Evaluation of cardiovascular diseases risk calculators for CVDs prevention and management: scoping review

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Abstract

Background: Cardiovascular diseases (CVDs) are the leading cause of morbidity and mortality globally. This review aimed to summarise evidence on the key features, usability and benefits of CVD risk calculators using digital platforms for CVDs prevention and management in populations.

Methods: We used search engines and thematic analyses to conduct a scoping review. As the reporting guideline for this review, we used Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR).

Results: A total of 17 studies meeting eligibility criteria were included in the analysis, from which about 70% of the studies have prognostic level I (n = 8) and level II (n = 4) evidence. The review found that various guidelines are recommending different algorithms for CVD risk prediction. The QRISK® was the most accurate CVD risk calculator for several study populations, whereas World Health Organization/International Society of Hypertension (WHO/ISH) risk scores were the least accurate. The key features of CVD risk calculators are variables, predictive accuracy, discrimination index, applicability, understandability, and cost-effectiveness.

Conclusion: For the selected risk prediction tool, development and validation research must be done, which considers a mix of stroke-specific risk and CVD risk to establish its usability in the local community and advantages to the particular health-care environment. To get healthcare professionals more involved in preventing and treating CVDs, each healthcare setting should use an online CVD risk assessment tool that is more useful, accurate, and easy to use, based on the population and health system.

Keywords: Cardiovascular diseases, Risk calculator, Risk assessment, CVD risk, Digital health, Population health

Background

Cardiovascular disease (CVD) is the primary cause of illness and deaths globally that contribute to enormous healthcare costs. The prevalence of CVD-related deaths is increased from 12.1 million in 1990 to 18.6 million in 2019 and is estimated to reach 24 million by 2030 [1], which results in considerable financial burdens due to high CVD managing costs and the related loss of income. In 2035, CVD will affect more than 130 million people with a total cost of $1.1 trillion [2].

CVD refers to any disorder that can affect the heart and blood vessels, including coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic
heart disease, congenital heart disease and deep vein thrombosis [3]. Public health strategies to reduce CVD morbidity and mortality consist of population-level risk factor reduction, individual-based primary prevention and secondary prevention and treatment. Population-level strategies focus on decreasing the whole population’s exposure to CVD risk factors across the life course regardless of the CVD risk, focusing on lifestyle factors. CVD risk refers to the risk of suffering fatal or nonfatal CVD events, for example, the risk of myocardial infarction or stroke in the next ten years [4]. Individual-based primary prevention is targeted at high-risk groups to prevent the onset of CVD through risk factor reduction. The secondary prevention and treatment aim at early detection and treatment to prevent disease progression in people with established CVD [5]. CVD treatments resulted in minimal reductions in risk factors [6]. The ‘vertical’ and ‘total’ cardiovascular risk approaches can mitigate individual CVD risks. The ‘vertical’ approach refers to managing a single risk according to predefined thresholds for treatment initiation, with the presence or absence of levels of concomitant risk factors. The World Health Organization (WHO) recommends the ‘total’ cardiovascular risk approach in preventing CVD with consideration of healthcare resources, cost-effectiveness and high-risk groups [4]. The approach deems the individual’s probability of having fatal or nonfatal cardiovascular events in a given estimated period considering the presence of several predicting risk factors rather than a single risk factor [7].

Several risk calculators directly estimate the outcome of Stroke specifically or as a combined outcome of CVD risk, such as Stroke Riskometer™, a unique tool for assessing the specific risk of Stroke and endorsed by the World Stroke Organization [8]. While other risk calculators are developed to assess the individuals’ total CVD risk, the first risk scores were from the Framingham Heart Study (FHS) done in 1976 [9]. The study was based on the western population that may not apply to other populations [10] in developing countries including, Brunei Darussalam.

