Time to tip the scales: tackling overweight and obesity in primary care

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Chapter 5

The value of measuring waist circumference in primary care: a mixed-methods study

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Abstract

Background

It remains a challenge for GPs to identify and treat all patients at increased risk of cardiovascular disease (CVD), because cardiovascular risk assessment in all patients is not feasible.

Aim

To investigate the value of measuring waist circumference in primary care by investigating: current recording practices of GPs; barriers and facilitators; its contribution to the identification of patients at increased risk of CVD.

Design and setting

A mixed-methods study in Dutch primary care

Methods

We investigated three datasets: routine data from general practices (n=676,708 health records of adults); qualitative data from 6 focus groups (n=21 GPs); data from the Netherlands Epidemiology of Obesity (NEO) study (n=6,671 middle-aged individuals).

Results

Between 2012 and 2023, incidence rates of recorded waist circumference by GPs decreased from 47 to 3 per 1000 person-years. Barriers of GPs to measure waist circumference included discomfort, inability to measure it accurately, lack of measuring tape, and perceived uselessness. Facilitators included knowledge that increased waist circumference is a cardiovascular risk factor. In the NEO study population, after excluding patients already treated for the prevention of CVD (n=2407), 1731 patients were at increased risk of CVD (n=1113 intermediate risk, n=618 high risk). Measuring waist circumference would identify 89% of those at intermediate and 93% of those at high predicted cardiovascular risk.

Conclusion

Measuring waist circumference may be a valuable tool to identify patients at increased risk of CVD in primary care. Since GPs currently rarely measure waist circumference, inclusion in guidelines and addressing identified barriers and facilitators is warranted.

Introduction

In the current Dutch guideline for cardiovascular risk management in primary care (1), which is based on European guidelines (2), obesity (defined by Body Mass Index (BMI)≥30 kg/m^2), but not increased waist circumference is included in the criteria for the selection of patients eligible for a cardiovascular risk assessment (1). Only in individuals who are eligible for cardiovascular risk assessment, a predicted cardiovascular risk is calculated using the Systematic Coronary Risk Evaluation-2 (SCORE2) to estimate the 10-year fatal and non-fatal cardiovascular risk, and treatment options are considered (1, 3). However, BMI alone is an insufficient marker of abdominal adiposity and offers insufficient information to identify and manage all patients at increased risk of obesity-related health problems (4, 5).

Whereas it is previously shown that adding waist circumference to current risk scores does not improve the prediction of cardiovascular disease (CVD) in the total population, it clearly improves risk stratification of individuals without obesity, showing increased risks in those with a BMI below 30 kg/m^2, but with increased waist circumference (6, 7). Therefore, measuring waist circumference alone, but also addition of waist circumference in the criteria for the selection of patients eligible for cardiovascular risk assessment, may help to identify patients at increased cardiovascular risk, and subsequent CVD prevention.

Body height and weight are frequently measured, and BMI (height/(weight*weight)) is recorded in electronic health records in some countries, while in others it is not (8-12). In contrast, waist circumference is rarely assessed in primary care (13-16). To address this issue, it is crucial to understand the barriers and facilitators of healthcare providers concerning measuring waist circumference, as this could enhance patient care and health outcomes (5). Few studies have explored these barriers and facilitators. Identified barriers in these studies include lack of time and feeling discomfort by the physician (13, 17).

The aim of this study was therefore to investigate the potential value of measuring waist circumference in primary care, focusing on first, current recording practices of general practitioners (GPs) regarding waist circumference measurements, secondly current barriers and facilitators of GPs for measuring waist circumference, and thirdly the contribution of measuring waist circumference in the identification of patients at increased risk of CVD.

Methods

A mixed-method approach was used based on data from three different datasets (Figure 1).

Measuring waist circumference in primary care

1. Current practice	2. Barriers and facilitators of GPs	3. Contribution to CVRM
Aim: exploring current recording practices regarding waist circumference measurements	**Aim**: exploring the barriers and facilitators of Dutch GPs for measuring waist circumference	**Aim:** exploring the contribution of measuring waist circumference in the identification of patients at risk of CVD
Data: routine primary healthcare data from the Extramural LUMC Academic Network (ELAN)	**Data:** qualitative data collected by focusgroups	**Data:** prospective cohort study with data from the Netherlands Epidemiology of Obesity study (NEO)
n= 676,708 patients	**n= 21** general practitioners	**n=6,671** participants
Outcome: incidence rates of recorded waist circumference between 2007 and 2023	**Outcome:** identified barriers and facilitators using the theoretical domains framework	**Main outcome**: proportions of individuals identified at intermediate or high predicted cardiovascular risk by measuring waist circumference **Secondary outcome**: mean ten-year predicted cardiovascular risk calculated with SCORE2 stratified by sex, waist circumference and BMI

Figure 1 An illustration of the study methods using a mixed-method approach with three different datasets GP: general practitioner, CVRM: cardiovascular risk management, CVD: cardiovascular disease, SCORE2: Systematic Coronary Risk Evaluation 2, BMI: body mass index

Current recording practices

Study design and study population

For our first aim, we used routine collected healthcare analyses from 676,708 individuals of 152 general practices from the Extramural LUMC Academic Network (ELAN). ELAN is a regional integrative population-based data infrastructure in which medical, social and public health data are linked at the patient level from the greater The Hague and Leiden area (18, 19). The study population used for our first aim, was also included in a previous study by van den Hout et al. (12) (Chapter 2 of this thesis). However, measuring waist circumference had not been investigated and reported previously. Individuals were included in the analyses when they were registered between 1 January 2007 and 30 June 2023 at a general practice participating in the ELAN database and over 18 years. The study design and exclusion criteria are described elsewhere (12, 19).

Data collection

For waist circumference as outcome, we used the values coded within the structured electronic health records as a laboratory result.

Age, year of birth and sex were derived at cohort entry. For BMI, we used height, weight and BMI coded within the structured electronic health records as a laboratory result. BMIs were derived from an already available BMI (automatically calculated by the GPs information system), or BMI was calculated using a recorded height and weight on the same date or a recorded weight and a previously recorded height. BMI was calculated by dividing weight in kilograms by the square of height in metres. BMI measurements between 17 and 50 kg/m^2 were included in our analysis. We assessed the data for extreme values and inconsistencies, removing less than 2% of records due to inadequate or extreme values for height, weight, and BMI.

Statistical analysis

Baseline characteristics were expressed as median (25th, 75th percentiles) or as percentage. Follow-up time in person-years was calculated from cohort entry (at least 18 years and registered in a general practice from 1st of January 2007) until deregistration with a participating general practice, death, or end of the study period (30th of June 2023).

