A comparison of the prevalence and clustering of major cardiovascular risk factors in the Netherlands and China

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Abstract
Background: Cardiovascular risk factors tend to be clustered. Variations in clusters across populations have not been widely investigated. This study aims to compare the prevalence and clustering of major cardiovascular risk factors between adults in the Netherlands and China.

Methods: A total of 6542 Dutch adults was recruited from 2001 to 2006 for the Utrecht Health Project, an ongoing cohort study among inhabitants of a newly developing area near Utrecht, the Netherlands. A total of 37,141 Chinese employees who received health screening in Changchun City, China was enrolled from 2003 to 2010, and 3850 residents from Dehui, another city from northeast China, were enrolled in 2007.

Results: The Dutch and Chinese populations shared similar patterns with increasing prevalence with age for most cardiovascular risk factors. Age-specific levels of body mass index, blood pressure and total cholesterol were higher in the Dutch than in the Chinese population. An exception to this was young men (18–44 years old): Chinese young men had similar body mass index levels compared to their Dutch counterparts. The age-standardised prevalence of current smoking was much higher in Chinese men compared to Dutch men (P < 0.05). The clustering patterns of risk factors differed between the Dutch and Chinese with the smoking-heavy drinking cluster while smoking-hypercholesterolemia was more common in both Dutch young men and women.

Conclusions: Cardiovascular risk profiles and clustering patterns differ between the Dutch and the Chinese and seem to differ between men and women. This calls for race and sex-specific targeted prevention programmes.

Keywords
Cardiovascular, risk factors, clustering, comparison, China

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Introduction
Although cardiovascular disease (CVD) is rapidly declining in Western European countries, CVD is rising in Asia.1 In China, the number of patients with CVD is 230 million, and about 3 million Chinese die of CVD annually.2 Although treatment strategies for CVD and control of its risk factors in high-income countries are well described, many individuals from developing countries do not receive any care.3 Translations of this knowledge into solutions for rapidly developing countries are not easy, given different culture contexts, social structures and financial structures. Apart from social environmental differences, the associations between risk factors and cardiovascular outcomes vary across countries. The Asia Pacific Cohort Studies Collaboration (APCSC) pointed out those differences; blood pressure is more strongly
related to CVD in Asia than in Australia and New Zealand. In addition, the INTERHEART study showed abdominal obesity was a great contributor to CVD risk in Western Europe, while it had the smallest contribution in China. Cardiovascular risk factors tend to cluster within individuals and clustering is associated with a higher risk of cardiovascular events. As clustering of risk factors is getting increasingly common, information on clusters is relevant for targeting prevention, management and treatment strategies for CVD. To adopt evidence-based western preventive strategies into locally effective preventive strategies for China, understanding the extent and nature of differences between populations in the clustering of CVD risk factors is of great importance. So far, variations in risk factor clusters across populations have not been widely investigated. Therefore, this study aims to compare the prevalence and clustering of major cardiovascular risk factors among adults in the Netherlands and China.

**Methods**

**Study population**

Data in the Netherlands were derived from the Utrecht Health Project (UHP), an ongoing prospective cohort study among inhabitants of a newly developed housing estate in Utrecht, the Netherlands. The UHP started in 2000 and is estimated eventually to enroll two-thirds of the growing population of inhabitants of the area over the coming years. The UHP was approved by the medical ethical committee of the University Medical Centre, Utrecht, the Netherlands, and all participants gave written informed consent. The present analysis is based on the information of adults (18 years and older) of this project recruited from January 2001 to December 2006, that is, a total of 5960 participants.

Data on the Chinese population were derived from two databases. One database was collected by the International Health Promotion Center in the 1st Hospital of Jilin University, Changchun, China. This centre provides health examinations to residents of Changchun, which is the capital and largest city of Jilin Province, located in the northeast of China. As described previously, from 2003 to 2010, 37,141 individuals who received a health screening programme in the International Health Promotion Center in the 1st Hospital of Jilin University were enrolled. Participants were mainly current and retired employees from government institutions, universities or companies. As health screening is considered as welfare offered by their employers, almost all employees tend to participate. The protocol was approved by the ethics committee of the 1st Hospital of Jilin University. Written informed consent was obtained from each participant.

