*BJGP OPEN*

# Blood pressure and cholesterol measurements in primary care: cross-sectional analyses in a dynamic cohort

de Boer, Annemarijn; Hollander, Monika; van Dis, Ineke; Visseren, Frank L.J.; Bots, Michiel L; Vaartjes, Ilonca

DOI: https://doi.org/10.3399/BJGPO.2021.0131

To access the most recent version of this article, please click the DOI URL in the line above.

Received 20 July 2021
Revised 19 October 2021
Accepted 22 October 2021

**Blood pressure and cholesterol measurements in primary care: cross-sectional analyses in a dynamic cohort**

*Authors: Annemarijn R. de Boer[1,2], Monika Hollander[1], Ineke van Dis[2], Frank L.J. Visseren[3], Michiel L. Bots[1], Ilonca Vaartjes[1,2]*

Affiliations:

1. Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands
2. Dutch Heart Foundation, The Hague, the Netherlands
3. Department of Vascular Medicine, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands

Corresponding author: Annemarijn R. de Boer, MD, Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Heidelberglaan 100, 3584 CX, Utrecht, the Netherlands. E-mail: a.r.deboer-9@umcutrecht.nl. Fax number: 088 75 68099.

**Abstract**

**Background** Guidelines on cardiovascular risk management (CVRM) recommend blood pressure (BP) and cholesterol measurements every five years in men ≥40 and (post-menopausal) women ≥50 years.

**Aim** Evaluate CVRM guideline implementation.

**Design and Setting** Cross-sectional analyses in a dynamic cohort using primary care electronic health record (EHR) data from the Julius General Practitioners' Network (n=388,929).

**Method** We assessed trends (2008-2018) in the proportion of patients with at least one measurement (BP and cholesterol) every one, two, and five years, in those with a history of (1) cardiovascular disease (CVD) and diabetes, (2) diabetes only, (3) CVD only, (4) cardiovascular risk assessment (CRA) indication based on other medical history, or (5) no CRA indication. We evaluated trends over time using logistic regression mixed model analyses.

**Results** Trends in annual BP and cholesterol measurement increased for patients with a history of CVD from 37.0% to 48.4% (p< 0.001) and 25.8% to 40.2% (p<0.001). In the five-year window 2014-2018, BP and cholesterol measurements were performed in respectively 78.5% and 74.1% of all men ≥40 years and 82.2% and 78.5% in all women ≥50 years. Least measured were patients without a CRA indication: men 60.2% and 62.4%; women 55.5% and 59.3%.

**Conclusion** The fairly high frequency of CVRM measurements available in the EHR of patients in primary care suggests an adequate implementation of the CVRM guideline. As nearly all individuals visit the general practitioner once within a five-year time window, improvement of CVRM remains very well possible, especially in those without a CRA indication.

Keywords: Electronic health record data, CVRM guideline, general practice, blood pressure, cholesterol, trends

**How this fits in**

Guidelines on cardiovascular risk management recommend blood pressure and cholesterol measurements every five years in men ≥40 and (post-menopausal) women ≥50 years. This study shows that a majority of these men and women (74%-82%) receive these measurements in primary care. Patients without an indication for cardiovascular risk assessment except age were least often measured (55%-62%). As nearly all individuals visit the general practitioner once within a five-year time window, improvement of CVRM remains very well possible, especially in those without a CRA indication.

**Introduction**

Cardiovascular disease (CVD) is the leading cause of disability and death in the world.[1-3] Potentially, a large proportion of CVD can be prevented by controlling modifiable risk factors such as elevated blood pressure (BP), raised cholesterol, smoking, or obesity.[4]

Guidelines on cardiovascular risk management (CVRM) were introduced to improve detection and treatment of patients with already established CVD and those at high risk of CVD.[5-8] Decisions about initiating treatment are, among other things, made on the basis of an individual patient' cardiovascular risk, often expressed as 10-year risk of developing a (non-fatal or) fatal CVD. To monitor cardiovascular risk, guidelines advice to perform regular cardiovascular risk assessment (CRA), which includes the measurement of two important CVD risk factors: BP and cholesterol.[5-8] Evidence regarding the optimal frequency of BP and cholesterol measurements for CVRM is still inconclusive, illustrated by the variation in text among the various guidelines regarding this topic, sometimes only expressed as 'regularly'.[5-9] The most recent revision of the Dutch CVRM guideline in 2019, endorsed by both general practitioners (GPs) and medical specialists, suggests to perform a CRA every five years in all men ≥40 and all postmenopausal women or women ≥50 years of age.[10] Up until 2019, although the guideline specified the population in which a CRA should be performed, the frequency of this assessment was not defined.[11-13]

Given this change in recommendation, we aimed to evaluate the implementation of the CVRM guideline up to 2018 and formulate in which patients improvement may be considered given the 2019 guideline, when appropriate. We propose to do this by assessing temporal trends in BP and cholesterol measurements in primary care using routine electronic health record (EHR) data in patients with and without an indication for CRA.

## Methods

*Data source and study design*

Data were obtained from the Julius General Practitioners' Network (JGPN) database. The database contains routine clinical care data anonymously extracted from structured fields within the EHRs from all patients registered in 72 general practices from the city of Utrecht and it's vicinity in the Netherlands.[14] The JGPN can be seen as a dynamic cohort, since the membership of the cohort is not fixed. Patients can enter the JGPN cohort by being born or moving to the catchment area of one of the JGPN general practices, or leave the cohort by dying or moving away. In the Netherlands, all inhabitants (except elderly people dwelling in nursing homes) are obliged to register at a general practice and have access to health care, since health care insurance is mandatory. GPs act as gatekeepers to hospital care and play a key role in CVRM. The JGPN population is considered representative of the Dutch population with regard to sex and age.[14]

*Study population*

We included all patients ≥18 years of age registered at one of the affiliated general practices of the JGPN between January 1st 2008 and December 31st 2018 who contributed at least one calendar year to the database.