We estimated the incidence rates of a recorded waist circumference within each calendar year (from 2007 to 2023) per 1000 person-years. If multiple recorded waist circumferences for an individual were recorded within one year, only the first recorded waist circumference within that year was included. Individuals were censored after their first recorded waist circumference for that calendar year but were included again in subsequent years. Furthermore, in the electronic health records of the n=676,708 individuals, all BMI recordings between 17 and 50 kg/m^2 were selected. For each of these BMI values, we assessed the frequency of waist circumference measurements taken on the same day. This aimed to determine the frequency of waist circumference recordings for each recorded BMI value within 17-50 kg/m^2, to identify at which BMI values, waist circumference is most frequently recorded.

Barriers and facilitators of GPs

Study design and study population

For our second aim, we conducted a qualitative focus group study with 21 Dutch GPs to explore the barriers and facilitators to diagnosing obesity in primary care, including the use of a waist circumference measurement.

Data collection

The qualitative data used for the second aim were derived from van den Hout et al. (20) (Chapter 3 of this thesis). In this previous study, barriers and facilitators to diagnosing obesity were explored. At the start of the focus group sessions, we explained that diagnosing obesity referred to measuring height and weight (for BMI calculation), and preferably also waist circumference, and recording these values in the electronic health records. Participants were reminded of this throughout the discussions. Although waist circumference was not addressed through a dedicated question, participants frequently raised it when discussing the barriers and facilitators to diagnosing obesity. In the present study, we conducted a more in-depth analysis focusing specifically on the barriers and facilitators mentioned by GPs regarding measuring waist circumference. This analysis is presented in greater detail here.

We used purposive sampling to recruit a heterogenous sample of GPs in terms of age, sex, working experience, GP practice setting, and patient populations. Focus groups were organized with three to five GPs, and new groups were added until data saturation was reached (that is, until no new themes were brought forward). Details of the data collection process are described elsewhere (20).

Analysis

Details of the analysis process are described elsewhere (20). In short, the transcripts were analysed using a thematic analysis approach using Atlas ti (version 22). All fourteen theoretical domains of the refined theoretical domains framework (TDF) were used for deductive coding. The TDF is a framework specifically designed to understand determinants of healthcare professional behaviour (21-23). Each domain of the TDF relates to a component in the overarching “Capability, Opportunity, Motivation and Behaviour” (COM-B) model. This model identifies three key factors that need to be present for any behaviour to occur: capability, opportunity, and motivation. Barriers and facilitators using the TDF, and the overarching COM-B model were identified for measuring and recording waist circumference.

Contribution of measuring waist circumference to cardiovascular risk management

Study design and study population

For our third aim, data from the Netherlands Epidemiology of Obesity (NEO) study, a population-based cohort study of 6671 individuals were used. Inclusion criteria for participating in the NEO study were men and women aged between 45 and 65 years with a self-reported BMI of 27 kg/m^2 or higher, living in the greater area of Leiden (in the West of the Netherlands). In addition, all inhabitants aged between 45 and 65 years from one municipality (Leiderdorp) were invited, irrespective of their BMI. Participants were invited to a baseline visit between September 2008 and September 2012 at the NEO study center of the Leiden University Medical Center (LUMC). At baseline, participants completed several questionnaires to report demographic and clinical information and underwent anthropometric measurements and blood sampling. Participants were followed for the occurrence of CVD through GP records. The study design and population have been described in detail elsewhere (24).

Definitions of the populations

For the present analysis, we first excluded individuals who were already treated by their GP to prevent CVD: those using lipid-lowering or antihypertensive treatment (n=2407). Then, we excluded those with missing data for the SCORE2 (n=32). In the remaining population we calculated the predicted cardiovascular risk using SCORE2, to identify those at intermediate or high risk of CVD. In this study we refer to this population as the risk assessment population (n=4232) (Figure 5).

From this risk assessment population, we selected two populations by two different approaches: (1) based on guideline-defined risk factors (i.e. individuals with pre-existing CVD, diabetes mellitus, rheumatoid arthritis, chronic obstructive pulmonary disease, obesity, chronic kidney disease, a suspected hereditary dyslipidemia, elevated blood pressure, elevated cholesterol concentrations, an active smoking status and a burdened family history of premature CVD); and (2) based on an increased waist circumference (men >94cm, women >80cm). The definitions of each risk factor are explained in Supplemental file 1.

Data collection

Outcomes

Main outcome was predicted 10-year fatal and non-fatal cardiovascular risk and categorized into low, intermediate and high risk. Individuals were categorized into these risk categories either based on an priori high-risk factor or a calculated predicted risk score with SCORE2 (3). Individuals classified as high risk a priori were those with pre-existing CVD, diabetes mellitus, chronic kidney disease, severely increased systolic blood pressure, or diagnosed hereditary dyslipidemia, regardless of their SCORE2 result (1). For others, the predicted cardiovascular risk score was calculated with SCORE2. For individuals with rheumatoid arthritis, risk scores were multiplied by 1.5. The calculated predicted cardiovascular risks were categorized into low, intermediate, and high based on age and predicted cardiovascular risks, in accordance with the Dutch guideline for cardiovascular risk management (Supplemental file 2) (1).

Secondary outcomes were incidence rates of incident CVD events. The GP records were searched for information on incident myocardial infarction, stroke (ischemic and non-ischemic) and transient ischemic attacks coded according to the International Classification of Primary Care (Supplemental file 3). Time of follow-up was defined as the number of days between the baseline visit and the date of a first CVD event, or censoring due to death, loss to follow-up, or the end of follow-up (extraction date at the GP), whichever came first.

Covariates

The variables used in the SCORE2 were collected at baseline: age, sex, systolic blood pressure, total cholesterol/high-density lipoprotein (HDL) cholesterol ratio and smoking status. BMI was calculated by dividing the weight by the height squared (kg/m^2) categorized into normal (<25kg/m^2), overweight (25-30kg/m^2) and obesity (≥30kg/m^2). Waist circumference was measured with a measuring tape placed midway horizontally between the lower costal margin and the iliac crest and categorized into normal (men ≤ 94 cm, women ≤ 80 cm), increased (men > 94 - 102 cm, women > 80 - 88 cm) and substantially increased (men > 102 cm, women > 88 cm) (25).

Statistical analysis

Baseline characteristics of the risk assessment population were expressed as mean (SD), median (25^{th}, 75^{th} percentiles), or percentages. Mean predicted risk scores with 95% confidence intervals (CI) were calculated, stratified by BMI, waist circumference, and sex. A Venn diagram was created to identify the overlap between the two populations: the population based on guideline-defined risk factors and the population based on an increased waist circumference. To evaluate the proportion of individuals identified at increased risk of CVD in each population, proportions of individuals at low, intermediate, and high predicted risk were calculated in each population and compared with the total risk assessment population. Finally, in each population, we calculated the incidence rates of observed incident CVD events per 1000 person-years.