The other Chinese database was derived from a cross-sectional survey among the residents of Dehui, Jilin Province, China, entitled ‘The Healthy Diet Survey of Urban and Rural Residents in Dehui, Jilin Province’ in 2007. Dehui city is located in Jilin Province of northeast China, with a population of 943,695 living in 14 towns and 308 villages. This survey was multistage random sampling. A total of 6043 residents was selected from this area, and 3702 residents agreed to participate in the study, including questionnaires, physical examinations and blood tests. The committee on human research of the Public Health School of Jilin University, Changchun, Jilin, China, approved the study protocol. Written informed consent was obtained from every participant.

**Measurements**

All participants from the UHP went through a general health questionnaire with a trained nurse and information was obtained on medical history, current drug use and lifestyle. Height and weight were measured. Blood pressure was measured in the dominant arm with an Omron M4 device. The cuff sizes were adjusted to the arm circumference. Blood pressure was measured twice in the sitting position with 2 minutes in between. The average of both measurements was used. Cholesterol and glucose levels were measured on a Synchron LX20 (Beckman-Coulter, Brea, CA, USA).

In the International Health Promotion Center in the 1st Hospital of Jilin University, body weight and height of participants were measured by an anthropometer, Biospace BSM 330. Blood pressure was measured twice in the sitting position after 5 minutes of rest using an Omron BP-203RV IIIIC. The average of these two measurements was used. Cholesterol and glucose levels were measured on a Hitachi 7600-210 auto analyser (Hitachi, Tokyo, Japan). Smoking and alcohol use were not assessed.

All participants from the Dehui survey underwent a questionnaire with trained medical staff and information was also obtained on medical history, current drug use and lifestyle. Height and weight were measured in light clothing. Blood pressure was measured three times in a sitting position after 10 minutes of rest using a mercury sphygmomanometer. The average of these three measurements was used. Cholesterol and glucose levels were measured on a Synchron LX20 (Beckman-Coulter).
Definitions for cardiovascular risk factors

Information about smoking was collected from self-administered questionnaires. Participants were asked whether they were current smokers, former smokers or non-smokers. Daily alcohol consumption was calculated by multiplying alcohol concentration, volume and number of drinks. Excessive alcohol intake or heavy drinking was defined as consuming more than 30 g of alcohol per day. Body mass index (BMI) was calculated as body weight (in kilograms) divided by height (in meters) squared. World Health Organization (WHO) expert consultation reviewed scientific evidence and has suggested that, for a given BMI, Asians have a higher risk of diabetes and cardiovascular risk than Caucasians. This has led to the suggestion that the BMI cutoffs defining overweight and obesity should be lowered for Asian populations. Therefore, over-BMI cutoffs defining overweight and obesity should be used for the Chinese population. Obesity was defined as having a BMI ≥ 30 kg/m² for the Dutch population and a BMI ≥ 28 kg/m² for the Chinese population. 10,11 Diabetes was defined as having a fasting plasma glucose level ≥ 7.0 mmol/L. 12 Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg. 13 Hypercholesterolemia was defined as having a total cholesterol level ≥ 5.2 mmol/L. 14

Statistical analysis

We combined the Changchun health screening database and the Dehui survey database together to estimate cardiovascular profiles in the Chinese population. When smoking and alcohol consumption information was needed, only data from the Dehui survey was used, based on availability. Data were presented as means with standard deviations for continuous variables or as percentages for categorical variables. Differences in continuous variables were estimated using t tests for independent samples, and prevalence values for categorical variables were compared using Pearson’s chi square test. In order to compare prevalence estimates between the Netherlands and China, we standardised the overall prevalence of cardiovascular risk factors by the direct method to the age distribution of the Chinese populations from the 2000 census. To compare components of clustering patterns in Dutch and Chinese populations, we made bar charts to present the percentages of different clustering combinations in the group of people with two risk factors stratified by age and sex group (young: 18–44 years old; older: 45+ years old). A two-tailed P value of < 0.05 was considered statistically significant. All data were analysed with SPSS 20.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

In the Netherlands, a total of 6542 inhabitants (44.8% were men) from the ongoing cohort study UHP was enrolled. The average age was 39.4 ± 12.6 years; 40.6 ± 12.6 years for men and 38.4 ± 12.5 years for women. In China, a total of 40,843 participants (59.5% were men) from the Changchun health screening programme and the Dehui survey was included. The average age was 45.2 ± 13.7 years; 45.9 ± 14.0 years for men and 44.0 ± 13.2 years for women.

