Changes in the levels of major cardiovascular risk factors in the multi-ethnic population in Singapore after 12 years of a national non-communicable disease intervention programme

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ABSTRACT

Introduction: The National Healthy Lifestyle Programme, a population-wide non-communicable disease intervention programme, was started in 1992. A National Health Survey is carried out every six years to evaluate the impact of this programme on the cardiovascular risk factor profile of the resident population of Singapore.

Methods: The 2004 National Health Survey (NHS 04) was a population-based survey carried out over a period of four months from September to December 2004. A combination of disproportionate stratified sampling and systematic sampling was used to select a representative sample (n=7,078) for the survey. The reference population comprised 2.4 million multi-racial Singaporeans aged 18-69 years. Anthropometric and blood pressure measurements were carried out on all subjects and blood samples were taken for biochemical analysis. The results were compared with those of a similar survey conducted in 1998.

Results: A total of 4,084 Singapore residents took part in the survey, giving a response rate of 57.7 percent. The age-standardised prevalence of hypertension (greater than or equal to 140/90 mmHg) in Singapore residents aged 30-69 years decreased from 28.0 percent in 1998 to 24.0 percent (p-value is less than 0.001) in 2004. The prevalence of high total cholesterol (greater than or equal to 6.2 mmol/L) among those aged 18-69 years fell from 26.0 percent in 1998 to 18.1 percent (p-value is less than 0.001) in 2004. The prevalence of diabetes mellitus in residents aged 18-69 years in 2004 was 7.8 percent, compared to the 1998 level of 9.5 percent (p-value is less than 0.01). The level of obesity (body mass index is greater than or equal to 30 kg/sqm) increased slightly from 6.2 percent in 1998 to 6.8 percent (p-value equals 0.1627). The prevalence of daily smoking decreased from 15.0 percent in 1998 to 12.5 percent in 2004 (p-value is less than 0.001), while that of regular exercise increased from 17.0 percent to 25.0 percent (p-value is less than 0.001). Ethnic differences in the prevalence of diabetes mellitus, hypertension, hypercholesterolaemia, and exercise were observed.

Conclusion: The NHS 04 results suggest that the National Healthy Lifestyle Programme significantly decreased daily smoking, high blood cholesterol and hypertension, and increased regular exercise over 1998 levels. The results also suggest that the programme stabilised the prevalence of obesity and diabetes mellitus.

Keywords: cardiovascular risk factors, diabetes mellitus, hypertension, lipids, National Health Survey

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INTRODUCTION

Singapore is a highly urbanised city-state with a per capita gross domestic product of 42,581. Singapore dollars and a literacy rate of 94.6% in 2004. The total population has grown more than 18 times within the last hundred years, from 0.23 million in 1901 to 4.24 million in 2004. Singapore's population density at 6,066 people per km^2 in 2004 is among the highest in the world. In 2004, life expectancy at birth was 81 years for females and 77 years for males, and the total fertility rate was at an all-time low of 1.24 per resident female. The median age of the resident population stood at 35.7 years in 2004, with the elderly aged 65 years and above comprising 8.0% of the population.

Like most countries that have undergone rapid economic and demographical transition, non-

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communicable diseases, especially cardiovascular diseases, are the major causes of mortality and morbidity in Singapore, accounting for over 29% of all deaths in 2004[1]. Rising trends have been observed in the incidence and hospitalisation rates related to these diseases since the late 1970s. Over the years, progress has been made in the treatment of non-communicable diseases and in the pharmacological control of many risk factors. However, the most cost-effective and sustainable way of controlling these diseases is still through altering the risk-factor distribution in the population. This can be done through lifestyle changes such as increasing regular physical activity, eating healthily and remaining tobacco-free.

Singapore has adopted a national disease control strategy with emphasis on health promotion to get Singaporeans to lead healthy lifestyles and thus mitigate the risk factors for chronic non-communicable diseases[2]. The National Healthy Lifestyle Programme is a population-wide health promotion programme aimed at providing information, skills training, and the social and physical environments necessary to encourage healthy living by Singaporeans. Started in 1992, this multiple-strategy programme comprises innovative media and communication activities, systematic involvement of government agencies, community organisations, workplaces and schools, and collaboration with the food industry to provide healthier food choices.

