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Diabetes Mellitus in Malaysia: Effectiveness of Screening Programmes.

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Abstract

Diabetes mellitus (DM), traditionally widespread in the elderly, is now being diagnosed more frequently in the younger population as a result of unhealthy lifestyle. A health screening programme was conducted to identify the incidence and/or prevalence of diabetes mellitus (DM) in a specific target group of individuals, the target for this objective being 80%.

The purpose of this study is to determine whether the health screening program met its objective of identifying the incidence and /or prevalence of DM in the targeted population's blood glucose (HbA1c, cut point ≥6.3%) levels.

A cross-sectional study was conducted to analyse HbA1c data from 188 participants in the Klang Valley, Malaysia. The study included Malaysian citizens and permanent residents aged 40 to 59 years who attended the free health screenings at a registered clinics in the Klang Valley. Ethical clearance was granted (RMC/OCTOBER/2024/EC07). The HbA1c data were collected from a private laboratory between September 1, 2023, and December 31, 2023.

Out of the total of 188 individuals, in the age group between 40 and 59, 47.35% (n=89) were males and 52.65% (n=99) were females. As for the races, the participants were 41.5% (n=78) Malay, 40.4% (n=76) Chinese, 14.4% (n=27) Indians, and 3.7% (n=7) others. Out of n=188, 27.12% (n=51) were found to have HbA1c ≥6.3%. When the data was broken by ethnicities, 29% Malays (23 out of 78), 23.68% Chinese (18 out of 76), 33.33% Indians (9 out of 27) and 14.28 % (1 out of 7) others. The results indicate that less than 80% of individuals have HbA1c of ≥6.3% and Indians stand higher at 33.3%. Analysis using SPSS v.27 and ANOVA with HbA1c as the dependent variable and age, gender, and race as predictors showed an F-statistic of 1.613 and a p-value of 0.188. The non-significant p-value indicates that the model may not effectively explain the variation in HbA1c based on the predictors used.

The health screening programme did not achieve the target of identifying incidence or prevalence of 80% in the population. Indians 33.33% had the highest prevalence of diabetes mellitus in the sample population. This model may not be a good fit for explaining the variation in HbA1c, considering the given predictors i.e. age, gender and race in this population.

Keywords: health screening, diabetes, prevalence, incidence

1. Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by hyperglycaemia due to defects in insulin secretion, insulin action, or both[1]. It has become a significant global health challenge, leading to complications like cardiovascular disease, kidney failure, and neuropathy[2]. The condition also imposes a psychosocial burden on patients, severely impacting their quality-of-life[3]. The global prevalence of DM, particularly in developing countries, is rising and calls for a multifaceted approach, including healthcare interventions, lifestyle modifications, and policy support from governments and health organizations[4].

1.1 Prevalence of Diabetes Mellitus in the Adult Population Worldwide

The prevalence of diabetes is growing at an alarming rate, with an estimated 537 million people worldwide living with the condition in 2021, projected to rise to 783 million by 2045[5–6]. This increase is fuelled by factors such as population growth, aging, urbanization, and the obesity epidemic[7]. Type 2 diabetes mellitus (T2DM), which constitutes around 90% of all cases, is the dominant form of diabetes[8]. Countries like China, India, and the United States have the highest number of people affected[9]. In the Western Pacific region, including Malaysia, the prevalence is notably high, raising significant public health concerns[10]. The Malaysian Clinical Practice Guidelines (CPG) emphasize the need for more aggressive measures in managing this public health issue[11].

1.2 Undiagnosed Diabetes

A substantial proportion of people with diabetes are undiagnosed, particularly in low- and middle-income countries[12]. As of 2021, it is estimated that 1 in 2 adults with diabetes worldwide remain undiagnosed, increasing the risk of severe complications[13]. Late diagnosis contributes to higher healthcare costs and worsens health outcomes[14]. In Malaysia, about 50% of people with diabetes are unaware of their condition[15]. The Malaysian CPG advocates for earlier screening and better public awareness campaigns to tackle this issue[16].