Levels and prevalence of cardiovascular risk factors

In each age group, the Dutch population had higher levels of BMI, SBP and total cholesterol for both men and women compared to the Chinese population, and had a lower level of high-density lipoprotein cholesterol (Supplementary Table 1). Figure 1 shows that, apart from the absolute levels, the patterns of change in risk factor level with age are similar between Dutch and Chinese populations for blood pressure, total cholesterol and glucose levels, and for BMI in women. Interestingly, there were no differences in BMI levels between Dutch men and Chinese men in the younger age group (18–44 years old).

Table 1 presents the prevalence of major cardiovascular risk factors in both Dutch and Chinese populations stratified by age and sex groups. In men, the age-standardised prevalence of current smoking was 54.3% for the Chinese and 25.5% for the Dutch (P < 0.05). Heavy drinking was more prevalent in Dutch women: 12.6% of Dutch women and 0.7% of Chinese women were heavy drinkers (P < 0.05). Using different cutoffs of BMI for defining obesity (BMI ≥ 30 kg/m² for Dutch; BMI ≥ 28 kg/m² for Chinese), the age-standardised prevalence of obesity was higher in Chinese men compared to Dutch men, while the prevalence was lower in Chinese women compared to Dutch women (P < 0.05). Hypercholesterolemia was more prevalent in Dutch than in Chinese; 49.6% versus 34.9% for men and 50.5% versus 29.7% for women (both P < 0.05). The age-standardised prevalence of diabetes was higher in Chinese than in Dutch men (8.1% vs. 4.2%) and women (3.5% vs. 2.8%), although the difference was not statistically significant in women.

The two Chinese populations were also analysed separately. Details of cardiovascular profiles of the Changchun health screening database and the Dehui survey database are given in Supplementary Table 2 and Supplementary Figure 1.
Clustering of cardiovascular risk factors

In total, 26.6% of Dutch men and 23.4% of Dutch women had a cluster of two risk factors. These numbers were 30.5% for Chinese men and 18.5% for Chinese women. Figure 2 shows percentages of different clustering combinations among people with two cardiovascular risk factors. The ‘current smoking–heavy drinking’ cluster was most prevalent in Chinese young men (18–44 years old) (33.6%). For Chinese young women, the ‘obesity–hypertension’ cluster was most prevalent (37.8%). In both Dutch young men and

Figure 1. Distributions of cardiovascular risk factors across age groups in Dutch and Chinese men (left part) and women (right part). BMI: body mass index; SBP: systolic blood pressure; GLU: glucose; TC: total cholesterol; HDL: high-density lipoprotein cholesterol. Continuous line, Dutch; dashed line, Chinese.

*P values for the difference between the Dutch and Chinese were <0.05.
Table 1. Prevalence (in %) of major cardiovascular risk factors in Dutch and Chinese adults presented by age, sex, and age-standardised.

