PLOS ONE

RESEARCH ARTICLE

Prevalence of type-2 diabetes and prediabetes in Malaysia: A systematic review and meta-analysis

Sohail Akhtar[1]*, **Jamal Abdul Nasir**[2], **Aqsa Ali**[2], **Mubeen Asghar**[2], **Rizwana Majeed**[2], **Aqsa Sarwar**[2]

1 Department of Mathematics and Statistics, The University of Haripur, Haripur, Khyber Pakhtunkhwa, Pakistan, 2 Department of Statistics, GC University Lahore, Lahore, Pakistan

* s.akhtar@uoh.edu.pk, Akhtar013@gmail.com

Abstract

Objective

The main purpose of this study was to investigate the pooled prevalence of prediabetes and type-2 diabetes in the general population of Malaysia.

Method

We systematically searched Medline (PubMed), Embase, Web of Science, Google Scholar and Malaysian Journals Online to identify relevant studies published between January 1, 1995, and November 30, 2021, on the prevalence of type-2 diabetes in Malaysia. Random-effects meta-analyses were used to obtain the pooled prevalence of diabetes and prediabetes. Subgroup analyses also used to analyze to the potential sources of heterogeneity. Meta- regression was carried to assess associations between study characteristics and diabetes prevalence. Three independent authors selected studies and conducted the quality assessment. The quality of the final evidence was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.

Results

Of 2689 potentially relevant studies, 786 titles and abstract were screened. Fifteen studies with 103063 individuals were eligible to be included in the meta-analyses. The pooled prevalence of diabetes was 14.39% (95% CI, 12.51%–16.38%; I^2 = 98.4%, 103063 participants from 15 studies). The pooled prevalence of prediabetes was 11.62% (95% CI, 7.17%–16.97%; I^2 = 99.8, 88702 participants from 9 studies). The subgroup analysis showed statistically significant differences in diabetes prevalence by the ethical sub-populations with highest in Indians (25.10%; 95% CI, 20.19%–30.35%), followed by Malays (15.25%; 95% CI, 11.59%–19.29%), Chinese (12.87%; 95% CI, 9.73%–16.37%), Bumiputeras (8.62%; 95% CI, 5.41%–12.47%) and others (6.91%; 95% CI, 5.71%–8.19%). There was no evidence of publication bias, although heterogeneity was high (I^2 ranged from 0.00% to 99·8%). The quality of evidence based on GRADE was low.

Conclusions

Results of this study suggest that a high prevalence of prediabetes and diabetes in Malaysia. The diabetes prevalence is associated with time period and increasing age. The Malaysian government should develop a comprehensive approach and strategy to enhance diabetes awareness, control, prevention, and treatment.

Trial registration

Trial registration no. PROSPERO CRD42021255894; https://clinicaltrials.gov/.

Introduction

Diabetes mellitus is one of the most serious worldwide public health issues, posing a significant global burden on both public health and socioeconomic development. Although the incidence of diabetes has begun to decline in some nations, diabetes prevalence has climbed in most other developing and developed countries in recent decades [1–6]. According to the International Diabetes Federation (IDF), 9.3 percent (463 million) of adults worldwide have diabetes in 2019. The number is expected to rise to 10.2% (578 million) by 2030 and 10.9% (700 million) by 2045 if effective prevention methods are not implemented [7,8]. Furthermore, in 2017, nearly half of all people with diabetes (50.1%) were undiagnosed, approximately 374 million individuals (18–99 years) [8]. Similarly, prediabetes is estimated to affect 374 million (7.5%) of the global population in 2019 and is expected to increase to 8.0 percent (454 million) by 2030 and 548 million (8.6%) by 2045, with 48.1% of individual with prediabetes are under the age of 50 [8]. Type-2 diabetes reduces the average lifespan by around ten years [9].

Malaysia has the highest rate of diabetes in Western Pacific region and one of the highest in the world and costing around 600 million US dollars per year [10,11]. The prevalence of diabetes raised from 11.2% in 2011 to 18.3% in 2019, with a 68.3% increase [12]. According to a national survey report, in Malaysia in 2019, 3.6 million adults (18 and above years) had diabetes, 49% (3.7 million) cases were undiagnosed [13]. Diabetes is expected to affect 7 million Malaysian adults aged 18 and older by 2025, posing a major public health risk with a diabetes prevalence of 31.3% [12]. The prevalence of diabetes in Malaysia, based on published articles, ranges from 7.3% to 23.8% [14,15]. The increasing trend is a result of a variety of causes, including population expansion, population ageing, urbanization, and rising rates of obesity and physical inactivity [16]. The alarming prevalence of diabetes and its complications in Malaysia prompted this study to systematically identify, summarize available evidence on the prevalence of diabetes and prediabetes, and to estimate the pooled prevalence of diabetes and prediabetes in Malaysia. To our knowledge, no prior effort has been made to combine existing data on the prevalence of diabetes and prediabetes in Malaysian populations.

Methods

Design and registration

Our systematic review and meta-analysis protocol was registered with PROSPERO in March 2021 (registration number CRD42021255894). We conducted this study in accordance with the PRISMA guidelines [17], and the PRISMA 2009 checklist is attached in supplementary file (S1 File).

Literature search

Similar to our previous systematic reviews [18–20], we systematically searched Medline (PubMed), Web of Science, Google scholar, Embase and Malaysian Journals Online to identify relevant studies published between January 1, 1995, and November 30, 2021, on the prevalence of prediabetes and diabetes in Malaysia. The following keywords were combined to design the search strategy: "diabetes", "type-II diabetes", "type 2 diabetes", "prediabetes", "T2D", "non-communicable diseases", "prevalence", "impaired fasting glucose", "impaired glucose tolerance", "risk factor", "risk factors", "epidemiology", "glucose abnormalities", "glucose intolerance", "Malaysia", "Malaysian" and "Malays", as well as variations thereof. To identify potential additional studies and reports, we also scrutinized the reference list of all selected articles. The results of search strategy are provided in the supplementary file (S1 Table).

Inclusion and exclusion criteria

For this study, studies were included if they provided enough data to calculate prevalence of diabetes and prediabetes; included a community-or population-based survey and published in English between January 1995 to September 2021; participants residing in Malaysia. The following studies were excluded: were review articles, case studies, qualitative studies, case series, abstracts, and intervention studies; was irrelevant to type-2 diabetes; reported on gestational or type-1 diabetes; based on Malaysian community living outside of Malaysia; and based on duplicated information (data); and based on data that was published in more than one study (the latest data version was considered).