1.3 The Use of HbA1c

HbA1c, or glycated haemoglobin, is a valuable tool for both diagnosing and managing diabetes. Unlike other blood glucose tests that provide a snapshot of blood sugar levels, HbA1c offers an average over two to three months, giving a more comprehensive picture of glycaemic control[17]. Both the American Diabetes Association (ADA) and Malaysian CPG recommend an HbA1c level of 6.5% or higher for diagnosing diabetes[18–19]. HbA1c testing has several advantages, such as not requiring fasting, but it may produce misleading results in patients with conditions like anemia[20].

1.4 Diabetes Contributes to Financial Burden

The financial burden associated with diabetes is substantial, both in terms of direct healthcare costs and indirect costs such as productivity loss[21]. In Malaysia, diabetes-related healthcare expenses accounted for a significant portion of healthcare spending, with $3.6 billion spent in 2018[22]. These costs

primarily go toward managing complications arising from poorly controlled diabetes[23]. Preventive measures and early intervention programs are essential to alleviate this financial strain, as emphasized by the Malaysian CPG[24].

1.5 A Comparison of Healthcare Interventions Pertaining to Diabetes

Countries worldwide have implemented various strategies to combat the diabetes epidemic. In the UK, the National Health Service (NHS) launched the National Diabetes Prevention Programme, which emphasizes lifestyle interventions such as diet and physical activity[25]. In the United States, the "Exercise is Medicine" program integrates physical activity into the healthcare system[26]. China has implemented the National Standardized Metabolic Disease Management Centre (MMC) to improve access to diabetes care[27]. In Singapore, the "War on Diabetes" campaign focuses on public awareness and early screening[28]. In Malaysia, the Ministry of Health has introduced initiatives for glycaemic control and medical nutrition therapy to reduce complications, as outlined in the Malaysian CPG[29].

1.6 The Health Screening Program (HSP)

The Malaysian Health Screening Program (HSP), introduced in 2013, is aimed at early detection of non-communicable diseases such as diabetes[30]. Targeting individuals aged 40 to 59, the HSP offers a variety of screening services, including blood tests, urine analysis, and clinical evaluations[31]. The program is designed to identify individuals at high risk and encourage early intervention, contributing to improved long-term health outcomes[32]. The success of the HSP is measured by its ability to identify cases of diabetes, with a particular focus on achieving an 80% prevalence of diagnosed cases using HbA1c screening criteria, as recommended by the Malaysian CPG[33]. Hence this study was carried out with the objective to determine the effectiveness of the Health Screening Program (HSP) in identifying the prevalence of diabetes mellitus (80%), using HbA1c levels, among Malaysian employees aged 40 to 59 who meet the inclusion criteria. The study also intended to compare the HbA1c levels among age, gender and race.

2. Materials and Methods

2.1 Study Design

This is a cross-sectional study that analysed the HbA1c results from the health screening programme using descriptive and inferential statistics to measure the incidence or prevalence of DM among the participants in Malaysia.

2.2 Sample and Setting

The sample was that of Malaysians and permanent residents aged 40 to 59 years who attended the screening conducted by a registered panel clinic in the Klang Valley. The inclusion criteria were individuals who were Malaysians, aged between 40 and 59 years old, active employment insurance contributors with at least one (1) month of contribution in the 2023, and at least 12 months of total contributions. Exclusion criteria included individuals who did not fulfil the above criteria. The study procured ethical exemption as patient data was not recognizable.

HbA1c Data was generated from a private laboratory from 1st September 2023 to 31st December 2023.

2.3 Data Analysis

The data was examined with SPSS version 27. Numerical data was entered into excel and spreadsheet tools For all tests, a significance level of less than 0.05 was determined.

3. Results

Among the total population of 199 participants extracted from the raw data, 188 participants were aged between 40 to 59 years. Table 3.1 provides the distribution of the 188 participants aged 40 to 59 years, categorized by ethnicity and further divided into two age groups: 40 to 50 years and 51 to 59 years.

Table 3.1 Demographic data (gender, age and ethnicity) of the 188 participants.