CVDs such as Ischemic Heart Disease (IHD) and stroke are the top causes of death and significant public health problems in Brunei Darussalam [11]. In 2019, CVDs accounted for 25.5% of all causes of death at an age-standardised rate of 165.5 deaths per 100,000 population [12]. Brunei Darussalam has adapted the CVD risk scoring system from the WHO/International Society of Hypertension (ISH) chart for the Western Pacific Region A (WPRA) with the absence of evaluation for validity and accuracy in the local population. The Ministry of Health (MOH) Brunei Darussalam introduced the BruHealth mobile application during the COVID-19 pandemic using a digital platform with several key features [13] that have vast impacts on the population health.

The Framingham Risk Score (FRS) is the first CVD risk assessment tool developed about 60 years ago with the concept of primary prevention and estimates a 10-year risk for CVD [14]. The European Society of Cardiology Guidelines in 2016 recommended using the Systematic Coronary Risk Evaluation (SCORE) algorithm [15], based on 12 European cohort studies. It is composed of two distinctive charts for implementation in high and low-risk countries [15]. The American College of Cardiology/American Heart Association (ACC/AHA) Guidelines endorses (ACC/AHA) CVD risk calculator among individuals from 20 to 79 years to detect the high-risk group and predict atherosclerotic cardiovascular disease (ASCVD) as acute myocardial infarction (MI) [16]. The National Institute for Health and Care Excellence (NICE), United Kingdom (UK), advocates the QRISK® risk score and updates it every year [17]. The QRISK® is validated by comparing it against the FRS, and the Scottish ASSIGN scores [18]. The WHO and ISH have jointly developed the WHO/ISH risk prediction charts using data collected from the different regions of WHO sub-regions [19]. The WHO/ISH risk prediction consists of two sets of charts used in settings where blood cholesterol can be measured and settings in which blood cholesterol cannot be measured. The charts categorise individuals into different risk levels [4]. The Stroke Riskometer™ has the aptitude to improve Stroke and NCD prevention markedly. The algorithm is derived from the Framingham Stroke Risk Score (FSRS) prediction based on the INTERSTROKE study. It has performed comparatively poor in predicting stroke events with FSRS and QStroke [20].

There are online cardiovascular risk calculators to measure the probability of developing CVD without defining the appropriate population. Studies evaluate the CVD risk calculators that are clinically effective and cost-effective [21]. This review aims to summarise evidence on CVD risk calculators’ key features, usability, and benefits using digital platforms for CVDs prevention and management. Also, we discuss the development and validation process, variables, predictive accuracy, discrimination index, applicability, understandability and cost-effectiveness for CVD risk assessment, in developed and developing countries including Brunei Darussalam.

Methods of scoping review
We conducted a scoping review using the following search engines: PubMed, SpringerLink, ScienceDirect, and Google Scholar. The duration of the search was from 1998 to 2020. The search keywords were combined using Primary Medical Subject Headings (MeSH) and Boolean terms. The main keywords used include...
"cardiovascular risk assessment", "CVD risk assessment", "cardiovascular risk score", "cardiovascular disease risk score", "CVD risk score", "cardiovascular risk calculator", "cardiovascular disease risk calculator", "CVD risk calculator", "cardiovascular risk", "coronary risk score", "risk equation", "risk scoring method", "risk prediction", "risk algorithms", "QRISK" and "WHO/ISH". The type of included articles are reviews and observational studies. We used Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) in the review (Fig. 1) [22]. The initial literature search of this review yielded about 230 eligible abstracts. We analysed the abstracts of the publications and excluded abstracts, case reports, letters, commentaries and clinical trials. We reviewed 80 full-text articles and only included 17 articles in the final analysis that met the eligibility inclusion criteria of this review, which primarily included studies published only in the English, focused on CVD risk calculators for primary CVDs prevention and management, and provided evidence on CVD risk calculators with defined population and apparent outcomes of interest.