Data extraction

Three investigators (JAN, AA, and RM) independently conducted data extraction using a pre-conceived and standardized data extraction form. The collected information was: surname name of the author, year of publication, year of investigation, study design, state where study was conducted, mean or median age of participants, total sample size, percentage of male participants, percentage of hypertensive participants, sampling strategy, percentage of smoker participants, area (rural vs urban), diagnostic criteria and percentage of overweight or obese participants. Disagreements and uncertainties were addressed by mutually consensus or consultation with the 4th investigator (SA).

Methodological quality assessment

Three of investigators (JAN, AA, and RM) independently evaluated the quality of each study by using the JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data [21]. Any discrepancies were discussed between the investigators, and another investigator (SA) made a final judgment if no mutual consensus could be reached. Each study received a score ranging from 0 to 9. We classified each study as high risk (for scores <50%), moderate risk (for quality scores above 50–69%), or low risk of bias based on its score (for quality scores ≥70%).

Statistical analysis

Statistical software R (version 4.1.0) was used to generate meta-analysis for diabetes and prediabetes prevalence. Because of the significant expected heterogeneity among studies, random-effects meta-analyses were used. Prior to pooling prevalence estimates, the Freeman-Tukey double arc-sine transformation was applied to stabilise the variance of the raw prevalence estimates from each included study. The I^2 index was considered to evaluate heterogeneity between studies, with I^2 values between 25% or below indicate mild degree of heterogeneity,

between 26%-50% indicate moderate degree of heterogeneity, and greater than 50% indicate the presence of substantial heterogeneity [22–24]. Forest plots were created to visually assess the results of pooling.

We used subgroup meta-analysis to explore causes of substantial heterogeneity. For this purpose, we stratified meta-analyses by area of residence (urban vs rural), participant age group, gender, time period, and ethical subgroup. We investigated sources of heterogeneity with a meta-regression. The covariates in the meta-regression considered were state where study was conducted, study year, area of residence (rural vs urban), sample size, baseline year of data collection, mean age of participants, methodological quality, and gender. Visual inspection of the funnel plots was performed to evaluate publication bias in the meta-analyses. Egger's test and Begg's test method were also considered for quantitative estimate of the publication bias. Cohen's coefficient was used to determine inter-rater agreement among the authors who were engaged in data extraction and study selection [25]. The quality of this systematic review and meta-analysis was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [26].

Results

The PRISMA diagram with the flow of articles through this study is described in Fig 1. Our initial electronic search identified 2682 potentially relevant articles, and an additional 7 articles were identified by checking reference lists. After excluding of duplicates (n = 1903), we screened 786 articles by title and abstract and excluded 733 irrelevant articles. Inter-rater agreement among the investigators on abstract selection was very high (κ = 0.846, p<0.001). We scrutinized the eligibility of potentially relevant studies (n = 53) in full text against the inclusion and exclusion criteria. The articles were removed as 12 studies did not mention the results of diabetic patients, duplication of dataset (n = 10), only assessed patients with type-1 diabetes (n = 11), did not include enough information to compute prevalence (n = 5). Thus, 15 studies were identified as the eligible studies in the meta-analysis (Fig 1).

Table 1 summarizes the general characteristics of 15 selected studies [11,14,15,27–38]. In total, 103063 individuals were included. A cross-sectional study design was utilised in 11 of the 15 investigations, and 4 studies did not explicitly describe a study strategy, it can be inferred as a cross-sectional study design. Sample sizes ranged from 119 to 34539 individuals, with a median of 1489 individuals. The age of participants enrolled ranged from 15 to 85 years overall in 15 studies. The studies were published between 1996 and 2020, while the participants were enrolled between November 1993 and June 2019. In 14 studies, the proportion of male participants in the study sample was recorded. Male participation ranged from 0 to 54.8%, and the percentage of overweight participants ranged from 11 percent to 49.1 percent. Following an evaluation of the studies' quality, 11 were found to be of low-risk bias, 5 to be of moderate level, and none to be of high-risk bias. The authors had a high level of agreement on the extracted data (k = 0.86, p = 0.001).

Quantitative synthesis

The findings of the overall and subgroup meta-analyses are shown in Table 2. The diabetes prevalence was reported in 15 studies, with a total of 103063 individuals. The prevalence of diabetes ranged from 7.8% to 23.8%. The overall pooled estimated prevalence of diabetes was 14.39% (95% CI, 12.51%–16.38%; prediction interval: 7.37–23.23). Fig 2 shows diabetes prevalence estimates derived from meta-analysis. The analysis revealed a significant heterogeneity. The level of heterogeneity in the meta-analysis was high (I^2 = 98.4%; P < 0.001) (Fig 2). The Egger's and Begg's tests did not find any publication bias in the meta-analysis (p = 0.7296 and
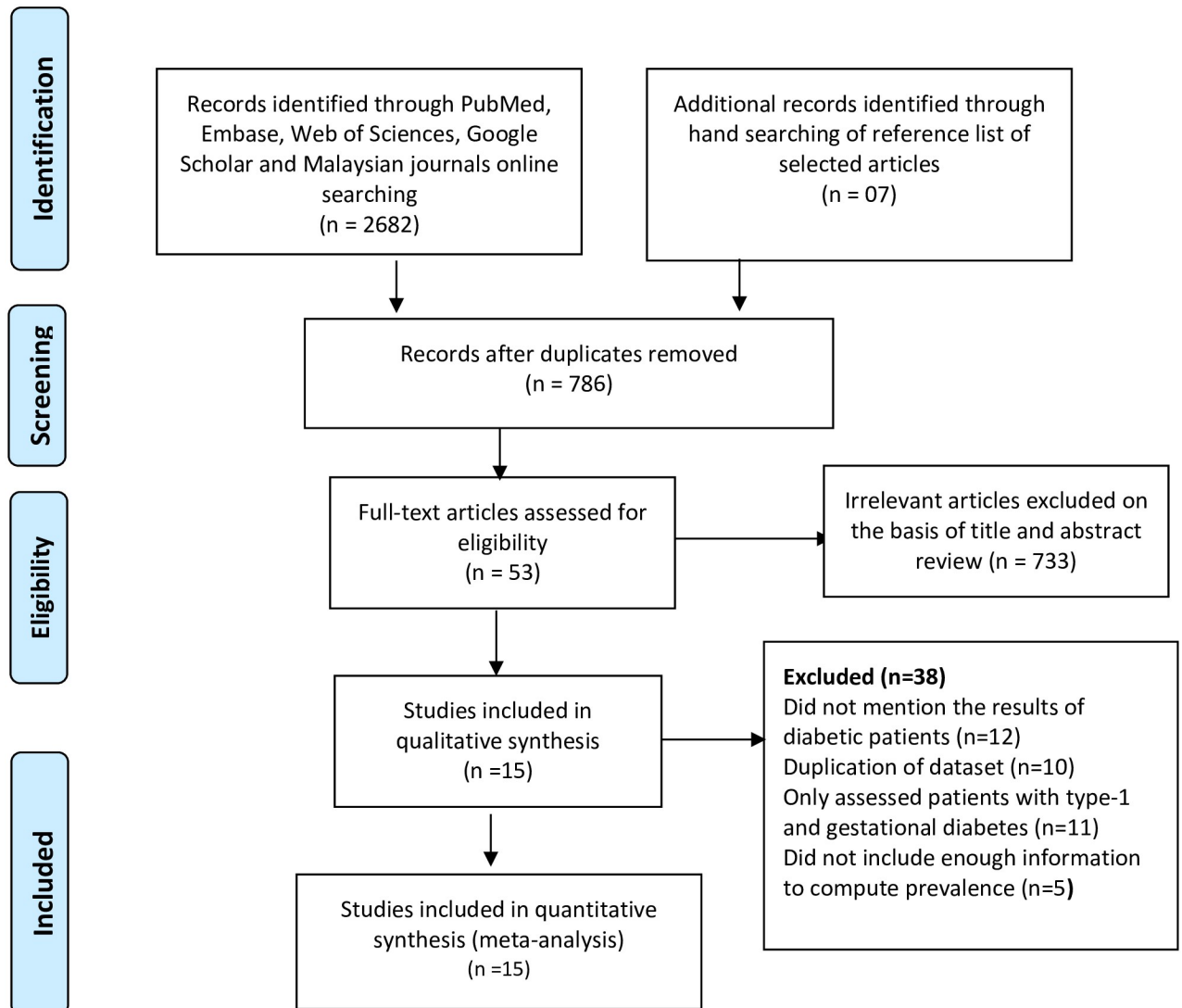
Fig 1. Study and data inclusion, using PRISMA 2009 guideline [17].

