Changes in cardiovascular disease risk predicted by the Framingham risk model in the Hong Kong population between 2003-2005 and 2014-2015: data from Population Health Surveys

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ABSTRACT

Introduction: The Framingham risk model estimates a person's 10-year cardiovascular disease (CVD) risk. This study used this model to calculate the changes in sex- and age-specific CVD risks in the Hong Kong Population Health Survey (PHS) 2014/15 compared with two previous surveys conducted during 2003 and 2005, namely, PHS 2003/2004 and Heart Health Survey (HHS) 2004/2005.

Methods: This study included individuals aged 30 to 74 years from PHS 2014/15 (n=1662; n=4 445 868 after population weighting) and PHS 2003/2004 and HHS 2004/2005 (n=818; n=3 495 074 after population weighting) with complete data for calculating the risk of CVD predicted by the Framingham model. Sex-specific CVD risks were calculated based on age, total cholesterol and high-density lipoprotein cholesterol levels, mean systolic blood pressure, smoking habit, diabetic status, and hypertension treatment. Mean sex- and age-specific CVD risks were calculated; differences in CVD risk between the two surveys were compared by independent *t* tests.

Results: The difference in 10-year CVD risk from 2003-2005 to 2014-2015 was not statistically significant (10.2% vs 10.6%; P=0.29). After age standardisation according to World Health Organization world standard population data, a small decrease in CVD risk was observed, from 9.4% in 2003-2005 to 8.8% in 2014-2015. Analysis according to age-group showed that more participants aged 65 to 74 years were considered high risk in 2003 to 2005 (2003-2005: 66.8% vs 2014-2015: 53.1%; P=0.028). This difference may be due to the decrease in smokers among men (2003-2005: 30.5% vs 2014-2015: 24.0%; P<0.001).

Conclusion: From 2003-2005 to 2014-2015, there was a small decrease in age-standardised 10-year CVD risk. A holistic public health approach simultaneously targeting multiple risk factors is needed to achieve greater decreases in CVD risk.

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New knowledge added by this study

- The stagnation in 10-year cardiovascular disease (CVD) risk between 2003 and 2015 suggests that despite improvements in treatment, more effective prevention strategies (eg, improvements in diet and physical activity levels) are needed.
- The effect of the decreasing number of current smokers was not strongly reflected in the change in 10-year CVD risk. This may be due to an increased prevalence of diabetes and an increased proportion of participants receiving antihypertensive medications.

Implications for clinical practice or policy

- The findings suggest that the use of lipid-lowering drugs and antihypertensive medications does not effectively translate into overall cardiovascular risk reduction in the Hong Kong population, unless these treatments are simultaneously paired with prevention strategies targeting CVD risk factors.

Introduction

Cardiovascular disease (CVD) constitutes a spectrum of diseases that affect the heart and blood vessels. Worldwide, CVD is the leading cause of death as well as a major cause of premature death and chronic disability in numerous regions.[1] In 2017, CVD was responsible for an estimated 17.8 million deaths, representing 31% of all global deaths.[2] Hypertension, smoking status, hyperlipidaemia, and diabetes mellitus are prominent risk factors for CVD.[3] The global prevalence of CVD risk factors is increasing. Currently, an estimated 15% of the world's population (1.13 billion people) has hypertension, and the prevalence is expected to increase to 29% by 2025.[4,5] Additionally, the global prevalence of diabetes increased from 211 million in 1990 to 476 million in 2017, representing a 129.7% increase in nearly three decades.[6] The prevalences of CVD and its risk factors are expected to continue to increase in the near future due to industrialisation and population ageing. Fortunately, the World Health Organization (WHO) has estimated that premature CVD is preventable in >75% of cases, and risk factor amelioration can help reduce the burden caused by CVD.[7]

The risk of CVD over the next 10 years for an individual can be estimated using prediction models. Cardiovascular disease risk prediction is important at the individual and population levels. At the individual level, CVD risk prediction allows primary care medical professionals to identify high-risk patients. Risk factors for CVD, such as hypertension, can be treated accordingly to reduce the patient's future risk of CVD. At the population level, CVD risk trends allow health policy planners to make evidence-based decisions and review current public health strategies used in CVD prevention.[8]

Changes in CVD risk can serve as a reference to indicate changes in public health status within a population. Two studies have evaluated changes in the 10-year CVD risk in the United States (US) population. In a study by Ajani and Ford,[9] risk models adopted by the National Cholesterol Education Program Adult Treatment Panel III were utilised to estimate coronary heart disease risk, rather than the more precise Framingham formulae for estimation of overall CVD risk. Notably, their analysis lacked age stratification. On the other hand, Lopez-Jimenez et al[10] evaluated the changes in CVD risk between 1976 and 2004. To our knowledge, no previous study has evaluated the change in 10-year CVD risk in an Asian population, and insights are needed regarding the cardiovascular health status of the population in a more recent time period.

