Trends in coronary risk factors in the WHO MONICA Project

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Background The World Health Organization (WHO) MONICA Project was established to determine how trends in event rates for coronary heart disease (CHD) and, optionally, stroke were related to trends in classic coronary risk factors. Risk factors were therefore monitored over ten years across 38 populations from 21 countries in four continents (overall period covered: 1979–1996).

Methods A standard protocol was applied across participating centres, in at least two, and usually three, independent surveys conducted on random samples of the study populations, well separated within the 10-year study period.

Results Smoking rates decreased in most male populations (35–64 years) but in females the majority showed increases. Systolic blood pressure showed decreasing trends in the majority of centres in both sexes. Mean levels of cholesterol generally showed downward trends, which, although the changes were small, had large effects on risk. There was a trend of increasing body mass index (BMI) with half the female populations and two-thirds of the male populations showing a significant increase.

Conclusions It is feasible to monitor the classic CHD risk factors in diverse populations through repeated surveys over a decade. In general, the risk factor trends are downwards in most populations but in particular, an increase in smoking in women in many populations and increasing BMI, especially in men, are worrying findings with significant public health implications.

Keywords WHO MONICA Project, cardiovascular epidemiology, risk factor, cigarette smoking, systolic blood pressure, cholesterol, body mass index

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From around the middle of the 20th century many western countries showed a rapid rise in coronary heart disease (CHD), as judged from routine mortality statistics, but these peaked in the US in the early 1960s and started to decline. These declines predominantly affected westernized countries with most other countries lagging behind. One of the key questions asked at the National Institutes of Health's Conference in Bethesda, USA in 1978 was, 'Could the changes in coronary event rates be related to population trends in the known coronary risk factors of cigarette smoking, blood pressure and serum cholesterol?' The Conference concluded that the information was insufficient to answer such questions. Subsequently, WHO mounted the ‘multinational MONItoring of trends and determinants in Cardiovascular disease (MONICA)’ Project to investigate and to complement the older cross-sectional studies of differences in disease rates, by means of longitudinal investigation of the dynamics of change. By replicating the same core of observations in diverse, contrasting communities to monitor multiple similar and dissimilar trends there was a potential for the investigation of the determinants of cardiovascular disease which would be beyond the scope of any single research unit or nation acting alone. The study of the classic risk factors, now including body mass index (BMI) because of its undoubted public health relevance, formed one part of the first main null hypothesis that there was no relationship between 10-year trends in the major cardiovascular disease risk factors (serum cholesterol, blood pressure and cigarette consumption) and 10-year trends in incidence rates of CHD. This paper will review the trends in risk factor levels which have been observed in the MONICA populations, discuss the magnitude and direction of the changes and their likely implications, comment on quality control and assurance aspects and make recommendations for future monitoring activities.
Methods

The 38 populations and 21 countries were mainly European, but there were three in Australasia and two in both North America and Asia. Power calculations determined that 200 or more subjects were needed in each age and sex group at each survey to best detect changes of epidemiological interest over time. Four 10-year age strata (25–64 years) were recommended giving a total of 1600 men and women. The youngest age category was optional and hence is not included in this analysis. Estimates were based on 100% participation and efforts were to be expended on achieving as high a response rate as possible. At least two surveys based on independent probability samples of the population were carried out at the beginning and the end of the 10-year period, usually with a third in between. The best available sampling frames were used. A total of 69 251 males and 69 187 females, aged 35–64 years, were surveyed over the 10 years of the MONICA Project.

Four centres did not include a middle survey, and two did not have their middle survey data used in the analysis. One centre surveyed only men in its middle survey.

Risk factors were measured using standardized procedures. The definition of a daily cigarette smoker was one who smoked at least one cigarette every day. The smoking questionnaire represented a compromise between several different proposals and was derived from the WHO Cardiovascular Survey Methods Questionnaire. It could be self-administered, or administered by a technician or nurse at the screening site or during a home visit. The critical recommendation, however, was that the methodology used for this measurement and for the other classic risk factors should not alter over time within a centre. It was important that interviewers should be trained and their performance evaluated and tested for precision and accuracy. It was also recommended that validation should take place against expired air carbon monoxide, serum cotinine or serum thiocyanate measurement. These recommendations, however, were not mandatory as a standard methodology for smoking validation across all populations was not achieved. Extensive quality assessment of the data was carried out for each of the surveys.

