BMJ Open

Characteristics of participants who take up screening tests for diabetes and lipid disorders: a systematic review

Hanyue Ding,[1] Junjie Huang,[1] Yunyang Deng,[1] Sze Pui Pamela Tin,[2] Martin Chi-Sang Wong,[1,3] Eng-kiong Yeoh[1,4]

To cite: Ding H, Huang J, Deng Y, *et al*. Characteristics of participants who take up screening tests for diabetes and lipid disorders: a systematic review. *BMJ Open* 2022;**12**:e055764. doi:10.1136/bmjopen-2021-055764

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-055764).

Received 22 July 2021
Accepted 03 April 2022

For numbered affiliations see end of article.

Correspondence to
Prof Eng-kiong Yeoh, JC School of Public Health and Primary Care, The Chinese University of Hong Kong, Hong Kong, People's Republic of China; yeoh_ek@cuhk.edu.hk and Prof Martin Chi-Sang Wong, JC School of Public Health and Primary Care, The Chinese University of Hong Kong, Hong Kong, People's Republic of China; wong_martin@cuhk.edu.hk

ABSTRACT

Objectives To perform a systematic review on the characteristics of participants who attended screening programmes with blood glucose tests, lipid profiles or a combination of them, respectively.

Design Systematic review following the Meta-analysis Of Observational Studies in Epidemiology checklist.

Data sources PubMed and Medline databases for English literature from 1 January 2000 to 1 April 2020.

Eligibility criteria Original observational studies that reported baseline characteristics of apparently healthy adult participants screening for diabetes and lipid disorders were included in this review.

Data extraction We examined their sociodemographic characteristics, including age, gender, body mass index (BMI) and lifestyle habits. The quality of the included articles was evaluated by the Appraisal of Cross-sectional Studies.

Results A total of 33 articles involving 38 studies in 22 countries were included and analysed in this systematic review. Overall, there was a higher participation rate among subjects who were female in all screening modalities (female vs male: 46.6%–63.9% vs 36.1%–53.4% for diabetes screening; 48.8%–58.4% vs 41.6%–51.2% for lipid screening; and 36.4%–76.8% vs 23.2%–63.6% for screening offering both). Compared with the BMI standard from the WHO, participants in lipid screening had lower BMI (male: 23.8 kg/m^2 vs 24.2 kg/m^2, p<0.01; female: 22.3 kg/m^2 vs 23.6 kg/m^2, p<0.01). Furthermore, it is less likely for individuals of lower socioeconomic status to participate in diabetes or lipid screening in developed areas.

Conclusions We identified that individuals from lower socioeconomic groups were less likely to take up programmes for diabetes and/or lipid screening in developed areas. These populations are also likely to be at higher risk of non-communicable diseases. Future studies should investigate the barriers and facilitators of screening among non-participants, where targeted interventions to enhance their screening uptake are warranted.

Strengths and limitations of this study

- ► To our knowledge, this is the first systematic review that presented the characteristics of screening participants in one-step diabetes and lipid screening programmes.
- ► Due to the descriptive manner, we cannot quantify the association between patients' characteristics and screening participation.
- ► We included articles that used different screening tests for diabetes, and this might pose challenges on comparison across studies.
- ► There are differences in the organisation of different screening programmes in terms of the tests offered, subsidy amount and accessibility of the screening centres, and these could influence the screening uptake rate.

INTRODUCTION

Cardiovascular disease (CVD) represents the major cause of mortality, accounting for 17.9 million deaths or 32% of all global deaths in 2019.[1] It caused more than half of all deaths across the European region, and the death rates were higher in the Russian Federation, Bulgaria and Romania than in other European regions.[2 3] Most Asian countries had higher age-adjusted mortality than Western countries.[4] Patients with CVD have a high risk of complications, including ischaemic heart disease, stroke and chronic kidney diseases.[5] The modifiable risk factors for CVD included smoking, inadequate physical activity, elevated blood pressure, increased body weight, increased plasma lipid (cholesterol and triglyceride), as well as diabetes.[6] Diabetes is not only the risk factor for CVD but is also associated with significant morbidity and mortality. About 1.6 million deaths were directly caused by diabetes mellitus in 2016. In addition, diabetes may lead to long-term complications, such as kidney failure, lower limb amputation, blindness, heart attacks and stroke.[7 8] Worldwide, there were 108 million patients with diabetes in 1980, and the number has increased to 422 million in 2014.[8] The global prevalence of diabetes has been predicted to rise to 10.2% (578 million) by 2030 and 10.9% (700 million) by 2045.[9]

Globally, ischaemic heart disease and stroke ranked the first and second causes of disability-adjusted life years (DALYs) in 2016, which were responsible for 12.8% of total DALYs lost.[10] Diabetes caused 65.7 million DALYs lost and 2.5% of the total global DALYs lost in 2016.[10] In addition, dyslipidaemia also poses a serious threat to the health of populations. Overall, elevated cholesterol was estimated to contribute to 4.5% of total deaths and 2.0% of total DALYs.[11] Disease screening is regarded as an effective approach for the early detection and prevention of diabetes and dyslipidaemia. It was demonstrated that cholesterol screening can save 14 300 quality-adjusted life years (QALYs) over 100 000 person-years incurring a cost of $33 800 per QALY in the USA.[12] Diabetes screening has been shown to be more cost-effective for individuals aged 55–75 years as compared with younger subjects.[13]

According to international guidelines for screening (online supplemental table 1), in the USA,[14] the UK,[15] Australia,[16] Canada[17] and Singapore,[18] cholesterol screening is recommended for adults, and the proposed age of onset for screening ranged from 35 to 45 years—or earlier for patients with CVD risk factors. Furthermore, Australia,[16] Canada[19] and Singapore[20] suggested diabetes screening for average-risk adults above 40 years old, and the USA recommended screening for adults aged 40–70 years who are overweight or obese.[21]

However, previous studies have shown that the uptake rate for diabetes and lipid screening was suboptimal. According to a cross-sectional study performed in the USA between 2005 and 2012, the diabetes screening rates for 'screening-recommended' and 'screening-not-recommended' participants were 46.2% and 29.6%, respectively.[22] Participation rates of the health examinations for CVD and diabetes ranged between 48% and 67% in Sweden.[23] Although the attendance rate for National Health Service health check in England quadrupled from 5.8% in 2010 to 30.1% in 2012, the uptake rates were still relatively low when compared with findings from other studies.[24] To our knowledge, there are no systematic reviews that explored the socioeconomic and demographic characteristics of participants who take up screening programmes for diabetes and lipid disorders, knowing their characteristics could help to target individuals who were less likely to receive screening and improve their participation. These results may help to provide a basis for future studies to examine the enablers and barriers for diabetes and lipid screening. Therefore, we performed a systematic review of the existing literature to evaluate the characteristics of participants who received screening tests for diabetes and lipid disorders.

METHODS

Search strategy

We followed the Meta-analysis Of Observational Studies in Epidemiology checklist to conduct this systematic review.[25] We searched the PubMed and Medline databases for English literature from 1 January 2000 to 1 April 2020. The characteristics of participants were influenced by health literacy, health development, health policy, etc, which are changing over time. The older articles showed limited quality to be involved in this study, so we included the studies of recent 20 years to conduct this review. The following keywords were used for the search: (1) AND (2) NOT (3): (1) "fasting plasma glucose test" OR "postprandial plasma glucose" OR "oral glucose tolerance test" OR "random plasma glucose test" OR "glycated hemoglobin" OR "lipid test" OR "cholesterol test" OR "triglyceride test" OR "lipid panel" OR "lipid profile" (2) "uptake" OR "participate" (3) "pediatric" OR "gestational" (online supplemental table 2).