https://doi.org/10.1371/journal.pone.0263139.g001

p = 0.5862, respectively). The visual inspection of funnel plot also showed no evidence of the presence of publication bias (Fig 3). The sensitivity analysis revealed that the pooled prevalence of diabetes varied from 13.76% (95% CI, 11.90%–15.72%) to 14.91% (95% CI, 12.96%–16.98%) after removing a one study at one time (Supplement file, S1 Fig), but no single study had a significant influence on the pooled prevalence.

The prevalence of prediabetes was reported in 9 studies, with a total of 88702 individuals. The overall pooled estimated prevalence of prediabetes was 11.62% (95% CI, 7.17%–16.97%, prediction interval: 0.25–35.23) by random-effects meta-analysis. The meta-analysis had a high level of heterogeneity (I^2 = 99.8%; P <0.001) (Fig 4). The visual inspection of the funnel plot (Fig 5) suggested no evidence of the presence of publication bias in the analysis. This was also not found to be statistically significant by the Egger's test of bias. The sensitivity analysis revealed that the pooled prevalence of diabetes varied from 10.43% (95% CI, 6.56%–15.07%) to 12.84% (95% CI, 7.40%–19.49%) after removing a one study at one time (Supplement file S2 Fig), but no single study had a significant influence on the pooled prevalence of prediabetes.

Table 1. Summary of the general characteristics selected studies.

Author	Year	Data collection Year	Sample Size	Positive for type-2 diabetes	Positive for prediabetes	Prevalence of diabetes	Avg. Age of participant	Research Design	Setting	Male (%)	State	Sampling strategy	Diagnostic method And criteria	% of hypertension	% of Over-weight/ Obese	% of smoker	Risk Bias
NHMS-2019 [11]	2019	2019	10464	1915	NA	18.3	NA	NA	Both	49.9	National	Two Stage Stratified Random	FBG≥7 mmol/l, 2hBG>11.1 mmol/l	32.7	NA	11.5	High
Harris et al. [14]	2019	February to May 2015	330	24	NA	7.3	43.7	CS	Rural	40.3	Eastern Sabah	Stratified Random Sampling	FBG≥7 mmol/l	26.79	NA	18.45	Medium
Samsudin et al. [15]	2016	September 2012 to February 2013	1414	337	NA	23.8	69.31	CS	Urban	NA	Northern Areas	Stratified, Multistage, and Snowball	NA	42.4	NA	NA	Medium
Khebir et al. [27]	1996	November 1993 to January 1994	260	38	30	14.6	46.5	CS	Rural	43.1	Kuala Selangor	Simple Random sampling	2hPG>11.1 mmol/l	NA	11	NA	High
NHMS-2006 [28]	2006	2006	34539	4007	1451	11.6	NA	CS	Both	44.8	National	Two Stage Stratified Random	FPG≥7 mmol/l, 2hPG≥11.1 mmol/l	NA	NA	NA	High
Nazri at al. [29]	2008	September 2005	348	27	NA	7.8	40.7	CS	Rural	47.3	Pulau Kundur	Simple Random Sampling	NA	12.6	49.1	55.8	Medium
Rampal at al. [30]	2009	2004	7683	1168	1321	15.2	46.8	CS	Urban	39.6	National	Stratified Two Stage Cluster Sampling	FBG≥7 mmol/l	NA	NA	NA	High
Mohamud et al. [31]	2010	NA	119	10	20	8.5	35.83	NA	Rural	0	Peninsular	NA	FPG≥7 mmol/l	NA	NA	NA	High
NHMS-2011 [32]	2011	2011	17783	2703	871	15.2	NA	NA	Both	46.7	National	NA	FBG≥6.1 mmol/l, 2hBG>11 mmol/l	32.7	NA	NA	High
Mustafa et al. [33]	2011	April to August 2008	3879	489	857	12.6	50.93	CS	Both	34	National	NA	FPG≥7 mmol/l, 2hPG≥11.1 mmol/l	76.5	NA	10.8	High
Nazaimoon et al. [34]	2013	NA	4336	993	939	22.9	48.02	CS	Both	35.1	National	Two Stage Stratified Random	FPG≥7 mmol/l, 2hPG≥11.1 mmol/ 1,6.3≤HbA1C≤6.5 mmol/l	NA	NA	NA	High
NHMS-2015 [35]	2015	2015	19935	3489	937	17.5	NA	NA	Both	47.6	National	NA	FBG≥6.1 mmol/l, 2hBG>11 mmol/l	30.3	NA	NA	High
Aniza et al. [36]	2016	March to November 2011	1489	162	NA	10.9	44.9	CS	Rural	38.7	Tanjung Karang	Convenient Sampling	NA	20.6	NA	NA	High
Naggar et al. [37]	2017	March 2016	316	34	NA	10.8	NA	CS	NA	53.5	Selangor	Simple Random Sampling	NA	30	19.7	21.3	Medium
Rahim et al. [38]	2020	August to November 2017	168	33	17	19.6	52.63	CS	Rural	54.8	Penang	Simple Random Sampling, Convenience Sampling	NA	39.5	23.7	25.2	Medium