Results

Current recording practices

This analysis included 676,708 individuals (Supplemental table 1) with median of 7.5 person years (i.q.r. 2.8 – 15.5 person-years) of follow-up in a general practice, and a total of 131,487 waist circumferences recorded. Of the total population, 6.7% had at least one recorded waist circumference. From 2007 to 2012 the incidence rate of a recorded waist circumference increased with 17 to 47 per 1000 person-years. Between 2012 and

2023, the incidence rate of a recorded waist circumference decreased to 3 per 1000 person years (Figure 2). For n=128,623 (97.8%) recorded waist circumferences, a BMI was also recorded at the same date. Waist circumference was most often recorded in individuals with BMIs between 25-33 kg/m^2 (Supplemental figure 1).

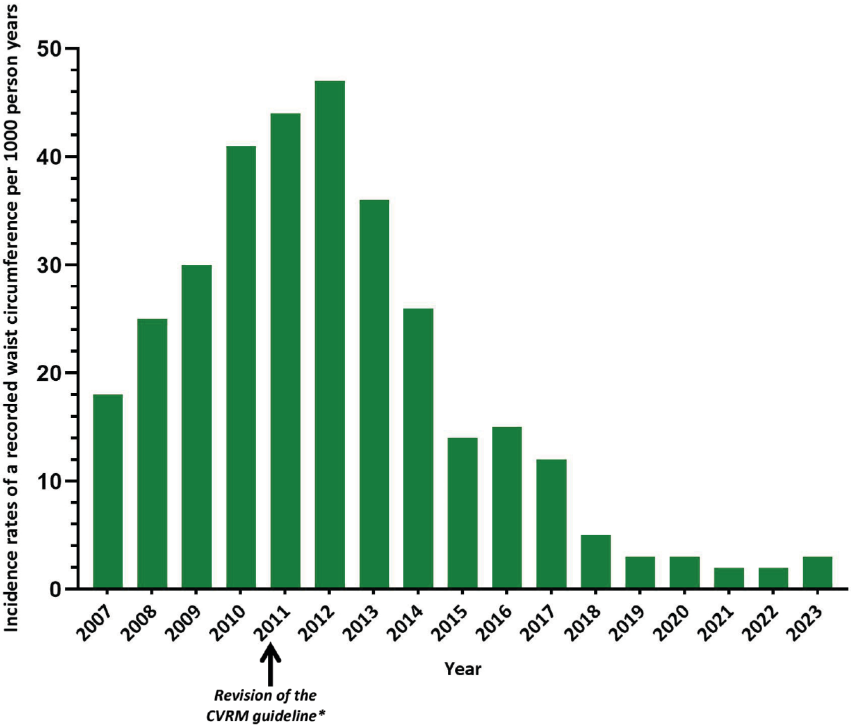


Figure 2 Incidence rates of a recorded waist circumference of n=676,708 electronic health records of Dutch general practitioners between 2007 and 2023
*The national guideline of the Dutch College of General Practitioners: cardiovascular risk management

Barriers and facilitators of GPs

We reached data saturation after six focus groups with three to five GPs (*n* = 21). The GPs had a mean age of 49 years (range 33–66 years) and the majority were women (76%) (Supplemental table 2). Barriers and facilitators for measuring waist circumference structured into the three COM-B components with the related domain of the theoretical domains framework in brackets are described below (Figure 3).

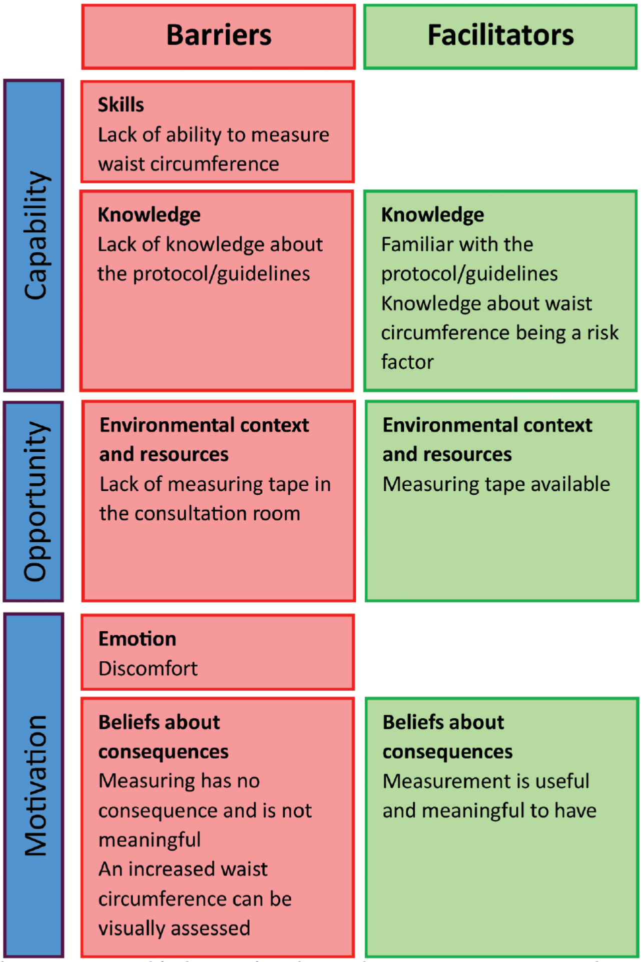


Figure 3 Barriers and facilitators of Dutch general practitioners in measuring and recording waist circumference

Capability

For capability, mainly topics belonging the domain *knowledge* were mentioned. A facilitator for measuring waist circumference was GPs knowledge that an increased waist circumference is a risk factor for developing CVD *(knowledge).* Additionally, as facilitator some GPs had familiarity with the guidelines for measuring waist circumference, while others did not, which acted as a barrier *(knowledge).*

As barrier, some GPs did indicate a lack of skill in measuring waist circumference. On the other hand, as facilitator, some GPs expressed they were able to measure waist circumference. However, their explanations on how to measure it did not always align with the guideline how to measure waist circumference *(skills).*

Opportunity

As a barrier, GPs mentioned the absence of measuring tape in their consultation room for measuring waist circumference *(environmental context and resources).*

Motivation

Some GPs mentioned that measuring waist circumference felt uncomfortable *(emotion).* The most important barrier, however, was related to the domain *beliefs about consequences*. Many GPs considered not to measure waist circumference since they felt it had no consequence for further management. They also considered it as an unreliable measurement. Additionally, in the domain *beliefs about consequences*, some GPs mentioned that they could visually assess if someone had an increased waist circumference thus deeming the measurement unnecessary.