Inclusion and exclusion criteria

Studies were included if they: (1) were cross-sectional or reported baseline characteristics of participants in cohort studies; (2) were conducted among adults without a known history of diabetes, pre-diabetes or CVD; (3) adopted one-step fingerstick or blood glucose (including fasting plasma glucose (FPG), oral glucose tolerance tests (OGTTs), glycated haemoglobin (HbA1c) and random blood glucose (RBG)) or blood lipid tests as screening tools; and (4) reported participants' characteristics. The exclusion criteria included the following: (1) conference abstracts, systematic reviews or studies published in languages other than English; (2) screening programmes for pregnant women, the paediatric population, and/or patients who were previously diagnosed with diabetes, pre-diabetes or CVD; (3) studies whose target population focused on obese or overweight subjects, people with a family history of diabetes or CVD; (4) studies that involved the measurements with multiple steps/stages; and (5) studies performed before 2000.

Data extraction and quality assessment

Two reviewers (HD and VL) independently searched and screened each title and abstract. Disagreements were solved by discussion. Once the title and abstract of each citation were assessed as eligible, two reviewers reviewed and appraised the full text. We used the Appraisal of Cross-sectional Studies (AXIS) to assess the quality of included articles, which consists of 20 questions and answers recorded 'yes', 'no' or 'don't know'.[26] AXIS does not involve a numerical scale that can be used to calculate and produce a quality assessment score. We extracted the following data from all included articles: the first author's name, publication year, country, region/city, project period, study type, subsidisation, the age range of the population, number of participants; the screening tests used (fingerprick, FPG, OGTT, HbA1c, RBG, fasting lipid profile, waist circumference, hip circumference, blood pressure and other relevant tests); participant characteristics: gender, age, body mass index (BMI), marital status, educational status, occupational status, other indicators of socioeconomic status (SES) (including household wealth index, social deprivation index and household income), family history, cigarette smoking, alcohol consumption, physical activity and the reason for non-participation.

Statistical analysis

We summarised and descriptively reported the socioeconomic and demographic characteristics of the population attending the screening in the included studies. Based on our findings in the initial literature review, we also selected gender as a subgroup to explore the difference in age and BMI of the study participants. Means±SDs of these parameters were obtained from included studies. Figures were plotted using R software V.3.6.3 with the ggplot package.

RESULTS

From the literature search, 6407 citations were identified, of which 5658 were from PubMed and 749 were from Medline (online supplemental figure 1). There were 5723 citations after the removal of duplicates. We retrieved 122 full-text articles to assess for eligibility after 5536 citations were excluded during the title or abstract screening with the predetermined criteria. We excluded 89 articles which were duplicate studies (n=1); performed before the year 2000 (n=9); had absence of full text or lack of sufficient data for extraction (n=22); had the presence of known diabetes, pre-diabetes or CVD (n=44); or target population whose subjects reported family history of diabetes, pre-diabetes or elevated BMI (n=13). Finally, we included 38 studies from 33 articles in the present systematic review.[27–59]

Regarding the AXIS for evaluating each included study, most studies presented with the following limitations: the sample size not being justified (23 of 33); absence of characterisation and categorisation of non-participants (29 of 33); a lack of control for non-response bias (30 of 33); and absence of description of non-participants (27 of 33). Overall, all studies (33 of 33) met the following criteria: appropriate objectives and study design; appropriate risk factors and outcome variables; clear and sufficient description of methods; adequate description of the participants' characteristics and internally consistent presentation of results (online supplemental table 3).

The characteristics of all eligible studies were presented in table 1. Among these 33 manuscripts, 15 were from Asia (China, Vietnam, Sri Lanka, Pakistan, Palestine, Thailand), 7 were from Europe (Spain, England, Ireland, Netherlands, Lithuania, Sweden, Portugal), 6 were from Africa (Mauritius, Cameroon, Uganda, Nigeria, Tunisia, South Africa), 4 were from Americas (USA, Ecuador) and 1 was from Oceania (New Zealand). Ten studies were from developed countries, and the other 23 studies were from developing countries. According to screening items, 11 studies only implemented diabetes screening, 4 studies only conducted lipid tests, and the rest of the 18 studies performed both diabetes and lipid screening.

Diabetes screening

Eleven studies adopted OGTT, HbA1c, FPG or RBG to screen for diabetes.[32 36 39–41 43 44 46 48 53 55] OGTT and HbA1c were the commonly used modalities (in seven articles), followed by FPG (in five articles) and RBG (in one article). Two of these studies evaluated combinations of FPG, OGTT and HbA1c. A total of four studies simultaneously took blood pressure during screening.[41 44 48 53] Except for three studies,[32 36 46] all the others included anthropometry measurements (body weight, height, waist and hip circumference). Nearly half of the studies were from developed countries (5 out of 11).[39 40 43 46 53] Among these 11 articles, 1 reported findings from workplace screening insured by employers,[39] 2 were national health surveys and fully subsidised by government organisations,[40 53] 5 were funded by research institutes or funding agencies,[32 41 44 46 55] 1 was supported by a pharmaceutical company for free metres and strips,[43] and 2 did not mention their financial support[36 48] (table 1).

The range of participation rate of female and male subjects in the diabetes screening programmes was 46.6%–63.9% and 36.1%–53.4%, respectively (online supplemental figure 2). More female participants participated in screening than men in 12 studies. Only two studies showed more male participants in Uganda (52.4%) and Nigeria (53.4%). The mean age of the participants ranged from 38.5 to 48.0 years in all included studies (figure 1). The studies varied in terms of participant age, where the average age of most studies was more than 40 years. We extracted the national mean BMI of adults in various jurisdictions reported by the WHO,[60] and compared these with the participants' average BMI (figure 2). The average BMI of participants tended to be higher than the national mean, in particular from studies performed in the Netherlands (26.1 kg/m^2 vs 25.4 kg/m^2, p<0.01),[46] Thailand (24.3 kg/m^2 vs 24.1 kg/m^2, p=0.39)[55] and the USA (30.2 kg/m^2 vs 28.8 kg/m^2, p<0.01).[53]

The sociodemographic information of the screening participants was shown in table 2. For educational status, different studies adopted different classification methods for educational levels. Mayega *et al* reported that 39.6% of participants had a higher primary level, followed by a lower primary (21.9%), none (17.5%), secondary (16.5%) and tertiary (4.5%) educational level in Uganda.[41] Zafar *et al* showed more than half of participants had matriculation level (same as the 10th grade) or above (52.5%).[48] They also investigated the household income and found that 72.5% of the participants had <30 000 Pakistani rupee (PKR) income (approximately US$300 in 2014).[40] Mainous *et al* reported the trend (2003, 2006, 2009, 2011) of the social deprivation index, which is a composite index based on income, employment, health deprivation and disability, education, skills and training, barriers to housing and services, crime and disorder, and living environment.[40] The most deprived quintile had the lowest

