Obesity, Family history and Consanguinity as predictors of Undiagnosed Type 2 Diabetes Among Adults

Sabah Desouky Lotfy [1], Amany Sobhy Sorour[2] , Huda Ibrahim Abd el-fattah[3]
1 B.Sc. Nursing Sciences, Zagazig University
2 Professor of Community Health Nursing , Faculty of Nursing, Zagazig University
3 Lecturer of Community Health Nursing , Faculty of Nursing, Zagazig University
Corresponding Author: Sabah Desouky Lotfy

Received: 28 October 2024, **Accepted:** 17 November 2024, **Published:** 20 November 2024

Abstract

Background: The global prevalence of type 2 diabetes mellitus (T2DM) continues to rise, with a substantial proportion of cases remaining undiagnosed, particularly among adults living with obesity. Early detection of silent hyperglycemia is essential to prevent microvascular and macrovascular complications and to reduce long-term healthcare burdens. Family history of diabetes is a well-established, powerful predictor of T2DM risk, reflecting a combination of shared genetic predisposition and lifestyle patterns. In many regions, particularly in the Middle East, North Africa, and South Asia, consanguineous marriage adds an additional genetic dimension by increasing the probability of homozygosity for diabetes-related susceptibility variants. These factors create clusters of high-risk individuals within households and communities, underscoring the need for targeted screening approaches.

Community health nursing plays a central role in identifying individuals at elevated risk through community-based outreach, home visits, risk assessment, point-of-care testing, and culturally sensitive health education. Integrating family history and consanguinity into screening algorithms can enhance detection efficiency, particularly in populations where consanguinity is culturally prevalent. This review highlights the interplay of obesity, familial predisposition, and consanguinity in shaping diabetes risk, and emphasizes community-level strategies for early detection. Strengthening community nursing capacities and tailoring screening programs to household risk patterns can significantly improve timely diagnosis and reduce the burden of undiagnosed T2DM among obese adults

Keywords: *Obesity, Family history, Consanguinity, predictors, Type 2 Diabetes, Adults*

Introduction

Type 2 diabetes mellitus (T2DM) represents a major and rapidly growing public health challenge, with global estimates indicating that over 537 million adults are currently living with the disease—and nearly half remain undiagnosed [1]. Early identification of asymptomatic hyperglycemia is critical, as many individuals present with microvascular or macrovascular damage by the time symptoms appear [2]. Obesity is one of the strongest modifiable risk factors for T2DM, and rising rates of overweight and obesity worldwide—especially in low- and middle-income countries—have contributed to a substantial increase in undiagnosed cases [3]. Excess adiposity promotes insulin resistance, pancreatic β-cell dysfunction, systemic inflammation, and metabolic abnormalities that can remain silent for years, making obese adults a priority group for community-based screening initiatives [4].

Beyond lifestyle factors, familial and genetic influences significantly shape diabetes risk. A positive

family history of T2DM markedly elevates the likelihood of developing the condition, particularly when one or more first-degree relatives are affected [5]. This increased risk reflects shared genetic traits as well as common health behaviors and environmental exposures within households. In many regions—especially the Middle East, North Africa, and South Asia—consanguineous marriage adds an additional genetic component by increasing the probability of homozygosity for diabetes-related susceptibility genes, thereby amplifying risk among offspring [6,7]. These combined factors result in clustered high-risk families and communities.

From a community health nursing perspective, recognizing the interplay between obesity, family history, and consanguinity is essential for designing effective screening programs, promoting early detection, and implementing culturally sensitive interventions at the household and community levels [8].