Every six years, the Ministry of Health conducts periodic population-based cross-sectional surveys to evaluate the effectiveness of the National Healthy Lifestyle Programme. The first National Health Survey held in 1992 provided baseline data for prevalence of the cardiovascular risk factors – diabetes mellitus, hypertension, obesity, smoking, physical inactivity and hypercholesterolaemia. We had previously reported on the second National Health Survey done in 1998[3]. This paper reports on the key findings of the third National Health Survey (NHS 04) conducted in 2004.

METHODS

The NHS 04 was a cross-sectional survey conducted between September and December 2004. The reference population of the survey was the 2004 resident Singapore population aged 18 to 74 years. Only Chinese, Malay and Indian residents were recruited for the study. The baseline prevalence of the predominant non-communicable diseases (diabetes mellitus and hypertension), and risk factors (obesity, smoking and physical inactivity) determined in the National Health Survey 1998 were used to estimate the sample size required to detect a change in prevalence levels between 1998 and 2004. It was calculated that a sample size of 5,000 respondents would be required to detect a 10% to 15% relative change from the baseline measurements in most of the diseases and risk factors with 80% power. To ensure that the survey had adequate number of respondents, it was estimated that at least 11,200 household units would be required to obtain the eventual sample size of 5,000, after taking into account the estimated non-response during the sampling stage and the health screening fieldwork. Six survey centres that were geographically well spread out across the island were selected as field sites for the survey.

The sample selection was divided into two phases. In Phase One, a sample of 12,700 household addresses was selected from the National Database on Dwellings in Singapore which is maintained by the Department of Statistics. The sample selection was based on a modified two-stage stratified design. For the first stage, sampling divisions within close proximity to the six selected survey centres were chosen, and dwelling units of each selected sampling division were stratified by house-type (a proxy for socioeconomic status) and systematically selected in the second stage. The eventual sample of 12,700 addresses selected was representative of the house-type distribution of the whole housing population in Singapore. All selected households were notified by post. This was followed up by house visits to enumerate all members of the households within the age group of 18 to 74 years.

In Phase Two, a random sample of 7,500 persons was selected from all individuals identified in Phase One to participate in the survey. The sampling design was based on a disproportionate stratified sampling design, where all individuals identified in Phase One were first stratified by age and ethnic group, and then systematically selected. The Malays and Indians were over-sampled to ensure sufficient sample size for reliable prevalence estimates for these minority groups. The ethnic composition of the sample was 59% Chinese, 26% Malays and 15% Indians. A total of 225 persons from the original 7,500 sample of adults aged 18 to 74 years selected had to be excluded due to pregnancy, deaths and being overseas during the survey period. The survey yielded a response rate of 57.3% (4,168/7,275). The response rate for the age group 18 to 69 years was 57.7% (4,084/7,078).

There were some differences between the socio-demographical characteristics of the respondents (unweighted) and the non-respondents (unweighted). Compared with the non-respondents, the respondent

sample had higher representations of females, Chinese and adults in the 40 to 69 age group. The respondent sample also had lower representation in the one- to three-room public flats sub-group (Table I).

To correct for the over-sampling of the minority ethnic groups in the survey and differential response levels, the survey sample was weighted to the age, ethnic group and gender distribution of the 2004 resident population estimates. The distribution of the survey sample after weighting yielded an age by ethnic group and gender distribution similar to the resident population estimates. Table II compares the demographical characteristics of the unweighted survey sample with that of the 2004 Singapore resident population.

A non-respondent follow-up survey was conducted between January and February 2005 to find out the reasons for non-participation in the NHS 04 and to assess the potential impact of non-response on the results of the main survey. A random sample of 782 persons aged 18 to 69 years was drawn out of 2,994 non-respondents of the NHS 04. The response rate was 77.1% (603/782). The survey was conducted via telephone interview by a trained interviewer using a structured questionnaire. Besides reasons for non-participation, the questionnaire also focused on the diabetes mellitus and hypertension (on medication) status of non-respondents.

The survey protocol closely followed that of the 1998 National Health Survey to ensure consistency. The National Health Survey protocol was based on the World Health Organisation (WHO)-recommended model protocol for diabetes mellitus and other non-communicable disease field surveys[4,5]. Before the start of the survey, an invitation letter was mailed to each of the selected participants. The letter included instructions on fasting overnight for at least ten hours before coming for the survey. Participants were reminded of their survey appointment and fasting instructions about three days before their survey date by phone calls from the survey team nurses. During the survey, a fasting blood sample was collected and

Table I: Socio-demographical profile (%) of survey respondents and non-respondents.