Table 1 Characteristics of included studies

Author	Published Year	Country	Region/City	Project period	Study design	Subsidisation
Only blood glucose tests						
Bali[39]	2018	USA		Jan 2012–Dec 2014	Workplace screening (Health Advocate)	Self–insured employers
Bumrerraj[55]	2012	Thailand	Khon Kaen	June–Dec 2009	Cross–sectional study	Research funding
Katulanda[32]	2019	Sri Lanka		Aug 2005–Sep 2006	Cross–sectional study	Research funding
Lin[36]	2014	China	Guangzhou	Oct 2010–Jan 2011	Cross–sectional survey	Not mentioned
Mainous[40]	2014	England		2003, 2006, 2009, 2011	Health Survey for England	Information Centre for Health and Social Care and the Department of Health
Mayega[41]	2014	Uganda	Iganga–Mayuge		Cross–sectional survey	Research funding
Rush[43]	2008	New Zealand	Waikato District	May 2004–Mar 2006	Te Wai o Rona Diabetes Prevention Strategy (cohort)	Roche company and research funding
Sabir[44]	2013	Nigeria	Gumbi&Wamakko		Cross–sectional study	Research funding
Valkengoed[46]	2015	Netherlands	Hague	June–Dec 2009 April–Nov 2010	DHIAAN screening	Research funding
Zafar[48]	2016	Pakistan	Rawalpindi	May–Sep 2014	Cross–sectional survey	Not mentioned
Ziemer[53]	2010	USA		Jan 2005–Mar 2008	Third National Health and Nutrition Examination Survey	Centres for Disease Control and Prevention
Plasma lipid tests only						
Deng[57]	2012	China	Yunnan	July–Oct 2010	Cross–sectional survey	Research funding
Koyama[33]	2018	USA		Jan 2012–Dec 2014	Workplace screening (Health Advocate)	Self–insured employers
Kutkiene[34]	2018	Lithuania		2009–2016	Lithuanian High Cardiovascular Risk Primary Prevention Programme	Ministry of Health
Zhao[51]	2007	China		2002	Chinese National Nutrition and Health Survey	Chinese Centre for Disease Control and Prevention
Programmes offering both diabetes and lipid tests						
Ali[27]	2019	Palestine	Nablus municipality	Aug 2017–Feb 2018	Cross–sectional study	Not mentioned
Andersson[28]	2016	Sweden		2013	Qualitative and quantitative study	Not mentioned
Bao[50]	2010	China	Shanghai	May 2007–Aug 2008	Cross–sectional survey	Research funding
Belfki[54]	2013	Tunisia		Apr 2004–Sep 2005	Transition and Health Impact in North Africa Project	Research funding
Cuong[56]	2007	Vietnam	Ho Chi Minh City	Mar–Apr 2004	Cross–sectional survey	Not mentioned
Falguera[58]	2020	Spain	Mollerussa	Mar 2011–July 2014	Cohort study	Research funding
Gao[59]	2008	China	Qingdao	Apr–July 2002	Cross–sectional survey	Research funding
Hare[29]	2013	Mauritius	Main island& Rodrigues		Mauritius and Rodrigues Non–Communicable Disease Surveys	Ministry of Health and Quality of Life, Mauritius
Hidalgo[30]	2006	Ecuador		Dec 2011–June 2012	Cross–sectional study	Research funding
Hwu[31]	2008	China	Taiwan		Cross–sectional study	Research funding
Li[35]	2012	China	Hainan	May 2010–Aug 2011	Health check–up	Not mentioned
Lissock[37]	2011	Cameroon	Ngambe&Littoral		Cross–sectional study	Not mentioned
Liu[38]	2016	China	Changchun	2011–2012	Cohort baseline survey	Not mentioned

Continued

Table 1 Continued

Author	Published Year	Country	Region/City	Project period	Study design	Subsidisation
Nunes[42]	2019	Portugal		2015	Portuguese National Health Examination Survey	Organisations of Ministry of Health
Sinnott[45]	2015	Ireland	Dublin	Jan 2009–Dec 2012	The Diabetes Mellitus and Vascular Health Initiative (cohort study)	Private health insurance provider (for members)
Wang[47]	2020	China	Shanghai	Mar–Aug 2010	Cohort baseline survey	Research funding
Zemlin[49]	2015	South Africa	Cape Town	2008	Cross–sectional survey	Research funding
Zhou[52]	2018	China	Shanghai	Jan–July 2013	Cohort baseline survey	Research funding

Author	Age range	Ethnicity	Participants number	Test FPG	OGTT	HbA1c	RBG	LP	BP	Weight	Height	WC	HC	Others
Blood glucose tests only														
Bali[39]		Non–Hispanic White 77%–78% African American 2.8%–4% Asian/Pacific Islander 1%–3% Hispanic 7% Other 2%	22790	√	–	√	–	–	–	√	√	–	–	–
Bumrerraj[55]			874	–	√	–	–	–	–	√	√	√	–	–
Katulanda[32]			4014	–	√	–	–	–	–	–	–	–	–	–
Lin[36]	>=50		1312	√	√	√	–	–	–	–	–	–	–	–
Mainous[40]	>=16	(2003 2006 2009 2011) White 92.6%–90.5% 92.2%–85.3% South Asian 4.2%–5.7% 3.0%–4.0% Black 1.6%–1.9% 2.9%–3.0% Mixed/other 1.5%–1.8% 1.9%–7.7%	20139	–	–	√	–	–	–	√	√	–	–	–
Mayega[11]	35–60		795	√	–	√	–	–	√	√	√	–	–	–
Rush[43]	>=28		5264	–	√	–	–	–	–	√	√	√	–	Point–of–care testing
Sabir[44]			393	√	√	–	√	–	√	√	√	√	√	–
Valkengoed[46]	18–60		1092	–	√	√	–	–	–	–	–	–	–	–
Zafar[48]	18–65		404	–	–	√	–	–	√	√	√	√	√	–
Ziemer[53]	18–87	non–Hispanic black and white	1581	√	√	√	–	–	√	√	√	√	–	–
Plasma lipid tests only														
Deng[57]	22–84	Han 51.7% Minority 48.3%	1415	–	–	–	–	√	–	√	√	√	√	Food frequency
Koyama[33]			18993	–	–	–	–	√	–	√	√	–	–	–
Kutkiene[34]	men 40–54 women 50–64		92373	–	–	–	–	√	–	–	–	–	–	–
Zhao[51]	>=18		49252	–	–	–	–	√	–	–	–	–	–	–

Continued

Table 1 Continued

Author	Age range	Ethnicity	Participants number	Test FPG	OGTT	HbA1c	RBG	LP	BP	Weight	Height	WC	HC	Others
Programmes offering both diabetes and lipid tests														
Ali[27]	24–60		140	√	–	–	–	√	√	√	√	–	–	–
Andersson[28]	30–75		43	–	√	√	–	√	√	√	√	√	–	–
Bao[50]	20–79		4886	√	√	√	–	√	√	√	√	√	–	–
Belfki[54]	35–74		4654	√	–	–	–	√	√	√	√	√	–	–
Cuong[56]	20–60	Vietnamese 89.1% Chinese 10.8% Other 0.1%	1488	√	–	–	–	√	√	√	√	√	√	Skinfold thicknesses
Falguera[58]	>=25		583	√	–	√	–	√	√	√	√	√	–	Renal function
Gao[59]	20–74		1856	–	√	–	–	√	√	√	√	√	√	–
Hare[29]	19–78	African (40.7%) South Asian (57.0%) Chinese (2.3%)	6701	–	√	√	–	√	√	√	√	√	√	–
Hidalgo[30]	40–65		204	√	–	–	–	√	√	√	√	√	–	–
Hwu[31]			49	√	√	–	–	√	√	√	√	√	–	–
Li[35]	27–91		1337	√	–	√	–	√	√	√	√	–	–	Uric acid/Liver Function
Lissock[37]	>=18		452	√	–	–	–	√	√	√	√	√	√	Resting heart rate
Liu[38]	>=40	Chinese	7611	√	√	√	–	√	√	√	√	√	√	–
Nunes[42]	25–74		4911	–	–	√	–	√	√	√	√	√	√	Blood count
Sinnott[45]	45–75		29144	√	–	–	–	√	√	√	√	√	√	–
Wang[47]	>=40		9389	√	√	√	–	√	√	√	√	√	–	–
Zemlin[49]			667	√	√	√	–	√	√	√	√	√	√	–
Zhou[52]	15–98	Chinese	7909	√	√	√	–	√	√	√	√	√	–	Heart rate

BP, blood pressure; FPG, fasting plasma glucose; HbA1c, glycated hemoglobin; HC, hip circumference; LP, lipid screening; OGTT, oral glucose tolerance tests; RGB, random plasma glucose; WC, waist circumference.