Contribution of measuring waist circumference to cardiovascular risk management

From the 6671 participants in the NEO study population, we observed that 2407 patients were already treated for the prevention of CVD. After exclusion of missing values for the SCORE2 (n=32), 4232 patients were eligible for cardiovascular risk assessment (Figure 4). Baseline characteristics of this risk assessment population are presented in Supplemental table 3. Mean age was 55 years (SD 6), and 46% were men. Within this population, 87% had increased waist circumference and 85% had overweight or obesity. In the risk assessment population (n=4232), 559 patients were considered a priori at high risk of CVD due to a specific risk factor. For the remaining 3673 patients, risk scores were calculated with SCORE2, resulting in 1113 at intermediate predicted risk and 59 at high predicted risk. This results in a total of 1731 patients at increased risk of CVD (1113 at intermediate predicted risk and 618 at high predicted risk) (Figure 4).

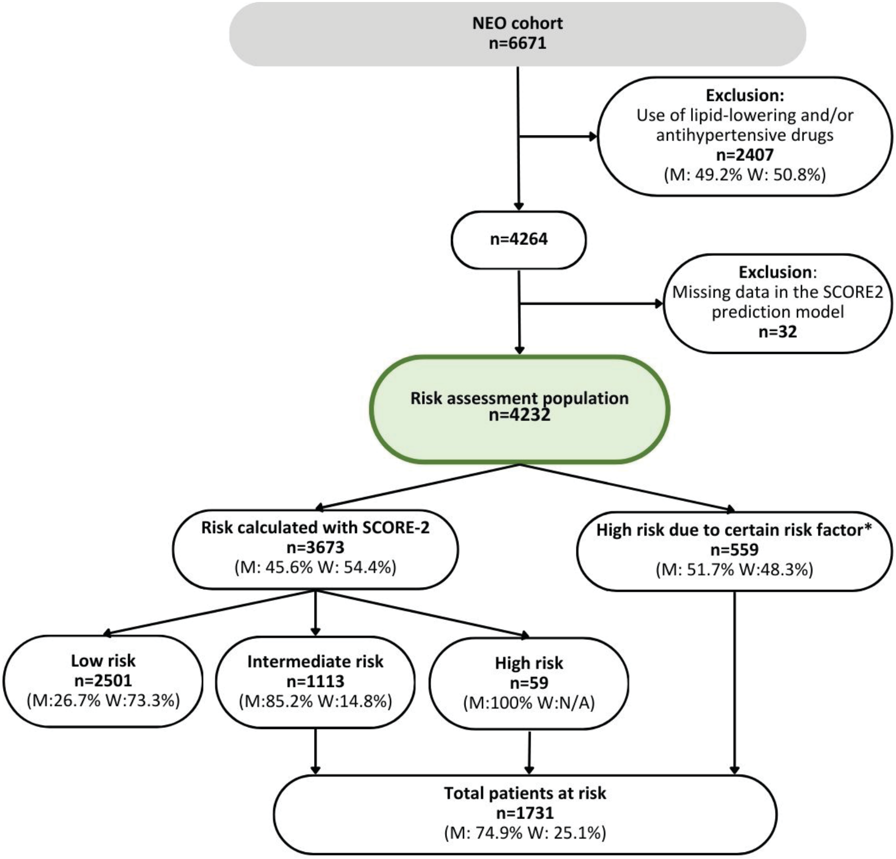


Figure 4 Flowchart of the risk assessment population and the number of individuals at low, intermediate, and high risk of cardiovascular disease in this population

*Individuals with pre-existing CVD n=48, diabetes mellitus n=97, moderate and severe chronic kidney disease n=15, severely elevated blood pressure (systolic>180mmHg) n=23, diagnosed hereditary dyslipidemia (LDL cholesterol>5 or total cholesterol>8) n=403

SCORE2: systematic coronary risk evaluation 2, M: men, W: women

Figure 5.A. illustrates the overlap between the risk assessment population (dark green, n=4232) and the two populations: the population based on guideline-defined risk factors (dark orange, n=3287), and the population based on an increased waist circumference (dark blue, n=3659). Patients with guideline-defined risk factors but without an increased waist circumference are shown in light orange (n=315), while those with an increased waist circumference but without guideline-defined risk factors are shown in light blue (n=687). Figure 5.B. shows the proportions of patients at low, intermediate and high predicted risk within each population. When in the risk assessment population (n=4232), the population with guideline-defined risk factors would be selected, 91% (n=1013/1113) of the total patients at intermediate predicted risk and 100% (n=618/618) of the total of patients at high predicted risk would be identified (Figure 5.C.2. and 5.C.3. dark orange population). When in the risk assessment population (n=4232), the population with increased waist circumference would be selected, 89% (n=993/1113) of the total patients at intermediate predicted risk and 93% (n=575/618) of the total patients at high predicted risk would be identified (Figure 5.C.2 and 5.C.3. dark blue population). Adding the population with an increased waist circumference to the population with current guideline-defined risk factors would identify an additional 6.4% (n=71/1113) of the total patients at intermediate predicted risk (Figure 5.C.2. light blue population).

In the population in which the risk of CVD could be calculated with SCORE2 (n=3673), the mean predicted cardiovascular risk was higher for those with increasing waist circumference in both normal weight and overweight categories (Figure 6). In men with substantially increased waist circumference and overweight, the mean predicted cardiovascular risk was 5.3% (95% CI 5.1-5.5%) compared with 4.4% (95% CI 4.0-4.7%) in those with normal weight and normal waist circumference. In women with overweight and substantially increased waist circumference this was 2.7% (95% CI 2.6-2.9%), compared with 2.1% (95% CI 2.0-2.3%) in women with normal weight and normal waist circumference (Figure 6).

Incidence rates of 10-year incident CVD per 1000 person years are similar in the two populations: 6.2 in the population based on guideline-defined risk factors versus 5.9 in the population based on an increased waist circumference per 1000 person years.