Characteristic	No. of respondents	No. of non-respondents
Total (no.)	4,084	2,994
Gender		
Male	46.5%	52.1%
Female	53.5%	47.9%
Age (years)		
18-29	20.7%	28.2%
30-39	23.1%	24.3%
40-49	30.2%	23.2%
50-59	17.3%	15.7%
60-69	8.7%	8.6%
Ethnic group		
Chinese	65.0%	50.3%
Malay	20.1%	33.6%
Indian	14.9%	16.1%
House type		
Public flat (1-3 rooms)	20.4%	26.1%
Public flat (4 rooms)	38.1%	36.9%
Public flat (5 rooms & larger)	29.4%	26.6%
Private houses and flats	12.1%	10.4%

Table II. Distribution of survey sample and the 2004 resident population by gender, age group and ethnic group.

Characteristic	Survey sample (unweighted)		Mid-2004 resident population	
	Percent	Number	Percent	Number ('000s)
Total	100.0	4,084	100.0	2,424.0
Gender				
Male	46.5	1,901	49.6	1,202.0
Female	53.5	2,183	50.4	1,222.0
Age (years)				
18-29	20.7	845	22.9	555.5
30-39	23.1	941	24.7	598.6
40-49	30.2	1,235	25.7	624.4
50-59	17.3	708	17.5	423.3
60-69	8.7	355	9.2	222.2
Ethnic group				
Chinese	65.0	2,653	79.3	1,921.3
Malay	20.1	823	12.6	305.2
Indian	14.9	608	8.1	197.5

all subjects, except patients with diabetes mellitus on medication, had a two-hour oral glucose tolerance test. Subjects also had their measurements of blood pressure, height, weight, and waist and hip circumferences taken and answered a structured questionnaire.

The WHO Diagnostic Classification criterion[6] was used for classifying glucose tolerance. Self-reported subjects with diabetes mellitus on medication were also taken to have diabetes mellitus. Blood pressure measurements followed the procedures prescribed in the WHO MONICA protocol[5]. To reduce the regression dilution bias and any intra-observer variation, two measurements were taken, at least ten minutes apart, in a quiet room after the subjects were rested. Hypertension was defined according to WHO criteria[7,8] i.e. mean systolic pressure of ≥140 mmHg or diastolic pressure of ≥90 mmHg, or both, or self-reported current use of anti-hypertensive medication.

Smoking status and physical activity participation were determined through the interviewer-administered questionnaire according to WHO guidelines[9] and the American College of Sports Medicine's classification[10]. Body mass index (BMI) was measured as weight (kg)/height^2 (m^2). The WHO's classification of weight status and abdominal fatness was used[11]. Two readings of height and weight as well as waist and hip circumferences were obtained and the means used for calculation of the body mass index and waist: hip ratio, respectively. Classification of cholesterol status followed that set by the United States National Institutes of Health guidelines[12].

As the questionnaire was lengthy and took about 15-30 minutes in administration, it was crucial to keep the interview structured and objective. To achieve this, all interviewers were trained intensively and a standard interviewer script was closely followed to reduce variability between and within interviewers and also to prevent the interview from getting too tedious for the participants. The interviewers were also trained in the standard protocols for physical measurements including blood pressure. Exit audits and random measurements were conducted by independent observers to identify any interviewer bias and for quality checks.

All data were transferred to the Epidemiology and Disease Control Division of the Ministry of Health, where validity checks and statistical analysis were done. Information recorded on the questionnaires was manually checked for missing values, data-entry errors and consistency. Data anomalies were confirmed and amended through direct verification with the participants through telephone, whenever necessary. The questionnaire data were then entered into a formatted database and were subjected to a series of range, logic and consistency checks. Information on physical exercise was missing in 0.3% of cases, complete blood pressure readings were not available for 0.3% of cases and serum cholesterol test was not done on 0.4% of cases due to lack of adequate blood sample. The NHS 04 was approved by the Health Promotion Board (HPB) Ethics Committee. All participants provided informed consent before taking part in the study.

Blood specimens for plasma glucose measurement were collected in fluoride/oxalate tubes and centrifuged on-site, and specimens for cholesterol measurement were collected in plain tubes. At the end of each survey day, all blood specimens were sent to the Biochemistry Laboratory of the Department of Pathology, Singapore General Hospital for analysis. Plasma glucose levels, total cholesterol and HDL-cholesterol were directly measured on the Roche Modular DP analyser (Hitachi High-Technologies Corp, Ibaraki, Japan) with the enzymatic colorimetric method. LDL cholesterol was measured with the homogenous turbidimetric method.