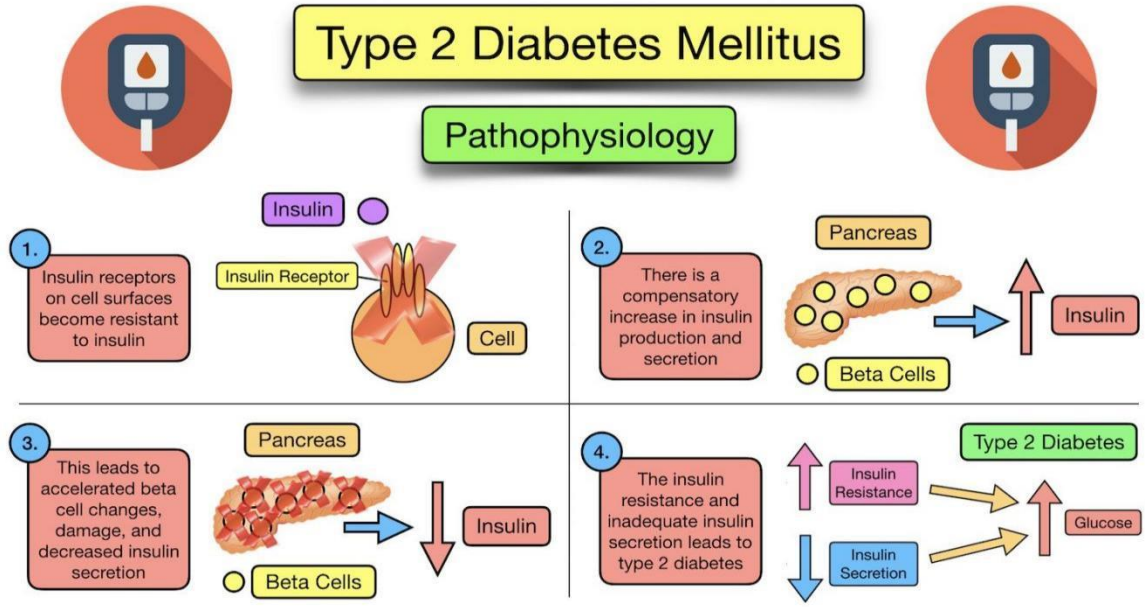

Figure [1]: Pathophysiology

Source: **Watson, C., & EZmed.** Pathophysiology. Type 2 Diabetes Mellitus: Symptoms, Medications & Treatment.

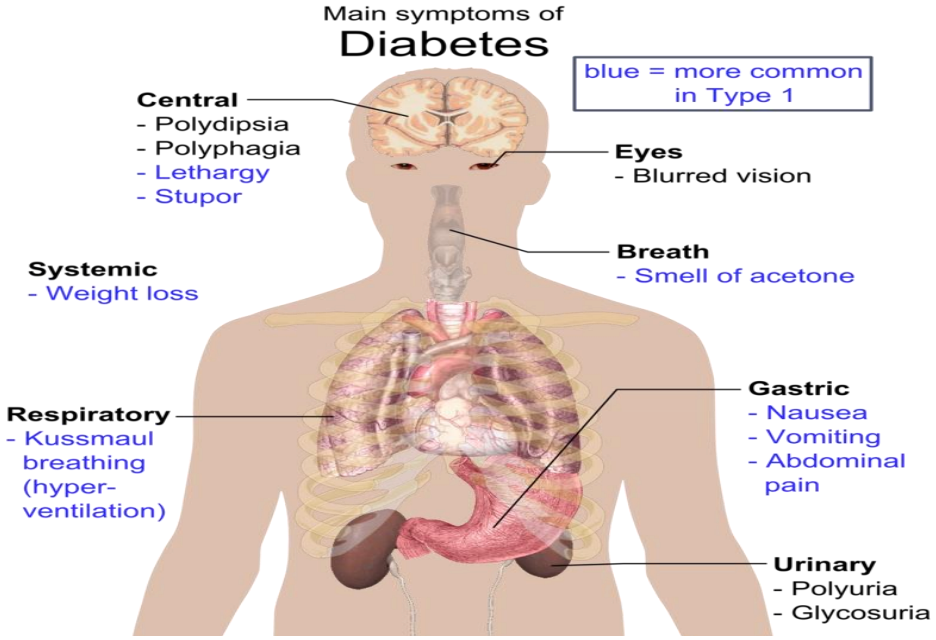

Figure [2]: Main symptoms of diabetes

Epidemiology of Undiagnosed Type 2 Diabetes

Type 2 diabetes mellitus (T2DM) continues to expand globally, with undiagnosed cases representing nearly half of all individuals living with the disease. The International Diabetes Federation reports that approximately 240 million adults worldwide have undiagnosed diabetes, leading many to present only when complications such as neuropathy, retinopathy, cardiovascular disease, or nephropathy are already established. This silent progression highlights the critical need for earlier community-based detection efforts [9].