In this study, we aimed to calculate and compare the changes in sex- and age-specific CVD risks predicted by the Framingham model in a Hong Kong general population by using the Hong

弗雷明翰風險模型評估的2003至2005年及2014至2015年間香港人口心血管疾病風險變化：人口健康調查數據

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引言：弗雷明翰風險模型（Framingham risk model）適用於計算十年內患上心血管疾病的風險。本研究比較香港2003/2004年度人口住戶健康調查和2004至2005年心臟健康調查與2014/15年度人口健康調查，並利用這模型計算該些調查中性別和年齡特定的心血管疾病風險變化。

方法：本研究包括香港2014/15年度人口健康調查的30至74歲人士（n=1662；在人口加權後為n=4445868）以及2003/2004年度人口住戶健康調查和2004至2005年心臟健康調查的人士（n=818；在人口加權後為n=3495074），這些人士具有用於計算弗雷明翰風險模型的完整數據。我們基於年齡、總膽固醇和高密度脂蛋白膽固醇水平、平均血壓、吸煙習慣、糖尿病狀態和高血壓治療計算性別特定的心血管疾病風險，並通過獨立樣本t檢定比較兩次人口健康調查的心血管疾病風險差異。

結果：2003至2015年間的十年心血管疾病風險差異在統計上並不顯著（10.2%與10.6%；P=0.29）。根據美國人口普查資料進行調整後，2014至2015年的年齡標準化心血管疾病風險低於2003至2005年（10.0%與10.7%）。依年齡組別分析顯示，2003至2005年年齡介乎65至74歲之間的參與者中的高風險者較多（2003-2005：66.8%與2014-2015：53.1%；P=0.028）。這差異可能是由於男性吸煙者減少所致（2003-2005：30.5%與2014-2015：24.0%；P<0.001）。

結論：從2003至2005年到2014至2015年間，年齡標準化的十年心血管疾病風險略有下降。政府需採取全面的公共衛生措施針對多個風險因素，以進一步降低市民患上心血管疾病的風險。

Kong Population Health Survey (PHS) 2014/15 in combination with two previous surveys conducted in 2003 to 2005, namely, PHS 2003/2004 and Heart Health Survey (HHS) 2004/2005.

Methods

Study design and sampling

The data in this study were sourced from PHS 2003/2004[11] and PHS 2014/15.[12] Population Health Surveys are territory-wide cross-sectional surveys conducted by the Department of Health of the Hong Kong SAR Government. These surveys target the land-based non-institutional population of individuals aged ≥15 years in Hong Kong, excluding foreign domestic helpers and visitors. Systematic replicate sampling was adopted to select living quarters that were representative of the Hong Kong general population. All domestic households in the selected living quarters and household members in the target population were individually surveyed. Written consent was obtained from individuals

who agreed to participate in a PHS. Participants were invited to complete a face-to-face interview, where they provided information about their socio-demographic characteristics, disease status, and daily lifestyle habits. After the interview, consenting participants aged 15 to 84 years were randomly selected to undergo a health examination that included physical measurements and biochemical testing.[12] Health examinations for participants of PHS 2003/2004 were conducted as part of the HHS 2004/2005.

The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist was followed for preparing this manuscript.

Predicted risk of cardiovascular disease over the next 10 years

The main outcome of this study was the predicted risk of CVD over the next 10 years among people aged 30 to 74 years. Thus far, no specific prediction models have been developed for the Hong Kong population. In this study, we adopted the prediction model for primary care developed by the Framingham Heart Study Cohort in the general adult population aged 30 to 74 years.[13] The Framingham CVD risk model was validated and can be applied to the Chinese population, but requires recalibration in men.[14] A CVD event was defined as a composite of coronary heart disease, cerebrovascular events, peripheral artery disease, and heart failure in the Framingham model. The predicted CVD risk over the next 10 years was calculated for each participant using the following information: age, total cholesterol level, high-density lipoprotein cholesterol level, systolic blood pressure, use of antihypertensive medication, current smoking status, and diabetes status.