Statistical analysis was performed using the statistical software package, Statistical Analysis System (SAS) (Statistical Analysis Software Institute Inc, Cary, NC, USA). The survey sample data was weighted to the age, ethnic group and gender distribution of the 2004 Singapore resident population. Age-standardisation of prevalence was performed by the direct method using the 2000 Singapore resident population as the standard. Changes in age-standardised prevalence levels between 1998 and 2004 were tested for statistical significance using the Z-test[13] and 95% confidence limits for the difference in prevalence were calculated.

RESULTS

To ensure comparability with the results of the previous two surveys, the prevalence levels for all cardiovascular risk factors except for hypertension are reported for the population aged 18-69 years. Hypertension prevalence is reported for the population aged 30-69 years. The age-standardised prevalence of diabetes mellitus among Singapore residents aged 18-69 years fell significantly to 7.8% in 2004, compared to 9.5% in 1998 ($p<0.01$) (Tables IIIa-c). The prevalence of impaired glucose tolerance also fell significantly from 15.3% in 1998 to 11.5% in 2004 ($p<0.001$).

A higher proportion of males (8.4%) was found to have diabetes mellitus in the survey, compared

Table IIIa. Age-standardised prevalence of major cardiovascular risk factors in Singapore men in 2004 and difference in prevalence.

	% prevalence in men			
Risk factor	1992 (n=1,803)	1998 (n=2,181)	2004 (n=1,901)	2004-1998 Difference
Diabetes mellitus	10.2 (8.7, 11.7)	9.1 (7.9, 10.4)	8.4 (7.1, 9.7)	-0.7
Impaired glucose tolerance	15.3 (13.5, 17.2)	15.3 (13.7, 16.8)	10.6 (9.1, 12.0)	-4.7***
Hypertension (BP ≥140/90 mmHg)	27.9 (25.2, 30.6)	31.7 (29.3, 34.1)	28.7 (26.3, 31.1)	-3.0
Obesity (≥30 kg/m^2)	4.0 (3.1, 4.9)	5.4 (4.4, 6.3)	6.4 (5.3, 7.5)	1.0
High cholesterol (≥6.2 mmol/L)	21.9 (19.9, 24.0)	27.9 (26.0, 29.9)	19.5 (17.7, 21.4)	-8.4***
Cigarette smoking (at least one cigarette a day)	32.7 (30.4, 35.0)	27.1 (25.2, 29.0)	21.5 (19.6, 23.4)	-5.6***
Regular exercise (at least three times a week; 20 minutes or more per session)	18.5 (16.6, 20.4)	20.3 (18.5, 22.0)	29.3 (27.2, 31.4)	9.0***

Age-standardised to the 2000 Singapore resident population.

Prevalence of all risk factors except hypertension relate to persons aged 18-69 years. Prevalence for hypertension is for population aged 30-69 years.

** 0.001< p<0.01

*** p<0.001

Table IIIb. Age-standardised prevalence of major cardiovascular risk factors in Singapore women in 2004 and difference in prevalence.

	% prevalence in women			
Risk factor	1992 (n=1,765)	1998 (n=2,542)	2004 (n=2,183)	2004-1998 Difference
Diabetes mellitus	9.8 (8.5, 11.2)	9.9 (8.8, 11.1)	7.2 (6.1, 8.3)	-2.7***
Impaired glucose tolerance	15.3 (13.6, 17.0)	15.4 (13.9, 16.9)	12.4 (10.9, 13.8)	-3.0**
Hypertension (BP ≥140/90 mmHg)	20.1 (17.9, 22.4)	24.4 (22.5, 26.4)	19.3 (17.4, 21.3)	-5.1***
Obesity (≥30 kg/m^2)	6.6 (5.6, 7.7)	6.9 (6.0, 7.8)	7.3 (6.3, 8.3)	0.4
High cholesterol (≥6.2 mmol/L)	20.8 (18.9, 22.7)	24.1 (22.4, 25.8)	16.6 (15.0, 18.3)	-7.5***
Cigarette smoking (at least one cigarette a day)	3.1 (2.3, 4.0)	3.1 (2.4, 3.8)	3.5 (2.8, 4.3)	0.4
Regular exercise (at least three times a week; 20 minutes or more per session)	8.4 (7.1, 9.8)	13.8 (12.5, 15.2)	20.8 (19.0, 22.6)	7.0***

Age-standardised to the 2000 Singapore resident population.