*Outcome measures*

For both BP and cholesterol, we defined for each study year all patients as 'measured' or 'not measured'. A patient was defined as 'measured' for BP if that patient had at least one registered systolic or diastolic BP measurement during that study year. A patient was defined as 'measured' for cholesterol if that patient had at least one registered measurement of either LDL, HDL, total cholesterol, triglycerides, or total cholesterol/HDL ratio during that study year. If patients had multiple registered measurements in a year, we included the first measurement in the analyses.

*Determinants*

Information about sex, age, medical history, and antihypertensive or lipid lowering medication use was extracted from the EHR for each patient. Medical history was defined based on the International Classification of disease in Primary Care (ICPC) codes (Supplementary Table 1). Medication use was classified according to Anatomical Therapeutic Chemical (ATC) Classification System.

We classified each patient into one of five categories based on medical history: 1. History of CVD and diabetes; 2. History of diabetes without CVD; 3. History of CVD without diabetes; 4. CRA indicated on the basis of other medical history; 5. No CRA indicated. Since patients with diabetes most commonly receive 3-monthly check-ups within primary care as part of a disease management programme in the

Netherlands including BP measurement, we analysed patients with diabetes as a separate group. Patients were classified as having a history of CVD based on the definition of CVD mentioned in the CVRM guideline used in primary care in the Netherlands between 2012 and 2019: myocardial infarction, angina pectoris, heart failure, stroke/cerebrovascular accident, transient ischemic attack, peripheral arterial disease, aortic aneurysm.[12] The 'CRA indicated' category was defined on the basis of the 2012 CVRM guideline and encompassed patients with certain medical history and characteristics on the basis of which they were suspected to be at high cardiovascular risk and in which the guideline recommends regular CRA: rheumatoid arthritis, pre-eclampsia, pregnancy induced diabetes, family history of CVD, obesity, smoking, hypertension, dyslipidaemia, chronic kidney disease, and use of antihypertensive or lipid lowering medication (Supplementary Table 2). If patients could not be classified into category 1-4 they were categorized as 'No CRA indicated'.

*Statistical analyses*

First, we described for every other year the characteristics of the study population.

Second, to analyse trends over time, proportion of men and women with a registered measurement (BP and cholesterol separately) were calculated for each year of the study period. We stratified for the five categories of medical history, sex, and the following age categories: 18-39, 40-49, 50-59, 60-69, and 70 years and older. Next, we calculated the proportion of men and women with a registered measurement at least once in two years and once in five years. Only patients who respectively contributed a consecutive two and consecutive five calendar years to the database were included. To investigate whether trends over time were statistically significant, we performed logistic regression mixed model analyses with random effects for time (in years) and general practice to account for clustering. To adjust for possible confounding we added age and sex to the model. Time and age were standardized and the optimizer 'Neal-Head' from the R package 'lme4' was used to allow for model convergence.[15] To investigate differences in temporal trends between the five categories of medical history, we added an interaction term between time and category of medical history to the model (reference group: no CRA indicated). If significant, we performed a stratified analysis for each category of medical history to investigate whether trends over time in these subgroups were statistically significant. We used the likelihood ratio test to compute p-values. A two sided p value $<0.05$ was deemed statistically significant.

Third, to evaluate the new recommendation of the 2019 CVRM guideline we calculated the percentages of all men ≥40 and women ≥50 years of age with at least one measurement between 2014-2018 and stratified for category of medical history.

All analyses and visualizations were performed in R Statistical Software version 4.3, Foundation for Statistical Computing, Vienna, Austria.[16]

*Privacy and ethics procedures*

Research with data from the Julius GP Network is observational and non-interventional, data used consists of non-identifiable no identifiable information. Therefore, according to Dutch laws on privacy and research on human subjedts (WMO) The Medical Ethics Committees in the Netherlands do not rank our research as subject to the WMO conditions. Researchers need to conform to privacy legislation.(14)

**Results**

Between January 1st 2008 and December 31st 2018, 388,929 patients ≥18 years of age were registered within the JGPN database with a total of 2,271,084 observed patient years (median follow-up time 5 years, IQR 2-9 years). Table 1 presents characteristics of the studies population.

*Trends in measurements*

For both BP and cholesterol measurements, the proportion of men and women (≥18 years of age) with a registered measurement increased between 2008 and 2018 from respectively 12.4% to 17.8% and 11.1% to 15.4% in men and 15.5% to 20.6% and 12.1% to 16.1% in women (Supplementary Figure 1). Consistently, a registered measurement was more common in women than in men, and a registered BP measurement was more commonly performed than a cholesterol measurement (Supplementary Figure 1).

Older individuals, irrespective of medical history, more often had a measurement compared to younger individuals. Furthermore, in older individuals the largest increase in proportion of patients with an annual registered measurement over time was seen (Supplementary Figure 2).

Across all disease groups, there is a clear age effect seen: the proportion of annual measurements is much lower, despite though a clear indication, such as diabetes or CVD or the combination, among those at younger age groups (Figure 1 and Figure 2).