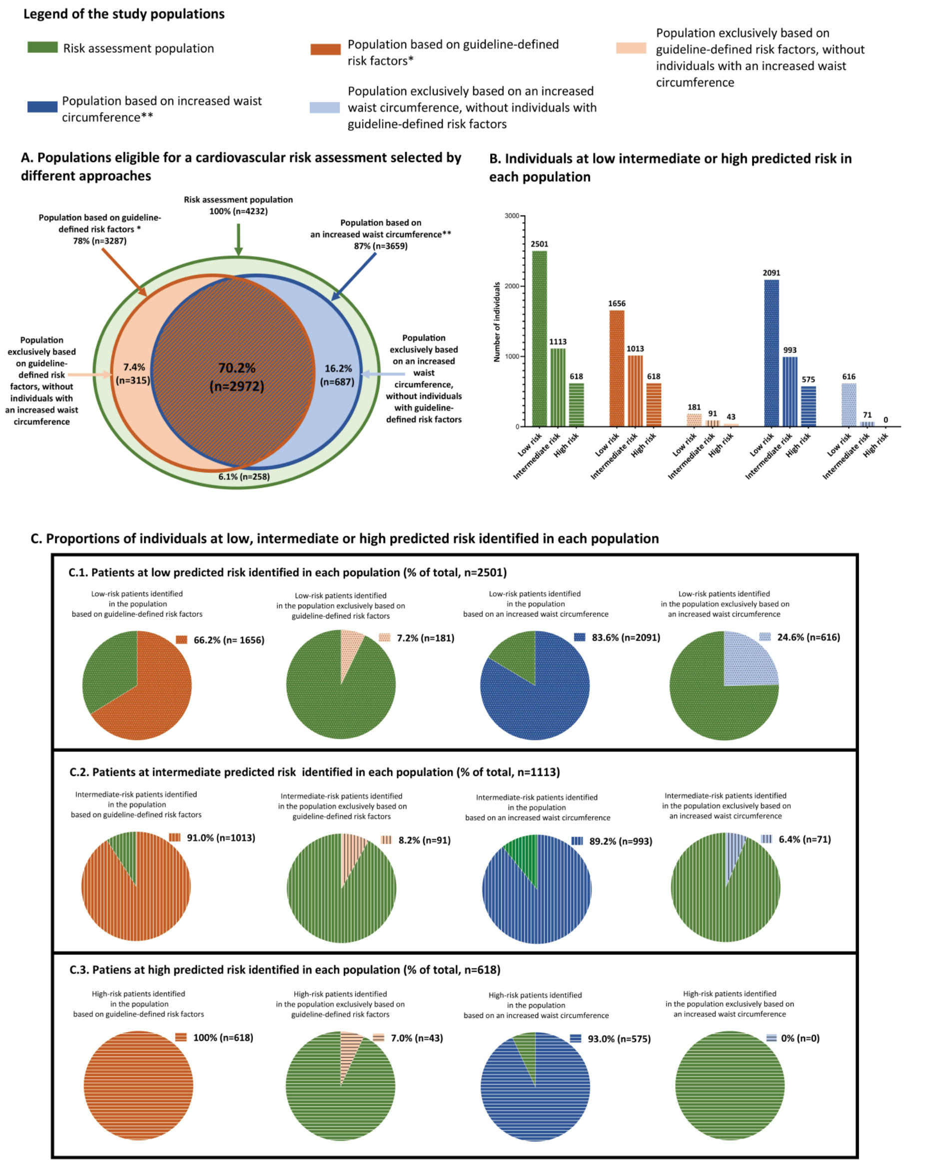
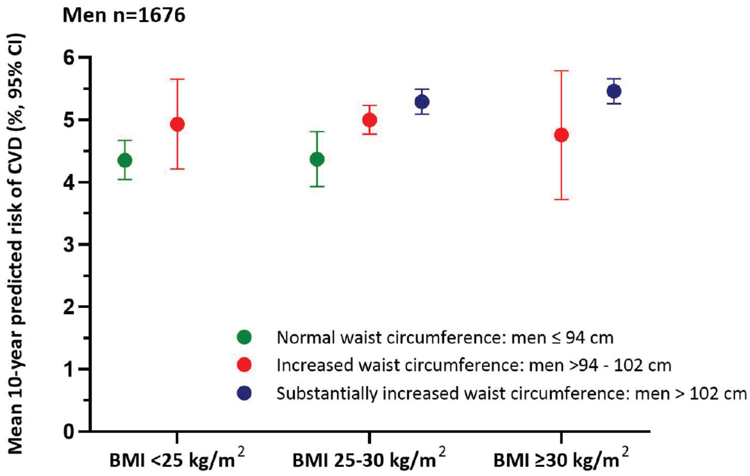


Figure 5 Individuals at low, intermediate, and high predicted cardiovascular risk (calculated with SCORE2°) identified by two different approaches 1. guideline-defined risk factors and 2. an increased waist circumference

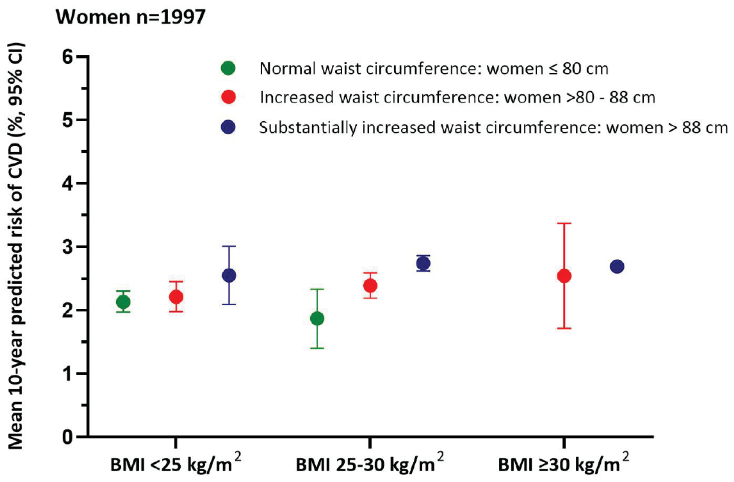
SCORE2: Systematic Coronary Risk Evaluation 2

*Population based on guideline-defined factors: individuals with a family history of premature cardiovascular disease, pre-existing CVD, diabetes mellitus, an active smoking status, obesity (BMI≥30kg/m²), elevated blood pressure (systolic blood pressure 140>mmHg), suspected hereditary dyslipidemia, elevated cholesterol concentrations (total cholesterol/hdl ratio >5), chronic obstructive pulmonary disease, rheumatoid arthritis, chronic kidney disease.