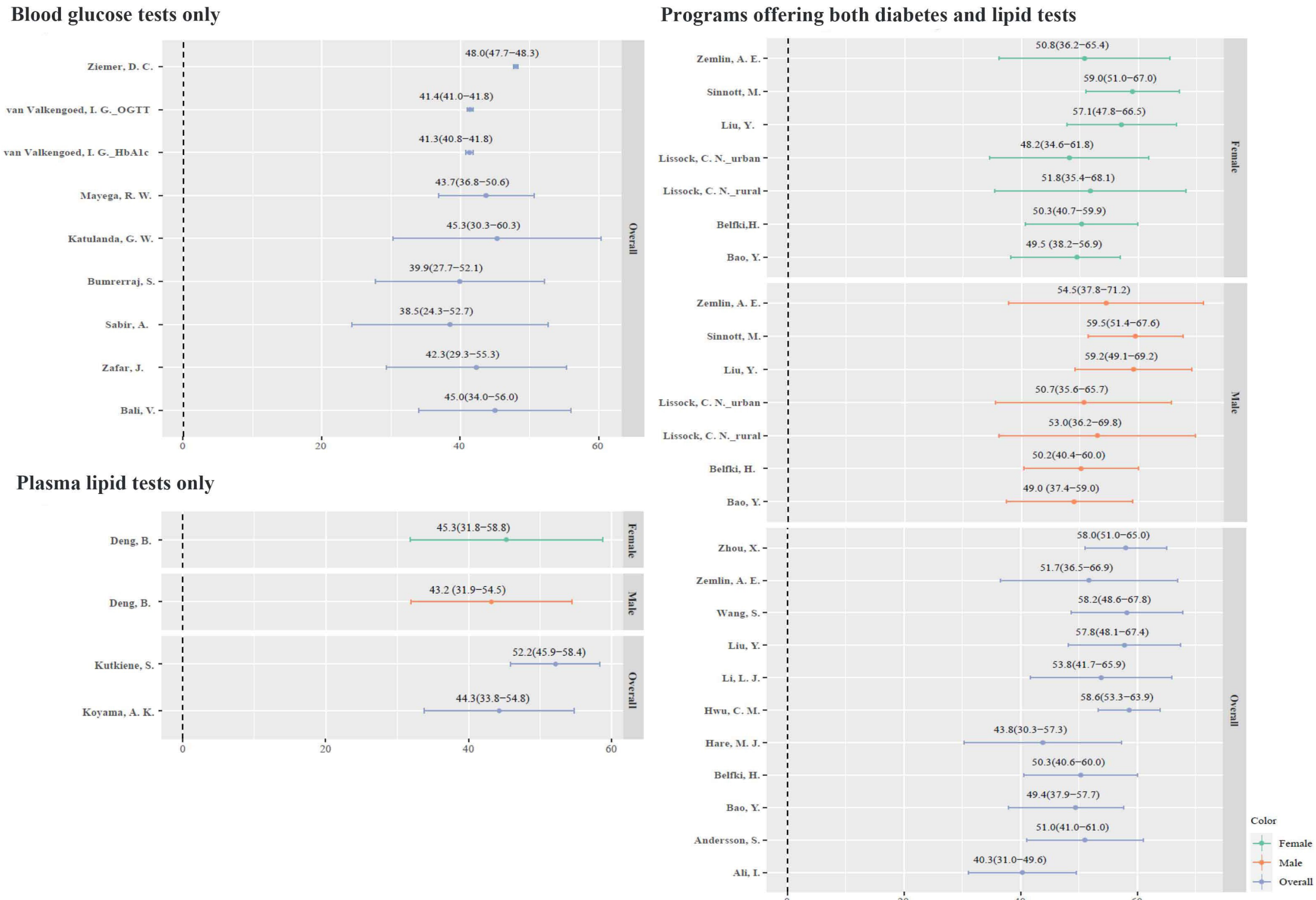

Figure 1 The mean age of screening participants.

participation percentages in all the years (16.5%–17.7%), and the other four levels of fewer deprivation quantities presented similar proportions (18.1%–23.1%). In addition, the proportions of single, divorced or widowed status were also lower than that of married participants.[48]

Apart from age, gender, BMI and sociodemographic information, we also extracted data on family history and lifestyle habits (table 3). A study from the Netherlands reported that around 70% of participants had a family history of type 2 diabetes,[46] whereas this uptake rate was under 40% in diabetes screening in Pakistan.[48] Of the two studies including smoking status, Sabir *et al* and Zafar *et al* reported low rates of participation among current smokers (9.7% and 13.4%, respectively).[44 48] Sabir *et al* also reported a very low proportion of screening uptake among alcohol drinkers (0.3%) in Nigeria.[44]

Lipid screening

A total of four studies offered lipid screening[33 34 51 57]: one cross-sectional screening survey was covered by research funding,[57] one study was workplace-based screening and insured by employers[33] and the other two studies were for national screening programmes supported by government organisations.[34 51] Only one study was from a developed country[33] (table 1).

In these four articles, two articles reported body weight and height,[33 57] and one study stated both waist and hip circumference.[57] For participants, the proportion of women ranged from 48.8% to 58.4%. Only one study that targeted rural residents of Yunnan China showed a higher percentage of men (51.2%) among participants (online supplemental figure 2). The mean age of the screening participants was older than 40 years (figure 1). Turning to mean BMI, however, both male and female subjects had lower than the national mean BMI reported by the WHO (male: 23.8 kg/m^2 vs 24.2 kg/m^2, p<0.01; female: 22.3 kg/m^2 vs 23.6 kg/m^2, p<0.01) (figure 2). Studies from Deng *et al* and Koyama *et al* reported the highest proportion of individuals having a higher educational level in China and the USA (38.4% and 58.3%, respectively)[33 57] (table 2).

Deng *et al* reported the smoking, drinking and physical activity habits of their lipid screening participants in China.[57] One-third of them were current smokers. Moreover, 39.4% of subjects reported that they were current drinkers. For physical activity, 57.0% of them took exercise or participated in physical labour activities more than twice per week for at least 30 min each (table 3).

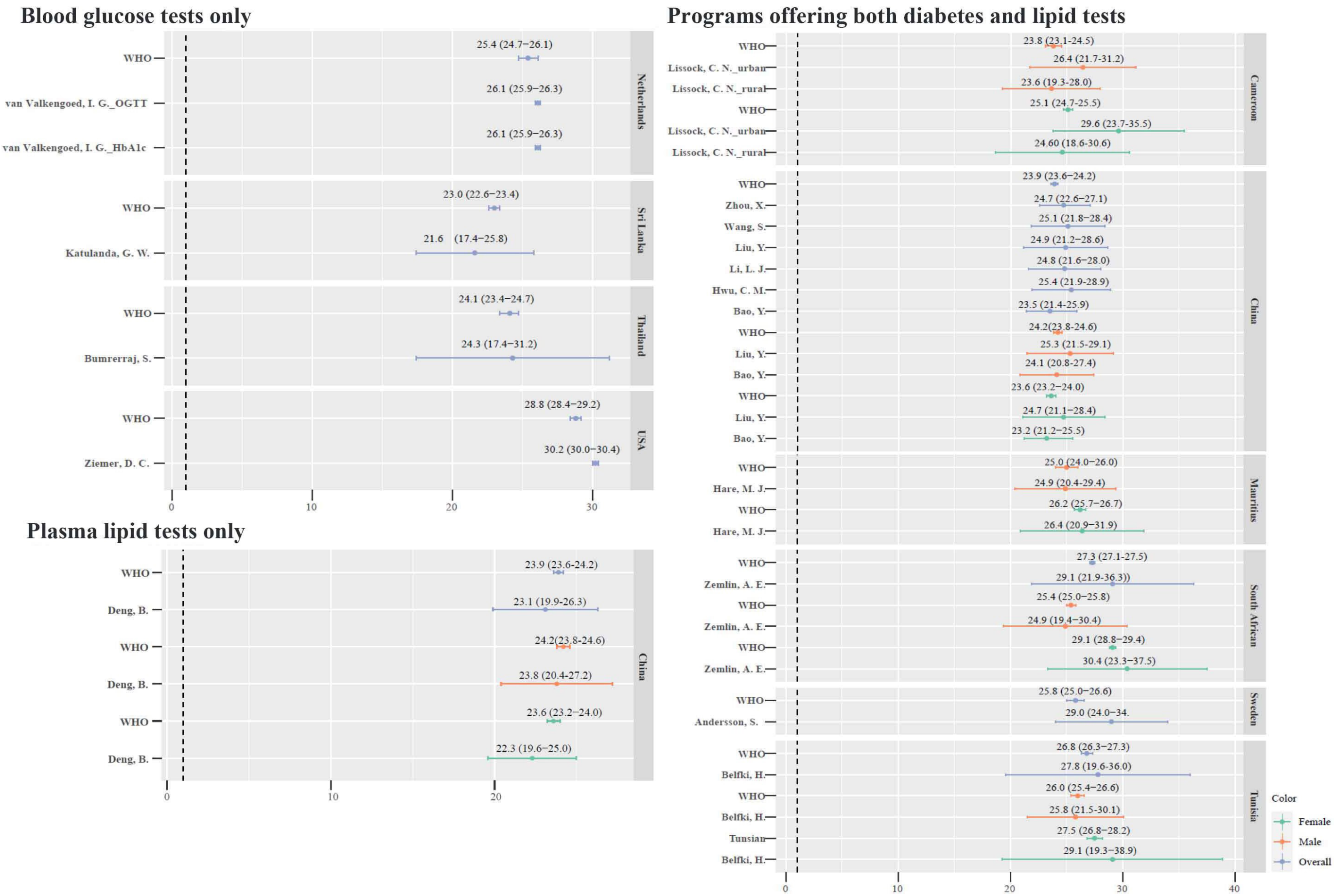

Figure 2 The body mass index of screening participants.

