	32.0
1990	28.5	9.6	18.8	58.4	32.5	45.0	101.3	48.6	78.8	39.8	14.8	27.3
1991	33.2	11.4	22.1	68.0	24.2	45.5	82.7	40.2	64.1	42.2	14.6	28.4
1992	39.4	8.2	23.5	83.8	31.0	56.6	86.9	36.9	67.0	49.3	12.6	30.9
1993	30.2	10.5	20.2	71.9	25.7	47.9	56.5	23.3	42.5	37.7	12.9	25.3
1994	26.5	7.5	16.9	60.5	25.0	42.0	78.9	36.5	60.1	35.0	11.2	23.1
1995	22.5	5.4	13.9	42.6	17.9	29.7	55.6	12.8	35.8	27.2	7.4	17.2
1996	24.8	4.3	14.5	60.4	12.8	35.6	78.4	18.2	50.9	32.6	6.3	19.4
1997	22.6	7.2	14.9	42.7	16.5	29.3	52.9	21.3	37.9	27.2	9.2	18.2
Average rate per year	29.5	8.4	18.8	63.7	24.4	43.5	78.3	29.8	57.2	38.0	11.6	24.8
Average % change per year	-4.9	-8.3	-5.5	-5.0	-8.4	-6.2	-5.8	-9.2	-7.0	-5.9	-8.6	-6.5
95% confidence interval for % change	(-8.5, -1.1)	(-13.1, -3.1)	(-8.7, -2.1)	(-9.3, -0.6)	(-14.1, -2.4)	(-9.9, -2.4)	(-9.6, -1.8)	(-16.4, -1.4)	(-11.7, -2.0)	(-8.8, -2.9)	(-12.5, -4.5)	(-9.1, -3.9)

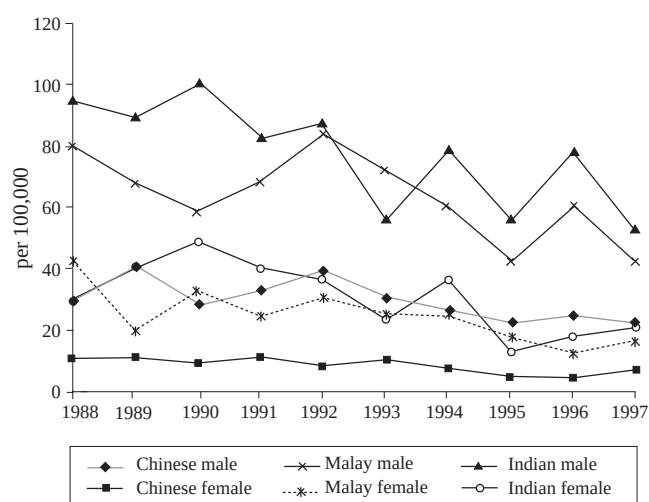


Fig. 4. Trends in age-standardised acute myocardial infarction mortality rates per 100,000 Singaporeans aged 20 to 64 years by gender and ethnic group (1988 to 1997).

therapeutic programmes implemented, there is a need for a national infarct registry with set standardised criteria ensuring data accuracy and enabling comparisons internationally with other countries. The criteria for MI in the Singapore Myocardial Infarction Registry, set up in 1986, have been standardised to the MONICA study¹⁴ to enable such comparative studies.

The uniqueness of SMIR is that it is a nationwide population-based registry, capturing the incidence and death rates from MI occurring in an entire country of over 3 million population.¹⁸ To our knowledge, SMIR is the largest nationwide acute myocardial infarct registry in the world, being, in addition, a registry in a country where data collection is relatively easy and accurate.

Being a multiethnic country, SMIR has also enabled us to compare the incidence and death rates in the different ethnic groups, and to evaluate the impact of different preventive and therapeutic programmes in the 3 ethnic groups during the study period.

The high incidence of coronary artery disease in Indians has been well documented in several studies covering migrant Indians.^{20,21} In our study, both Indian males and females recorded incidences which were 2.9 and 3.6 times higher than Chinese males and females, respectively. It is worth noting that among those aged 20 to 64 years, the incidence of myocardial infarct in Singaporean Indian females approximated that of Singaporean Chinese males. Singaporean Malay males and females had intermediate levels with incidences of 1.7 and 2.9 times that of Singaporean Chinese males and females, respectively.

The incidence of myocardial infarct in Singapore declined from 104.3/100,000 in 1988 to 82.6/100,000 in 1997, *equivalent decline of 16%*. During the study period, the

TABLE IV: AGE-SPECIFIC INCIDENCE RATES OF ACUTE MYOCARDIAL INFARCTION EVENTS FOR PATIENTS AGED 20 TO 64 YEARS (1988 TO 1997)