Obesity significantly contributes to the epidemiology of undiagnosed T2DM, particularly in regions such as the Middle East and North Africa (MENA), where obesity rates are among the highest globally. Evidence consistently shows that adults with obesity are more likely to have unrecognized hyperglycemia compared to individuals with normal weight. Central obesity is especially predictive of insulin resistance and undiagnosed diabetes, making anthropometric measures such as waist circumference essential tools for early community-level screening [10–11].

In many low- and middle-income countries, structural and social barriers—including low health literacy, limited access to preventive care, and cultural stigma—create substantial gaps in early diagnosis. Community-based prevalence studies from Oman, South Asia, and parts of Africa reveal that more than half of individuals newly identified with diabetes had no previous diagnosis. These data emphasize the need for targeted screening among high-risk groups such as obese adults, those with a family history of diabetes, and individuals living in communities with high consanguinity rates [12–13].

For community health nursing practice, recognizing these epidemiological patterns is essential. Nurses working in primary care, household outreach programs, and community-based screening initiatives are strategically positioned to identify undiagnosed cases and facilitate early intervention. Aligning outreach strategies with local epidemiological data enhances the efficiency of screening programs and supports long-term prevention of diabetes-related complications [9–13].

Obesity as a Major Risk Factor

Obesity is one of the strongest and most well-established predictors of type 2 diabetes mellitus (T2DM), with excess adiposity driving a cascade of metabolic disturbances that often remain clinically silent for years. The pathophysiological link between obesity and T2DM is primarily mediated through insulin resistance, chronic low-grade inflammation, altered adipokine secretion, and ectopic fat deposition, all of which impair glucose homeostasis and β-cell function. Evidence shows that individuals with obesity have a several-fold higher risk of developing undiagnosed diabetes compared to those with normal weight, highlighting the significance of early screening in this group [14].

Central (visceral) obesity is particularly associated with impaired glucose tolerance and undetected hyperglycemia. Waist circumference and waist-to-hip ratio correlate more strongly with insulin resistance than BMI alone, making them valuable anthropometric tools for community-level risk assessment. Studies across diverse populations indicate that visceral adiposity plays a more significant role in driving metabolic dysfunction than general obesity, suggesting that simple measurements obtained during home visits or community outreach can effectively flag individuals at risk for undiagnosed T2DM [15].

The rising global burden of obesity amplifies the number of adults living with silent metabolic abnormalities. In many regions—including the Middle East, North Africa, and parts of Asia—obesity has reached epidemic levels, particularly among women and individuals of lower socioeconomic status. Limited access to preventive healthcare, reduced physical activity, and the adoption of calorie-dense dietary patterns contribute to this growing trend. Because obesity develops gradually and often becomes normalized within communities, many individuals do not perceive themselves as at risk, further contributing to the high prevalence of undiagnosed T2DM [16].

From a community health nursing perspective, obesity represents a crucial entry point for diabetes risk stratification. Nurses can integrate routine anthropometric screening into home visits, school health programs, workplace initiatives, and community health campaigns. Educating families about the risks associated with central obesity—particularly in households with a strong family history of diabetes or consanguinity—strengthens early detection efforts and enhances community engagement in preventive care [14–16].

Role of Family History in Diabetes Risk

Family history is one of the most powerful non-modifiable predictors of developing type 2 diabetes mellitus (T2DM). Individuals with one or more first-degree relatives affected by diabetes have a substantially higher lifetime risk, reflecting both genetic susceptibility and shared household environments. Evidence from large cohort studies, including the Framingham Offspring Study, demonstrates that having a parent with T2DM can more than double an individual's risk, with even greater risk observed when both parents are affected. This intergenerational clustering highlights the strong familial contribution to undiagnosed diabetes among obese adults [17].