Statistical analysis

A complete-case analysis approach was utilised in this study. Descriptive statistics were used to present the characteristics of included individuals. Sex- and age-specific predicted CVD risks in 2003-2005 and 2014-2015 were calculated to summarise the change in risk according to sex and age-group. Significant differences in the above factors between the two PHSs were tested by independent t test or Chi squared test, as appropriate.

To summarise results at the population level, population weighting established by the Department of Health was applied according to age-group and sex for participants in each PHS. To compare results at the population level, age-standardised predicted CVD risk was calculated using WHO 2000-2025 world standard population data[15] and the US population census data in 2000.[16]

All statistical analyses were performed with SPSS software (Windows version 26.0; IBM Corp, Armonk [NY], US). All significance tests were two-tailed, and P values <0.05 were considered statistically significant.

Results

In total, 1662 and 818 participants were included in the PHS 2014/15 cohort and the PHS 2003/2004 and HHS 2004/2005 cohort, respectively. These individuals represented populations of 4 445 868 and 3 495 074, respectively. Table 1 shows the baseline characteristics of the PHS and HHS cohorts according to Framingham predictors. The mean age

TABLE 1. Summary statistics for risk factors among the participants in the health surveys[*]

	Sample level				Population level			
	PHS 2014/15 (n=1662)		PHS 2003/2004 and HHS 2004/2005 (n=818)		PHS 2014/15 (n=4 445 868)		PHS 2003/2004 and HHS 2004/2005 (n=3 495 074)	
	Female (n=864)	Male (n=798)	Female (n=385)	Male (n=433)	Female (n=2 356 978)	Male (n=2 088 890)	Female (n=1 891 688)	Male (n=1 603 386)
Age, y	50.3 ± 12.1	49.9 ± 12.5	49.2 ± 11.0	50.9 ± 11.9	50.5 ± 11.7	51.1 ± 12.1	47.9 ± 11.1	49.3 ± 11.5
Total-C, mg/dL	201.7 ± 36.5	201.0 ± 38.6	191.8 ± 36.1	193.7 ± 33.7	201.9 ± 36.4	202.4 ± 40.6	190.0 ± 35.9	193.8 ± 33.5
HDL-C, mg/dL	57.1 ± 12.5	48.0 ± 10.9	61.2 ± 14.0	50.1 ± 12.7	57.0 ± 12.5	48.1 ± 11.1	61.3 ± 14.0	50.1 ± 12.6
Systolic BP, mm Hg	119.6 ± 20.6	124.1 ± 17.6	126.9 ± 22.0	133.8 ± 19.1	119.8 ± 20.5	124.9 ± 17.8	125.4 ± 21.4	132.7 ± 18.6
BP treatment	110 (12.7%)	108 (13.5%)	33 (8.6%)	55 (12.7%)	300 514 (12.7%)	304 448 (14.6%)	142 296 (7.5%)	179 902 (11.2%)
Smoking	28 (3.2%)	187 (23.4%)	10 (2.6%)	130 (30.0%)	79 347 (3.4%)	501 381 (24.0%)	53 059 (2.8%)	489 052 (30.5%)
Diabetes	59 (6.8%)	97 (12.2%)	17 (4.4%)	39 (9.0%)	163 065 (6.9%)	266 340 (12.8%)	76 729 (4.1%)	128 056 (8.0%)

Abbreviations: BP = blood pressure; HDL-C = high-density lipoprotein cholesterol; HHS = Heart Health Survey; PHS = Population Health Survey; total-C = total cholesterol
* Data are shown as No. (%) or mean ± standard deviation

was similar in both cohorts (2003-2005: 48.6 years vs 2014-2015: 50.8 years) and the proportions of male and female participants were similar (female participants in 2003-2005: 54.1% vs 2014-2015: 53.0%).