GENDER	ETHNICITY				
	MALAY	CHINESE	INDIAN	OTHERS	TOTAL
MALE	**N=47**	**N=26**	**N=13**	**N=3**	**N=89**
40 – 50 YEARS	n=37	n=21	n=8	n=3	69
51 – 59 YEARS	10	5	5	0	20
FEMALE	**31**	**50**	**14**	**4**	**99**
40 – 50 YEARS	18	40	12	3	73
51 – 59 YEARS	13	10	2	1	26

Majority of the participants were Malay males in the age group between 40 and 50 years old, whereas Chinese females were the majority in the same age group. The participants had a mean HbA1c of 6.5567 % (N=188). Out of the total of 188 individuals, in the age group between 40 and 59, 47.35% (n=89) were males and 52.65% (n=99) were females. As for the races, the participants were 41.5% (n=78) Malay, 40.4% (n=76) Chinese, 14.4% (n=27) Indians, and 3.7% (n=7) others. Out of n=188, 27.12% (n=51) were found to have HbA1c ≥6.3%. When the data was broken by ethnicities, 29% Malays (23 out of 78), 23.68% Chinese (18 out of 76), 33.33% Indians (9 out of 27) and 14.28 % (1 out of 7) belonged to other ethnic groups. The results indicate that less than 80% of individuals have HbA1c of ≥6.3% and Indians stand higher at 33.3%.

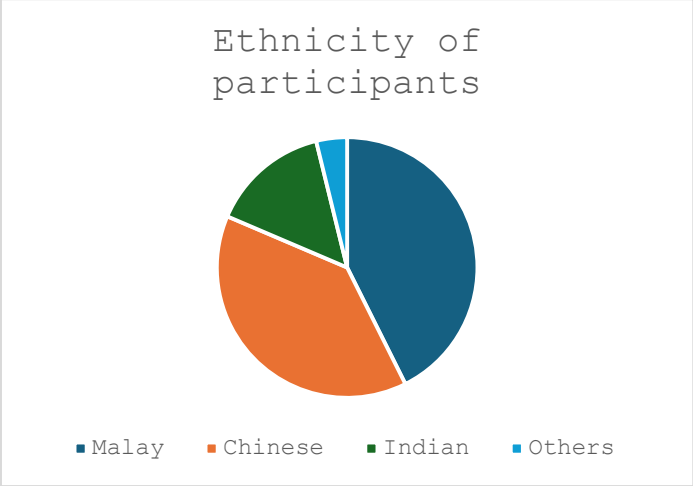

Figure 1. The pie chart of the ethnicity of the participants.

The descriptive analysis showed that only 27.12% of the participants had HbA1c results in the diabetic range, which is ≥6.3 as stated in the Malaysian CPG on Management of Type 2 Diabetes Mellitus (6th edition).

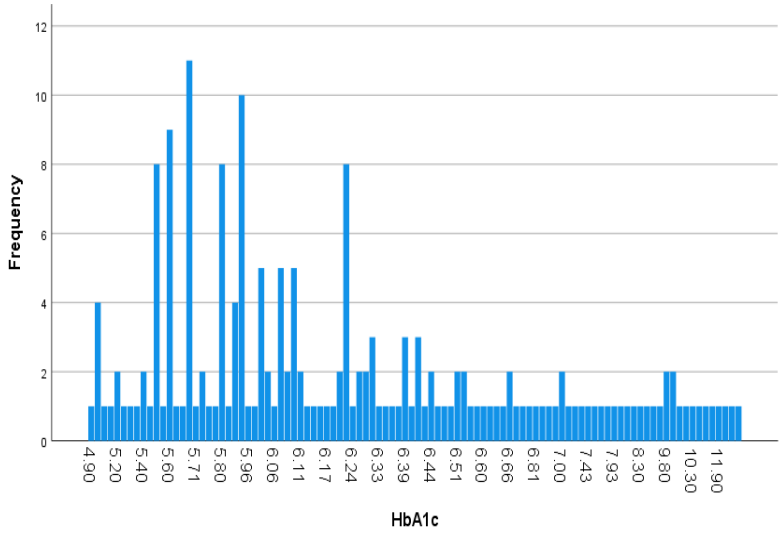

Figure 2. Bar chart of the distribution of HbA1c values among the participants.

Table 3.2 illustrates the gender distribution of participants in the HbA1c tests. This table presents the number and percentage of male and female participants included in the study examining HbA1c levels.