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>18–29</th>
<th>30–44</th>
<th>45–59</th>
<th>≥60</th>
<th>Total</th>
<th>Age-standardised</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>24.3</td>
<td>50.2</td>
<td>25.5</td>
<td>55.6</td>
<td>30.4</td>
<td>61.9</td>
<td>20.5</td>
</tr>
<tr>
<td>Excessive alcohol use</td>
<td>21.3</td>
<td>16.9</td>
<td>24.1</td>
<td>31.9</td>
<td>43.4</td>
<td>34.5</td>
<td>37.8</td>
</tr>
<tr>
<td>Overweight</td>
<td>35.5</td>
<td>32.7</td>
<td>43.0</td>
<td>45.2</td>
<td>51.5</td>
<td>50.6</td>
<td>51.3</td>
</tr>
<tr>
<td>Obesity</td>
<td>5.8</td>
<td>18.1</td>
<td>10.6</td>
<td>21.4</td>
<td>17.3</td>
<td>20.7</td>
<td>13.4</td>
</tr>
<tr>
<td>Hypertension</td>
<td>19.6</td>
<td>15.4</td>
<td>21.6</td>
<td>31.1</td>
<td>44.7</td>
<td>47.4</td>
<td>64.6</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.1</td>
<td>0.9</td>
<td>1.1</td>
<td>4.5</td>
<td>7.1</td>
<td>10.7</td>
<td>14.3</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>32.7</td>
<td>20.6</td>
<td>47.8</td>
<td>34.5</td>
<td>65.9</td>
<td>42.9</td>
<td>45.5</td>
</tr>
<tr>
<td><strong>Women</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>16.3</td>
<td>2.5</td>
<td>20.6</td>
<td>15.0</td>
<td>31.1</td>
<td>28.9</td>
<td>15.5</td>
</tr>
<tr>
<td>Excessive alcohol use</td>
<td>6.2</td>
<td>0.0</td>
<td>10.2</td>
<td>1.2</td>
<td>20.1</td>
<td>0.7</td>
<td>19.6</td>
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<tr>
<td>Overweight</td>
<td>23.4</td>
<td>10.0</td>
<td>27.5</td>
<td>21.0</td>
<td>37.7</td>
<td>38.3</td>
<td>46.4</td>
</tr>
<tr>
<td>Obesity</td>
<td>7.4</td>
<td>2.4</td>
<td>13.7</td>
<td>5.0</td>
<td>17.7</td>
<td>10.9</td>
<td>22.6</td>
</tr>
<tr>
<td>Hypertension</td>
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<td>3.2</td>
<td>8.5</td>
<td>10.1</td>
<td>29.6</td>
<td>33.9</td>
<td>57.1</td>
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<tr>
<td>Diabetes</td>
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<td>0.6</td>
<td>0.7</td>
<td>1.0</td>
<td>4.6</td>
<td>5.0</td>
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</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>33.0</td>
<td>12.5</td>
<td>40.6</td>
<td>18.1</td>
<td>68.4</td>
<td>42.5</td>
<td>80.6</td>
</tr>
</tbody>
</table>

NS: not statistically significant.  
*P is the P value for the difference between the Dutch and Chinese based on age standardised data.

Figure 2. Components of clustering of cardiovascular risk factors in Dutch and Chinese men and women.  
Smoke: current smoking; Drink: heavy drinking; HTN: hypertension; TC: hypercholesterolemia.  
*P values for the difference between the Dutch and Chinese were < 0.05.
women, current smoking commonly coincided with hypercholesterolemia (19.8% and 26.4%). In Chinese older men (45+ years old), the current smoking–hypertension cluster was most prevalent (33.8%), while the most prevalent cluster for Dutch older men was the hypertension–hypercholesterolemia cluster (32.0%). For both Dutch and Chinese older women, the most common cluster was hypertension–hypercholesterolemia (28.0% and 28.3%, respectively).

Discussion

This study compared the prevalence and clustering of major cardiovascular risk factors in the Netherlands and China. We found that the Dutch and the Chinese populations shared similar patterns with increasing age in the prevalence of most cardiovascular risk factors. However, the prevalence of most risk factors was higher in the Dutch population. Young Chinese men had similar BMI levels compared to their Dutch counterparts, along with a higher prevalence of smoking and excessive alcohol intake. Furthermore, marked differences in clustering patterns were observed between the Dutch and the Chinese populations.

Comparison of cardiovascular risk factors between the Dutch and the Chinese

The observed unfavourable cardiovascular risk profiles in Dutch adults compared to Chinese adults are consistent with data from WHO, for instance, WHO reported that the age-standardised mean total cholesterol of the Dutch population was 5.3 mmol/L in both men and women, while the mean total cholesterol of the Chinese population was 4.5 mmol/L in men and 4.7 mmol/L in women. WHO data also show that total cholesterol and blood pressure levels are higher in people from high-income regions such as North America, Western Europe and Australasia. High fat energy intake and high saturated fats in the western diet could have partly accounted for high cholesterol levels in the Dutch compared to the Chinese. The increased intake of fat in developing countries parallelizing with economic development, urbanisation and nutrition transition will continue to increase the total cholesterol level. As a consequence, the rates of coronary heart disease are expected to rise considerably among the Chinese.