Abbreviations; HbA1C, glycated hemoglobin; FBG, fasting blood glucose, FBG, fasting blood glucose, FPG, fasting plasma glucose CS, cross-sectional; 2hBG, 2-hour blood oral glucose; mmol/l, millimoles per liter, NA, not available.

https://doi.org/10.1371/journal.pone.0263139.t001

Table 2. Summary of overall and subgroup meta-analyses.

| Variable	Studies	Sample size	Positive cases	Prevalence, % (95% CI)	I^2	95%, Prediction interval	p-Heterogeneity	p Egger	P-Difference
Prediabetes	9	88702	6443	11.62 (7.17–16.97)	0.998	(0.29–35.23)	< 0.001	0.1209	0.8978
Male prediabetes	7	39241	2796	10.98 (6.95–15.79)	0.994	(0.58–31.47)	< 0.001		
Female prediabetes	8	49201	3565	11.40 (6.55–17.40)	0.997	(0.01–37.55)	< 0.001		
Diabetes	15	103063	15429	14.39 (12.51–16.38)	0.984	(7.37–23.23)	< 0.001	0.7296	
Undiagnosed	8	91526	6798	8.60 (6.48–10.99)	0.992	(2.25–18.48)	< 0.001	0.2363	
By Gender								0.7555	0.6063
Male	12	45580	6697	13.80 (11.94–15.77)	0.961	(7.53–21.56)	< 0.001		
Female	13	55678	7992	14.54 (12.50–16.70)	0.973	(7.49–23.40)	< 0.001		
By Setting								0.8733	0.0594
Rural	11	37307	5060	12.72 (10.63–14.97)	0.966	(5.84–21.73)	< 0.001		
Urban	7	61561	9285	15.89 (13.59–18.34)	0.984	(8.23–25.48)	< 0.001		
By Age								0.3720	0.0001
20 to 29	5	2078	110	3.16 (3.62–6.94)	0.493	(1.35–11.05)	0.0915		
30 to 45	4	5935	815	13.71 (12.85–14.60)	0.000	(11.84–15.69)	< 0.001		
46 to 59	4	11165	2517	25.66 (20.60–31.07)	0.966	(5.70–53.57)	< 0.001		
60+	6	10191	3489	33.45 (28.45–38.64)	0.955	(17.14–52.08)	< 0.001		
Time period								0.7296	0.0210
1995–2010	5	42949	5250	11.82 (9.44–14.43)	0.951	(4.56–21.81)	< 0.001		
2011–2020	10	64615	11003	15.77 (13.75–17.89)	0.974	(8.98–24.00)	< 0.001		
Ethnicity								0.1269	<0.0001
Malay	10	56435	7718	15.25 (11.59–19.29)	0.993	(3.70–32.67)	0.0001		
Chinese	9	18057	1949	12.87 (9.73–16.37)	0.974	(3.29–27.38)	0.0233		
Indian	9	7909	1724	25.10 (20.19–30.35)	0.959	(9.14–45.65)	0.0001		
Bumiputeras	9	9699	704	8.62 (5.41–12.47)	0.968	(0.37–25.27)	0.3535		
Others	6	1710	122	6.91(5.71–8.19)	0.000	(5.25–8.76)	0.8290		
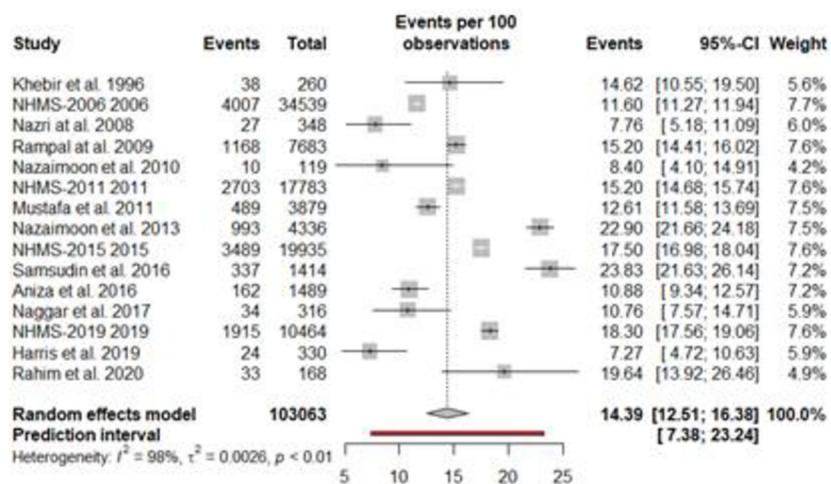
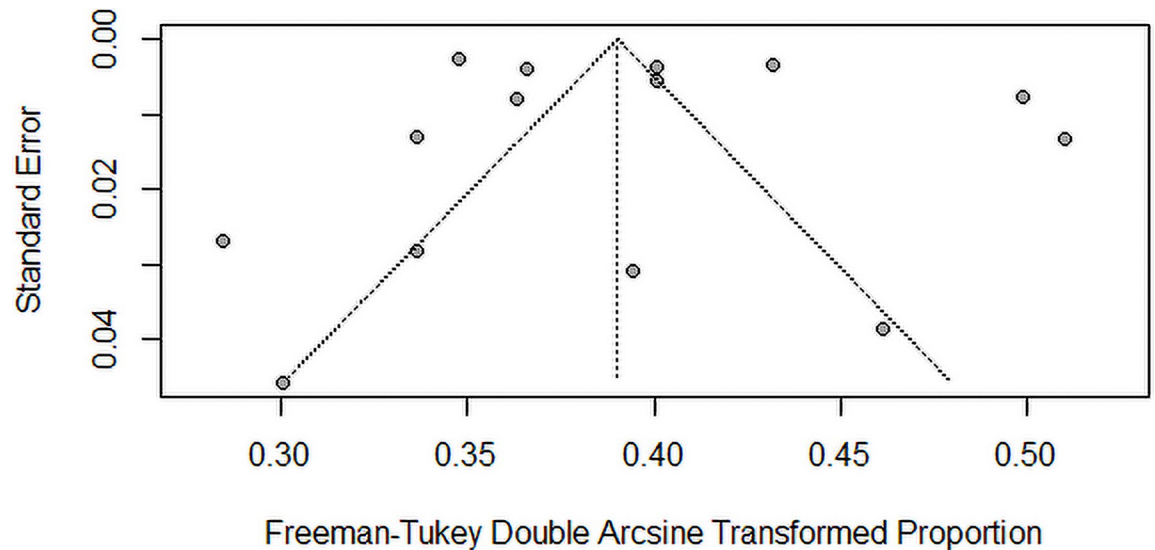**Fig 2. Pooled prevalence of type-2 diabetes in Malaysia.**