Genetic predisposition plays an important role in shaping metabolic pathways related to insulin secretion, glucose regulation, and fat distribution. Variants in genes such as **TCF7L2**, **FTO**, and **PPARG** are strongly associated with diabetes risk, and many of these heritable polymorphisms amplify the impact of obesity on insulin resistance. However, the influence of family history extends beyond genetics. Shared dietary habits, sedentary behaviors, cultural eating patterns, and health beliefs within families significantly shape diabetes risk. Families with high-calorie traditional diets, limited physical activity, or limited awareness of early diabetes symptoms are more likely to have multiple undiagnosed cases [18].

Research also indicates that individuals with a family history of T2DM tend to develop metabolic abnormalities earlier and at lower levels of adiposity compared to those without such history. This suggests that routine community-based screening should prioritize adults with positive familial risk—especially when combined with obesity or central adiposity. In many cultures, extended family living arrangements further increase shared exposure to risk factors, intensifying the clustering of undiagnosed cases within households [19].

For community health nursing, incorporating family history assessment into routine screening and home visits is essential. Nurses can identify at-risk individuals through simple structured questionnaires, family health mapping, and culturally sensitive discussions. Recognizing families with multiple affected members allows community health teams to target high-risk households for early detection, follow-up testing, and lifestyle counseling. When combined with obesity and consanguinity, the predictive value of family history becomes even stronger, making it a cornerstone of community-level diabetes risk stratification [17–19].

Consanguinity and Diabetes Risk

Consanguinity—marriage between biologically related individuals—remains a culturally accepted practice in many regions, particularly across the Middle East, North Africa, South Asia, and parts of Africa. This practice significantly increases the likelihood of inheriting autosomal recessive genetic variants due to increased homozygosity. While type 2 diabetes mellitus (T2DM) is a polygenic disorder, evidence shows that consanguinity contributes to higher clustering of metabolic diseases, including diabetes, dyslipidemia, and obesity, within families and communities. Studies conducted in Qatar, Pakistan, and Saudi Arabia have shown higher diabetes prevalence among offspring of consanguineous unions compared with non-consanguineous families [20].

The biological basis for this association is linked to the enrichment of genetic susceptibility variants involved in glucose metabolism, adiposity regulation, and β-cell function. Consanguineous marriages may increase the expression of recessive alleles affecting metabolic pathways, thereby amplifying diabetes risk among individuals who are already predisposed through lifestyle factors or obesity. This genetic influence interacts with environmental exposures such as diet, sedentary behavior, and socioeconomic factors, creating a compounded risk profile for undiagnosed T2DM in communities with

high rates of consanguinity [21].

In addition to biological implications, consanguinity often overlaps with social and cultural characteristics that indirectly increase diabetes risk. Families practicing consanguineous marriage may share strong dietary traditions, reduced mobility patterns, and common health beliefs, which can reinforce obesogenic environments and delay health-seeking behaviors. Limited awareness of early metabolic symptoms and reliance on intrafamily healthcare decision-making can further contribute to delayed diagnosis and underrecognition of T2DM [22].

For community health nursing, understanding consanguinity as both a genetic and social determinant of health is essential. Nurses working in culturally diverse settings must approach the topic with respect, sensitivity, and cultural competence. Integrating consanguinity into risk assessment tools, family health mapping, and community education allows for early identification of high-risk households. When combined with obesity and positive family history, consanguinity greatly enhances the predictive value of screening efforts, guiding community nurses toward more targeted and efficient detection strategies [20–22].

Tools and Approaches for Early Community-Based Detection

Early detection of undiagnosed type 2 diabetes mellitus (T2DM) in obese adults requires a combination of simple, accessible, and culturally appropriate tools that can be applied effectively at the community level. International guidelines from the World Health Organization (WHO), American Diabetes Association (ADA), and International Diabetes Federation (IDF) recommend opportunistic and targeted screening for high-risk individuals, particularly those with obesity, family history of diabetes, or a background of consanguinity. Community health nurses play a central role in operationalizing these recommendations through field-based assessments, outreach campaigns, and household screening initiatives [23].