Compared to Dutch men, Chinese men showed more unfavourable CVD-related behaviour: smoking was much more common, with 54.3% of men smoking. This result was consistent with the 2010 China Global Adults Smoking Survey (GATS) conducted by the Chinese Center for Disease Control and Prevention; in which 53% of men aged older than 15 years were current smokers. At the same time, heavy drinking seems to coincide with heavy smoking, as was shown in our study, most notably in Chinese young men up to the age of 44 years. The excessive alcohol use is even higher in the Dutch population, a group known for their considerable alcohol consumption. WHO data also indicated that consumption of alcohol has increased dramatically in men in countries undergoing a nutrition transition such as China in the past few decades. In addition to their unhealthy smoking habits and excessive alcohol intake, the young Chinese men already have an equal level of obesity compared to Dutch young men. In urban areas, Chinese young men have more opportunities to attend social events where high-fat and high-energy foods are more likely to be used than traditional Chinese food. Meanwhile, sedentary behaviours have increased dramatically. Harmful CVD-related behaviour together with an obesity and diabetes epidemic in Chinese young men will have a huge impact on productivity and on the healthcare system.

In our analyses, we combined the Changchun health screening database and the Dehui survey database together to estimate cardiovascular profiles in the Chinese population. The reason we did this was due to our research aim, which was to compare patterns of cardiovascular risk factors at the country level. People living in one province in one country are exposed to similar environmental factors and have similar lifestyles. To this extent, two Chinese populations came from the same domain. Therefore, we pooled two Chinese databases together to give us more precise estimations about cardiovascular profiles among adults in northeast China.

Clustering of cardiovascular risk factors

Evidence on clustering of risk factors between countries is quite limited, especially when a comparison is made between high and middle income countries. The present study is among the first to compare clustering patterns of risk factors between countries. We found marked differences in clustering patterns between the sexes and across populations. For instance, harmful behaviours such as smoking and heavy drinking are more often accompanied by hypercholesterolemia in the Dutch and by hypertension in the Chinese. Unraveling the causes underlying these cluster patterns is beyond the scope of the present study design, but understanding how these differences come about could be instrumental for guiding future cardiovascular prevention strategies. For example, for western countries, diets with high saturated fats could be made healthier by introducing more vegetables and fruits and thereby reducing cholesterol and fat intake, while in
China, more strict measures to reduce tobacco exposure is clearly needed. At the same time, the consequences of different cluster patterns are worth exploring. There are well known differences in CVD between China and the West. In China, stroke is more common while coronary heart disease is the predominant form of CVD in the West.²⁴ If different clustering patterns could explain differences in the incidence of CVD between regions, identifying the most ‘dangerous’ clustering patterns for specific CVD forms could help to identify high-risk populations effectively. Preventive measures based on this evidence are more likely to meet the challenges of preventing CVD in the local context than a one-size-fits-all approach.

**Strengths and limitations**

The key strength of our present study is that it is one of the first to compare clustering of cardiovascular risk factors between developing and developed countries. Some limitations of the study should be mentioned as well. First, our Chinese participants were mainly employees undergoing a routine health check-up paid for by their companies or institutions. It might be possible that this study population represents a higher socioeconomic and nutritional status, and in a country like China they tend to have a more unfavorable cardiovascular risk profile than those from a lower socioeconomic class.²⁵ Nevertheless, one could also argue that this study population in China is more suitable to compare with the Dutch population at large, given the higher living standards in the Netherlands. Also, differences in cardiovascular risk profiles between the north and the south of China have been suggested.²⁶ Our Chinese participants were from northeast China and could not represent the general population on a national level. However, limited evidence is available about whether clustering patterns would have regional differences. Given similar health behaviours within Chinese people, it is highly likely that clustering patterns of risk factors would remain the same for the south of China and the north of China. Next, our definitions concerning hypertension, diabetes and hypercholesterolemia were all based on the measured values, without taking treatment information into account. As in the Netherlands inhabitants will have easier access to treatment to improve their cardiovascular risk factors to lower risk levels, this could have underestimated the true differences between cardiovascular risk factors between the two countries.²⁷ Finally, when smoking and alcohol consumption information was needed, only data from the Dehui study was used because this information was not available in the Changchun data. Smaller samples might limit the interpretation of the findings for clustering. However, this enabled us at least to explore those clusterings including smoking and alcohol use.

In conclusion, our findings suggest that cardiovascular risk profiles and clustering patterns differ between the Dutch and the Chinese and seem to differ between men and women. This calls for race and sex-specific targeted prevention programmes.

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**Declaration of conflicting interests**

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