Prevalence of all risk factors except hypertension relate to persons aged 18-69 years. Prevalence for hypertension is for population aged 30-69 years.

** 0.001< p<0.01

*** p<0.001

Table IIIc. Age-standardised prevalence of major cardiovascular risk factors in Singapore residents in 2004 and difference in prevalence.

	% prevalence in both genders			
Risk factor	1992 (n=3,568)	1998 (n=4,723)	2004 (n=4,084)	2004-1998 Difference
Diabetes mellitus	10.0 (9.0, 11.0)	9.5 (8.7, 10.4)	7.8 (7.0, 8.6)	-1.7**
Impaired glucose tolerance	15.3 (14.1, 16.6)	15.3 (14.3, 16.4)	11.5 (10.5, 12.5)	-3.8***
Hypertension (BP ≥140/90 mmHg)	24.0 (22.3, 25.8)	28.0 (26.5, 29.6)	24.0 (22.5, 25.6)	-4.0***
Obesity (≥30 kg/m^2)	5.3 (4.6, 6.0)	6.2 (5.5, 6.8)	6.8 (6.1, 7.6)	0.6
High cholesterol (≥6.2 mmol/L)	21.4 (20.0, 22.8)	26.0 (24.8, 27.3)	18.1 (16.8, 19.3)	-7.9***
Cigarette smoking (at least one cigarette a day)	17.8 (16.5, 19.1)	15.0 (14.0, 16.1)	12.5 (11.4, 13.5)	-2.5***
Regular exercise (at least three times a week; 20 minutes or more per session)	13.5 (12.3, 14.6)	17.0 (15.9, 18.1)	25.0 (23.6, 26.4)	8.0***

Age-standardised to the 2000 Singapore resident population.

Prevalence of all risk factors except hypertension relate to persons aged 18-69 years. Prevalence for hypertension is for population aged 30-69 years.

** 0.001< p<0.01

*** p<0.001

to females (7.2%). Diabetes mellitus prevalence increased sharply with age; from 0.5% among those aged 18-29 years to 7.9% of adults in the 40-49 year age group, and 28.7% in those aged 60-69 years. 49.4% of people who had diabetes mellitus were diagnosed for the first time during the survey. In 1998, the proportion of previously-undiagnosed subjects with diabetes mellitus was 62.1%. 27.6% of patients with known diabetes mellitus had unacceptable blood sugar control (HbA1C >8%) in 2004, which was much lower than the proportion of 53.2% in 1998.

The survey showed a significant decline in the prevalence of hypertension in the population aged 30-69 years from 28.0% in 1998 to 24.0% in 2004 (p<0.001). Hypertension was more common among males (28.7%) than females (19.3%). As expected, the age-specific prevalence for hypertension increased markedly from age 40 onwards. Among those found to have hypertension at the survey, 38.5% had not been previously diagnosed. This is an improvement from the 53.0% of subjects previously undiagnosed to have hypertension in 1998. 49.5% of all subjects with known hypertension had good blood pressure control compared to only 29.9% in 1998.

The prevalence of obesity (BMI ≥30 kg/m^2) increased slightly from 6.2% in 1998 to 6.8% in 2004. The difference was not statistically significant at 5% level of significance. A higher proportion of females was obese (7.3%) compared to males (6.4%). The highest prevalence of obesity was noted in the 60-69 year age group. Using the new BMI cut-offs for cardiovascular risk in the Asian population[14], it was found that 38.1% of Singapore residents aged 18 to 69 years had acceptable cardiovascular risk (BMI 18.5-22.9 kg/m^2), 36.7% had moderate risk (BMI 23.0-27.4 kg/m^2) and 16.0% were at high risk (BMI 27.5 kg/m^2 or more).

The prevalence of high total cholesterol (≥6.2 mmol/L)[15] among those aged 18-69 years fell from 26.0% in 1998 to 18.1% in 2004 (p<0.001). While significant decreases were detected in both genders, the hypercholesterolaemia was more prevalent in males (19.5%) compared to females (16.6%). The mean total cholesterol was found to be 5.3 mmol/L. This was about the same as 5.5 mmol/L in 1998 and 5.3 mmol/L in 1992.

The prevalence of regular cigarette smoking (at least one cigarette a day) declined significantly from 15.0% in 1998 to 12.5% in 2004 (p<0.001). The decline was largely due to a significant decrease in prevalence of regular smoking in males from 27.1% in 1998 to 21.5% in 2004. The analysis of data by age groups showed an increasing trend of

Table IV. Age-standardised prevalence of major cardiovascular risk factors in Singapore residents in 2004 by ethnic group.