Table 3.2 Mean HbA1c according to gender

	Gender	N (%)	Mean	Std. Deviation	Std. Error Mean
HbA1c	**Female**	99 (52.66)	6.5877	1.71964	.17283
	Male	89 (47.34)	6.5222	1.50832	.15988

The mean HbA1c among the male participants was 6.5%, which included almost everyone included in the diabetes group, while for female, the mean was 6.6% which was only 0.1% higher than the male group. The normal A1c level should be below 5.7%. The participants who measured higher than ≥6.3% have a higher probability of suffering from type 2 diabetes mellitus as stated in the Malaysian CPG on Management of Type 2 Diabetes Mellitus (6th edition)

Since the data was normally distributed, means of HbA1c, between male and female groups were compared using independent T test. The analysis of HbA1c levels showed that the Levene's Test for Equality of Variances yielded an F-statistic of 0.155 with a non-significant p-value of 0.694, indicating equal variances. The t-test for Equality of Means compared male and female groups, resulting in a t-statistic of 0.276, 186 degrees of freedom, and a p-value of 0.783, showing no significant difference. The mean difference was 0.06543 with a 95% confidence interval from -0.40230 to 0.53316, confirming no significant gender-based difference in HbA1c levels.

The ANOVA analysis of the model with HbA1c as the dependent variable and age, gender and race as independent variables shows that the model's regression explains a portion of the variation in HbA1c. The F-statistic is 1.613, but with a p-value of 0.188, it is not statistically significant ($p > 0.05$). This indicates that the model may not effectively explain the variation in HbA1c with the given predictors.

4. Discussion

This study sets out to test the effectiveness of health screening programme in Malaysia to identify the prevalence of type II diabetes in the target population. Though the target was 80%, the data from this study revealed that the screening programme failed to achieve its target (27.12% HbA1c ≥6.3%) in the intended population. This could be due to the smaller sample size of the study and those working in the Klang Valley. The screening programme was apt to be conducted in Malayia indeed has one of the highest rates of diabetes in the Western Pacific region and is also among the highest globally. From 2011 to 2019, the prevalence of diabetes in Malaysia increased by 68.3%. In 2019, there were 3.6 million Malaysians aged 18 and above diagnosed with diabetes, and another 3.7 million were undiagnosed. By 2025, it is projected that 7 million Malaysians will have

diabetes, resulting in a prevalence rate of 31.3%. Reported prevalence rates in Malaysia have varied widely, ranging from 7.3% to 23.8%, depending on the study and population group examined [34].

According to the Demographic Data for Malaysia's 4th quarter of 2022, published by the Department of Statistics Malaysia (DOSM), the total population of the country was 33 million. The ethnic composition included 17.6 million Malays (57.8%), 6.9 million Chinese (22.7%), 2.0 million Indians (6.6%), 3.7 million Other Bumiputera (12.2%), and 0.2 million others (0.7%) [35.] In this study also the highest number of participants were Malay at 40.4% (n=76). But the number of participants of Indian ethnicity (n=9 out of 27 (33%)) had HbA1c more than the cut-off point. A study conducted in Malaysia in 2013 among 4341 subjects showed a prevalence of 22.9%. Similar to our results, diabetes was most prevalent amongst Indians (37.9%) and Malays (23.8%) [35].

Studies have explored the relationships between ethnicity, age, gender, and HbA1c levels among non-diabetic adults across different populations. For instance, a Community-Based Cross-Sectional Study in Northern and Eastern Sudan found that HbA1c levels were notably higher in Eastern Sudan compared to Northern Sudan. The study revealed that ethnicity and BMI had significant associations with HbA1c levels, while age and gender did not show significant correlations in these regions. These findings emphasize the impact of ethnic and regional differences on HbA1c levels, suggesting the need to consider these factors in diabetes management and prevention strategies in Sudan[36].

A cross-sectional study in Shenzhen, China, analysed 18,265 adults without a prior diabetes diagnosis to examine the association between HbA1c levels, age, and gender. The study found that HbA1c levels increase with age and are significantly higher in males compared to females. These findings suggest that both age and gender should be considered when using HbA1c as a diagnostic criterion for diabetes in Chinese populations [37]. In our study, females had a higher mean of HbA1c than males indicating a change in Malaysian population. The difference could also be due to a smaller sample size.