Participants receiving both diabetes and lipid screening

The studies that presented the characteristics of screening participants in programmes that offered screening for both diabetes and lipid profiles were listed in table 1. Fourteen of these papers adopted FPG to evaluate blood glucose.[27 30 31 35 37 38 45 47 49 50 52 54 56 58] Ten studies used HbA1c,[28 29 35 38 42 47 49 50 52 58] nine studies used OGTT,[28 29 31 38 47 49 50 52 59] while five of the included studies offered all three tests.[38 47 49 50 52] Only four studies were from developed countries.[28 42 45 58] Two were organised by the government,[29 42] and one was offered by a private health insurance provider for their members.[45]

For comparison of diabetes and lipid screening participation between men and women, only one study reported having more male than female subjects joining the screening programme in Hainan, China[35] (online supplemental figure 2). Five studies indicated that male participants were older than female participants,[37 38 45 49] while the other two studies reported female participants being older[50 54] (figure 1). Turning to the mean BMI of participants, most of the studies reported a higher number than the national BMI levels, including those conducted in China (24.7 kg/m^2 vs 23.9 kg/m^2, p<0.01[52]; 25.1 kg/m^2 vs 23.9 kg/m^2, p<0.01[47]; 24.9 kg/m^2 vs 23.9 kg/m^2, p<0.01[38]; 24.8 kg/m^2 vs 23.9 kg/m^2, p<0.01[35]; 25.4 kg/m^2 vs 23.9 kg/m^2, p<0.01)[31]; South Africa (29.1 kg/m^2 vs 27.3 kg/m^2, p<0.01)[49]; Sweden (29.0 kg/m^2 vs 25.8 kg/m^2, p<0.01)[28]; and Tunisia (27.8 kg/m^2 vs 26.8 kg/m^2, p<0.01)[54] (figure 2). Overall, women had higher BMI levels than their national average as reported in most studies, while only two studies showed a higher BMI among male participants when compared with the WHO report.[37 38] Some other screening tests were also included in other literature, such as skinfold thicknesses,[56] renal function,[58] uric acid,[35] liver function,[35] blood count[42] and heart rate.[37 52]

For educational status, we found a substantial difference in participants' educational status across different studies. Belfki *et al* showed that 77.2% of participants had a low educational level in Tunisia.[54] However, Wang *et al* reported that around 64.6% of the individuals had an educational level at higher school or above in Shanghai.[47] For occupational status, Belfki *et al* indicated more than half (56.6%) of the participants were retired or had no current jobs.[54] The corresponding proportion was only 24.2% in Cuong *et al*'s study.[56] Cuong *et al* also measured the household wealth index of participants and showed similar proportions among male (18.6%–21.2%) and female participants (18.8%–21.7%) across all levels of the index[56] (table 2).

Of the six studies that reported family history, one study described that 27.9% of the participants had a family history of dyslipidaemia,[27] another study indicated the proportion of a family history of CVD was 2.6%,[54] and

Table 2 Sociodemographic characteristics of participants in all included studies

Author	Marital status	Educational status	Occupational status	Others
Blood glucose tests only				
Mainous[40]	–	–	–	Social deprivation index
				(2003, 2006, 2009, 2011)
				Quintile 1 21.6%–20.6% 18.9%–20.1%
				Quintile 2 20.8%–20.2% 22.7%–23.1%
				Quintile 3 20.7%–22.3% 21.6%–21.0%
				Quintile 4 19.8% 20.4%–20.3% 18.1%
				Quintile 5 17.0%–16.5% 16.5%–17.7%
Mayega[41]	–	None 139 (17.5%)	Subsistence farmers 500 (62.9%)	–
		Lower primary 174 (21.9%)	Traders 164 (20.6%)	
		Higher primary 315 (39.6%)	Formal/salaried 39 (4.9%)	
		Secondary 131 (16.5%)	Mechanics 92 (11.6%)	
		Tertiary 36 (4.5%)		
Valkengoed[46]	–	Primary or less 14.7%–16.5%	Paid work	–
		Secondary 11.7%–13.6%	(OGTT, HbA1c)	
		Lower vocational 56.8%–53.5%*	74.1%–71.5%	
		Higher vocational 16.8%–16.5%*		
Zafar[48]	Married 322 (79.7%)	Illiterate 55 (13.6%)	Govt. Employee 61 (15.1%)	Income (Pakistani rupee)
	Unmarried 61 (15.1%)	Primary (1–5 grade) 59 (14.6%)†	Private Employee 61 (15.1%)	<10000 118 (29.2%)
	Widow/Divorced 21 (5.2%)	Middle (6–8 grade) 61 (15.1%)‡	Self–Employee 80 (19.8%)	10 000–30,000 175 (43.3%)
		>Matric (9–10 grade)212 (52.5%)‡	Un–employed 84 (20.8%)	31 000–50,000 72 (17.8%)
		Conventional 17 (4.2%)	Labourer 12 (3.0%)	>50,000 39 (9.7%)
			Any other 106 (26.2%)	
Plasma lipid tests only				
Deng[57]	Single 94 (6.6%)	Never 21 (1.5%)	–	–
	Married 1306 (92.3%)	Elementary school 116 (8.2%)†		
	Divorced 8 (0.6%)	Junior–middle school 348 (24.6%)‡		
	Widow(er) 7 (0.5%)	Senior–high school 386 (27.3%)‡		
		Higher 544 (38.4%)*		
Koyama[33]	–	Education, median (IQR)	–	Median income, median (IQR)
		Less than high school		US$57 622
		9.5% (5.7%–15.1%)		(US$45,161–US$75,313)
		High school or equivalent‡		
		27.0% (19.5%–33.9%)		
		Some college*		
		29.1% (24.2%–33.5%)		
		College degree*		
		29.2% (19.2%–43.2%)		
Programmes offering both diabetes and lipid tests				
Belfki[54]	Single 117 (2.5%)	Illiterate 2041 (43.9%)	No working/retired 2479 (56.6%)	–
	Married 4035 (86.7%)	Low (<=6 years) 1552 (33.3%)†	Employee/worker 1205 (27.5%)	
	Widowed/divorced 502 (10.8%)	Intermediate(7–13 years) 805 (17.3%)‡	Intermediate 202 (4.6%)	
		Higher(>=14 years) 238 (5.1%)*	Upper 494 (11.3%)	

Continued

Table 2 Continued

Author	Marital status	Educational status	Occupational status	Others
Cuong[56]	–	No schooling (1.8%)	Teacher, Professional (10.2%)	Household wealth index
		Primary school (16.3%)†	Government officers (14.9%)	(Male, female)
		Junior high school (33.3%)‡	Small business, Skilled workers (17.9%)	Lowest 19.9%, 19.9%
		Senior high school (33.3%)‡	Labourers, street or home traders (24.3%)	Second 19.8%, 20.1%
		College/University (15.3%)*	Retired/home maker/students (21.3%)	Middle 20.5%, 19.5%
			Others (8.5%)	Fourth 21.2%, 18.8%
			No Job (2.9%)	Highest 18.6%, 21.7%
Falguera[58]	–	High level	–	–
		(>=secondary high school education)		
		421 (72.2%)		
Hare[29]	–	Primary or none 3317 (49.8%)	–	–
		Secondary 2832 (42.5%)		
		Tertiary 515 (7.7%)		
Hidalgo[30]	Married 93 (45.6%)	0–6 73 (35.8%)†	–	–
	No 111 (54.4%)	7–12 68 (33.3%)‡		
		13 63 (30.9%)*		
Wang[47]	–	High school education or more	–	–
		6037 (64.6%)		

*same as tertiary education.
†same as the primary education.
‡same as secondary education.
HbA1c, glycated hemoglobin; OGTT, oral glucose tolerance tests.

the other four studies mentioned that 9.4%–31.9% of the participants with a family history of diabetes joined the screening programmes[45 47 52 58] (table 3).