Risk factor	% prevalence								
	Chinese			Malay			Indian		
	Men (n=1,241)	Women (n=1,412)	Total (n=2,653)	Men (n=360)	Women (n=463)	Total (n=823)	Men (n=300)	Women (n=308)	Total (n=608)
Diabetes mellitus	7.0 (5.7-8.3)	5.9 (4.7-7.0)	6.4 (5.5-7.4)	12.0 (8.9-15.1)	10.8 (8.0-13.6)	11.4 (9.2-13.6)	16.9 (13.1-20.6)	15.0 (11.3-18.8)	15.9 (13.0-18.9)
Impaired glucose tolerance	10.3 (8.7-12.0)	11.8 (10.2-13.4)	11.1 (9.9-12.3)	11.4 (8.0-14.7)	16.0 (12.6-19.3)	13.7 (11.3-16.0)	12.1 (8.4-15.8)	12.3 (8.6-15.9)	12.2 (9.6-14.8)
Hypertension (BP ≥140/90 mmHg)	29.8 (27.1-32.5)	18.8 (16.8-20.8)	24.3 (22.5-26.2)	22.6 (17.7-27.5)	23.4 (19.2-27.5)	23.0 (19.7-26.2)	26.9 (21.4-32.3)	18.1 (13.5-22.8)	22.5 (18.8-26.2)
Obesity (≥30 kg/m^2)	4.7 (3.5-5.8)	3.9 (2.9-4.9)	4.3 (3.5-5.1)	16.7 (12.5-20.9)	21.7 (17.9-25.5)	19.2 (16.5-21.9)	7.8 (4.7-10.9)	19.2 (14.8-23.6)	13.5 (10.8-16.2)
High cholesterol (≥6.2 mmol/L)	18.2 (16.1-20.2)	16.5 (14.7-18.3)	17.3 (15.9-18.8)	28.6 (23.7-33.5)	18.3 (14.9-21.7)	23.5 (20.5-26.4)	18.6 (14.4-22.9)	15.3 (11.3-19.2)	17.0 (14.0-19.9)
Cigarette smoking (at least one cigarette a day)	20.3 (18.0-22.5)	3.2 (2.2-4.1)	11.7 (10.5-12.9)	29.1 (24.1-34.0)	7.2 (4.7-9.7)	18.1 (15.5-20.7)	22.1 (17.3-26.9)	1.5 (0.2-2.8)	11.8 (9.3-14.2)
Regular exercise (at least three times a week; 20 minutes or more per session)	28.3 (25.8-30.8)	20.1 (18.0-22.2)	24.2 (22.6-25.8)	31.4 (26.4-36.4)	24.7 (20.6-28.8)	28.0 (24.9-31.1)	35.7 (30.2-41.2)	21.3 (16.8-25.9)	28.5 (24.9-32.0)

Figures within parentheses represent the 95% confidence intervals.

smoking among females. The smoking prevalence of females aged 18 to 24 years in 2004 was 5.8%, about the same as the 1998 level of 5.9%. However, the smoking prevalence of females in the 25-44 age group increased significantly from 2.6% in 1998 to 4.2% in 2005 ($p<0.05$). In contrast, the smoking rate of males for both the age groups declined between the two years; from 25.5% to 13.4% for the 18-24 age group and from 27.2% to 24.3% for the 25-44 age group.

The prevalence of regular exercise (at least three times a week for at least 20 minutes per session) among Singapore residents aged 18 to 69 years increased significantly from 17.0% in 1998 to 25.0% in 2004 ($p<0.001$). The survey found that 48.1% of adult Singaporeans did not participate in any leisure physical activity. While there was a significant increase in prevalence in both males and females, a higher proportion of females (54.8%) than males (41.4%) were physically inactive. Physical inactivity increased with age, with the prevalence rising from 29.7% among adults aged between 18 and 29 years to 64.2% among adults aged between 60 and 69 years.