Systolic blood pressure was taken as the mean of two consecutive measurements. The MONICA Manual laid down a strict protocol on the blood pressure and arm circumference measurements. The recommended instrument was the Random Zero Sphygmomanometer, although a standard mercury sphygmomanometer was admissible. It was considered that the key to good blood pressure measurement was training, certification of measurers, constant monitoring of performance and feedback. The Manual specified the sequence of blood pressure measurement: it was measured in the right arm with the subject sitting, having rested for 5 minutes with no change in position. Crucially, it had to precede any painful or anxiety-inducing procedures such as venipuncture or electrocardiography. As with smoking, blood pressure measurement data were subject to quality assessment. Blood pressure was measured at the same period of the day within each centre in each survey to obviate any problems of diurnal variation. In general the quality assessment showed that reliable data had been collected for the estimation of trends in most centres. Standardization of cuff sizes received more attention in the middle and final MONICA surveys after the lessons from quality assessment were learned.

The MONICA Manual gave strict rules on the standardization of lipid measurement. Stress was placed on longitudinal standardization within the centres. Samples could be non-fasting so they would be spread throughout the day in the same way as for blood pressure measurement. About half of the centres adopted a semi-fasting approach, i.e. 4 hours of fasting, the rest employed overnight fasting. Blood was taken from subjects in the sitting position avoiding the use of tourniquets, although they were used in a number of MONICA centres. A thorough external quality control procedure was adopted to cover the analytical stage of the measurement; a procedure provided by the WHO Regional Lipid Reference Centre in Prague (Czech Republic). Links were also established with the Centers for Disease Control in Atlanta, Georgia, USA. It was recommended that an enzymatic cholesterol method with practically 100% cholesterol ester hydrolysis should be used. A system was established within MONICA to detect inaccurate or imprecise total cholesterol determination methods and also to detect relevant shifts in accuracy over time, which might affect estimates of total cholesterol trends. This was intended to be complementary to the internal quality control procedure employed by the participating centres’ laboratories. In addition, external quality assessment was organized and quality scores were assigned. The performance of the laboratories tended to improve over the study period.

The calculation of relative weight or BMI was dependent on two variables: weight and height. The MONICA Survey Manual clearly delineated the methods desirable to ensure accuracy of these measurements. Information on height was recorded to the nearest full centimetre. The importance of testing with standard weights was stressed. Weight was measured to the nearest 200 g. Retrospective quality assessment of weight and height measurement in MONICA revealed relatively few problems, particularly in the middle and final surveys. Analysis of height within birth cohorts supported the view that relatively few problems occurred in its measurement.

External quality assessment also took place for other factors affecting the survey comparability and trend estimates: age, date of examination and survey periods, participation rates, quality of sampling frames and sampling fractions.

The 10-year trends were calculated taking all available surveys into account. The data from the middle survey were included as they helped give firmer trend estimates. To obtain the 10-year trend the average yearly change was calculated and extrapolated to the full 10-year period. Risk factor trends were age standardized by taking the weighted means of the trends using weights 12, 11 and 8 for the age groups 35–44, 45–54 and 55–64 years, respectively. They were calculated by simple regression of the individual observations on the day of examination. Data for all populations were included in the figures, regardless of quality, although quality problems may bias the results for some populations.

If the data were available for the optional middle survey, they were incorporated, except for two populations where the data quality was poorer than for the other surveys.

Results

Figures 1–4 present the 10-year trend results for the classic risk factors of cigarette smoking, systolic blood pressure, total cholesterol and BMI. The figures employ a standard format. The
two-tone shaded bars represent 95% CI. If the bar does not lie astride the zero line the trend is significantly different from zero, at the 5% level. In addition, wider bars are observed in those populations in which the sample size was relatively small or, for other reasons, the estimates were less precise. The 10-year trends in the percentage of daily cigarette smokers are shown in Figure 1. In roughly half the male population the trend is significantly downward and in another third there is a downward but insignificant trend. Only in the Beijing centre in the People’s Republic of China is there a significant increase in male smoking, where the levels were already particularly high.

The largest decrease is observed in Stanford in California, as is the case for women. Only about one-third of the female populations show a significant decrease in smoking with over half showing increases, albeit only one-third of these are significant. Women, in particular, in eastern European countries show an increasing trend whereas a significant decrease in Chinese women is apparent, unlike their male counterparts.