Risk assessment tools are foundational in community-based detection. Instruments such as the Finnish Diabetes Risk Score (FINDRISC), ADA Diabetes Risk Test, and the Indian Diabetes Risk Score (IDRS) can be administered quickly during community visits, health fairs, or routine clinic encounters. These tools integrate variables including age, BMI, waist circumference, physical activity, and family history to estimate diabetes risk. Studies confirm their utility across diverse populations, particularly when laboratory testing resources are limited. Incorporating consanguinity into adapted versions of these tools may further improve risk stratification in regions where consanguineous marriage is common [24].

Point-of-care testing enhances early identification by providing rapid, inexpensive biochemical assessment in community settings. Measurements such as random blood glucose, HbA1c, and fasting capillary glucose can be conducted during home visits or community outreach using portable devices. HbA1c testing, in particular, has gained prominence due to its convenience and ability to detect chronic hyperglycemia without fasting requirements. When combined with anthropometric assessments—BMI, waist circumference, and waist-to-hip ratio—community nurses can efficiently categorize individuals based on metabolic risk and refer them for confirmatory testing or follow-up care [25].

Anthropometric screening is another essential approach, especially where laboratory access is limited. Waist circumference, waist-to-hip ratio, and BMI are reliable indicators of central obesity and insulin resistance. These measurements can be conducted easily during school programs, women's health initiatives, workplace screenings, or household visits. Community health nurses can also employ culturally sensitive communication strategies to discuss weight, lifestyle, and familial risk while respecting social norms around body image, privacy, and family decision-making [26].

Integrating these tools into community health practice fosters earlier detection and improved disease prevention. Combining risk scores, point-of-care testing, and anthropometric measurements enables nurses to identify high-risk adults—particularly those with obesity, positive family history, or consanguineous background—and connect them with timely diagnostic and preventive services [23–26].

Health Education and Behavioral Interventions

Health education is a cornerstone of community-based strategies for reducing the burden of undiagnosed

type 2 diabetes mellitus (T2DM), especially among obese adults who possess additional familial or genetic risks. Community health nurses are uniquely positioned to deliver culturally tailored education that enhances awareness, promotes lifestyle modification, and encourages early screening. Effective diabetes prevention relies not only on disseminating information but also on transforming health behaviors within households—particularly important in communities where family history and consanguinity amplify metabolic risk [27].

Lifestyle counseling focused on nutrition, physical activity, and weight management significantly reduces diabetes risk among high-risk individuals. Evidence from major clinical trials, such as the Diabetes Prevention Program (DPP), demonstrates that modest weight loss (5–7%) and increased physical activity can reduce the incidence of T2DM by up to 58% in adults with prediabetes. Community health nurses can adapt these interventions during home visits, group education sessions, workplace outreach, and women's health programs, guiding families toward healthier dietary choices and increased daily movement. Tailoring advice to cultural food patterns and addressing misconceptions around obesity and diabetes are essential to improving adherence [28].

Addressing cultural beliefs and stigma is critical to successful behavioral interventions. In many communities where consanguinity is common, discussions about hereditary disease risk must be handled sensitively to avoid stigma or family conflict. Nurses can facilitate open dialogue on the relationship between shared lifestyle habits, family history, and metabolic risk without assigning blame. Additionally, recognizing barriers such as low health literacy, gender norms, limited autonomy in health decision-making, and economic constraints allows nurses to provide realistic, achievable lifestyle recommendations that respect the social context of each household [29].

Family-centered education is particularly effective for communities with strong familial ties and shared household routines. Engaging entire families—rather than individuals—helps align dietary practices, reinforce physical activity, and normalize routine screening behaviors. In families affected by obesity or with a history of T2DM, community nurses can promote preventive behaviors early, including monitoring waist circumference, recognizing early symptoms, and seeking timely metabolic screening. Empowering families increases the likelihood of sustained behavioral change and improved early detection among high-risk adults [27–29].