**Results**

Table 1 shows the characteristics of included studies on CVD risk calculators. The included studies can be categorised into Level I \( (n = 8) \), II \( (n = 4) \) and IV \( (n = 5) \) based on the levels of evidence for prognostic studies [23].

![Fig. 1 Identification of studies via databases](image-url)
Summary of existing CVD risk calculators

The CVD risk calculators widely investigated in studies include FRS, SCORE, ACC/AHA (ASCVD) Risk Estimator, QRISK® and WHO/ISH risk prediction charts [36]. The typical evaluation method for CVD risk calculators comprises a sample of local patients without prior CVD and with a presence of acute MI. Then, individuals apply the different calculators to estimate the predicted 10-year risk of CVD events if presented just before suffering the acute MI [21]. QRISK® is the most accurate CVD risk calculator for several study populations. A study conducted in Saudi Arabia states high-risk estimates for each calculator, including ACC/AHA (44.2%), Euro-SCORE (22.5%), FRS (29.5%), and QRISK® (95.3%). The QRISK® is the most accurate CVD risk assessment tool besides being most applicable for the Saudi population [21]. Another study in India showed higher risks for the Joint British Societies (JBS), FRS and ACC/AHA instruments.
(55.9%, 38.3% and 30.2%, respectively) than the WHO/ISH risk scores (13.4%) [30]. The ACC/AHA scored 50.2% as the most helpful guide for initiating statin therapy for primary prevention of CVD and 16.9% for the FRS, and 15.2% for the WHO/ISH risk chart in the Indian population. The WHO/ISH risk scores are the least accurate CVD risk assessment tool [32].

Table 2 compares QRISK® and WHO/ISH risk calculators. The WHO utilizes a hypothetical dataset for each of the six regions based on the prevalence of risk factors discovered by a previous Collaborative Risk Assessment Project [37]. The WHO/ISH model regression equations have not been released for academic or clinical use [19]. The QRISK® was created using Cox proportional hazards from a large UK cohort database [18]. The QRISK® CVD risk calculators were checked internally and externally by a number of studies with different ratings for ethnicity and poverty [38].

Table 3 compares QRISK® and WHO/ISH risk calculators. The QRISK® risk calculator is a CVD risk score that is dynamically updated from anonymized e-health records to reflect changes in the population. The WHO/ISH risk charts, on the other hand, can be used in healthcare settings with limited resources because they use simple variables. Due to the submission of CVD risk variables, some QRISK® data are missing. An estimated score is made using previously recorded data and expected values based on ethnicity, age, and sex. WHO/ISH risk charts will only apply to the region's most populous country.

Table 4 compares the variables of QRISK®2 and WHO/ISH. Gender, age, systolic blood pressure (SBP), diabetes, total cholesterol (mmol/l), and smoking status were variables in the WHO/ISH CVD risk chart [4]. The QRISK® risk score takes into account your ethnicity, family history (angina or heart attack in a first-degree relative younger than 60 years), cholesterol/HDL ratio, BMI, hypertensive medication, rheumatoid arthritis, chronic kidney disease, and atrial fibrillation [17, 18]. Table 5 compares CVD risk assessment tools' discrimination. QRISK® outperformed other CVD risk calculators. Discrimination performance is based on the area under the curve (AUC) metric [10, 17, 18, 25].
Discussion

Key features of CVD risk calculators

Development and validation

The WHO/ISH risk prediction charts seem the only option available for the populations for which prospective studies are not available [30]. The WHO CVD Risk Chart Working Group updated the WHO CVD risk charts in 2019 based on newly validated risk prediction models using Cox proportional hazards models to estimate CVD risk in 21 Global Burden of Disease