Predicted CVD risk increases with age and is higher in men (Table 2). In PHS 2003/2004 and HHS 2004/2005, the mean CVD risk increased with age in both sexes, from 1.6% among women aged 30-44 years to 17.8% among women aged 65-74 years, and from 5.1% among men aged 30-44 years to 33.4% among men aged 65-74 years. Between the two surveys, there was no significant difference in overall 10-year CVD risk (2003-2005: 10.2% vs 2014-2015: 10.6%; P=0.29). After age standardisation according to WHO world standard population data, the age-standardised predicted CVD risks in the 2003-2005 cohort and the 2014-2015 cohort were 9.4% and 8.8%, respectively (Table 3). The small decrease in predicted CVD risk may be due to the decrease in smokers among men (30.5% vs 24.0%; P<0.001) [Table 1].

The risk of cardiovascular events over the next 10 years was classified as low (CVD risk <10%), medium (CVD risk ≥10% and <20%), and high (CVD risk ≥20%); the distributions of risk groups are presented in Table 4. Among participants aged 30 to 74 years, the risk group distributions were similar in both cohorts. When analysed according to sex, 29.1% of men and 5.1% of women were classified as high-risk in PHS 2014/15, whereas 28.2% of men and 6.4% of women were classified as high-risk in PHS 2003/2004 and HHS 2004/2005. When analysed according to age-group, more participants aged 65 to 74 years were classified as high-risk in PHS 2003/2004 and HHS 2004/2005 (66.8% vs 2014-2015: 53.1%; P=0.028).

Discussion

Using representative samples from the Hong Kong PHS and HHS, we found that the 10-year CVD risk increases with age and is consistently higher in men (men: 15.5% vs women: 6.2%; P<0.001, in PHS 2014/15) [Table 2]. This trend is consistent with previous reports; for example, an analysis of NHANES (National Health and Nutrition Examination Survey) III data showed that men have a significantly higher CVD risk (11.8% in men vs 5.1% in women) and that CVD risk is higher in older age-groups (16.2% for participants aged 60-74 years vs 11.2% for participants aged 50-59 years).[10] Thus, risk management for older adults may represent a challenge to the current health infrastructure. The burden of CVD is directly associated with increased morbidity and mortality in patients, and it translates to substantial healthcare costs. In Hong Kong, the number of people aged ≥65 years is predicted to reach 2.58 million (35.9% of the population) by 2064.[17] Thus, there is a critical need to achieve a more comprehensive understanding of the aetiologies associated with CVD in older adults.

The results have extensive public health implications. Although age-standardised rates of death from CVD in Hong Kong greatly decreased from 93.4 per 100 000 standard population in 2001 to 56.0 per 100 000 standard population in 2017,[18] there was no significant difference in overall 10-year CVD risk between 2003-2005 and 2014-2015 (10.2% vs 10.6%; P=0.29) [Table 2]. After age standardisation according to WHO world standard population data, a small decrease in CVD risk was observed, from

TABLE 2. Mean weighted 10-year cardiovascular disease risk predicted by the Framingham model among participants aged 30 to 74 years in the health surveys according to age-group and sex

Age-group, y	PHS 2014/15 (n=4 445 868)			PHS 2003/2004 and HHS 2004/2005 (n=3 495 074)		
	Female	Male	Total	Female	Male	Total
30-44	1.5%	4.1%	2.7%	1.6%	5.1%	3.1%
45-54	4.7%	11.7%	8.0%	5.1%	11.7%	8.0%
55-64	8.9%	23.0%	15.9%	9.8%	24.4%	17.0%
65-74	15.7%	33.2%	24.0%	17.8%	33.4%	26.4%
30-74	6.2%	15.5%	10.6%	5.6%	14.5%	10.2%

Abbreviations: HHS = Heart Health Survey; PHS = Population Health Survey

TABLE 3. Age-standardised estimates of cardiovascular disease risk for the participants of the health surveys

Weighted CVD risk for PHS 2003/2004 and HHS 2004/2005 participants aged 30 to 74 years		Age-standardised CVD risk			
		Based on WHO 2000-2025 standard population		Based on the United States census population in 2000	
PHS 2014/15 (n=4 445 868)	PHS 2003/2004 and HHS 2004/2005 (n=3 495 074)	PHS 2014/15 (n=4 445 868)	PHS 2003/2004 and HHS 2004/2005 (n=3 495 074)	PHS 2014/15 (n=4 445 868)	PHS 2003/2004 and HHS 2004/2005 (n=3 495 074)
10.6%	10.2%	8.8%	9.4%	10.0%	10.7%

Abbreviations: CVD = cardiovascular disease; HHS = Heart Health Survey; PHS = Population Health Survey; WHO = World Health Organization