Yet another study involving 8,665 participants from two cohorts (SHIP-0 and SHIP-Trend) aimed to prevent diabetes misdiagnosis in the elderly by establishing age-dependent HbA1c reference intervals. The study found that HbA1c levels increase with age, with the upper reference limit (URL) rising from 42.1 mmol/mol (6.0%) for individuals aged 20-39 to 47.5 mmol/mol (6.5%) for those aged 60 and above. These age-dependent reference values for HbA1c, derived from healthy populations, are crucial for improving diabetes diagnosis and care in elderly patients, helping to avoid misdiagnosis and overtreatment [38].

A Malaysian study by Ismail et al. (2000) investigated the factors influencing glycaemic control in young diabetic patients across Peninsular Malaysia. The study analysed various sociodemographic variables, such as age, gender, ethnicity, educational

background, and socioeconomic status, to determine their impact on patients' ability to manage blood sugar levels effectively. The findings suggest that socioeconomic and educational factors play a significant role in determining glycaemic control among these patients, highlighting the need for targeted interventions to improve diabetes management based on these determinants [39].

However, in this study, the ANOVA analysis of the model, which examines HbA1c levels based on age, gender, and race, reveals that while the model's regression does explain some variation in HbA1c, it is not statistically significant. The F-statistic of 1.613 indicates the ratio of the variance explained by the model to the unexplained variance, but the p-value of 0.188 (greater than 0.05) suggests that this explanation is likely due to chance. Therefore, the model may not effectively capture how age, gender, and race impact HbA1c levels, indicating that other factors may be more relevant in explaining the variation.

Another issue that may come up is whether HbA1c was the correct test to do instead of fasting blood glucose (FBG) or random blood glucose (RBG). HbA1c is usually preferred for prevalence studies because it indicates long-term glucose control and is straightforward to use. However, fasting blood glucose (FBG) or random blood glucose (RBG) may be chosen instead in certain scenarios. FBG is often used for immediate diabetes or prediabetes diagnosis, especially in clinical settings requiring precise measurements, in resource-limited environments, or when conditions like anaemia affect HbA1c accuracy. RBG is beneficial for rapid confirmation of high glucose levels, especially in emergencies or community screenings where fasting isn't possible. Thus, while HbA1c is favoured for long-term monitoring, FBG and RBG are selected for immediate, specific, or practical reasons [40,41].

As an overall prevalence, this highlighted the increase in the prevalence of diabetes in Malaysia, regardless of the diagnostic criteria used [35]. It has also elucidated that the HbA1c threshold of ≥6.3% as a diagnostic criterion may underestimate the burden of this disease, and the HbA1c with a cut-off point of ≥6.3% together with FBG or RBG are found to give maximal sensitivity [35].

Conclusion

The health screening program aimed to assess diabetes mellitus incidence and / or prevalence among the participants. Despite being accessible and free, the program achieved only a 27% diabetes detection rate, falling short of expectations. Contributing factors included the program’s short duration, which did not account for aging and increasing life expectancy, self-selection bias, leading to underrepresentation of higher-risk individuals and its focus on health-conscious individuals, potentially excluding a more diverse population. The social media campaign probably failed to effectively reach the elderly, and the lack of non-fasting tests limited opportunistic screening. Additionally, the lack of fasting blood glucose (FBG) and random blood glucose (RBG) tests reduced screening opportunities. As HbA1c is generally

preferred for prevalence studies due to its reflection of long-term glucose control and ease of use, FBG and RBG may be used in specific contexts for immediate or precise diagnosis.

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Conflicts of Interest: The authors declare no conflict of interest

5. References

1. American Diabetes Association. (2021). Standards of medical care in diabetes—2021. *Diabetes Care, 44*(Supplement 1), S111-S124. https://doi.org/10.2337/dc21-S001

2. World Health Organization. (2021). *Global report on diabetes*. Geneva: WHO.

3. Lloyd, C. E., & Holt, R. I. G. (2020). The psychosocial impact of diabetes. *Diabetes Research and Clinical Practice, 162*, 108112. https://doi.org/10.1016/j.diabres.2020.108112

4. Ministry of Health Malaysia. (2020). *National Health and Morbidity Survey 2020: Diabetes prevalence report*. Putrajaya: Ministry of Health Malaysia.

5. Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., & Karuranga, S. (2019). Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045. *Diabetes Research and Clinical Practice, 157*, 107843. https://doi.org/10.1016/j.diabres.2019.107843

6. International Diabetes Federation. (2021). *IDF Diabetes Atlas* (10th ed.). Brussels: IDF.

7. Zimmet, P., Alberti, K. G. M. M., & Shaw, J. (2001). Global and societal implications of the diabetes epidemic. *Nature, 414*(6865), 782–787. https://doi.org/10.1038/414782a

8. Wild, S., Roglic, G., Green, A., Sicree, R., & King, H. (2004). Global prevalence of diabetes. *Diabetes Care, 27*(5), 1047–1053. https://doi.org/10.2337/diacare.27.5.1047

9. Centers for Disease Control and Prevention. (2020). *National Diabetes Statistics Report*. https://www.cdc.gov/diabetes/data/statistics-report/index.html

10. Yuen, L., & Wong, V. W. (2015). Diabetes in the Western Pacific region: The implications of the rising prevalence of diabetes for obesity. *Diabetologia, 58*(5), 1181–1196. https://doi.org/10.1007/s00125-015-3533-3

11. Ministry of Health Malaysia. (2020). *Management of Type 2*

Diabetes Mellitus (6th ed.). Putrajaya: Ministry of Health Malaysia.

12. Beagley, J., Guariguata, L., Weil, C., & Motala, A. A. (2014). Global estimates of undiagnosed diabetes in adults. *Diabetes Research and Clinical Practice, 103*(2), 150–160. https://doi.org/10.1016/j.diabres.2013.11.001

13. International Diabetes Federation. (2021). *IDF Diabetes Atlas* (10th ed.). Brussels: IDF.

14. Khunti, K., & Davies, M. (2017). Clinical inertia in the management of Type 2 diabetes mellitus: A focused literature review. *British Journal of Diabetes, 17*(2), 65–69. https://doi.org/10.15277/bjd.2017.132

15. Ministry of Health Malaysia. (2020). *Clinical practice guidelines: Management of type 2 diabetes mellitus* (5th ed.). Putrajaya: Ministry of Health Malaysia.

16. Nathan, D. M., Kuenen, J., Borg, R., Zheng, H., Schoenfeld, D., & Heine, R. J. (2008). Translating the A1C assay into estimated average glucose values. *Diabetes Care, 31*(8), 1473-1478. https://doi.org/10.2337/dc08-0545

17. American Diabetes Association. (2021). Standards of medical care in diabetes—2021. *Diabetes Care, 44*(Supplement 1), S111-S124. https://doi.org/10.2337/dc21-S001

18. Fayed, M. (2020). *Impact of anemia on HbA1c in diabetes mellitus patients: A systematic review and meta-analysis*. Journal of Diabetes Research, 2020(Article ID 9410384), 1-7. https://doi.org/10.1155/2020/9410384

19. NHS England. (2020). *Healthier You: NHS Diabetes Prevention Programme (NHS DPP)*. https://www.england.nhs.uk/diabetes/diabetes-prevention/

20. American College of Sports Medicine. (2021). *Exercise is Medicine®: Moving healthcare towards physical activity prescription*. https://www.exerciseismedicine.org/

21. Bommer, C., et al. (2017). The global economic burden of diabetes in adults aged 20-79 years: A cost-of-illness study. *The Lancet Diabetes & Endocrinology, 5*(6), 423-430. https://doi.org/10.1016/S2213-8587(17)30097-9

22. Riddle, M. C., Herman, W. H., & Bayliss, E. A. (2021). Managing the costs of diabetes care: A call to action. *American Journal of Managed Care, 27*(8), S148-S155.

https://doi.org/10.37765/ajmc.2021.88888

23. Ministry of Health Malaysia. (2015). *Clinical practice guidelines: Management of diabetes in adults* (5th ed.). Putrajaya: Ministry of Health Malaysia.

24. Seuring, T., Archangelidi, O., & Suhrcke, M. (2015). The economic costs of Type 2 diabetes: A global systematic review. *PharmacoEconomics, 33*(8), 811-831. https://doi.org/10.1007/s40273-015-0268-9

25. Ministry of Health Malaysia. (2013). *Health Screening Program (HSP) Overview*. Putrajaya: Ministry of Health Malaysia.