Table 3  Comparison of advantages and disadvantages between QRISK® risk calculator and WHO/ISH risk charts

| Advantages | QRISK®2 | WHO/ISH risk charts |
|------------|---------|---------------------|
| 1. Dynamically updated CVD risk score developed from annually updated anonymized e-health records to reflect changes in the population characteristics | 1. Charts can be used even in resource-constraint healthcare settings due to simple variables |
| 2. Various ethnicity and deprivation groups are included in calculating the CVD risk score for population groups most likely disadvantaged by the other risk algorithms | 2. Allow improvement and effectiveness of CVD risk assessment even in the countries that do not possess sophisticated technology for the use of online calculators through established health information systems |
| 3. Additional modifiable risk factors and ongoing clinical conditions are included to quantify the CVD risk score for every individual patient | 3. The WHO/ISH risk charts provide an optimal visual illustration when explaining the implications of elevated CVD risk to the patients through colour-coded CVD risk categories [24] |
| 4. CVD Risk scores could be saved through digital online platforms if embedded within mobile or computer applications | |
| 5. Upgradeable to a national comprehensive CVD risk factors profile and a rank-ordered recall list | |

| Disadvantages | QRISK®2 | WHO/ISH risk charts |
|---------------|---------|---------------------|
| 1. Some data are usually missing due to the submission of several CVD risk factors; an estimated QRISK® score is usually calculated using the previously recorded data and predicted values based on the patient’s ethnicity, age, and sex | 1. Results will be only applicable to the country with the largest population in the region |
| 2. High costs are needed for incorporating into a primary health setting with an appropriate computer system and costly screening investigations and examinations are needed for complete “actual” QRISK® CVD risk assessment | 2. Charts underestimate the risk in several groups of people, e.g. Hypertensive with blood pressure persistently ≥ 160/100 mm Hg, people with blood cholesterol ≥ 8 mmol/l, diabetics, people with a history of diagnosed ischemic heart disease or renal patients [40] |
| 3. Patients presented with a QRISK® score acknowledged their CVD risk level, but it is usually unclear if they correctly understood the 10-year CVD percentage risk. It needs after-score recommendations and lifestyle modifications to prevent the poor patient recall of CVD risk, confusion or misunderstanding [39] | 3. The WHO/ISH risk charts often incorrectly categorize most people into the low CVD risk group due to no prior validation, leading to a higher under-treatment rate and more complications and costs to incur [31] |
| 4. The over-simplification and absence of information on validation or discrimination index have a real effect on the sensitivity, specificity and predictive accuracy of the WHO/ISH risk charts [31] | 4. The over-simplification and absence of information on validation or discrimination index have a real effect on the sensitivity, specificity and predictive accuracy of the WHO/ISH risk charts [31] |

Table 4  Comparison of variables for QRISK®2 risk calculator and WHO/ISH risk charts

| Variables | QRISK®2 | WHO/ISH |
|-----------|---------|---------|
| Fixed Risk Factors | Age | X |
| Gender | X | X |
| Ethnicity | X | – |
| Relevant family history | X | – |
| Modifiable Risk Factors | Smoking status | X | X |
| Systolic blood pressure | X | X |
| HDL Cholesterol level | X | – |
| Total Cholesterol Level | X | X |
| Body mass index | X | – |
| Deprivation score | X | – |
| Ongoing clinical Conditions | Ongoing Diabetes | X | X |
| Ongoing hypertensive medication | X | – |
| Ongoing Rheumatoid arthritis | X | – |
| Ongoing chronic kidney disease | X | – |
| Ongoing Atrial Fibrillation | X | – |
allow patients with incomplete data included in analy-
\[10\] Framingham risk score
\[18\] Framingham risk score
\[25\] Framingham risk score
\[17\] Framingham risk score

level (mmol/l), and smoking status [4]. The QRISK
© (SBP), presence or absence of diabetes, total cholesterol