Fig 3. Funnel plot of the prevalence of type-2 diabetes in Malaysia.

According to GRADE approach (Table 3), the quality of evidence on the pooled prevalence of diabetes was found to be of low certainty because of inconsistency (the presence of high heterogeneity).

Table 2 also demonstrates the prevalence of diabetes according to gender, setting (rural or urban), ethical sub-groups, time period and age of participants. The prevalence of prediabetes and diabetes did not differ significantly when stratified by sex. The pooled prevalence of diabetes by gender was 13.80% (95% CI, 11.94%–15.77%; I^2 = 96.1%) for men and 14.54% (95% CI, 12.50%–16.70%; I^2 = 97.3%) for women in the population-based studies while pooled
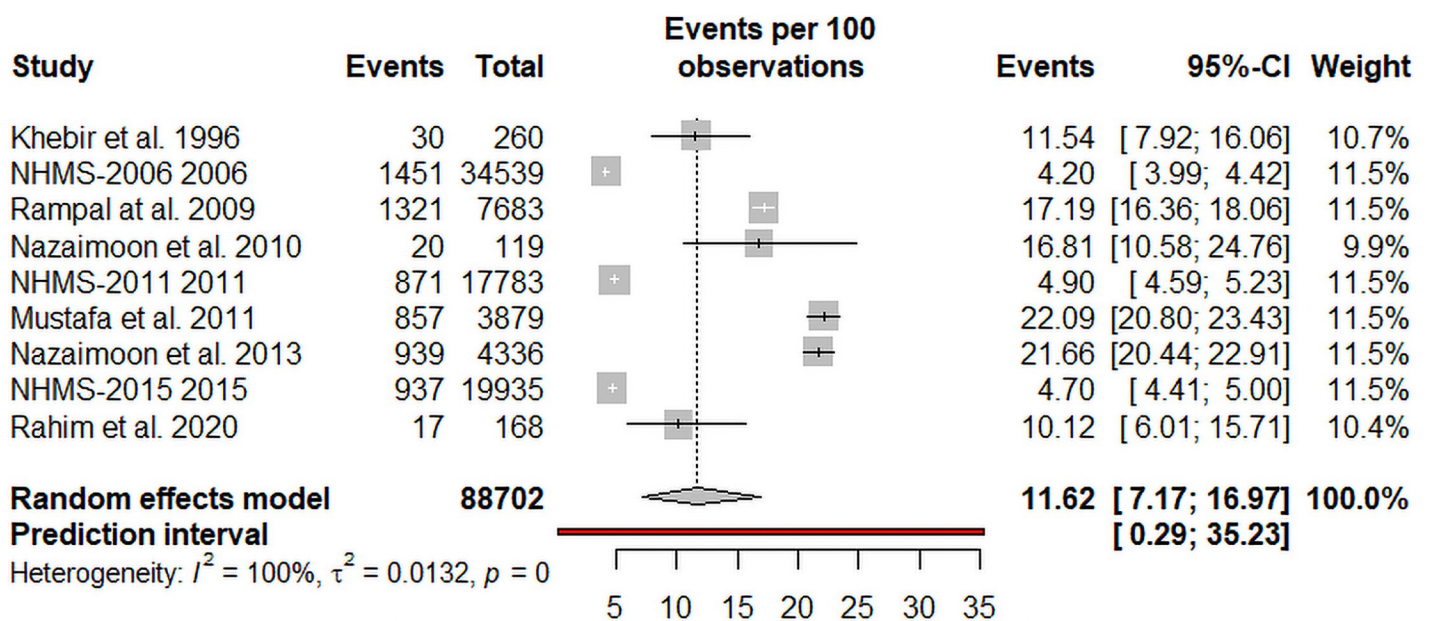

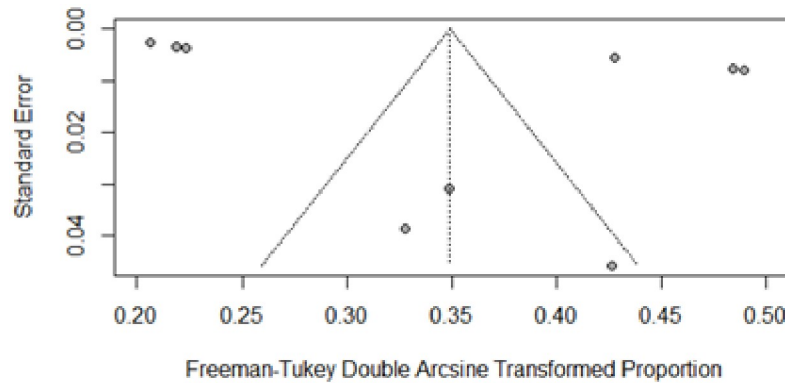**Fig 4. Pooled prevalence of prediabetes in Malaysia.**

Fig 5. Funnel plot of the prevalence of prediabetes in Malaysia.

prevalence of prediabetes was 11.40% (95% CI, 6.55%–17.40%; I^2 = 99.7%) for women and 10.98% (95% CI, 6.95%–15.79%; I^2 = 99.4%) for men. The prevalence of diabetes for each ethical subpopulation was highest in the Indians sub-population (25.10%; 95% CI, 20.19%–30.35%), followed by Malays (15.25%; 95% CI, 11.59%–19.29%), Chinese (12.87%; 95% CI, 9.73%–16.37%), Bumiputeras (8.62%; 95% CI, 5.41%–12.47%) and others (6.91%; 95% CI, 5.71%–8.19%). There was a significant (p<0.001) increasing trend in diabetes prevalence with increasing age, from 3.16% (95% CI: 3.62%–6.94%) in the 20–29 years age group, 13.71% (95% CI, 12.85%–14.60%) in the 30–45 years age group, 25.66% (95% CI, 20.60%–31.07%) in the 46–59 years of age group, and 33.45% (95% CI, 28.45%–38.64%) in the 60 and above years age groups.