26. NHS England. (2019). *NHS Diabetes Prevention Programme: Information for health care professionals*. https://www.england.nhs.uk/diabetes/diabetes-prevention/

27. American College of Sports Medicine. (2019). *Exercise is Medicine initiative overview*. https://www.exerciseismedicine.org/support_page.php/about/

28. Li, Y., et al. (2020). China's response to diabetes: A comprehensive review of China's diabetes burden, programs, and policies. *Journal of Diabetes Research, 2020*(Article ID 9654934). https://doi.org/10.1155/2020/9654934

29. Ministry of Health Singapore. (2021). *War on Diabetes: Singapore's response to tackling diabetes*. https://www.healthhub.sg/programmes/180/war-on-diabetes

30. Ministry of Health Malaysia. (2020). *Clinical practice guidelines: Management of Type 2 Diabetes Mellitus (6th ed.)*. Putrajaya: Ministry of Health Malaysia.

31. Mohamud, W. N., et al. (2011). Prevalence of overweight and obesity among adult Malaysians: An update. *Asia Pacific Journal of Clinical Nutrition, 20*(1), 35-41.

32. Ministry of Health Malaysia. (2017). *Annual report on the Health Screening Program*. Putrajaya: Ministry of Health Malaysia.

33. Aris, T., et al. (2014). *The Health Screening Program: Impact assessment report*. Putrajaya: Ministry of Health Malaysia.

34. Ganasegeran K, Hor CP, Jamil MFA, Suppiah PD, Noor JM, Hamid NA, Chuan DR, Manaf MRA, Ch'ng ASH, Looi I. Mapping the Scientific Landscape of

Diabetes Research in Malaysia (2000–2018): A Systematic Scientometrics Study. *International Journal of Environmental Research and Public Health*. 2021; 18(1):318. https://doi.org/10.3390/ijerph18010318

35. Wan Nazaimoon WM, Md Isa SH, Wan Mohamad WB, Khir AS, Kamaruddin NA, Kamarul IM, Mustafa N, Ismail IS, Ali O, Khalid BA. Prevalence of diabetes in Malaysia and usefulness of HbA1c as a diagnostic criterion. Diabetic Medicine. 2013 Jul;30(7):825-8.

36. Ahmed SF, Hassan AA, Eltayeb MM, Omar SM, Adam I. Ethnicity, Age, and Gender Differences in Glycated Hemoglobin (HbA1c) Levels among Adults in Northern and Eastern Sudan: A Community-Based Cross-Sectional Study. *Life*. 2023; 13(10):2017. https://doi.org/10.3390/life13102017

37. Ma, Q., Liu, H., Xiang, G., Shan, W., & Xing, W. (2016). Association between glycated hemoglobin A1c levels with age and gender in Chinese adults with no prior diagnosis of diabetes mellitus. *Biomedical reports*, *4*(6), 737–740. https://doi.org/10.3892/br.2016.643

38. Masuch, A., Friedrich, N., Roth, J. *et al.* Preventing misdiagnosis of diabetes in the elderly: age-dependent HbA1c reference intervals derived from two population-based study cohorts. *BMC Endocr Disord* **19**, 20 (2019). https://doi.org/10.1186/s12902-019-0338-7

39. Ismail, I. S., Wan Nazaimoon, W. M., Wan Mohamad, W. B., Letchuman, R., Singaraveloo, M., Pendek, R., Faridah, I., Rasat, R., Sheriff, I. H., & Khalid, B. A. K. (2000). Socioedemographic determinants of glycaemic control in young diabetic patients in peninsular Malaysia. *Diabetes Research and Clinical Practice*, *47*(1), 57–69. https://doi.org/10.1016/s0168-8227(99)00104-7

40. NCD Risk Factor Collaboration (NCD-RisC) (2023). Global variation in diabetes diagnosis and prevalence based on fasting glucose and hemoglobin A1c. *Nature medicine*, *29*(11), 2885–2901. https://doi.org/10.1038/s41591-023-02610-2

41. Ghazanfari, Z., Haghdoost, A. A., Alizadeh, S. M., Atapour, J., & Zolala, F. (2010). A Comparison of HbA1c and Fasting Blood Sugar Tests in General Population. *International journal of preventive medicine*, *1*(3), 187–194.