TABLE 4. Ten-year cardiovascular disease risk level among non-institutionalised individuals aged 30 to 74 years according to age-group based on the Framingham risk model[*]

Age-group, y/ risk level	PHS 2014/15 (n=4 445 868)			PHS 2003/2004 and HHS 2004/2005 (n=3 495 074)		
	Female	Male	Total	Female	Male	Total
30-44						
Low risk	100.0%	96.0%	98.2%	100.0%	90.4%	94.6%
Medium risk	N/A	3.4%	1.5%	N/A	9.1%	5.1%
High risk	N/A	0.7%	0.3%	N/A	0.5%	0.3%
45-54						
Low risk	92.1%	48.2%	71.7%	89.1%	56.0%	72.4%
Medium risk	6.6%	42.0%	23.0%	8.5%	33.5%	20.8%
High risk	1.3%	9.9%	5.3%	2.4%	10.5%	6.7%
55-64						
Low risk	70.8%	18.2%	44.7%	62.8%	6.9%	28.5%
Medium risk	24.6%	31.3%	27.9%	32.9%	40.1%	37.8%
High risk	4.7%	50.6%	27.4%	4.3%	53.1%	33.7%
65-74						
Low risk	27.3%	2.3%	15.4%	20.1%	0%	6.1%
Medium risk	48.6%	12.8%	31.5%	40.1%	17.2%	27.0%
High risk	24.0%	84.9%	53.1%	39.8%	82.8%	66.8%
30-74						
Low risk	80.0%	48.8%	65.4%	81.1%	49.0%	63.3%
Medium risk	14.9%	22.1%	18.3%	12.5%	22.8%	18.6%
High risk	5.1%	29.1%	16.4%	6.4%	28.2%	18.1%

Abbreviations: HHS = Heart Health Survey; N/A = not applicable; PHS = Population Health Survey

[*] Because of rounding, not all percentages total 100

9.4% in 2003-2005 to 8.8% in 2014-2015 [Table 3]. A study of NHANES data revealed a similar trend, consisting of a small decrease in CVD risk from 1988 to 2004 (7.9% to 7.4%; P<0.001).[10] The stagnation in 10-year CVD risk between 2003-2005 and 2014-2015 suggests that despite improvements in treatment, more effective prevention strategies (eg, improvements in diet and physical activity levels) are needed.[19] Primary care intervention to manage modifiable risk factors, such as hypertension, dyslipidaemia, and diabetes, can complement population-based policies. Efforts to ensure access to appropriate healthcare and affordable medications will help control abnormal risk factor levels.[20] Furthermore, despite the importance of targeting individual risk factors to reduce prevalence, the long-term objective should be reduced overall risk of CVD. This objective requires a holistic approach simultaneously targeting multiple risk factors.

Our results highlight the need for overall risk assessment, in addition to targeted efforts focused on specific CVD risk factors. During the past decade, numerous public health initiatives (eg, smoking cessation campaigns) have been implemented to reduce the prevalence of established risk factors for CVD. It is reasonable to expect that CVD risk would decrease over time in conjunction with the decreased prevalences of various risk factors, such as the declining number of current smokers. Surprisingly, these changes were not strongly reflected in the change in 10-year CVD risk. One explanation is that decreases in the prevalence of some risk factors are offset by increases in others. For example, population ageing in Hong Kong may shift more adults into the high-risk group. However, because the Framingham model was limited to individuals aged 30 to 74 years, the change in mean age between the two surveys is inconsequential. Other possible changes in risk factors include increases in the prevalence of diabetes and hypertension, as reflected by the increased proportion of participants receiving antihypertensive medications (Table 1). Although CVD mortality has considerably decreased, it is concerning that CVD risk has not substantially diminished over the past decade. This lack of improvement in CVD risk may lead to an increasing community burden of CVD in the near future, especially in the context of population ageing.

The overall 10-year CVD risk for participants aged 30 to 74 years in 2003-2005 after age adjustment to US census population data in 2000 was 10.7%. During a similar time period (1999-2004), the US population had a 10-year CVD risk of 7.4%.[10] When Hong Kong men were stratified according to risk group in 2014-2015, 48.8% were classified as low-risk, 22.1% were classified as medium-risk, and 29.1% were classified as high-risk (Table 4). For comparison, among men in the United Kingdom population during 2012, 46.5% were classified as low-risk, 39.9% were classified as medium-risk, and 13.6% were classified as high-risk using the National Institute for Health and Care Excellence Framingham risk model.[21] In terms of risk distribution, a greater proportion of Hong Kong men were classified as high-risk compared with men in the United Kingdom in the early 2010s. In terms of age-standardised risk, the Hong Kong population had a higher 10-year CVD risk than the US population in 2003.