Of the 10 studies with information on the smoking status, 3 reported high rates of current smoking,[27 54 56] which were 37.1%, 28.6% and 30.7%, respectively. Four studies stated the participants' alcohol consumption; one reported a higher rate (79.8%),[45] compared with that reported in two studies (10.5%–13.64%).[47 52] Among the five studies which included physical activity, three of them reported that more than half of the participants performed adequate physical activity (60.5%–71.2%)[29 47 58] (table 3).

The reasons for non-participation

Four studies mentioned the reasons for non-participation. Two studies on diabetes screening assessed reasons for non-participation. Mayega *et al* reported 5.4% of subjects refused to participate due to travel distance and 4.2% of non-participants declined the blood tests.[41] Valkengoed *et al* described that 'no time' and 'no interest' were the major reasons among prospective eligible participants.[46] Regarding lipid screening, Deng *et al* explained that 1.0% of subjects declined screening tests due to time constraints.[57] Nunes *et al* showed that 43.9% of individuals participated in the first Portuguese National Health Examination Survey involving both diabetes and lipid screening.[42] Furthermore, they found that work-related issues (26.6%) and lack of time (26.6%) were the most frequently mentioned reasons for not joining.

DISCUSSION

This systematic review provided socioeconomic and demographic characteristics of participants who received screening tests for diabetes and lipid disorders, including age, gender, BMI, sociodemographic status, family history and lifestyle habits. We found a higher proportion of women among the screening participants when compared with the male gender in most studies, irrespective of the tests offered. Participants who joined diabetes screening tended to have higher BMI values, while those who received lipid screening tended to have lower BMI values. Regarding screening programmes offering both diabetes and lipid tests, female participants had higher BMI values and male participants had lower BMI values than the national means reported by the WHO.

Sargeant *et al* conducted a stepwise programme to screen diabetes, and they reported male gender was significantly associated with lower uptake of RBG testing, which is consistent with our findings on diabetes screening.[61] A serial study of cross-sectional data (1992–2008) evaluated the utilisation of preventive health assessments in the UK, and found that the participation rate of lipid tests increased with age, but they reported an absence of association between gender and participation in lipid tests.[62] They also showed that smokers (vs non-smokers) had significantly lower uptake of lipid tests. In our review, around one-third of participants were current smokers in lipid tests and programmes offering both diabetes and

Table 3 Family history and lifestyle habits of participants

Author	Family history	Smoking	Drinking	Physical activity
Blood glucose tests only				
Sabir[44]	–	Total 38 (9.7%) Male 38 (18.1%) Female 0 (0%)	Total 1 (0.3%) Male 1 (0.5%) Female 0 (0%)	–
Valkengoed[46]	Type 2 diabetes mellitus 74.8% (75g OGTT group) 68.4% (HbA1c group)	–	–	–
Zafar[48]	Diabetes Parental history 161 (39.9%) Siblings history 88 (21.8%)	Smokers 54 (13.4%)	–	Exercise 105 (26.0%)
Plasma lipid tests only				
Deng[57]	–	Current smoking 476 (33.6%)	Current drinking 557 (39.4%)	>2/week /at least 30 mins 806 (57.0%)
Programmes offering both diabetes and lipid tests				
Ali[27]	Dyslipidaemia 27.9%	Smokers 37.1%	–	–
Andersson[28]	–	Smoking 19%	–	–
Belfki[54]	Cardiovascular disease 119 (2.6%)	Never 3246 (71.4%) Smoker 1301 (28.6%)	–	–
Cuong[56]	–	Non/ex–smoker (69.3%) Current smoker (30.7%)	–	–
Falguera[58]	Diabetes 180 (30.9%)	Current smoker 148 (25.4%)	–	394 (67.6%)
Hare[29]	–	1417 (21.2%)	None 3217 (49.7%) Moderate 2728 (42.1%) Excessive 531 (8.2%)	Sedentary 694 (10.6%) Insufficient (<150 min/week) 1883 (28.8%) Sufficient (>=150 min/week) 3951 (60.5%)
Hidalgo[30]	–	–	–	Sedentary Yes 69 (33.8%) No 135 (66.2%)
Sinnott[45]	Diabetes 9301 (31.9%)	Ever smoked 11 648 (40.0%)	23 245 (79.8%)	>=5 days/week 10 343 (35.5%)
Wang[47]	Diabetes 884 (9.4%)	Current smoking 1926 (21.2%)	958 (10.5%)	>=600 MET–min/week 6670 (71.2%)
Zhou[52]	Diabetes 847 (10.71%)	1746 (22.1%)	1079 (13.64%)	–

HbA1c, glycated hemoglobin; MET, metabolic equivalent of task; OGTT, oral glucose tolerance tests.

lipid tests. A longitudinal study indicated that current smokers had limited health literacy and lower cognitive ability than ever smokers,[63] which may explain their lower screening uptake rates. Interventions to address the health literacy of prospective participants are needed to improve screening participation, which at the same time could also help to change their lifestyle habits for the prevention of chronic diseases.[64]

A postal survey investigated the participation rate of women's health check-ups, including identification of CVD risk factors, as well as examinations for type 2 diabetes and kidney disease in Germany in 2004.[65] Its adjusted model showed that single, divorced, separated or widowed women (OR=0.63, 95% CI: 0.57 to 0.71) were less likely to receive a preventive health check-up when compared with married women. The proportions of single, divorced or widowed status were also lower than that of married participants in our review, except for a study performed in Italy. This may be due to peer effects where family members may exert a motivational influence on chronic disease screening. It is well recognised that SES influenced disease risk, health behaviour and healthcare of individuals. These health inequities have been affirmed by the WHO.[66] Researchers in Germany found that there was a significant association between women with lower SES (estimated based on educational status, occupational position and household income) (OR=0.82, 95% CI: 0.74 to 0.92) and lower participation rate of health screening attendance.[65] This is consistent with our finding that health inequities might exist as the most deprived population had the lowest participation rates in England, where only blood glucose tests were provided. Meanwhile, participants of studies in Spain and China (Shanghai) had higher educational status, whereas studies in Tunisia, Mauritius and Ecuador recruited more participants with lower educational level. Health inequities are more likely to be found in developed areas,[67] yet they also exist in developing countries due to differential health literacy and access to primary care services. For the non-participation of screening programmes among those with lower educational levels, health literacy plays an important role in screening participation. The American Heart Association highlighted that low health literacy is a barrier to healthcare screening and basic services for diabetes and CVD.[68] A systematic review included studies that evaluated the effectiveness of health literacy interventions using pre-programme and post-programme assessment, and concluded their positive impact on enhancing screening uptake.[64]

Hypertension is also a risk factor that contributes to CVD, but we did not include it as a target measurement, because the blood tests had more obstacles than the blood pressure tests, for example, the fear of needles, fear of pain, and cost of test strips and needles.[69] Thus, in this study, we focused on the blood glucose tests and lipid profiles to explore the characteristics of participants.

To our knowledge, this is the first systematic review that presented the characteristics of screening participants in diabetes and lipid screening programmes. The findings inform population groups where interventions to enhance screening uptake should be targeted. Nevertheless, there are several limitations. First, this is a systematic review of literature presented in a descriptive manner. Therefore, we cannot quantify the association between patients' characteristics and screening participation. In addition, we included articles that used different screening tests for diabetes, and this might pose challenges on comparison across studies. The American Diabetes Association proposed that FPG is the best screening test and also a component of the diagnostic test for diabetes.[70] FPG is more convenient and acceptable to patients since it is easier and faster to perform, and is less expensive than OGTT. There are differences in the organisation of different screening programmes in terms of the tests offered, subsidy amount and accessibility of the screening centres, and these could influence the screening uptake rate. In addition, the prevalence of risk factors in screening participants who take up the tests might be different from those who do not.