Results based on subgroups are presented in Table 2. In patients with a clear disease entity (CVD, diabetes) the proportion of patients with an annual measurement and measurements every two years has significantly increased (Figure 3, Supplementary Figure 3). A significant increase for measurements every 5 years was seen in patients with CVD, in patients with an indication for CRA the trend decreased (Supplementary Figure 4).

*Evaluation of the 2019 CVRM guideline*

In the five years between 2014-2018, 78.5% of men of ≥40 years received at least one BP measurement and 74.1% at least one cholesterol measurement, for women this was 82.2% and 78.5%. Figure 4 shows the percentage measured patients stratified for category of medical history. The percentage measured patients was highest in patients with diabetes, and lowest in those without an indication for CRA.

## Discussion

### *Summary*

Overall, the proportion of individuals in primary care with a BP and a cholesterol measurement has increased between 2008 and 2018. This occurred in men and women, especially in those of ≥50 years. Furthermore, it increased in those groups of patients in which the prevailing guidelines recommended doing so. In the subgroup with a CRA indication but without a clear disease entity (CVD, diabetes) no change was observed between 2008-2018. Importantly, over 80% of men ≥40 and women ≥50 years with a CRA indication in general practice had at least one BP and/or cholesterol measurement taken in a five year period. Moreover, around 50-60% of those without any indication had these measurements done.

### *Strengths and limitations*

The strengths of the present study are the large dynamic cohort with comprehensive data representative of routine clinical care. Some aspects need consideration before the interpretation of the results. A limitation that is inherent to using EHR data is that the quality of the data depends on the registration by the GP. Misclassification of patients into one of the five categories of medical history could have occurred when medical history was not properly registered. This would most likely work in a direction that absence of a disease is not registered, and thus individuals are assigned to the 'no indication' category. Please note that for this study we only used data registered within fixed fields of the EHRs, but not those in the free text fields. Since physicians sometimes write BP measurement results in free text fields, this could have led to an underestimation of the proportion of patients with a BP measurement. Cholesterol is only registered in fixed field data. Since trends in BP and cholesterol measurements were very similar, we do not expect this underestimation to have influenced trends in BP measurements. Furthermore, we did not have access to CRA data performed in secondary care. It is possible for a medical specialist to be responsible for CVRM in a patient instead of the GP, especially in patients with a history of CVD treated by a cardiologist, or individuals at a younger age with a risk condition. It therefore may be that we underestimated the proportion of patients with a measurement, assuming that these measurements are performed in secondary care. Lastly, this study was set in a country with an organized healthcare system and mandatory healthcare insurance, which limits the generalizability of our results to countries with a different healthcare structure. The present paper does not address the levels of the measured risk factors. Although that might be seen as a limitation, its absence does not affect the findings we report on implementation of the first part of the CVRM guideline: obtaining the information.

### *Comparison with existing literature*

In the present study we found an increase between 2008 and 2018 in the proportions of patients with an annual BP and cholesterol measurements for patients with diabetes and/or CVD. Similar trends have been described in other studies situated in the Netherlands[17], New Zealand[18], Australia[19], and the UK[20]. A likely explanation for these increasing trends is the growing awareness for primary and secondary prevention as well as the growing target population for CRA with every CVRM guideline update.[10-12] We expand the evidence by showing that assessment of BP and cholesterol with risk indicated disease groups seems to strongly vary by age. Potentially, such a finding might point towards CVRM control in secondary care, particularly, but the finding clearly warrants further validation.

*Implications for practice*

The most recent revision of the Dutch CVRM guideline in 2019 recommends CRA in a large population by suggesting to perform CRA every 5 years in all men ≥40 and postmenopausal women or women ≥50 years, but does not clearly state who is responsible for carrying out these recommendations.[10] We showed that in routine general practice in the Utrecht area in the Netherlands between 81-97% of men ≥40 and women ≥50 years with diabetes and/or CVD or another indication for regular CRA were measured in five years, while patients without an indication were less often measured: between the 56 and 63%. In the Netherlands, no national organized systematic screening program is implemented to detect patients at high cardiovascular risk. At present, most practices use an opportunistic screening approach, which depends on the patient visiting the GP practice, on the GP remembering that the patients should receive such an assessment, and on available time during the consultation. We show that usual general practice care already yields a substantial amount of the targeted population. One approach to further improve CVRM in primary care could be to implement a systematic screening program. A recent study into the effect of a selective cardiometabolic prevention program showed that an approach with proactively inviting individuals to come for CVRM screening on top of the opportunistic screening at the GP office was (not cost-) effective.[21] The participation rate in this study was 41%[22] and the most reported reasons for non-response were 'forgot/no time' or feeling no need for a test.[23] Selective non-response is a major problem in the implementation and effectiveness of screening programs in general. The NHS health check, a CRA program in the UK has participation between 32.7%-47.0%, while they anticipated a rate of 75%.[24-26]

Rather than inviting people, is to make the opportunistic screening approach more efficient. In the Netherlands, 75% of people visits the GP at least once a year, and this percentage is higher for patients of older age.[27, 28] If these patients were to be measured during these visits irrespective of the reason of their visit, reaching the goal of measuring all men over 40 and women over 50 once

every five years would be more attainable. Such a change should be proposed in close collaboration with GPs, and must meet preconditions such as a fair compensation and a manageable workload. To support GPs in identifying patients in whom risk factor measurements are indicated, electronic decision support tools have shown to improve risk factor measurement.[29] Furthermore, the use of benchmarks can facilitate dialogue between practices to learn from each other's approaches and subsequently improve upon certain indicators for health and diminish variation between practices, as has been shown by a regional initiative in the Netherlands.[30]

In conclusion, the fairly high frequency of CVRM measurements available in the EHR of patients in primary care suggests an adequate implementation of the CVRM guideline. As nearly all individuals visit the general practitioner once within a five-year time window, improvement of CVRM remains very well possible, especially in those without a CRA indication.