Analysis according to age showed that the proportion of low-risk participants increased from 2003-2005 to 2014-2015, particularly in the age-groups of 55-64 and 65-74 years (2003-2005: 28.5% vs 2014-2015: 44.7% for participants aged 55-64 years, and 6.1% vs 15.4% for participants aged 65-74 years) [Table 4]. This increased proportion may be the result of primary care clinicians recognising age as a prominent risk factor for CVD, leading to more aggressive treatment of modifiable risk factors. Furthermore, there were fewer male smokers in

2014-2015 than in 2003-2005 (24.0% vs 30.5%; P<0.001) [Table 1], suggesting that the success of recent anti-smoking campaigns also contributed to this paradigm shift.

Contrary to a previous report addressing changes in several CVD risk factors,[22] we used the widely validated Framingham risk model to predict the risk of CVD. By measuring the net change in cardiovascular risk, we more comprehensively estimated the impacts of prevention strategies; this is particularly important because some risk factors worsened, some improved, and some remained stable over time. To our knowledge, this is the first study to evaluate the change in 10-year CVD risk in an Asian population. The results reinforce the need for more aggressive community-wide and clinic-based preventions, with an emphasis on increased exercise hours during leisure time, dietary changes that promote higher intake of vegetables and fruits, as well as lower intake of salt and saturated fats, weight maintenance, and smoking cessation. The findings also suggest that the discovery and use of lipid-lowering drugs and antihypertensive medications does not effectively translate into overall risk reduction in an Asian population, unless these treatments are simultaneously paired with prevention strategies targeting CVD risk factors.

Strengths and limitations

This study was based on two Hong Kong population health surveys, and thus the sample is highly representative of the general population. Baseline data were collected through laboratory tests and face-to-face interviews, suggesting that these data are highly reliable. The long interval between the two health surveys (2003-2005 to 2014-2015) also provides insights regarding the effectiveness of current CVD prevention strategies. Limitations of the current study involve its use of the Framingham risk prediction model and the PHS and HHS. Similar to other surveys, the PHS and HHS are susceptible to participation bias because the sample data might not provide an accurate representation of the overall population. Many PHS variables are self-reported and may lead to reporting bias. Considering the effort required to complete the long questionnaires, the collected data may be susceptible to non-response bias and recall bias. Furthermore, because the Framingham cohort primarily consisted of Caucasians, the predicted 10-year CVD risk in the Hong Kong population calculated using the Framingham model should be interpreted cautiously. The Framingham risk model was developed for people without a history of CVD; thus, a small proportion of the overall sample lacking a history of CVD might have been included in the study, causing inaccuracies in the results. Additionally, the model may overestimate the 10-year CVD risk for

men in Hong Kong,[14] and a recalibrated model with greater predictive power may be required. Although several limitations and assumptions may hinder the prediction of CVD risk, these potential sources of bias were present in both surveys. Therefore, the effects of such biases may be less important when comparing the change in predicted 10-year CVD risk between the two time points.

Conclusion

During the period from 2003-2005 to 2014-2015, the change in predicted 10-year CVD risk was not statistically significant. However, the proportion of low-risk participants within older age-groups was higher in PHS 2014/15 than in PHS 2003/2004 and HHS 2004/2005. More aggressive CVD prevention strategies and primary care interventions are needed to address CVD risk factors.

Author contributions

Concept or design: BMY Cheung, CLK Lam.
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All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Ethics approval

The requirement for ethics approval for this research was waived by the Institutional Review Board of The University of Hong Kong/Hospital Authority Hong Kong West Cluster, Hong Kong as this study involved secondary analysis of de-identified governmental data.