**Population based on an increased waist circumference: men >94 cm, women >80 cm.



BMI <25 kg/m^2 and normal WC n=158; BMI <25 kg/m^2 and increased WC n=34; BMI <25 kg/m^2 and substantially increased WC n=0; BMI 25-30 kg/m^2 and normal WC n= 99; BMI 25-30 kg/m^2 and increased WC n=356; BMI 25-30 kg/m^2 and substantially increased WC n=481; BMI ≥30kg/m^2 and normal WC n=0, BMI ≥30kg /m^2 and increased WC n=20; BMI ≥30kg/m^2 and substantially increased WC n=528



BMI <25 kg/m^2 and normal WC n = 252; BMI <25 kg/m^2 and increased WC n=106; BMI <25 kg/m^2 and substantially increased WC n=38; BMI 25-30 kg/m^2 and normal WC n= 24; BMI 25-30 kg/m^2 and increased WC n=143; BMI 25-30 kg/m^2 and substantially increased WC n=595; BMI ≥30kg/m^2 and normal WC n=0; BMI ≥30kg /m^2 and increased WC n=12, BMI ≥30kg/m^2 and substantially increased WC n=827

Figure 6 Mean 10-year predicted cardiovascular risk of fatal and non-fatal cardiovascular disease calculated with the SCORE2 stratified by waist circumference, BMI, and sex n=3673
CVD: cardiovascular disease, BMI: body mass index, WC: waist circumference, SCORE2: Systematic Coronary Risk Evaluation 2

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Discussion

Summary

In this mixed-methods study we investigated the value of measuring waist circumference in primary care. Currently, this is not standard practice in primary care in the Netherlands. Only in 6.7% of the GP records of patients aged 18 years and older, a waist circumference measurement was recorded. Incidence rates of recorded waist circumference decreased from 2012 to 2023 from 47 to 3 per 1000 person-years. Barriers of GPs to measure waist circumference were feeling discomfort, the inability to measure it accurately, lack of measuring tape and perceived uselessness. Facilitators included the availability of measuring tape and the comprehension that increased waist circumference is a cardiovascular risk factor. We showed that measuring waist circumference is a valuable measurement in the identification of patients at increased risk of CVD. Selecting patients with an increased waist circumference for cardiovascular risk assessment identified 89% of those at intermediate and 93% of those at high predicted cardiovascular risk. This approach is particularly relevant for practices that lack access to comprehensive tools e.g., blood pressure and blood tests, or in situations where time is too limited to conduct a broad range of measurements.

Strengths and limitations

Strengths of this study are the mixed-methods approach, which ensures that both quantitative and qualitative data were collected. This allows for a broad interpretation of the research results and ultimately, well-tailored interventions that lead to improvements and a more efficient approach in cardiovascular risk management in current practice. Other strengths of this study are the access to a large population (n=676,708) with routine healthcare data. We also identified barriers and facilitators using a well-established theoretical framework (Theoretical Domains Framework) (21). Additionally, we had access to extensive and uniform measurements of all information needed for calculating the 10-year cardiovascular risk with SCORE2. Several limitations should be taken into account though. In the routine heath care data, measured waist circumference could have been missed because analysis was limited within the structured electronic health records, as we did not include free text data. It is likely that more waist circumferences have been recorded in free text in the electronic health records, as not all GPs translate their medical assessment to accurately coded recordings. This would have led to an underestimation of available recorded waist circumference. It is important to note that routine healthcare data were used. To use these data accurately, we evaluated the data for extreme values and inconsistent records. Only less than one percent of the values was removed due to non-adequate or extreme values of waist circumference. For the qualitative study, focus groups could have yielded socially acceptable answers. Additionally, GPs who attended the focus groups might have had a special interest in obesity and may have been more motivated to optimize the care for patients with obesity. However, only two GPs expressed having a special interest in obesity or lifestyle medicine (Supplemental table 1). The first limitation in the NEO study may be the oversampling of individuals with a BMI ≥ 27 kg/m^2. This may have led to overestimation of the number of patients with an intermediate or high risk of CVD that can be identified by an increased waist circumference. However, patients with overweight are more likely to visit their GP for other complaints than patients without overweight, (26, 27) and therefore the NEO study population might be viewed as a typical population visiting general practice. Second limitation in the NEO study is that some individuals in our risk assessment population may already be identified by their GP and monitored accordingly, e.g., those with self-reported diabetes, pre-existing CVD, or chronic obstructive pulmonary disease. We included these individuals in our analysis since we were uncertain whether the baseline diagnosis in the NEO study fully aligns with real-life medical records of GPs, leaving it unclear whether these individuals have been identified by their GP. For individuals not yet identified by their GP, measuring waist circumference could be a valuable tool to identify those at increased risk in general practice.

Comparison with existing literature

The decrease in recorded waist circumference from 2012 to 2023 may be explained by revisions in the Dutch cardiovascular risk management guidelines. Until 2011, both BMI and waist circumference were recommended as part of the physical examination (28). After 2011, the guidelines shifted focus to BMI, with waist circumference listed as an optional additional measurement (29, 30). The in 2024 updated guideline reintroduced waist circumference alongside the BMI as part of the physical examination but did not include it as a criteria for cardiovascular risk assessment eligibility (1). The low measurement rates are consistent with findings from other countries (Canada, United Kingdom, United States), where waist circumference is also rarely recorded (13-16). These trends contradict the increasing awareness that knowledge of waist circumference has added value for risk assessment. So, the barriers for measuring waist circumference should be overcome to ease implementation in practice and support guideline adherence.

Previous studies investigated the barriers and facilitators for measuring waist circumference (13, 17). We confirmed some of the barriers reported by these studies: the discomfort felt by GPs (13, 17), the perceived usefulness of a measurement (17) and the lack of measuring tapes (13). In our qualitative study, the most important barriers mentioned were that GPs felt measuring waist circumference had no consequence for further management and that they believed they could visually assess an increased waist circumference. We, however, showed that measuring and adding increased waist circumference to the current guidelines would lead to the identification of an additional 6.4% of patients at intermediate cardiovascular risk, who would need follow-up in cardiovascular risk management but would otherwise be missed. The identification of these patients is particularly important, because these are patients with a BMI below 30, in whom a large waist may be less visible but who are at increased risk of CVD.

Our results are in line with findings from two other studies that investigated the role of waist circumference in identifying patients at increased risk of CVD (31, 32), and showed that waist circumference (with cut-offs of 80 cm for women and 94 cm for men) can effectively identify individuals at increased risk, highlighting its value in general practice. Comparing these studies however requires careful consideration, as they used different endpoints, such individual risk factors (e.g., hypertension, cholesterol), or other prediction models than the SCORE2 model used in our study, which is currently widely adopted in Europe. Furthermore, our findings suggest that the population with an increased waist circumference, in addition to the high number of patients identified at high predicted risk, also showed a high observed risk, deeming this population suitable for cardiovascular risk assessment eligibility. The high number of patients identified at high predicted/observed cardiovascular risk by measuring waist circumference can be explained by the strong association between waist circumference and visceral fat, which is associated with CVD (5, 33-36).