Table 5 Discrimination performance of CVD risk assessment tools according to (AUC) metric

| Study                  | Models                        | AUC (95% CI)          |
|-----------------------|-------------------------------|-----------------------|
|                       |                               | Men                   | Women                 |
| Collins et al. (2010) | Framingham risk score         | 0.75 (0.747 to 0.753) | 0.774 (0.771 to 0.777) |
|                       | QRISK1®                       | 0.771 (0.768 to 0.774) | 0.799 (0.796 to 0.802) |
|                       | QRISK2®                       | 0.773 (0.770 to 0.776) | 0.801 (0.798 to 0.804) |
| Collins et al. (2009) | Framingham risk score         | 0.752 (0.749 to 0.755) | 0.770 (0.766 to 0.774) |
|                       | QRISK1®                       | 0.762 (0.759 to 0.765) | 0.789 (0.785 to 0.793) |
| Hippiisley-Cox et al. | Framingham risk score         | 0.779 (0.776 to 0.782) | 0.800 (0.797 to 0.803) |
|                       | QRISK1®                       | 0.788 (0.786 to 0.791) | 0.814 (0.811 to 0.817) |
|                       | QRISK2®                       | 0.792 (0.789 to 0.794) | 0.817 (0.814 to 0.820) |
| Hippiisley-Cox et al. | Framingham risk score         | 0.759 (0.756 to 0.764) | 0.774 (0.771 to 0.778) |
|                       | QRISK1®                       | 0.767 (0.763 to 0.772) | 0.788 (0.785 to 0.791) |
|                       | ASSIGN                        | 0.764 (0.760 to 0.769) | 0.784 (0.781 to 0.787) |

(GBD) regions [34]. It utilised data from 85 prospective
cohorts based on the Emerging Risk Factors Collab-
oration (ERFC). The charts are recalibrated using data
from the GBD studies and the Non-Communicable Dis-
ease Risk Factor Collaboration (NCD-RISC) and exter-
ally validated using data from a further 19 prospective
cohorts [34]. Evidence suggests that the updated WHO
CVD Risk Charts are not formally endorsed and not
widely applied, except in a study done among a cohort
of Bangladeshi adults [41]. The study’s findings stated
that the charts could enhance the accuracy, practicabil-
ity, and sustainability of efforts to reduce the burden of
CVDs [34]. It is mentioned above that the QRISK
© was developed from an extensive UK cohort database and
the statistical method used was the Cox proportional
hazards. Also, multiple imputation statistical techniques
allow patients with incomplete data included in analy-
\[75\] = 0.96) is

Variables
It is highlighted in Table 4 that the WHO/ISH CVD risk
chart variables were gender, age, systolic blood pressure
(SBP), presence or absence of diabetes, total cholesterol
level (mmol/l), and smoking status [4]. The QRISK
© risk score incorporates more variables including ethnicity,
relevant family history (angina or heart attack in a first-
degree relative younger than 60 years old), cholesterol/
HDL ratio, body mass index, hypertensive medication,
rheumatoid arthritis, chronic kidney disease and atrial
fibrillation [17, 18]. Nevertheless, a shortage of cohort
studies analysing CVD risk and weighting such variables
in different populations, particularly the Asian popula-
tion, led to the poor discrimination between observed
CVD events and estimated CVD risk in Asians [42]. The
updated QRISK
© risk prediction models were devel-
oped with the inclusion of additional clinical variables.
The variables include chronic kidney diseases (including
stage 3 CKD), systolic blood pressure, migraine, corti-
costeroids and systemic Lupus Erythematosus. It enables
doctors to identify those at most risk of heart disease and
stroke [43].