References

1. Roth GA, Johnson C, Abajobir A, et al. Global, regional, and national burden of cardiovascular diseases for 10 causes, 1990 to 2015. J Am Coll Cardiol 2017;70:1-25.
2. GBD 2017 Causes of Death Collaborators. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018;392:1736-88.
3. Romero CX, Romero TE, Shlay JC, Ogden LG, Dabelea D. Changing trends in the prevalence and disparities of obesity and other cardiovascular disease risk factors in three racial/ethnic groups of USA adults. Adv Prev Med 2012;2012:172423.
4. World Health Organization. Hypertension. 2019. Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension. Accessed 8 Jan 2021.
5. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. Lancet 2005;365:217-23.
6. Lin X, Xu Y, Pan X, et al. Global, regional, and national burden and trend of diabetes in 195 countries and territories: an analysis from 1990 to 2025. Sci Rep 2020;10:14790.
7. World Health Organization. Cardiovascular diseases. 2016. Available from: https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1. Accessed 8 Jan 2021.
8. World Health Organization. Prevention of cardiovascular disease. Guidelines for assessment and management of cardiovascular risk. 2007. Available from: https://apps.who.int/iris/bitstream/handle/10665/43685/9789241547178_eng.pdf?sequence=1&isAllowed=y. Accessed 8 Jan 2021.
9. Ajani UA, Ford ES. Has the risk for coronary heart disease changed among U.S. adults? J Am Coll Cardiol 2006;48:1177-82.
10. Lopez-Jimenez F, Batsis JA, Roger VL, Brekke L, Ting HH, Somers VK. Trends in 10-year predicted risk of cardiovascular disease in the United States, 1976 to 2004. Circ Cardiovasc Qual Outcomes 2009;2:443-50.
11. Department of Health, Hong Kong SAR Government; Department of Community Medicine, The University of Hong Kong. Population Health Survey 2003/2004 2015. Available from: https://www.chp.gov.hk/files/pdf/report_on_population_health_survey_2003_2004_en.pdf. Accessed 8 Jan 2021.
12. Surveillance and Epidemiology Branch, Centre for Health Protection, Department of Health, Hong Kong SAR Government. Report of Population Health Survey 2014/2015. 2017. Available from: https://www.chp.gov.hk/files/pdf/dh_phs_2014_15_full_report_eng.pdf. Accessed 8 Jan 2021.
13. D'Agostino RB Sr, Vasan RS, Pencina MJ, et al. General cardiovascular risk profile for use in primary care: the Framingham Heart Study. Circulation 2008;117:743-53.
14. Lee CH, Woo YC, Lam JK, et al. Validation of the Pooled Cohort equations in a long-term cohort study of Hong Kong Chinese. J Clin Lipidol 2015;9:640-6.e2.
15. World Health Organization. Age standardization of rates: a new WHO standard. 2001. Available from: https://cdn.who.int/media/docs/default-source/gho-documents/global-health-estimates/gpe_discussion_paper_series_paper31_2001_age_standardization_rates.pdf. Accessed 6 May 2024.
16. United States Census Bureau. Introduction to Census 2000 Data Products. Available from: https://usa.ipums.org/usa/resources/voliii/pubdocs/2000/mso-01icdp.pdf. Accessed 1 May 2024.
17. Census and Statistics Department, Hong Kong SAR Government. Hong Kong population projections 2017-2066. 2017. Available from: https://www.censtatd.gov.hk/media_workers_corner/pc_rm/hkpp2017_2066/index.jsp. Accessed 8 Jan 2021.
18. Department of Health, Hong Kong SAR Government. Non-Communicable Diseases Watch. Overview of cardiovascular diseases. September 2018. Available from: https://www.chp.gov.hk/files/pdf/ncd_watch_sep_2018.pdf. Accessed 8 Jan 2021.
19. National Prevention Council, United States Government. National Prevention Strategy. America's plan for better health and wellness. June 2011. Available from: https://www.hhs.gov/sites/default/files/disease-prevention-wellness-report.pdf. Accessed 8 Jan 2021.
20. Chow CK, Nguyen TN, Marschner S, et al. Availability and affordability of medicines and cardiovascular outcomes in 21 high-income, middle-income and low-income countries. BMJ Glob Health 2020;5:e002640.
21. Collins GS, Altman DG. Predicting the 10-year risk of cardiovascular disease in the United Kingdom: independent and external validation of an updated version of QRISK2. BMJ 2012;344:e4181.
22. Carroll MD, Lacher DA, Sorlie PD, et al. Trends in serum lipids and lipoproteins of adults, 1960-2002. JAMA 2005;294:1773-81.