**Funding**

A.R. de Boer and I. Vaartjes are supported by the 'Facts and Figures' grant from the Dutch Heart Foundation. This study has in part been made possible by a grant from the Netherlands Organization for Health Research and Development (#555003011).

**Competing interests**

The authors have nothing to disclose.

**References**


[1] 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.

[2] GBD 2017 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392:1859-922.

[3] World Health Organisation. The top 10 causes of death. [Internet]. Available from: https://www.who.int/en/news-room/fact-sheets/detail/the-top-10-causes-of-death. [Accessed 10-06-2020].

[4] Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364:937-52.

[5] Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, Catapano AL, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts)Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). Eur Heart J. 2016;37:2315-81.

[6] Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation. 2019;140:e596-e646.

[7] National Institute for Health and Care Excellence. Cardiovascular disease: risk assessment and reduction, including lipid modification. [Internet]. Available from: https://www.nice.org.uk/guidance/cg181. [Accessed 07-01-2021].

[8] National Vascular Disease Prevention Allicance. Guidelines for the management of absolute cardiovascular disease risk. 2012.

[9] Piper MA EC, Burda BU, Margolis KL, O'Connor E, Smith N, Webber E, Perdue LA, Bigler KD, Whitlock EP. *Screening for high blood pressure in adults: a systematic evidence review for the U.S. Preventive Services Task Force*. Report no. 13-05194-EF-1, 2014.

[10] Federatie voor Medisch Specialisten; Richtlijnendatabase. Cardiovasculair risicomanagement (CVRM) Derde herziening. [Internet]. Available from: https://richtlijnendatabase.nl/richtlijn/cardiovasculair_risicomanagement_cvrm/samenvatting_cvrm.html. [Accessed 06-07-2020].

[11] Stalman WAB, Stehouwer CDA and werkgroep cardiovasculair risico. Multidisciplinaire richtlijn Cardiovasculair risicomanagement. 2006.

[12] The NHG-guideline Cardiovascular risk management (first update). Huisarts Wet. 2012;55:14-28.

[13] Smulders YM, Burgers JS, Scheltens T, van Hout BA, Wiersma T, Simoons ML, et al. Clinical practice guideline for cardiovascular risk management in the Netherlands. Neth J Med. 2008;66:169-74.

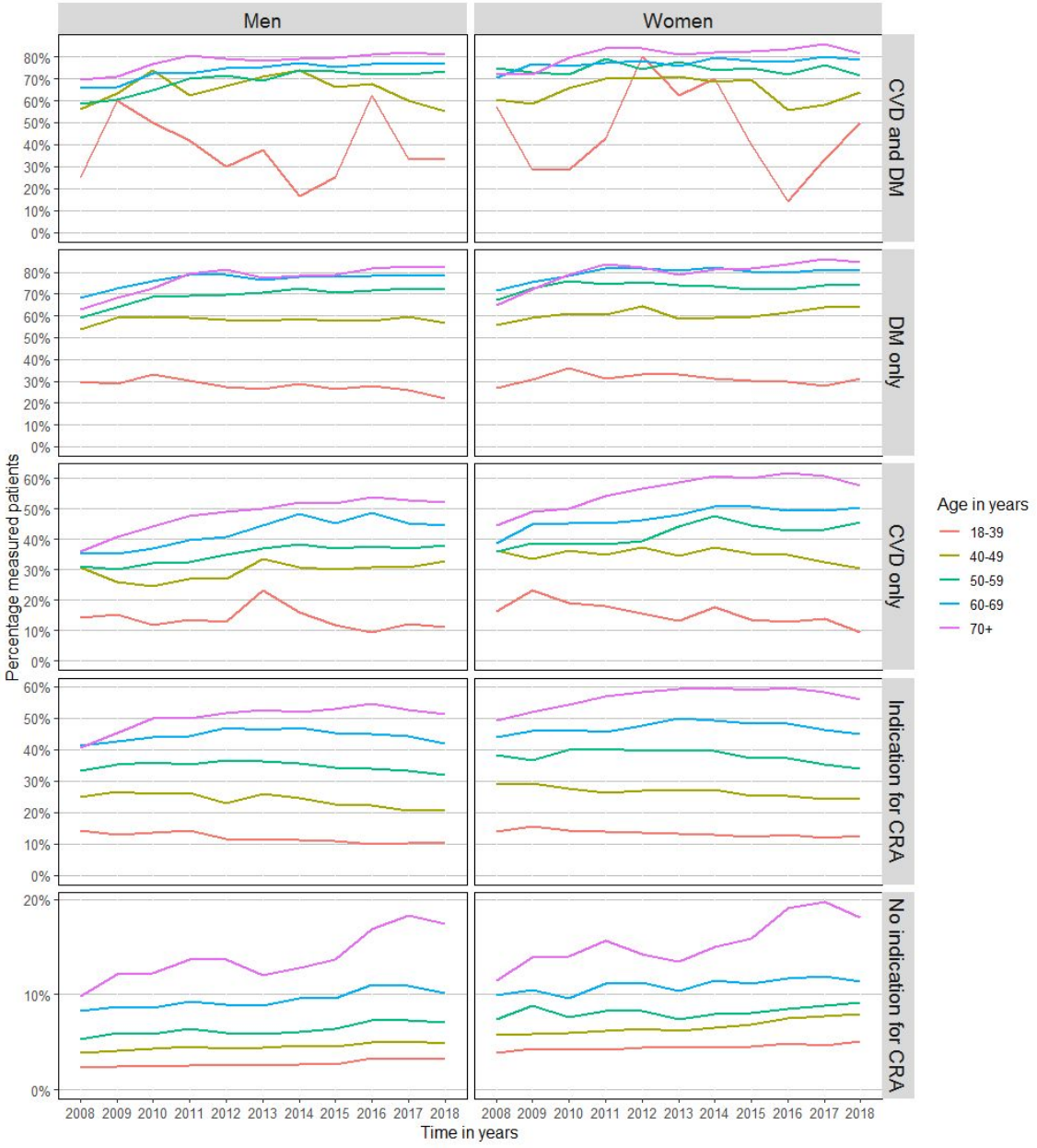
[14] Smeets HM, Kortekaas MF, Rutten FH, Bots ML, van der Kraan W, Daggelders G, et al. Routine primary care data for scientific research, quality of care programs and educational purposes: the Julius General Practitioners' Network (JGPN). BMC Health Serv Res. 2018;18:735.