Overall, the present study systematically summarised the characteristics of screening participants in diabetes and lipid screening programmes. A higher proportion of female participants was found in diabetes and lipid screening programmes than men in most studies. For diabetes screening, participants tended to have higher BMI, while it was the opposite for subjects who participated in lipid screening. Meanwhile, women tended to have higher BMI and men tended to have lower BMI in screening programmes offering both diabetes and lipid tests. Participants with lower SES were less likely to undergo screening in developed areas. Around one-third of participants were current smokers in lipid screening and a combination of lipid and diabetes screening programmes. The proportion of participants using alcohol and performing regular physical activity varied substantially among included studies. Our findings could inform future studies to investigate the enablers and barriers to screening among participants and non-participants based on their characteristics, and also interventions to enhance their screening uptake.

Author affiliations

[1]JC School of Public Health and Primary Care, The Chinese University of Hong Kong Faculty of Medicine, Hong Kong, People's Republic of China
[2]Healthcare & Social Development, Our Hong Kong Foundation, Hong Kong, People's Republic of China
[3]School of Public Health, Peking University, Beijing, People's Republic of China
[4]Centre for Health Systems and Policy Research, The Chinese University of Hong Kong, Hong Kong, People's Republic of China

Acknowledgements We appreciate the invaluable contributions of Ms. Xiao Chen and Ms. Veeleah Lok.

Contributors HD—formal analysis, investigation, data curation, writing (original draft). JH—writing (review and editing). YD—validation, writing (review and editing). PSPT—writing (review and editing). MC-SW—methodology, supervision, project administration, guarantor. EKY—conceptualisation, supervision, guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests PSPT is from Our Hong Kong Foundation. The other authors declare no competing interests.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplemental information. All data generated or analysed during this study are included in the article (and its supplemental information files).

ORCID iDs

Hanyue Ding http://orcid.org/0000-0001-9977-0985
Junjie Huang http://orcid.org/0000-0003-2382-4443

Yunyang Deng http://orcid.org/0000-0003-4848-2953
Martin Chi-Sang Wong http://orcid.org/0000-0001-7706-9370
Eng-kiong Yeoh http://orcid.org/0000-0002-1721-9450

REFERENCES

1 World Health Organization. Cardiovascular diseases (CVDs). *World Heal. Organ* 2017.
2 World Health Organization. WHO/Europe | Cardiovascular diseases - Data and statistics., 2020. Available: http://www.euro.who.int/en/health-topics/noncommunicable-diseases/cardiovascular-diseases/data-and-statistics [Accessed 13 May 2020].
3 American Heart Association. Statistical Fact Sheet - International Cardiovascular Disease Statistics, 2004. Available: http://www.sld.cu/galerias/pdf/servicios/hta/international_cardiovascular_disease_statistics.pdf [Accessed 13 May 2020].
4 Ohira T, Iso H. Cardiovascular disease epidemiology in Asia: an overview. *Circ J* 2013;77:1646–52.
5 Mendis S, Puska P, Norrving B. Global atlas on cardiovascular disease prevention and control. 2011.
6 Francula-Zaninovic S, Nola IA. Management of measurable variable cardiovascular disease' risk factors. *Curr Cardiol Rev* 2018;14:153–63.
7 American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 2014;37 Suppl 1:S81–90.
8 World Health Organization. Diabetes., 2020. Available: https://www.who.int/news-room/fact-sheets/detail/diabetes [Accessed 11 May 2020].
9 Saeedi P, Petersohn I, Salpea P. *Diabetes Res Clin Pract*. In: *Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International diabetes Federation diabetes atlas*. . 9th edition, 2019: 157. 107843.
10 World Health Organization. Disease burden and mortality estimates, 2020. Available: https://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html [Accessed 9 Jun 2020].
11 World Health Organization. WHO | Raised cholesterol., 2020. Available: https://www.who.int/gho/ncd/risk_factors/cholesterol_text/en/ [Accessed 7 Jul 2020].
12 Dehmer SP, Maciosek MV, LaFrance AB, *et al*. Health benefits and cost-effectiveness of asymptomatic screening for hypertension and high cholesterol and aspirin counseling for primary prevention. *Ann Fam Med* 2017;15:23–36.
13 Hoerger TJ, Harris R, Hicks KA, *et al*. Screening for type 2 diabetes mellitus: a cost-effectiveness analysis. *Ann Intern Med* 2004;140:689.
14 Bibbins-Domingo K, Grossman DC, *et al*, US Preventive Services Task Force. Statin use for the primary prevention of cardiovascular disease in adults: US preventive services Task force recommendation statement. *JAMA* 2016;316:1997–2007.
15 Nice guideline. cardiovascular disease: risk assessment and reduction, including lipid modification. *Natl. Inst. Heal. Care Excell* 2016.
16 The Royal Australian College of General Practitioners. *Guidelines for preventive activities in general practice*. 9, 2018. https://www.racgp.org.au/download/Documents/Guidelines/Redbook9/17048-Red-Book-9th-Edition.pdf
17 Allan GM, Lindblad AJ, Comeau A, *et al*. Simplified lipid guidelines: prevention and management of cardiovascular disease in primary care. *Can Fam Physician* 2015;61:857e439–50.
18 Ministry of Health.. Lipids executive summary., 2016. Available: https://www.moh.gov.sg/docs/librariesprovider4/guidelines/moh-lipids-cpg-executive-summary.pdf [Accessed 10 Jun 2020].
19 , Ekoe J-M, Goldenberg R, *et al*, Diabetes Canada Clinical Practice Guidelines Expert Committee. Screening for diabetes in adults. *Can J Diabetes* 2018;42 Suppl 1:S16–19.
20 Goh SY, Ang SB, Bee YM, *et al*. Ministry of health clinical practice guidelines: diabetes mellitus. *Singapore Med J* 2014;55:334–47.
21 Siu AL. *Screening for abnormal blood glucose and type 2 diabetes mellitus: U.S. preventive services task force recommendation statement. Ann. Intern. Med* 2015;163:861–8.
22 Kiefer MM, Silverman JB, Young BA, *et al*. National patterns in diabetes screening: data from the National health and nutrition examination survey (NHANES) 2005-2012. *J Gen Intern Med* 2015;30:612–8.
23 Norberg M, Wall S, Boman K. The Västerbotten intervention programme: background, design and implications. *Glob Health Action* 2010;3:4643.
24 Robson J, Dostal I, Sheikh A. The NHS health check in England: an evaluation of the first 4 years.
25 Stroup DF, Berlin JA, Morton SC. Meta-Analysis of observational studies in epidemiology: a proposal for reporting. *J Am Med Assoc* 2000;283:2008–12.
26 Downes MJ, Brennan ML, Williams HC, *et al*. Development of a critical appraisal tool to assess the quality of cross-sectional studies (axis). *BMJ Open* 2016;6:e011458.
27 Ali I, Kharma A, Samara M, *et al*. Prevalence of dyslipidemia in undiagnosed Palestinian men: a cross-sectional study. *J Lipids* 2019;2019:1–6.
28 Andersson S, Karlsson V, Bennet L, *et al*. Attitudes regarding participation in a diabetes screening test among an Assyrian immigrant population in Sweden. *Nurs Res Pract* 2016;2016:1–7.
29 Hare MJL, Magliano DJ, Zimmet PZ. Glucose-Independent ethnic differences in HbA1c in people without known diabetes. *Diabetes Care* 2013;36:1534–40.
30 Hidalgo LA, Chedraui PA, Morocho N. The metabolic syndrome among postmenopausal women in Ecuador. *Gynecol Endocrinol* 2006;22:447–54.
31 Hwu CM, Lin MW, Liou TL. Fasting triglyceride is a major determinant of postprandial triglyceride response in postmenopausal women. *Menopause* 2008;15:150–6.
32 Katulanda GW, Katulanda P, Dematapitiya C. Plasma glucose in screening for diabetes and pre-diabetes: how much is too much? analysis of fasting plasma glucose and oral glucose tolerance test in Sri Lankans. *BMC Endocr Disord* 2019;19:11.
33 Koyama AK, Bali V, Yermilov I. Identification of undiagnosed hyperlipidemia: do work site screening programs work? *Am J Heal Promot* 2018;32:971–8.
34 Kutkiene S, Petrulioniene Z, Laucevicius A. Lipid profile evaluation and severe hypercholesterolaemia screening in the middle-aged population according to nationwide primary prevention programme in Lithuania. *Atherosclerosis* 2018;277:267–72.
35 LJ L, Zhou JX, Chen HT. Effect of HbA 1c combined Fpg on screening diabetes in health check-up. *Asian Pac J Trop Med* 2012;5:472–5.
36 Lin S, Hu L, Li X, *et al*. Glycated haemoglobin A_1c for diagnosing diabetes in Chinese subjects over 50 years old: a community-based cross-sectional study. *Clin Endocrinol* 2014;80:656–61.
37 Lissock CNAA, Sobngwi E, Ngassam E. Rural and urban differences in metabolic profiles in a Cameroonian population. *Pan Afr Med J* 2011;10:1.
38 Liu Y, Xiao X, Sun C, *et al*. Ideal glycated hemoglobin cut-off points for screening diabetes and prediabetes in a Chinese population. *J Diabetes Investig* 2016;7:695–702.
39 Bali V, Yermilov I, Koyama A, *et al*. Secondary prevention of diabetes through workplace health screening. *Occup Med* 2018;68:610–6.
40 Mainous AG, Tanner RJ, Baker R, *et al*. Prevalence of prediabetes in England from 2003 to 2011: population-based, cross-sectional study. *BMJ Open* 2014;4:e005002.
41 Mayega RW, Guwatudde D, Makumbi FE. Comparison of fasting plasma glucose and haemoglobin A1c point-of-care tests in screening for diabetes and abnormal glucose regulation in a rural low income setting. *Diabetes Res Clin Pr* 2014;104:112–20.
42 Nunes B, Barreto M, Gil AP, *et al*. The first Portuguese National health examination survey (2015): design, planning and implementation. *J Public Health* 2019;41:511–7.
43 Rush E, Crook N, Simmons D. Point-Of-Care testing as a tool for screening for diabetes and pre-diabetes. *Diabet Med* 2008;25:1070–5.
44 Sabir A, Ohwovoriole A, Isezuo S, *et al*. Type 2 diabetes mellitus and its risk factors among the rural Fulanis of northern Nigeria. *Ann Afr Med* 2013;12:217–22.
45 Sinnott M, Kinsley BT, Jackson AD, *et al*. Fasting plasma glucose as initial screening for diabetes and prediabetes in Irish adults: the diabetes mellitus and vascular health Initiative (DMVhi). *PLoS One* 2015;10:e0122704.
46 van Valkengoed IGM, Vlaar EMA, Nierkens V, *et al*. The uptake of screening for type 2 diabetes and prediabetes by means of glycated hemoglobin versus the oral glucose tolerance test among 18 to 60-year-old people of South Asian origin: a comparative study. *PLoS One* 2015;10:e0136734.
47 Wang S, Niu J, Zhao Z, *et al*. Detection of diabetes and prediabetes using glycosylated hemoglobin in Chinese adults living in Shanghai: a prospective analysis. *J Diabetes* 2020;12:573-582.
48 Zafar J, Nadeem D, Khan SA, *et al*. Prevalence of diabetes and its correlates in urban population of Pakistan: a cross-sectional survey. *J Pak Med Assoc* 2016;66:922–7.
49 Zemlin AE, Matsha TE, Kengne AP, *et al*. Derivation and validation of an HbA1c optimal cutoff for diagnosing prediabetes in a South African mixed ancestry population. *Clin Chim Acta* 2015;448:215–9.