Diabetes prevalence stratified by publication period: 1995–2010, and 2011–2020. Diabetes prevalence was 11.82% (95% CI, 9.44%–14.43%) and 15.77% (95% CI, 13.75%–17.89%) for the publication periods, respectively. Over a 26-year period (1995–2020), the pooled prevalence of diabetes raised from 11.82% to 15.77%. Furthermore, there was no significant difference in the prevalence of diabetes based on diagnostic method (FBG/2hBG, 14.95%; FBG, 10.32%, with p = 0.2058). For all subgroup analyses, there was no publication bias.

Random-effects univariable meta-regression models (Table 4) revealed a stronger association with prevalence of diabetes and increasing age year (β = 0.0073; 95% CI: 0.0021–0.0125, p = 0.0059; R^2 = 12.45%), study year (β = 0.0039; 95% CI: 0.0007–0.0071, p = 0.0173; R^2 =

Table 3. GRADE assessment for the studies included in the synthesis with meta-analysis.

№ of studies				Quality assessment					
	Study design	Participants	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Estimated effect (95% CI)	Quality of Evidence
15	Observational studies	103063	Serious[1]	Very Serious[2]	Serious[3]	Serious[4]	Not Serious[5]	14.39% (12.51–16.38)	⊕⊕ LOW

[1] Study quality (assessed by the JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data) ranged from high to low risk of bias. More than 50% of studies included in this analysis were of low risk of bias.

[2] Based on substantial heterogeneity (I^2 ranged from 0.00% to 99·8%) and differing estimates of the effect across studies.

[3] Downgrade for serious indirectness due age and ethnical variation, therefore affecting the generalizability to the general population.

[4] The spread of the 95% CI exceeded 10% (±5%); and Only 2 studies had large 95% CIs.

[5] Visual inspection of funnel plot found no evidence of publication bias. The Egger's and Begg's tests also did not find any publication bias in the meta-analysis (p = 0.7296 and p = 0.5862, respectively).

Table 4. Summary of findings univariate meta-regression analyses.

Variable	Beta (β)	p-value	95%CI	R^2%
Publication year	0.0025	0.1975	(-0.0013–0.0063)	44.27
Study year	0.0039	0.0173	(0.0007–0.0071)	53.13
Age	0.0073	0.0059	(0.0021–0.0125)	12.45
Hypertension	0.0004	0.5777	(-0.0011–0.0020)	4.60
Methodology	-0.0387	0.1325	(-0.0898–0.0123)	14.89
Overweight	-0.0042	0.1484	(-0.0100–0.0015)	40.69
Gender (male)	0.0014	0.3164	(-0.0013–0.0040)	0.00
Setting	-0.1141	0.0438	(-0.2250–-0.0032)	12.63
Smoking	-0.0015	0.4588	(-0.0056–0.0025)	0.00

https://doi.org/10.1371/journal.pone.0263139.t004

53.13%), and study setting (β = -0.1141; 95% CI: -0.2250–-0.0032, p = 0.0438; R^2 = 12.63%). The diabetes prevalence was not statistically associated with gender, overweight, smoking status, and quality of studies.

Discussion

The primary goal of this systematic review and meta-analysis was to collect all available data on the prevalence of diabetes and prediabetes, as well as the risk factors associated with them, among adults in Malaysia between 1995 and 2021. The findings of this study will aid in the development of public health strategies to reduce the prevalence of prediabetes and diabetes. This analysis included 15 studies with a total of 103063 participants. The pooled prevalence of diabetes was 14.39%–approximately one out of every 7 people living in Malaysia is suffering from diabetes. Our results are consistent with a meta-analysis examining the prevalence of diabetes in another Asian country (Pakistan 14.62%) [20]. However, the prevalence of diabetes in Malaysia is significantly higher than the neighboring countries, like Singapore (5.5%) [39] and Indonesia (6.2%) [40].

When age groups were compared, the prevalence of diabetes in the 20–29 year age group was the lowest (3.16%), while the highest prevalence was reported in the 60 and older age group (33.46%). People aged 60 and more are more than 10 times as likely as those aged 20–29 to have type-2 diabetes. This is because that Malaysians is a fast-ageing population in world with average age is 74.4 years in 2017 [41,42]. At the population level, the increasing ageing population and low death rates will increase the proportion of people living with diabetes, putting a large number of people at risk of acquiring sequelae [43].

By stratifying ethically, subgroup analysis revealed that there is a strong association between pooled diabetes prevalence and major ethnic groups. The prevalence of diabetes was most common in the Indian's subpopulation (25.10%), followed by the Malays (15.25%), Chinese (12.87%), Bumiputera (8.62%) and others (6.91%). The results also suggest that the prevalence of diabetes is not influenced by year of publication, sex distribution, gender ratio, methodological quality of studies, setting and smoking.

This study has certain limitations. As expected, we found significant heterogeneity in the included studies, suggesting that about 97% of the variability in the measure of the prevalence of diabetes is due to heterogeneity between studies rather than chance. Subgroup analysis and meta-regression models were used to address the issue of high heterogeneity, with factors added to the univariate model. The findings of this meta-analysis should be interpreted with caution due to the high degree of heterogeneity. Another shortcoming of this review is that the articles chosen did not differentiate between type 1 and type 2 diabetes. As a result, we

hypothesized that all cases of diabetes reported were type-2 which accounts for 90 to 95 percent of all diabetes cases. Furthermore, this study is based on only a few publications (only 15). Because of the small number of studies included in this review, only univariate meta-regression (instead of multivariable meta-regression) analysis is used to analyze the importance of each covariate.

Despite these limitations, this is the first systematic review and meta-analysis to provide pooled prevalence of diabetes and prediabetes in Malaysia. Before beginning the study, we published a protocol outlining our methodology, and we employed scientific and statistical procedures to collect and pool data. Subgroup studies and random effect meta-regression analyses were performed to evaluate the numerous factors that could affect our estimate.