Waist circumference is a simple method to assess abdominal adiposity that is easy to perform in a clinical setting (5, 33, 35). Besides, it is a low-cost, low-risk tool, especially useful in countries where other assessments, e.g., cholesterol concentrations or blood pressure measurements, are not or less easily available. This makes it a practical option in settings where a more comprehensive screening is not feasible or in general practice where time and money is too limited to conduct a broad range of measurements in all patients. We previously showed that selecting patients with overweight or obesity for cardiovascular risk assessment by the GP may help to identify 70% of patients with a treatment indication who were not yet receiving treatment to prevent CVD (37). Our present findings may further help to identify patients at increased risk of CVD by measuring waist circumference in those patients who have overweight but no apparent obesity, enabling further treatment. Additionally, waist circumference is a measurement that can aid patients to recognize their own condition as it may lead to active attempts and successful weight loss (38). Furthermore, it could be used to know which patients should seek and be offered weight management and it enables monitoring the effects of weight management and healthy behaviors (5, 39).

Implications for practice and conclusion

Our findings show that measuring waist circumference may be a valuable addition in general practice as it identifies patients at increased risk of CVD, and particularly useful in patients with a BMI <30kg/m^2. Since GPs currently do not measure waist circumference frequently, it is not only important to include waist circumference in existing guidelines but also to address the barriers. This can be achieved by providing GPs with training, ensuring access to measuring tapes and enhancing their understanding of the clinical value of measuring waist circumference, but also in other practice workaround procedures like creating routine measurement opportunities. Future interventions should focus on tailored interventions to overcome these barriers, ultimately leading to the identification of intermediate and high-risk patients and the prevention of CVD.

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Supplemental table 1 Baseline characteristics routine healthcare cohort of ELAN, 2007-2023 from 18 years and older

	Total population n=676,708
Sex (% men)	48.0
Year of birth (calendar year)	1971 (1954-1987)
Age at entry cohort (years)	40.0 (26.0 -56.0)
Follow-up in general practice (years)	7.5 (2.8 – 15.5)
Recorded BMI (%)	28.8
Recorded waist circumference (%)	6.7
- First recorded waist circumference (normal)[1] (%)	0.3
- First recorded waist circumference (increased)[2] (%)	0.7
- First recorded waist circumference (substantially)[3] (%)	5.6

Skewed distributed data are shown as median (25th, 75th percentiles) and categorical data are shown as percentage
1 Normal waist circumference, waist circumference: men ≤ 94 cm, women ≤ 80 cm
2 Increased waist circumference, waist circumference: men >94 - 102 cm, women >80 - 88 cm
3 Substantially increased waist circumference, waist circumference: men > 102 cm, women > 88 cm

Supplemental table 2 Sample characteristics of the qualitative study reported by the general practitioners (n=21)

Characteristic	n
30-39	6
40-49	6
50-59	6
60-69	3
Sex	
Women	16
Men	5
Experience as general practitioner (years)	
0-9	8
10-19	5
20-29	6
30-39	2
Type of employment	
Practice owner	10
Salaried service	2
Locum	9
Practice location	
Urban	12
(Semi)rural	8
Both	1
Type of practice	
Solo practice	8
Duo practice	5
Group practice	5
Mixed	2
Unknown	1
Number of patients in practice	
≤3000 patients	9
>3000 patients	9
Unknown	3
Type of patient population	
Average population (reflection of the Dutch population)	10
Other	11
Specific areas of interest	
GP trainer	7
Obesity	1
Lifestyle coach	1
Other	6
None	6

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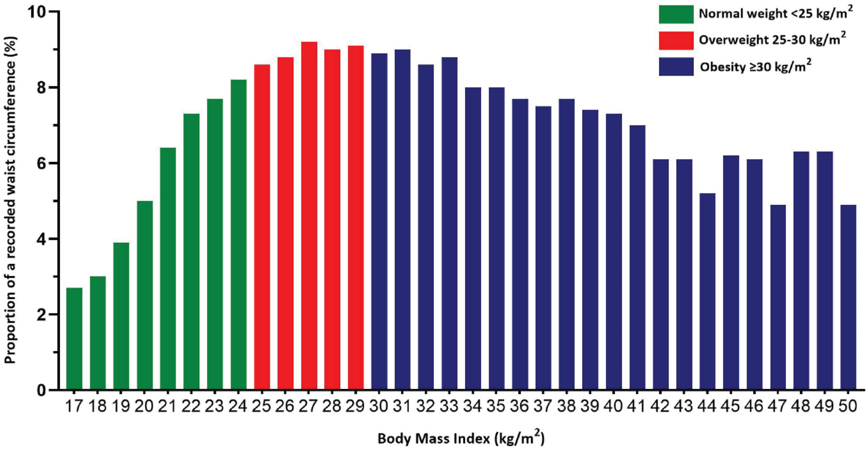
Supplemental table 3 Baseline characteristics of the risk assessment population

	Risk assessment population
Participants, n	4232
Men (%)	46.4
Age (years)	54.8 (6.0)
Ethnicity (Caucasian, %)	94.7
Educational level (high, %)	40.7
Follow-up (years)	6.7 (6.0-7.9)
BMI (kg/m^2)	29.3 (4.6)
• Normal (BMI<25kg/m^2) (%)	15.0
• Overweight (BMI 25-30 kg/m^2) (%)	46.5
• Obesity (BMI ≥30kg/m^2) (%)	38.5
Waist circumference (cm)	99.7 (12.9)
• Normal waist circumference (%)*	13.5
• Increased waist circumference (%)*	18.2
• Substantially increased waist circumference (%)*	68.3
Guideline-defined risk factors for cardiovascular risk management	
- Pre-existing CVD (%)	1.1
- Family history of premature CVD (%)	25.3
- Suspected hereditary dyslipidaemia (%)	9.5
- Elevated blood pressure (systolic>140mmHg) (%)	26.3
- Elevated cholesterol concentrations (%)	24.2
- Smoking status (current, %)	17.0
- Obesity (≥30kg/m^2 %)	38.5
- COPD (%)	5.2
- Diabetes mellitus (%)	2.3
- Rheumatoid arthritis (%)	1.6
- Chronic kidney disease	
• Mild (%)	3.9
• Moderate (%)	0.4
• Severe (%)	0