The 10-year trends in systolic blood pressure are given in Figure 2. In men and particularly in women, the downward trends are quite encouraging with two-thirds of the male populations showing a decrease (half of these significant) and

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**Figure 1** Daily cigarette smokers (%). Age 35–64 years, age standardized, with 95% confidence intervals

**Figure 2** Systolic blood pressure (mmHg). Age 35–64 years, age standardized, with 95% confidence intervals
three-quarters of females (nearly all significant). In general, the magnitude of downward trends is also greater than upward ones. Figure 3 gives the 10-year trends in total cholesterol and there are significantly declining trends in half of the male populations and a slightly greater proportion of the female populations. It should be pointed out that for the 10-year trends of blood pressure and cholesterol, those centres which had the largest change tended to have poorer quality.7,9

Lastly, Figure 4 shows 10-year trends in BMI. Although few male populations show a significant decrease in BMI, approximately half show significant increases with the rest showing non-significant increases. In females the situation is much more evenly poised with approximately half the centres showing an increase and half a decrease: around half of the upward and downward trends are significant.

Discussion

In the WHO MONICA Project it has proved feasible to monitor the classic risk factors for CHD across many populations over a
10-year period. Moreover, it has proved possible to standardize procedures within centres over the study period. It was also apparent that, for some of the factors, e.g. smoking and blood pressure, the accuracy of the measurements improved over the study period.

Declining trends in the prevalence of daily cigarette smoking in men was found in most of the study populations. Only in Beijing did men show a significantly increasing trend in smoking. In women more than half the populations showed an increasing trend in the prevalence of smoking and decreases in men but not in women occurred in most southern European and some eastern European populations. The biggest increase in the prevalence of daily cigarette smoking among women occurred in populations where the prevalence was relatively low, e.g. Poland, Spain and Russia. The contribution of anti-smoking campaigns to these trends is touched upon elsewhere.13

For systolic blood pressure and serum cholesterol the trends were most often downwards in both sexes in most populations. The changes in serum cholesterol were relatively modest in most populations. In Beijing there were significant increases in men and women starting from low levels. In cross-sectional cholesterol comparisons from the MONICA first survey, it was only the Chinese population which could be said to have physiologically ‘normal’ levels of serum cholesterol with around 85% of both men and women having serum cholesterol levels below 5.2 mmol/l.14

A most disturbing feature of the results is the increase in levels of BMI, particularly in males. Three-quarters of male populations show increases, with half of these being significant. Curiously, it was populations from Russia and the Baltic States, which showed decreases in both sexes. In contrast, increasing trends were most marked in North America and Australia where the declines in cardiovascular disease have been most pronounced. These facts are hard to reconcile as it is known that increasing BMI has adverse effects on blood pressure and lipid profiles.15

The continuing smoking epidemic, particularly in women, and the worrying trends in BMI, particularly in men, have serious implications for public health. The knowledge gained in intervention against these factors needs to be applied more fully. These surprising findings should banish complacency that present trends will continue into the future so the need for risk factor surveillance remains high. It should also be stressed that there is much room for further declines in smoking, blood pressure and cholesterol, and reductions in these would be expected to greatly reduce the burden of CHD. As we have seen it is possible to co-ordinate risk factor surveys at a multinational level but this depends on adequate local and central quality control and assessment. Experience in MONICA has shown that the methodology established can be used as a sound platform on which to build other studies. The combination of these factors in summary risk scores and the degree to which they can explain changes in incidence is described elsewhere.16

Lastly, an important lesson learnt in MONICA is that in planning population surveys of cardiovascular risk factors there are large advantages in mounting big, well-controlled, high-quality surveys, well separated in time, rather than opting for small, frequent, poorly controlled ones.

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KEY MESSAGES
• The WHO MONICA Project has monitored coronary risk factors in 38 populations from 21 countries over a 10-year period.
• Male smoking rates were mainly downward whereas, in females, the reverse was true.
• Systolic blood pressure increased in most centres in both sexes.
• Cholesterol generally showed downward trends, although the changes were small.
• Upward trends in body mass index were present in half the female and two-thirds of the male population.

References
3 WHO MONICA Project. MONICA Manual. Part I: Description and Organization of the Project. Section 1: Objectives and Outline