Predictive accuracy
Studies showed that the WHO/ISH risk prediction model
identifies most people with low CVD risk, for instance,
97% (95% CI 96.4, 97.7) for Cambodia, 89.6% (95%CI 86.8,
92.2) for Mongolia and 94.4% (95%CI 91, 97.8) for Malaya-
sia [29]. The prevalence of low CVD risk was 89.3% [44]
in Jamaica and 89.7% in Cuba [45]. Another study reported
that the prevalence of CVD risk factors was high, but it
did not translate into high CVD risk categorisation [31].
In addition, the prevalence of high total CVD risk was
estimated to be less than 10% in people aged 40 or over in
China (1.1%), Iran (1.7%), Sri Lanka (2.2%), Cuba (2.8%),
Nigeria (5.0%) Georgia (9.6%) and Pakistan (10.0%) [26].
It is plausible that the QRISK
© risk calculator demon-
strated more prediction accuracy than other CVD risk
assessment instruments (as shown in Table 5). The dis-
crimination performance is based on the area under the
curve (AUC) statistic and identifies individuals who will

superior to ASSIGN (AUROC = 0.93) and the Framingham risk prediction model (AUROC = 0.92) [35].

**Applicability and understandability**

It is stated in Table 2 about the applicability and understandability of the CVD risk calculators, that clinicians often used the WHO/ISH risk charts for quick and consistent estimation of total CVD risk in ‘individuals’ [46]. The charts provide an optimal visual aid when explaining the implications of elevated risk and treatment options. In the primary care settings, the charts are likely preferred due to their simplicity to patients and physicians and applicability, especially in low-resource settings where online risk calculators could be complex due to technological challenges [24]. The QRISK® risk calculator is an online CVD risk algorithm and is integrated into clinical management systems. It generates an estimated score based on existing data to evolve as data quality and completeness improve and population characteristics change [18]. Some patients might not understand the meaning or the significance of some CVD risk factors. It may make assumptions about missing data, leading to less accurate results [39]. The JBS recommendations on preventing CVD introduced the JBS3 risk calculator in 2014, focusing on lifetime risk. It uses various visual displays and other metrics, for example, "Heart Age". The JBS3 has main advantages over QRISK®, primarily having multiple ways of presenting risk information that may accommodate the needs and preferences of a range of patients and can facilitate practitioner communication [47].

**Cost-effectiveness**

The WHO/ISH risk charts can be used in low-resource healthcare settings as part of stepwise approaches to help target laboratory testing. Also, individuals most likely benefit from the extra information and can use the charts even when values for some risk factors are unavailable [19]. In contrast, the risk charts incorrectly categorised most people into the low CVD risk group due to no prior validation study done, leading to higher rates of undertreatment and subsequently more complications and cost spending [31]. The CVD risk assessment tools can identify patients for CVD prevention in primary care opportunistically or through active CVD risk assessment [15]. A study done in the UK reported CVD preventive measures using the QRISK® algorithm among 40–74 years individuals were highly cost-effective compared with opportunistic assessment [48]. Conversely, the QRISK® risk calculator implemented in the primary health setting will require spending high costs for the appropriate computer system, screening investigations and examinations for a complete QRISK® CVD risk assessment [18].

**CVD risk calculators in Asia and Brunei Darussalam**

The existing CVD risk-assessment tools are not universal due to genetic differences, cultures, lifestyle habits, and social and behavioural characteristics [49]. The Asia Pacific Cohort Studies Collaboration showed higher systolic blood pressure, total cholesterol, and CVD events in Framingham than in the Asian cohorts. Smoking is higher in the Asian cohort [50]. The FRS has overestimated the risk in the Asian population [51]. There is limited evidence on the most effective CVD risk calculator for risk stratification in Asian populations, including Brunei Darussalam. It is appropriate to develop a predictive equation using data obtained from a representative and contemporary cohort of a population [52]. Some health systems develop their stroke-specific risk calculator based on their unique population and apply it to primary prevention for populations without a history of cerebrovascular disease. However, some develop calculators to predict Stroke in atrial fibrillation, recent transient ischemic attack or history of previous stroke [8].