[15] Bates D, Mächler M, Bolker B and S. W. Fitting Linear Mixed-Effects Models Using lme4. J Stat Softw. 2015;67:1-48.

[16] R Core Team. R: A language and environmental for statistical computing. Vienna, Austria: R Foundation for Statistical Computing, 2018.

[17] Bartholomeeusen S, Vandenbroucke JP, Truyers C and Buntinx F. Trends in total cholesterol screening and in prescribing lipid-lowering drugs in general practice in the period 1994-2003. BMC Fam Pract. 2008;9:39.
[18] Exeter DJ, Moss L, Zhao J, Kyle C, Riddell T, Jackson R, et al. The distribution and frequency of blood lipid testing by sociodemographic status among adults in Auckland, New Zealand. J Prim Health Care. 2015;7:182-91.
[19] Staff M, Roberts C and March L. The completeness of electronic medical record data for patients with Type 2 Diabetes in primary care and its implications for computer modelling of predicted clinical outcomes. Prim Care Diabetes. 2016;10:352-9.
[20] Ravindrarajah R, Dregan A, Hazra NC, Hamada S, Jackson SHD and Gulliford MC. Declining blood pressure and intensification of blood pressure management among people over 80 years: cohort study using electronic health records. J Hypertens. 2017;35:1276-82.
[21] Stol DM, Badenbroek IF, Hollander M, Nielen MMJ, Kraaijenhagen RA, Schellevis FG, et al. Effectiveness of a stepwise cardiometabolic disease prevention program: Results of a randomized controlled trial in primary care. Prev Med. 2020;132:105984.
[22] Stol DM, Hollander M, Badenbroek IF, Nielen MMJ, Schellevis FG and de Wit NJ. Uptake and detection rate of a stepwise cardiometabolic disease detection program in primary care-a cohort study. Eur J Public Health. 2020;30:479-84.
[23] Badenbroek IF, Nielen MMJ, Hollander M, Stol DM, Drijkoningen AE, Kraaijenhagen RA, et al. Mapping non-response in a prevention program for cardiometabolic diseases in primary care: How to improve participation? Prev Med Rep. 2020;19:101092.
[24] Dalton AR, Bottle A, Okoro C, Majeed A and Millett C. Uptake of the NHS Health Checks programme in a deprived, culturally diverse setting: cross-sectional study. J Public Health (Oxf). 2011;33:422-9.
[25] Artac M, Dalton AR, Majeed A, Car J, Huckvale K and Millett C. Uptake of the NHS Health Check programme in an urban setting. Fam Pract. 2013;30:426-35.
[26] Public Health England. Public Health Profiles. Corrections to NHS Health Check 2019-20 Quarter 1,2, and 3. [Internet]. Available from: https://fingertips.phe.org.uk. [Accessed 06-11-2020].
[27] Van der Linden MW WG, de Bakker DH, Schellevis FG. *Tweede Nationale Studie naar ziekten en de verrichtingen in de huisartspraktijk. Klachten en aandoeningen in bevolking en in de huisartspraktijk*. 2004. Utrecht/Bilthoven: NIVEL/RIVM.
[28] Central Bureau of Statistics. Ongeveer drie kwart bezoekt jaarlijks huisarts en tandarts. [Internet]. Available from: https://www.cbs.nl/nl-nl/nieuws/2013/27/ongeveer-drie-kwart-bezoekt-jaarlijks-huisarts-en-tandarts. [Accessed 22-03-2021].
[29] Peiris D, Usherwood T, Panaretto K, Harris M, Hunt J, Redfern J, et al. Effect of a computer-guided, quality improvement program for cardiovascular disease risk management in primary health care: the treatment of cardiovascular risk using electronic decision support cluster-randomized trial. Circ Cardiovasc Qual Outcomes. 2015;8:87-95.
[30] Willems N RA, Smits G. Verminderen van praktijkvariatie in de eerste lijn. Huisarts Wet. 2017;60:580-3.