Differences in the prevalence of all cardiovascular risk factors studied were observed in the three major ethnic groups – Chinese, Malays and Indians (Table IV). The Malays had the highest prevalence of obesity (19.2%) and high cholesterol (23.5%). While the prevalence of hypertension was quite high in the three ethnic groups, the Chinese had the highest prevalence at 24.3%, especially among Chinese males (29.8%). Indians (15.9%) had the highest prevalence of diabetes mellitus, compared to Chinese (6.4%) and Malays (11.4%). However, Malays, especially females, had the highest prevalence of impaired glucose tolerance (13.7% and 16.0%, respectively). A higher proportion of Indians (28.5%) and Malays (28.0%) exercised regularly compared to Chinese (24.2%). Smoking prevalence was highest among the Malays (18.1%), compared to Chinese (11.7%) and Indians (11.8%). The highest ethnic-gender smoking prevalence was also found among Malay males (29.1%) and females (7.2%).

DISCUSSION

The number of subjects was close to the required sample size needed to detect a 10% to 15% relative change from the 1998 baseline although the response rate was about 58%. This was achieved by factoring in the likely response rate based on the experience from the previous survey in 1998 when selecting subjects for the survey. After weighting of the survey sample according to the population age, gender and ethnic group distribution, the survey respondents had slightly lower proportions of persons living in smaller public flats i.e. one to three room

HDB flats (20.0% in the sample versus 29.3% in the resident population) and of persons with primary or no formal education (14.1% versus 16.1% in the resident population). This distribution was similar to that seen in the 1998 study. There may also have been under-reporting of cigarette smoking and over-reporting of physical exercise as these measures were self-reported. To minimise the effects of this bias, the same basic structured questionnaire relating to these measures was used in the 1992, 1998 and 2004 surveys. Interviewers were carefully trained and potential bias due to misclassification of blood pressure status was minimised by using a standard protocol and repeat measurements.

The Indians and Malays are minority ethnic groups, comprising 8% and 12.6% of the Singapore population, respectively. If the Malays and Indians were sampled according to their population proportions, there would be insufficient numbers in the survey for reliable ethnic specific prevalence estimates broken down by age-group and gender; and inter-ethnic group comparisons. Over-sampling was done to ensure that there would be sufficient sample sizes for reliable prevalence estimates for the Indians and Malays. The resulting over-representation in the raw sample data was corrected by weighting back to the ethnic group, age and gender distribution of the reference population during analysis.

A non-respondent telephone-based follow-up survey conducted to assess the potential impact of non-response on the results of the main survey showed that incorporating data from the non-respondents could have increased the estimated prevalence of reported diabetes in the main survey by up to 0.3% and decreased the estimated prevalence of reported hypertension in the main survey by up to 0.4%. These results show that the non-response would not have caused a substantial bias in the NHS 04 results.

Based on comparison of key parameters with the general population and the findings of the non-respondent survey, the NHS 04 was a valid and fair assessment of the prevalence of cardiovascular risk factors in the Singapore resident population. The survey shows a significant improvement in the risk factor profile of adult population in Singapore over the past six years. On comparing age-specific rates in ten-year age groups between the 1998 and 2004 surveys, a largely consistent improvement in risk factors can be seen across all age groups. This shows that the successive cohorts are getting healthier, bearing in mind that a sampling variation is expected as the 2004 participants were not the same group as the 1998 participants.

The significant improvement in the health status of Singaporeans as reflected in the results of the NHS 04 could be largely attributed to the success of the National Healthy Lifestyle Programme (NHLP), which was started in 1992. The NHLP is a multi-pronged programme involving creative media campaigns and outreach activities; active engagement of government agencies, community organisations, workplaces, schools; and extensive collaboration with the food industry to provide healthier food choices and nutrition information. While the NHLP has taken advantage of international experiences and programmes, the interventions have been adapted to our local setting. Coordination of the programme within the broad framework of the National Disease Control Plans has ensured long-term sustainability and alignment of the programme with the national health priorities.

From its very conception, the NHLP was planned to be a multisectoral and multi-pronged programme. This was in recognition of the fact that the health of the individuals and population is fashioned by a wide range of factors besides availability and access to good quality yet affordable preventive and curative healthcare. These factors include education, socio-economic status, cultural influences, and environmental influences in homes, schools, community and workplaces. However, the initial emphasis of the NHLP was broad-based and focused mainly on raising awareness of the need to lead a healthy lifestyle among our population. The community had largely been a passive recipient, with most of the active work in health promotion carried out by the HPB and other related government agencies.