Conclusion

This study comprehensively describes the prevalence of prediabetes and diabetes in adult population from Malaysia from 1995 to 2021. This study suggests that the pooled diabetes prevalence in Malaysia was 14.39%, but varied significantly by ethical subpopulations with the highest in Indians and lowest in Bumiputeras. The prevalence of diabetes is higher than in neighbouring countries such as Indonesia and Singapore.

Because diabetes and prediabetes are on the increase in Malaysia, the Malaysian government should establish diabetes control programmes throughout the country. To minimize the prevalence of diabetes in Malaysia, the Malaysian government should develop a comprehensive approach and strategy to enhance diabetes awareness, control, prevention, and treatment.

Supporting information

S1 Fig. Forest plot of the sensitivity analysis for prevalence of type-2 diabetes in Malaysia.
(TIF)

S2 Fig. Forest plot of the sensitivity analysis for prevalence of prediabetes in Malaysia.
(TIF)

S1 Table. Search strategies for electronic databases.
(DOCX)

S1 File. PRISMA checklist.
(DOC)

Author Contributions

Conceptualization: Sohail Akhtar.

Data curation: Sohail Akhtar, Jamal Abdul Nasir, Aqsa Ali, Mubeen Asghar, Rizwana Majeed.

Formal analysis: Sohail Akhtar, Mubeen Asghar.

Investigation: Sohail Akhtar, Aqsa Ali, Mubeen Asghar, Rizwana Majeed.

Methodology: Sohail Akhtar.

Software: Sohail Akhtar, Aqsa Ali, Rizwana Majeed.

Supervision: Sohail Akhtar, Jamal Abdul Nasir.

Validation: Rizwana Majeed.

Visualization: Sohail Akhtar.

Writing – original draft: Sohail Akhtar.

Writing – review & editing: Jamal Abdul Nasir, Aqsa Sarwar.

References

1. Lin X, Xu Y, Pan X, Xu J, Ding Y, Sun X, et al. Global, regional, and national burden and trend of diabetes in 195 countries and territories: an analysis from 1990 to 2025. Scientific reports. 2020 Sep 8; 10 (1):1–1.

2. Patterson CC, Harjutsalo V, Rosenbauer J, Neu A, Cinek O, Skrivarhaug T, et al. Trends and cyclical variation in the incidence of childhood type 1 diabetes in 26 European centres in the 25 year period 1989–2013: a multicentre prospective registration study. Diabetologia. 2019 Mar; 62(3):408–17. https://doi.org/10.1007/s00125-018-4763-3 PMID: 30483858

3. Wang L, Gao P, Zhang M, Huang Z, Zhang D, Deng Q, et al. Prevalence and ethnic pattern of diabetes and prediabetes in China in 2013. Jama. 2017 Jun 27; 317(24):2515–23. https://doi.org/10.1001/jama.2017.7596 PMID: 28655017

4. Akhtar S, Khan Z, Rafiq M, Khan A. Prevalence of type II diabetes in District Dir Lower in Pakistan. Pakistan journal of medical sciences. 2016 May; 32(3):622. https://doi.org/10.12669/pjms.323.9795 PMID: 27375702

5. Dwyer-Lindgren L, Mackenbach JP, Van Lenthe FJ, Flaxman AD, Mokdad AH. Diagnosed and undiagnosed diabetes prevalence by county in the US, 1999–2012. Diabetes care. 2016 Sep 1; 39(9):1556–62. https://doi.org/10.2337/dc16-0678 PMID: 27555622

6. Akhtar S, Shah SW, Javed S, Alina A. Prevalence of diabetes and prediabetes in district swat Pakistan. Pak J Med Sci. 2021 Feb 1; 71:243–6.

7. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas. Diabetes research and clinical practice. 2019 Nov 1; 157:107843. https://doi.org/10.1016/j.diabres.2019.107843 PMID: 31518657

8. Federation ID. IDF diabetes atlas. 2013. International Diabetes Federation, Brussels, Belgium. 2015.

9. Boyle JP, Thompson TJ, Gregg EW, Barker LE, Williamson DF. Projection of the year 2050 burden of diabetes in the US adult population: dynamic modeling of incidence, mortality, and prediabetes prevalence. Population health metrics. 2010 Dec; 8(1):1–2.

10. Ganasegeran K, Hor CP, Jamil MF, Loh HC, Noor JM, Hamid NA, et al. A Systematic Review of the Economic Burden of Type 2 Diabetes in Malaysia. International journal of environmental research and public health. 2020 Jan; 17(16):5723. https://doi.org/10.3390/ijerph17165723 PMID: 32784771

11. Ganasegeran K, Hor CP, Jamil MF, Suppiah PD, Noor JM, Hamid NA, et al. Mapping the Scientific Landscape of Diabetes Research in Malaysia (2000–2018): A Systematic Scientometrics Study. International journal of environmental research and public health. 2021 Jan; 18(1):318. https://doi.org/10.3390/ijerph18010318 PMID: 33406730

12. Institute for Public Health (IPH), National Institutes of Health, Ministry of Health Malaysia. 2020. National Health and Morbidity Survey (NHMS) 2019: Vol. I: NCDs—Non-Communicable Diseases: Risk Factors and other Health Problems.

13. The Star News. https://www.thestar.com.my/news/nation/2019/03/27/malaysia-has-36-million-diabeticssays-dzulkefly [assessed 12 Oct 2021].

14. Harris H, Ooi YB, Lee JS, Matanjun P. Non-communicable diseases among low income adults in rural coastal communities in Eastern Sabah, Malaysia. BMC Public Health. 2019 Jun; 19(4):1–3. https://doi.org/10.1186/s12889-019-6854-6 PMID: 31196012

15. Samsudin S, Abdullah N, Applanaidu SD. The prevalence of diabetes mellitus and hypertension and its effects on healthcare demand among elderly in Malaysia. International Journal of Public Health Research. 2016 Jan 1; 6(2):741–9.

16. Ho BK, Jasvindar K, Gurpreet K, Ambigga D, Suthahar A, Cheong SM, et al. Prevalence, awareness, treatment and control of diabetes mellitus among the elderly: The 2011 National Health and Morbidity Survey, Malaysia. Malaysian family physician: the official journal of the Academy of Family Physicians of Malaysia. 2014; 9(3):12.