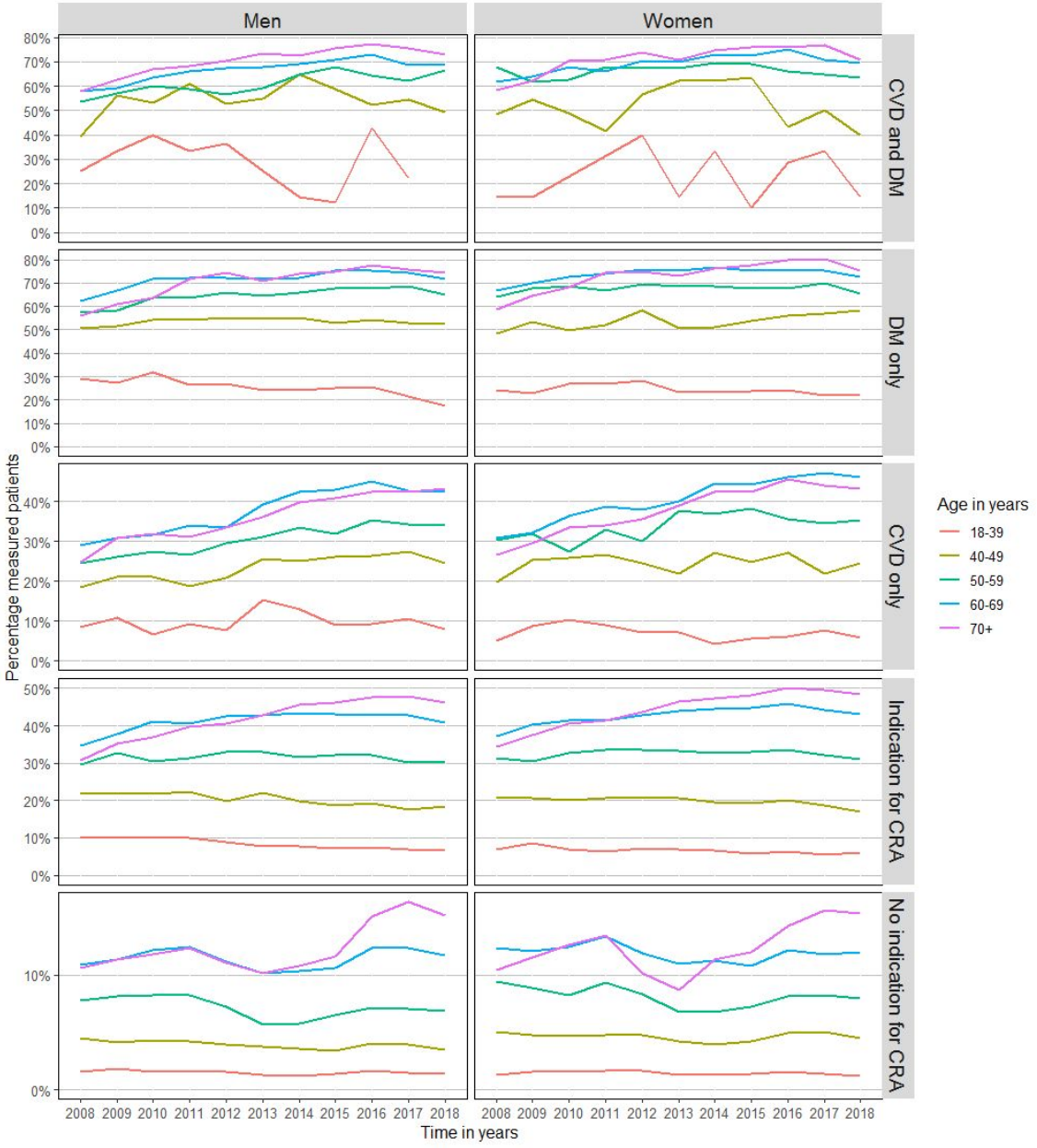
**Figure 2** Sex and age stratified trends in annual blood pressure measurement in patients with a history of CVD, diabetes mellitus, indication for CRA* or without an indication for CRA




*Abbreviations: CVD = cardiovascular disease; DM = diabetes mellitus; CRA = cardiovascular risk assessment*

**Patients were classified as 'Indication for CRA' if they did not have a history of cardiovascular disease or diabetes mellitus, but did have a history of one of the following: rheumatoid arthritis, pre-eclampsia, pregnancy induced diabetes, family history of cardiovascular disease, obesity, smoking, hypertension, dyslipidemia, chronic kidney disease, use of antihypertensive or lipid lowering medication.*

**Figure 3** Sex and age stratified trends in annual cholesterol measurement in patients with a history of CVD, diabetes mellitus, indication for CRA* or without an indication for CRA




*Abbreviations: CVD = cardiovascular disease; DM = diabetes mellitus; CRA = cardiovascular risk assessment*

**Patients were classified as 'Indication for CRA' if they did not have a history of cardiovascular disease or diabetes mellitus, but did have a history of one of the following: rheumatoid arthritis, pre-eclampsia, pregnancy induced diabetes, family history of cardiovascular disease, obesity, smoking, hypertension, dyslipidemia, chronic kidney disease, use of antihypertensive or lipid lowering medication.*