50 Bao Y, Ma X, Li H, *et al*. Glycated haemoglobin A1c for diagnosing diabetes in Chinese population: cross sectional epidemiological survey. *BMJ* 2010;340:1178.
51 Zhao W-H, Zhang J, Zhai Y, *et al*. Blood lipid profile and prevalence of dyslipidemia in Chinese adults. *Biomed Environ Sci* 2007;20:329–35.
52 Zhou X, Ruan X, Hao L, *et al*. Optimal hemoglobin A1c cutoff value for diabetes mellitus and pre-diabetes in Pudong new area, Shanghai, China. *Prim Care Diabetes* 2018;12:238–44.
53 Ziemer DC, Kolm P, Weintraub WS, *et al*. Glucose-Independent, black-white differences in hemoglobin A1c levels: a cross-sectional analysis of 2 studies. *Ann Intern Med* 2010;152:770–7.
54 Belfki H, Ben Ali S, Aounallah-Skhiri H, *et al*. Prevalence and determinants of the metabolic syndrome among Tunisian adults: results of the transition and health impact in North Africa (TAHINA) project. *Public Health Nutr* 2013;16:582–90.
55 Bumrerraj S, Kaczorowski J, Kessomboon P, *et al*. Diagnostic performance of 2 H postprandial capillary and venous glucose as a screening test for abnormal glucose tolerance. *Prim Care Diabetes* 2012;6:207–11.
56 Cuong TQ, Dibley MJ, Bowe S, *et al*. Obesity in adults: an emerging problem in urban areas of HO Chi Minh City, Vietnam. *Eur J Clin Nutr* 2007;61:673–81.
57 Deng B, Luo T, Huang Y, *et al*. Prevalence and determinants of hyperlipidemia in moderate altitude areas of the Yunnan-Kweichow plateau in southwestern China. *High Alt Med Biol* 2012;13:13–21.
58 Falguera M, Vilanova MB, Alcubierre N, *et al*. Prevalence of pre-diabetes and undiagnosed diabetes in the Mollerussa prospective observational cohort study in a semi-rural area of Catalonia. *BMJ Open* 2020;10:e033332.
59 Gao W, Dong Y, Nan H, *et al*. The likelihood of diabetes based on the proposed definitions for impaired fasting glucose. *Diabetes Res Clin Pract* 2008;79:151–5.
60 Mendis S, Armstrong T, Bettcher D. Global status report on noncommunicable diseases 2014. World health organisation. 2014.
61 Sargeant LA, Simmons RK, Barling RS, *et al*. Who attends a UK diabetes screening programme? findings from the ADDITION-Cambridge study. *Diabet Med* 2010;27:995–1003.
62 Labeit A, Peinemann F, Baker R. Utilisation of preventative health check-ups in the UK: findings from individual-level repeated cross-sectional data from 1992 to 2008. *BMJ Open* 2013;3:e003387.
63 Fawns-Ritchie C, Starr JM, Deary IJ. Health literacy, cognitive ability and smoking: a cross-sectional analysis of the English longitudinal study of ageing. *BMJ Open* 2018;8:e023929.
64 Walters R, Leslie SJ, Polson R, *et al*. Establishing the efficacy of interventions to improve health literacy and health behaviours: a systematic review. *BMC Public Health* 2020;20:1040.
65 Schülein S, Taylor KJ, Schriefer D. Participation in preventive health check-ups among 19,351 women in Germany. *Prev Med Reports* 2017;6:23–6.
66 World Health Organization. Social determinants of health. *World Heal. Organ* 2013 https://www.who.int/social_determinants/thecommission/finalreport/key_concepts/en/
67 Orach CG. Health equity: challenges in low income countries. *Afr Health Sci* 2009;9 Suppl 2:S49.
68 Magnani JW, Mujahid MS, Aronow HD, *et al*. Health literacy and cardiovascular disease: fundamental relevance to primary and secondary prevention: a scientific statement from the American heart association. *Circulation* 2018;138:e48–74.
69 Ong WM, Chua SS, Ng CJ, . Barriers and facilitators to self-monitoring of blood glucose in people with type 2 diabetes using insulin: a qualitative study. *Patient Prefer Adherence* 2014;8:237–46.
70 American Diabetes Association. Screening for diabetes. *Diabetes Care* 2002;25:s21–4.