After somewhat mixed findings of the survey in 1998, especially in relation to the effect on hypertension and cholesterol level[3], it was felt that getting individuals to be actively involved in taking charge of their health is crucial. One way to achieve this was through engaging the representative community groups to spearhead health interventions and to get their respective community members to put their knowledge into practice and lead healthy lifestyles. Dialogue and collaboration between the HPB and the communities has since become a common practice. HPB collaborates with the various community development councils to promote physical activity and healthy eating on a regular basis among their residents. Many community clubs now have regular healthy cooking demonstrations, fitness competitions and exercise groups aimed at providing individual members not only knowledge but also tools to improve their lifestyle. To address the issue of high prevalence of smoking among the Malay men, HPB has found

its biggest champions among the religious leaders. They have incorporated anti-smoking messages into their Friday sermons and regularly encourage their congregation to give up smoking.

The National Health Survey in 1998 also helped highlight certain specific sub-groups that could benefit from more customised interventions. Heeding this, the NHLP was supplemented by a focused approach targeted at specific sub-populations. For example, to address smoking in young women, the Fresh Air for Women Programme was launched to curb the increasing smoking prevalence among this group and the Workplace Health Promotion Grant scheme was put in place to assist implementation of screening and healthy lifestyle programmes in workplaces as an enabling factor for positive lifestyle changes among working adults.

Current scientific evidence can provide an estimate of the expected impact of the improvement in the population cardiovascular risk factor profile in Singapore. Findings from the recent INTERHEART study[16], a large 52-country case control study, clearly show that eating fruit and vegetables, regular exercise, and avoiding smoking could lead to about 80% lower relative risk for myocardial infarction. These results are similar to the findings of the Nurses Health Study[17] and the Lyon Heart Study[18], which suggest that simple lifestyle modifications could potentially cut the risks of coronary heart disease and strokes by half to three-quarters. In Singapore, the mortality due to stroke and coronary heart diseases has begun declining in the last decade[19]. While it might be too early to attribute this largely to the impact of a community-based programme such as NHLP, similar programmes in Finland[20,21], Poland[22], Mauritius[23] and USA[24] have been successful in resulting a significant decline in mortality due to coronary heart disease and stroke at population level.

Given the complexity involved in evaluating the effectiveness of the community level projects, it has been generally difficult to delineate the decline in mortality from chronic diseases directly due to primary prevention at general population level from the improvement in pharmacological interventions to reduce cholesterol levels[25], control hypertension[26] or improvements in overall clinical management leading to reduced case fatality[27]. Some of these questions have been addressed by a recent study in Finland[28] using mathematical modelling (IMPACT) to assess how much of the decline in the coronary heart disease mortality could be attributed to improved treatments and risk factor reductions. For the 63% decline in coronary heart disease mortality in Finland from 1982 to 1997, improved treatments explained approximately 23% of the mortality reduction, and risk factor reduction explained another 53-72% of the reduction. Another recent publication on the modelling of declining in deaths due to coronary heart diseases in England and Wales from 1981 to 2000[29] showed that a decrease in smoking prevalence by 35%, population total cholesterol by 4.2% and mean population blood pressure by 7.7% accounted for at least half of the total 54% reduction in coronary heart disease mortality from 1981 to 2000.

While it could be argued that the assumptions used in modelling techniques such as IMPACT are very country-specific in terms of utilisation of health resources, categorisation of primary and secondary prevention and that the declines in cardiovascular diseases as seen in many of the western countries may have been impacted by the change in human behaviours due to socio-economic factors[30]. Nevertheless, the findings are enough to make a strong case for primary prevention to be a key priority in a country like Singapore with high prevalence of cardiovascular diseases. This should be done in addition, and not replacement, to actively improving secondary prevention and access to effective treatments.

In conclusion, the results of the NHS 04 suggest that Singapore is on the right track with our NHLP launched in 1992. The critical factors behind the success of NHLP have been strong political support, multisectoral approach, continuous community involvement and emphasis on individual responsibility and empowerment. The health status of Singaporeans has improved considerably since the last National Health Survey in 1998. The prevalence of hypertension, diabetes mellitus and high blood cholesterol has fallen significantly. The proportion of Singaporeans who exercise regularly has continued to rise, while the proportion of smokers has continued to shrink. Among Singaporeans found to have hypertension or diabetes mellitus, a higher proportion are aware of their condition and have good blood pressure control and good blood sugar control, respectively, indicating improved diagnosis and management of these conditions. With the successive cohorts in Singapore getting healthier, the country can expect to gradually improve its cardiovascular disease profile within the next one or two decades, resulting in a significant decline in premature mortality from these diseases, shift in the age of onset towards older age groups, and even a decline in age-specific incidence across all ages.

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