**Table 1 Baseline characteristics of studied population**

| | 2008<br>n = 158,916 | 2010<br>n = 169,178 | 2012<br>n = 188,073 | 2014<br>n = 244,390 | 2016<br>n = 261,283 | 2018<br>n = 190,528 |
|---|---|---|---|---|---|---|
| Men, n (%) | 75,694 (47.6) | 80,777 (47.7) | 89,986 (47.8) | 117,063 (47.9) | 125,514 (48.0) | 92,078 (48.3) |
| Age, mean (sd) | 45.5 (17.1) | 45.7 (17.2) | 46.1 (17.3) | 46.4 (17.6) | 46.2 (17.6) | 46.2 (17.8) |
| Previous cardiovascular disease, n (%) | 9,394 (5.9) | 11,255 (6.7) | 13,226 (7.0) | 16,965 (6.9) | 18,974 (7.3) | 13,852 (7.3) |
| Diabetes mellitus, n (%) | 8,976 (5.6) | 10,640 (6.3) | 12,345 (6.6) | 15,766 (6.5) | 17,478 (6.7) | 12,786 (6.7) |
| Cardiovascular disease and diabetes mellitus, n (%) | 2,205 (1.4) | 2,846 (1.7) | 3,460 (1.8) | 4,553 (1.9) | 5,188 (2.0) | 3,732 (2.0) |
| Cardiovascular risk assessment indication*, n (%) | 25,355 (16.0) | 32,054 (18.9) | 39,882 (21.2) | 53,391 (21.8) | 61,000 (23.3) | 45,759 (24.0) |

**Patients were classified as 'Cardiovascular risk assessment indication' if they had no history of cardiovascular disease or diabetes, but did have a history of one of the following: rheumatoid arthritis, pre-eclampsia, pregnancy induced diabetes, family history of cardiovascular disease, obesity, smoking, hypertension, dyslipidemia, chronic kidney disease, use of antihypertensive or lipid lowering medication.*

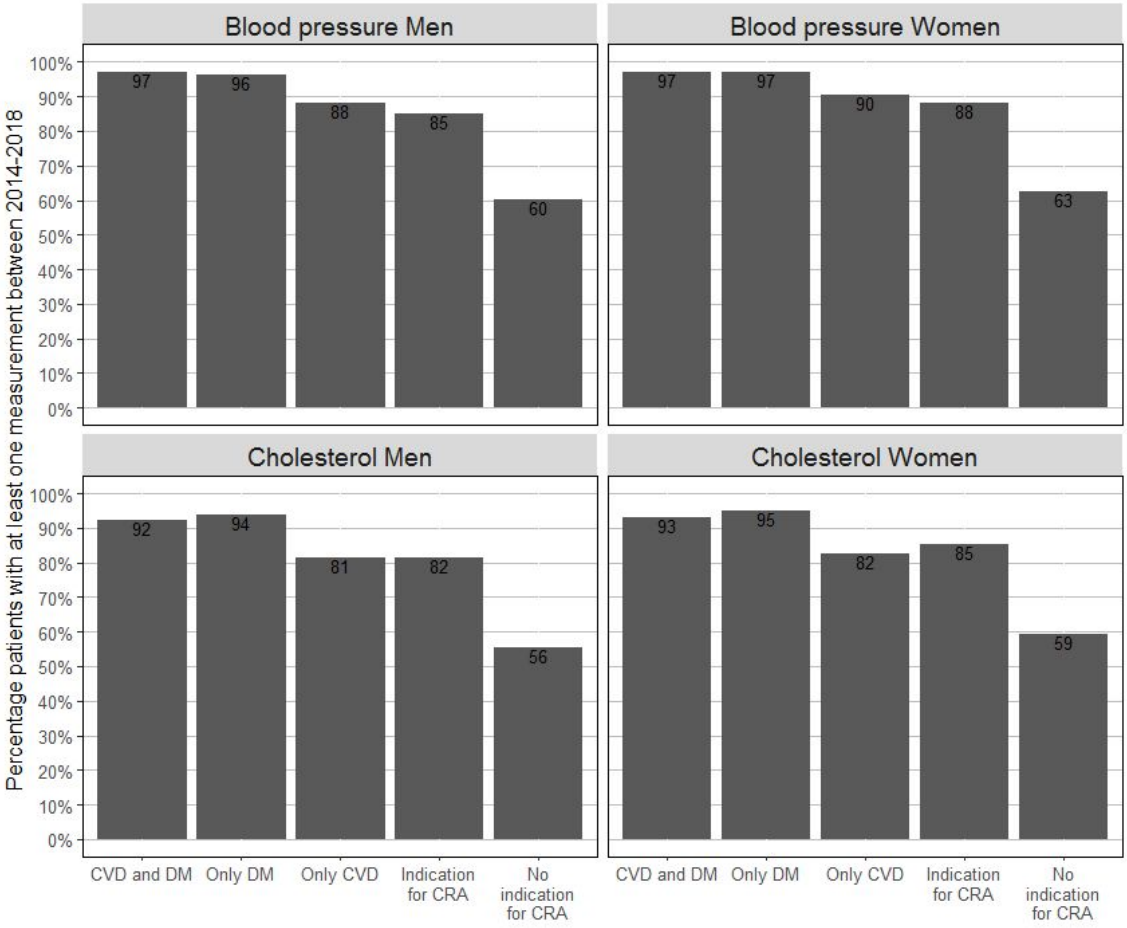
**Table 2 Trends in blood pressure and cholesterol measurements between 2008 and 2018**