Normally distributed data are shown as mean and standard deviation (SD), skewed distributed data are shown as median (25th and 75th percentiles) and categorical data shown as percentage
BMI: body mass index, CVD: cardiovascular disease, COPD: chronic obstructive pulmonary disease
*Normal waist circumference: men ≤ 94 cm, women ≤ 80 cm, increased waist circumference: men >94 - 102 cm, women >80 - 88 cm, substantially increased waist circumference: men > 102 cm, women > 88 cm
Missing values: ethnicity n=5, educational level n=34, follow-up n=59, pre-existing CVD=6, family history of premature CVD n=506, suspected hereditary dyslipidaemia n=2, elevated blood pressure n=1, elevated cholesterol concentrations n=1, smoking status n=2, COPD n=3, diabetes mellitus n=59, rheumatoid arthritis n=1, chronic kidney disease n=29



Supplemental figure 1 Proportion of recorded waist circumferences within a recorded body mass index value of n=676,708 electronic health records of Dutch general practitioners between 2007 and 2023*
* n=1,546,777 body mass index between 17 and 50 kg/m² were recorded and n=128,623 waist circumferences were recorded on the same date as a recorded body mass index

Supplemental file 1 Definitions of the different risk factors in the NEO study, collected at baseline

Obesity: body mass index 30 ≥ kg/m^2
Increased blood pressure: systolic blood pressure >140mmHg
Severely increased blood pressure: systolic blood pressure >180mmHg
Increased cholesterol levels: total cholesterol/HDL cholesterol ratio >5 mmol/L
Chronic kidney disease: estimated glomerular filtration rate (eGFR) <60 ml/min/1,73 m^2 and/or albumin-creatinine ratio (ACR) ≥ 3 mg/mmol divided into:

- Mild chronic kidney disease: eGFR ≥60ml/min/1,73 m^2 with ACR 3-30 mg/mmol, or eGFR 45-59 ml/min/1.73 m^2 with ACR
- Moderate chronic kidney diseases: eGFR 30-44 ml/min/1.73 m^2 with ACR <3 mg/mmol, or eGFR 45-59 ml/min/1.73 m^2 with ACR 3-30 mg/mmol, or eGFR ≥60 ml/min/1.73 m^2 with ACR >30 mg/mmol
- Severe chronic kidney disease: eGFR <29 ml/min/1.73 m^2, or eGFR 30-44 mL/min/1.73 m^2 with ACR 3-30 mg/mmol, or eGFR 45-59 mL/min/1.73 m^2 with ACR >30 mg/mmol

Plasma creatinine was used to calculate the estimated glomerular filtration rate using Modification of Diet in Renal Disease and was given in ml/min/1,73m^2 (1).
Suspected hereditary dyslipidemia: total cholesterol>8 mmol/L or low-density lipoprotein (LDL) cholesterol>5mmol/L (2). LDL cholesterol was calculated using Friedewald formula using triglyceride, total cholesterol and high-density lipoprotein concentrations (3).
Diagnosed hereditary dyslipidemia: Not reported at baseline, therefore we defined individuals with diagnosed hereditary dyslipidemia as suspected hereditary dyslipidemia.
Family history of premature cardiovascular disease (CVD): self-reported. Siblings and parents were reported as first-degree family members. The age of CVD of the family members was divided into age-groups defined as: < 50 years, 50-60 years, 60-70 years and > 70 years. For selecting the population eligible for cardiovascular risk assessment, the number of first-degree relatives with a history of CVD under 55 years for men and under 65 years for women was needed. We assumed Individuals had a first-degree male relative under 55 years if they reported at least one first-degree male relative under 60 years and a first-degree female relative under 65 years if they reported at least one first-degree female relative under 70 years.
Type I diabetes mellitus or type II diabetes mellitus: based on the use of anti-diabetic drugs or self-reported diabetes.
Active smoking status: self-reported current smoker.
Rheumatoid arthritis: self-reported rheumatoid arthritis.
Chronic obstructive pulmonary disease: self-reported lung emphysema or chronic bronchitis.

Pre-existing CVD: self-reported myocardial infarction, angina, congestive heart failure, stroke, or peripheral vascular disease.

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Supplemental file 2 Categorization of predicted cardiovascular risks according to the guideline cardiovascular risk management of the Dutch College of General Practitioners (NHG)

Low Risk:

Age <50 years: predicted cardiovascular risk score <2.5%

Age 50–69 years: predicted cardiovascular risk score <5%

Intermediate Risk:

Age <50 years: predicted cardiovascular risk score 2.5–7.5%

Age 50–69 years: predicted cardiovascular risk score 5–10%

Age ≥70 years: predicted cardiovascular risk score <15%

High Risk:

Age <50 years: predicted cardiovascular risk score ≥7.5%

Age 50–69 years: predicted cardiovascular risk score ≥10%

Age ≥70 years: predicted cardiovascular risk score ≥15%

Supplemental file 3 Ascertainment of cardiovascular diseases in the NEO study

New diagnoses of cardiovascular disease (CVD) were extracted between October 2017 and July 2018 from the electronic medical records of the general practitioner (GP) of the participants. These records cover all medical information of the patients regarding GP consultations, prescriptions, and reports from laboratories and specialist visits available at the GP office.

Data extraction was performed based on three criteria: (1) the diagnostic coding by the GPs to indicate the health problems or type of care, based on the International Classification of Primary Care (ICPC) (1), (2) finding of predefined CVD-related keywords, and (3) prescription of specific medication, registered according to the Anatomical Therapeutic Chemical (ATC) codes or by screening medication names (2). The date of diagnosis was defined as the date of an ICPC-coded diagnosis, a strong indication for the diagnosis based on keywords in the medical records, or prescription of relevant medication.

In case only a keyword was found without a confirmed ICPC code, laboratory results and the free text in the medical records were checked. These findings were discussed by the NEO study adjudication committee to decide on a diagnosis. If the diagnosis remained uncertain, the GP of the participants was contacted to confirm the date and diagnosis. A diagnosis was considered incident when the first date of diagnosis occurred after the baseline visit date.

In the present analysis, CVD was defined as a diagnosis of myocardial infarction (ICPC Code: K75 or K76.02), transient ischemic attack (K89), and stroke/cerebrovascular accident (K90 or its subtypes: K90.01, subarachnoid haemorrhage; K90.02, intracerebellar haemorrhage; or K90.03, cerebral infarction). Keywords included synonyms of myocardial infarction, chest pain, cardiovascular surgery procedures such as coronary artery bypass grafting (CABG) or angioplasty, and synonyms of cerebrovascular accident or haemorrhage. The medication list of participants was checked for the use of specific anticoagulants.

1. Dutch College of General Practitioners. ICPC. https://www.nhg.org/themas/artikelen/icpc.
2. World Health Organization. Anatomical Therapeutic Chemical (ATC) Classification https://www.who.int/tools/atc-ddd-toolkit/atc-classification.