Age group (y)	Per 100,000 resident population									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
All										
20 - 29	3.0	1.5	1.7	0.8	2.6	0.2	0.6	1.2	1.6	0.8
30 - 39	17.9	11.2	13.0	14.7	16.1	14.8	17.7	10.8	15.3	12.1
40 - 49	82.5	78.1	84.2	72.2	82.2	82.6	70.6	79.9	78.1	66.6
50 - 59	256.0	254.7	236.1	245.6	243.8	233.0	226.8	213.9	212.7	208.4
60 - 64	492.7	454.7	411.8	494.7	493.7	463.2	399.3	317.8	387.0	386.1
20 - 64	76.0	72.6	71.6	75.9	79.1	75.5	70.9	66.1	71.5	68.3
Male										
20 - 29	5.5	3.0	2.3	1.5	3.9	0.4	1.2	2.4	2.5	1.6
30 - 39	32.5	20.9	23.4	26.5	30.0	26.8	32.8	20.0	29.6	22.5
40 - 49	139.3	139.1	149.8	123.8	146.4	139.7	125.6	143.6	141.3	119.7
50 - 59	411.1	418.7	378.6	394.7	389.1	367.7	359.3	346.1	347.8	340.7
60 - 64	720.1	661.3	578.9	681.7	711.9	678.9	602.2	493.5	608.1	539.6
20 - 64	120.7	117.1	113.2	117.6	125.8	119.0	115.0	109.8	119.9	110.7
Female										
20 - 29	0.4	0.0	1.2	0.0	1.2	0.0	0.0	0.0	0.8	0.0
30 - 39	2.8	1.2	2.2	2.5	1.8	2.4	2.4	1.3	0.7	1.6
40 - 49	25.1	16.1	17.1	19.2	16.3	23.8	13.8	14.1	12.8	11.6
50 - 59	98.7	89.7	93.1	97.0	99.2	98.6	94.4	81.6	77.9	76.5
60 - 64	263.9	250.2	248.4	312.5	281.8	252.8	202.6	150.8	175.9	238.7
20 - 64	30.2	27.0	28.9	33.2	31.5	31.4	26.3	21.9	22.6	25.8

Source: Singapore Myocardial Infarct Registry

average decline experienced was 2.4% per year. The average annual decline in the incidence of MI among females was more than $1\frac{1}{2}$ times that of males, i.e. 3.7% in females compared to 2.1% in males. Among the 3 ethnic groups, there were also differences in the number of declining incidences. Chinese males showed an average annual decline of 1.4% compared with an average annual decline of 0.8% in Malay males and 1.6% in Indian males. Among females, Malay and Chinese females registered higher declines in their average annual incidence equivalent to 3.2% and 4.8% declines, respectively, compared to the 4.0% decline in the Indian female.

In the mid-80s, a National Healthy Lifestyle Programme was implemented in Singapore as a 10-year national effort to promote healthy living among Singaporeans. The decline in incidence seen in Singapore could reflect the effects of these organised preventive programmes. There was a decline in the number of incidences in all the 3 ethnic races and in both genders. More specific focussed programmes are required to reduce the number of incidences in Malay males and Indian males and females. Further research also needs to be directed to ascertain the reasons for the disparity in the different races and genders in their response to the national preventive programmes.

SMIR has also shown that the age-standardised mortality from MI in Singapore fell dramatically by 39.1% in 1997 compared to the 1988 level. Females showed a larger decline in mortality compared with males. By 1998, mortality in females declined by 41.8% compared with the level in 1988, with males showing a 38.0% decline over this period. The average annual decline in mortality for females was $1\frac{1}{2}$ times that of males, at 8.6% per year compared with 5.9% per year for males.

In a Singapore cohort aged 20 to 64 years, the mortality from MI was different among the 3 ethnic groups and genders. Males had higher mortality than females, a more than 3-fold difference. Amongst males, the Indians have the highest mortality followed by the Malays and the Chinese. This is similar to the picture in females, although the mortality rate was lower among females than males. Indian females had the highest and Chinese females the lowest mortality. It is interesting to note that the 10-year average annual mortality seen in Singaporean Indian females was even slightly higher than that of Singaporean Chinese males.

Mortality figures for coronary artery disease have been used as indices of the severity of coronary artery disease in any country. Though mortality is a definite endpoint, national death registries do not have strict criteria for the diagnosis of MI and are dependent on subjective documentation by medical practitioners.⁸⁻¹¹ The fall in death rates from MI could be attributed to a reduction in the

incidence of MI or improved survival following MI in this country. Examining incidence and mortality data enables differentiation to be made between these two factors, and assessment of the relative impact of preventive and therapeutic programmes. We have shown that in Singapore, from 1988 to 1996, there has been a more significant fall in mortality compared to the fall in incidence. The 10-year average decline in mortality was 6.5% compared to a 2.4% fall in incidence, a near 3-fold difference. Most infarcts in Singapore are treated in hospitals. Figures have shown that all 3 ethnic groups have benefited from improved treatment programmes in Singapore contributing to improved survival.

Fall in mortality from coronary heart disease had in the past been attributed more to a fall in the incidence of MI rather than improved therapeutic programmes.¹³ However, incidence studies of MI in the past in Singapore were based on hospital-based surveys or gender community sampling. The United States also experienced difficulty with incidence studies of MI usually involving single communities rather than being countrywide.²²⁻²⁷ In a recent large multicommunity study in the US, it was noted that there is a disparity between the dramatic fall in mortality and a gradual or no fall in the incidence of MI over the years.²⁸ In Singapore, the disparity between the fall in mortality and the fall in incidence suggests that therapeutic programmes may result in a faster and more dramatic impact on mortality than preventive programmes.²⁹ Being a small nation, the different races have easy access to modern therapeutic programmes for MI. The effects of preventive programmes on the incidence of infarction have been more gradual and would require a longer time to illustrate their effects. Recent surveys of cardiovascular risk factors in Singapore have shown a disappointing impact of preventive programmes on the cardiovascular risk factors prevalence in the Singapore population.³⁰

The changes in the incidence and mortality picture of MI seen in the population represent the result of a complex interaction of the different lifestyles and the differing impact of primary and secondary preventive and therapeutic programmes upon the 3 ethnic groups in Singapore. These preventive and therapeutic programmes have contributed significantly towards the decline in incidence and deaths from MI in Singapore. Being a compact multiracial urban society, further research will enable us to evaluate the impact of future changes in lifestyle and improved therapy on cardiovascular morbidity and mortality in the 3 major ethnic groups in Singapore in the next millennium.

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