The WHO/ISH risk prediction chart for WPRA is the algorithm adopted for CVD risk assessment among individuals in Brunei Darussalam [11]. The charts have not been validated in Brunei Darussalam due to the absence of prospective cohort studies [53]. This risk prediction chart might have underestimated the total CVD risk in the Bruneian population due to antihypertensive therapy, as noted in the WHO/ISH risk charts guidelines [54]. Health care professionals in Brunei Darussalam must consider the key features of the CVD risk calculator and carry out external validation of the tool to assess its feasibility and effectiveness. Besides, they must consider the predictive accuracy of using the calculator to ensure its beneficial outcome tool for the population.

**Recommendations**

The countries that need to develop national CVD risk calculators or plan to use one of the currently available CVD risk assessment tools should consider the key features that could affect the validity and accuracy of the calculator in determining the usability and benefits of the tool in its respective health care settings. Also, there is a need to consider the development and validation study of the tool, which considers a combination of stroke-specific risk with CVD risk. The key features are variables, predictive accuracy, discrimination index, applicability, understandability, and cost-effectiveness. For Brunei Darussalam, the digital deployment of the QRISK®3 or JBS3 CVD risk calculator through the national ‘BruHealth’ mobile application may be feasible.
and applicable to assess CVD risks in the population. In addition, the use of digital machine learning and laboratory measurements could provide more reliable predictive accuracy than the WHO/ISH risk charts. Health care professionals should consider the characteristics of a population in determining the most feasible and accurate tools for the respective health system. Research studies should be conducted focusing on the validation and evaluation (usability and feasibility) of a CVD risk calculator for a particular population, utilising comparative evidence for the CVD risk calculators.

Conclusion
We found that various guidelines are recommending different algorithms for CVD risk prediction. The QRISK® was found to be the more accurate CVD risk calculator for several study populations, whereas WHO/ISH risk scores were discovered to be the least accurate. The key features of CVD risk calculators are variables, predictive accuracy, discrimination index, applicability, understandability, and cost-effectiveness. Also, it is valuable to integrate stroke-specific risk assessment in the CVD risk calculator. A development and validation study must be conducted for the selected risk prediction tool to determine its usability to the local population and benefits to the respective health care setting. Overall, each health care setting should utilize a more feasible, accurate and user-friendly online CVD risk assessment tool tailored to the population and health system. Future research should focus on the validation and evaluation methods of the digital CVD risk calculators to assess the feasibility and benefits of tools to the respective populations.

Strengths and limitations
Our scoping review has several strengths, including the fact that it is the first scoping review on evidence related to CVD risk calculators’ key features, usability, and benefits when used with digital platforms for CVD prevention and management. We also made the scoping review process transparent by using a clear search methodology that referred to the level of evidence for prognostic studies for each study included in the review, as well as explicit inclusion and exclusion criteria. The key limitations are the lack of a critical evaluation of the included studies and little bias assessment, as well as the use of search engines rather than research databases to broaden the search area.

Abbreviations
ACC/AHA: American College of Cardiology/American Heart Association; ASCVD: Atherosclerotic cardiovascular disease; AUROC: Area Under the Receiver Operating Characteristic curve; CVDs: Cardiovascular diseases; FHS: Framingham Heart Study; FRS: Framingham Risk Score; IHD: Ischemic Heart Disease; ISH: International Society of Hypertension; MOH: Ministry of Health; NCD: Non-communicable diseases; NICE: National Institute for Health and Care Excellence; PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews; SCORE: Systematic Coronary Risk Evaluation; WHO: World Health Organization; WPR-A: Western Pacific Region A.

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Authors’ contributions
All authors contributed toward databases search, drafting and critically revising the paper and agree to be accountable for all aspects of the work. The author(s) read and approved the final manuscript.

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Availability of data and materials
All data analysed during this study and supporting its findings are included in this published article and all studies included in this review are available in the table (1).

Declarations
Ethics approval and consent to participate
As this review is based only on published studies, ethics approval and consent to participate are not applicable.

Consent for publication
Not applicable.

Competing interests
The authors have no conflict of interest to declare concerning this article’s authorship.

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