| Annual measurements (2008 and 2018) | | |
|---|---|---|
| | Blood pressure | Cholesterol |
| CVD and diabetes | 68.5%-78.7% (p<0.001) | 57.9%-69.6% (p<0.001) |
| Diabetes only | 61.5%-73.3% (p=0.002) | 56.8%-65.8% (p=0.001) |
| CVD only | 37.0%-48.4% (p<0.001) | 25.8%-40.2% (p<0.001) |
| Indication for CRA | 33.0%-31.9% (p=0.37) | 25.7%-27.7% (p=0.43) |
| No indication for CRA | 4.7%-6.2% (p=0.034) | 4.3%-3.9% (p=0.53) |
| **Measurements every two years (2009-2010 and 2017-2018)** | | |
| | Blood pressure | Cholesterol |
| CVD and diabetes | 80.8%-87.6% (p<0.001) | 75.9%-82.7% (p<0.001) |
| Diabetes only | 76.2%-82.2% (p=0.006) | 73.2%-79.3% (p<0.001) |
| CVD only | 54.5%-64.2% (p<0.001) | 45.7%-56.8% (p<0.001) |
| Indication for CRA | 47.0%-45.8% (p=0.99) | 41.7%-41.1% (p=0.85) |
| No indication for CRA | 9.2%-11.1% (p=0.36) | 8.0%-7.4% (p=0.12) |
| **Measurements every five years (2009-2013 and 2014-2018)** | | |
| | Blood pressure | Cholesterol |
| CVD and diabetes | 93.2-93.7% (p=0.073) | 88.1-89.1% (p=0.082) |
| Diabetes only | 88.5-88.9% (p=0.65) | 84.8-85.8% (p=0.057) |
| CVD only | 78.6%-81.2% (p<0.001) | 70.6-74.2% (p=0.002) |
| Indication for CRA | 68.5%-66.2% (p=0.023) | 62.7%-60.5% (p=0.009) |
| No indication for CRA | 19.6-22.4% (p=0.10) | 16.3%-16.0% (p=0.12) |

*Abbreviations: CVD = cardiovascular disease; CRA = cardiovascular risk assessment*

**Patients were classified as 'Indication for CRA' if they did not have a history of cardiovascular disease or diabetes mellitus, but did have a history of one of the following: rheumatoid arthritis, pre-eclampsia, pregnancy induced diabetes, family history of cardiovascular disease, obesity, smoking, hypertension, dyslipidemia, chronic kidney disease, use of antihypertensive or lipid lowering medication.*

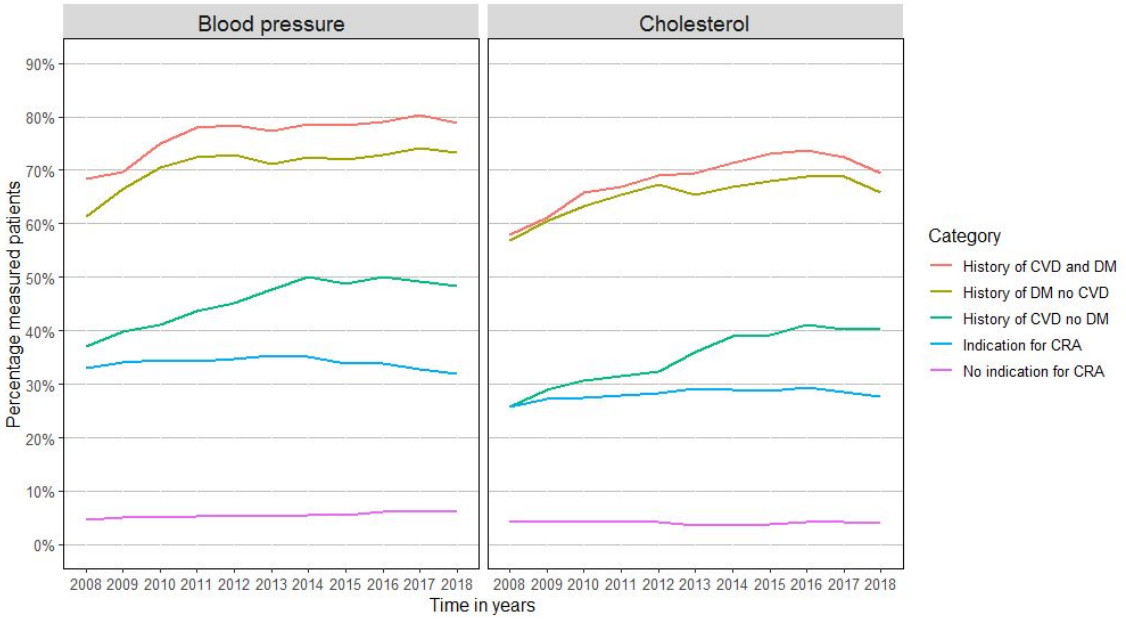
**Figure 4** Men ≥40 and women ≥50 years of age with at least one measurement between 2014-2018




*Abbreviations: CVD = cardiovascular disease; DM = diabetes mellitus; CRA = cardiovascular risk assessment*

**Patients were classified as 'Indication for CRA' if they did not have a history of cardiovascular disease or diabetes mellitus, but did have a history of one of the following: rheumatoid arthritis, pre-eclampsia, pregnancy induced diabetes, family history of cardiovascular disease, obesity, smoking, hypertension, dyslipidemia, chronic kidney disease, use of antihypertensive or lipid lowering medication.*

**Figure 1** Trends in annual blood pressure and cholesterol measurement stratified for medical history




*Abbreviations: CVD = cardiovascular disease; DM = diabetes mellitus; CRA = cardiovascular risk assessment*

**Patients were classified as 'Indication for CRA' if they did not have a history of cardiovascular disease or diabetes mellitus, but did have a history of one of the following: rheumatoid arthritis, pre-eclampsia, pregnancy induced diabetes, family history of cardiovascular disease, obesity, smoking, hypertension, dyslipidemia, chronic kidney disease, use of antihypertensive or lipid lowering medication.*