17. Moher D, Liberati A, Tetzlaff J, Altman DG, Prisma Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS medicine. 2009 Jul 21; 6(7):e1000097. https://doi.org/10.1371/journal.pmed.1000097 PMID: 19621072

18. Akhtar S, Nasir JA, Javed A, Saleem M, Sajjad S, Khan M, et al. The prevalence of diabetes in Afghanistan: a systematic review and meta-analysis. BMC public health. 2021 Dec; 21(1):1–8.

19. Akhtar S, Nasir JA, Sarwar A, Nasr N, Javed A, Majeed R, et al. Prevalence of diabetes and pre-diabetes in Bangladesh: a systematic review and meta-analysis. BMJ open. 2020 Sep 1; 10(9):e036086. https://doi.org/10.1136/bmjopen-2019-036086 PMID: 32907898

20. Akhtar S, Nasir JA, Abbas T, Sarwar A. Diabetes in Pakistan: a systematic review and meta-analysis. Pakistan journal of medical sciences. 2019 Jul; 35(4):1173. https://doi.org/10.12669/pjms.35.4.194 PMID: 31372163

21. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. International journal of evidence-based healthcare. 2015 Sep 1; 13(3):147–53. https://doi.org/10.1097/XEB.0000000000000054 PMID: 26317388

22. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. Bmj. 2003 Sep 4; 327(7414):557–60. https://doi.org/10.1136/bmj.327.7414.557 PMID: 12958120

23. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Statistics in medicine. 2002 Jun 15; 21(11):1539–58. https://doi.org/10.1002/sim.1186 PMID: 12111919

24. Higgins JP, Green S. Cochrane handbook for systematic reviews of interventions. Chichester, England; Hoboken.

25. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. Fam med. 2005 May 1; 37(5):360–3. PMID: 15883903

26. Guyatt GH, Oxman AD, Vist G, Kunz R, Brozek J, Alonso-Coello P, et al. GRADE guidelines: 4. Rating the quality of evidence—study limitations (risk of bias). Journal of clinical epidemiology. 2011 Apr 1; 64 (4):407–15. https://doi.org/10.1016/j.jclinepi.2010.07.017 PMID: 21247734

27. Khebir BV, Osman A, Khalid BA. Changing prevalence of diabetes mellitus amongst rural Malays in Kuala Selangor over a 10-year period. The Medical journal of Malaysia. 1996 Mar 1; 51(1):41–7. PMID: 10967978

28. National Health Morbidity Survey 2006. Kuala Lumpur: Institute for Public Health, Ministry of Health, Malaysia, 2006.

29. Nazri SM, Imran MK, Ismail IM, Faris AA. Prevalence of overweight and self-reported chronic diseases among residents in Pulau Kundur, Kelantan, Malaysia. Southeast Asian Journal of Tropical Medicine and Public Health. 2008 Jan 1; 39(1):162. PMID: 18567457

30. Rampal S, Rampal L, Rahmat R, Zain AM, Yap YG, Mohamed M, et al. Variation in the prevalence, awareness, and control of diabetes in a multiethnic population: a nationwide population study in Malaysia. Asia Pacific Journal of Public Health. 2010 Apr; 22(2):194–202. https://doi.org/10.1177/1010539509334816 PMID: 19443875

31. Mohamud WN, Suraiami M. Prevalence of diabetes, impaired fasting glucose and metabolic syndrome among female Orang Asli community in Peninsular Malaysia. International Journal of Diabetes in Developing Countries. 2010 Jul 1; 30(3):118.

32. National Health Morbidity Survey 2011. Kuala Lumpur: Institute for Public Health, Ministry of Health, Malaysia, 2011

33. Mustafa N, Kamarudin NA, Khir AS, Ismail IS, Musa KI, Kadir KA, et al. Prevalence of abnormal glucose tolerance and risk factors in urban and rural Malaysia. Diabetes Care. 2011 Jun 1; 34(6):1362–4. https://doi.org/10.2337/dc11-0005 PMID: 21498788

34. Nazaimoon WM, Md Isa SH, Wan Mohamad WB, Khir AS, Kamaruddin NA, Kamarul IM, et al. Prevalence of diabetes in Malaysia and usefulness of HbA1c as a diagnostic criterion. Diabetic Medicine. 2013 Jul; 30(7):825–8. https://doi.org/10.1111/dme.12161 PMID: 23413941

35. Institute for Public Health (IPH) 2015. National Health and Morbidity Survey 2015 (NHMS 2015). Vol. II: Non-Communicable Diseases, Risk Factors & Other Health Problems;2015.

36. Aniza I, Nurmawati A, Hanizah Y, Ahmad Taufik J. Modifiable risk factors of cardiovascular disease among adults in rural community of Malaysia: a cross sectional study. Malaysian Journal of Public Health Medicine. 2016; 16(1):53–61.

37. Al-Naggar RA, Osman MT, Ismail N, Ismail Z, Noor NA, Ruzlin AN, et al. Diabetes mellitus among selected Malaysian population: A cross-sectional study. International Journal of Medical Research & Health Sciences. 2017; 6(4):1–1.

38. Rahim FF, Abdulrahman SA, Kader Maideen SF, Rashid A. Prevalence and factors associated with prediabetes and diabetes in fishing communities in penang, Malaysia: a cross-sectional study. PloS one. 2020 Feb 10; 15(2):e0228570. https://doi.org/10.1371/journal.pone.0228570 PMID: 32040497

39. IDF Diabetes Atlas 10th edition 2021 https://www.diabetesatlas.org/data/en/country/179/sg.html [assessed 1 Oct. 2021].

40. Ligita T, Wicking K, Francis K, Harvey N, Nurjannah I. How people living with diabetes in Indonesia learn about their disease: A grounded theory study. PLoS One. 2019 Feb 22; 14(2):e0212019. https://doi.org/10.1371/journal.pone.0212019 PMID: 30794570

41. The Star News. https://www.thestar.com.my/opinion/letters/2021/03/16/malaysia039s-fast-ageingpopulation-are-we-ready-to-handle-the-consequences [Assessed 1 Oct 2021].

42. The Staitstimes News. https://www.straitstimes.com/asia/se-asia/malaysia-is-ageing-the-star [Assessed 1 Oct 2021].

43. Tan KW, Dickens BS, Cook AR. Projected burden of type 2 diabetes mellitus-related complications in Singapore until 2050: a Bayesian evidence synthesis. BMJ Open Diabetes Research and Care. 2020 Mar 1; 8(1):e000928. https://doi.org/10.1136/bmjdrc-2019-000928 PMID: 32184203