Ethical, Cultural, and Social Considerations

Ethical, cultural, and social factors play a significant role in the early detection of undiagnosed type 2 diabetes mellitus (T2DM), particularly in communities where obesity, family history, and consanguinity intersect to increase risk. Community health nurses must navigate these factors sensitively to ensure that screening and health education efforts are effective, culturally acceptable, and respectful. Ethical practice requires maintaining confidentiality, obtaining informed consent during screening, and ensuring that individuals understand the purpose and implications of diabetes testing. Trust-building is essential, especially in communities where health literacy may be limited or healthcare services are perceived with hesitation [30].

Cultural norms strongly influence perceptions of obesity and chronic disease. In some societies, higher body weight is associated with beauty, health, or prosperity, which may minimize perceived risk and reduce motivation to participate in screening or behavior change. Additionally, discussing family history of disease may be uncomfortable, as some families consider such topics private or stigmatizing. Nurses must therefore employ culturally sensitive communication strategies, framing risk discussions around wellness and family empowerment rather than illness or blame. Community engagement through local leaders, women's groups, or family elders can further enhance acceptance of preventive health efforts [31].

Consanguinity presents an additional cultural dimension that must be handled with great sensitivity. While consanguineous marriage is a longstanding and respected tradition in many regions, its association with increased genetic risk for metabolic diseases is not widely understood. Nurses should avoid framing consanguinity as harmful or inappropriate; instead, they can emphasize the value of informed decision-making, genetic counseling, and proactive screening for high-risk families.

Approaches that respect cultural traditions while promoting health awareness are more likely to be welcomed and sustained within communities [32].

Social determinants such as education level, economic status, gender norms, and access to preventive healthcare also shape diabetes risk and screening participation. Women in some cultures may have limited autonomy in seeking healthcare, while individuals from low-income households may prioritize immediate financial needs over preventive care. Community health nurses can address these barriers by offering flexible screening schedules, providing services at community centers or homes, and integrating diabetes education into ongoing public health activities. Strengthening supportive social environments enhances the uptake of screening and encourages early detection among individuals most at risk [30–32].

Implications for Community Health Nursing Practice

Community health nursing plays a pivotal role in reducing the burden of undiagnosed type 2 diabetes mellitus (T2DM), particularly among adults living with obesity and those with additional genetic or familial risk factors such as family history and consanguinity. Nurses working in community settings are often the first point of contact for individuals who do not routinely engage with healthcare services, making their role essential in identifying silent cases of hyperglycemia. Through home visits, screening campaigns, family assessments, and culturally sensitive communication, community health nurses can bridge gaps in early detection and prevention [33].

A key responsibility of community health nurses is integrating routine diabetes risk assessment into primary health care outreach. This includes measuring BMI, waist circumference, performing risk score evaluations, and conducting point-of-care glucose or HbA1c testing when appropriate. By prioritizing high-risk groups—obese adults, individuals with strong family histories, and members of communities practicing consanguinity—nurses can significantly enhance the efficiency of screening programs. Additionally, nurses are instrumental in coordinating referrals, ensuring continuity of care, and facilitating timely follow-up for those identified with elevated risk or abnormal glucose levels [34].

Community engagement is another essential component of nursing practice. Nurses must foster trust, build rapport, and deliver health messages in culturally acceptable ways. This involves working with community leaders, religious institutions, women's groups, and local organizations to promote awareness of diabetes symptoms, risk factors, and the importance of early screening. By addressing misconceptions about obesity, hereditary disease, and preventive health, nurses help shift community norms toward proactive health-seeking behaviors. Tailored communication strategies also support individuals in overcoming stigma and accepting screening based on family history or consanguinity [35].

Capacity-building and professional development further strengthen nursing contributions to early detection. Training in genetic counseling basics, culturally competent communication, and diabetes risk stratification allows community health nurses to deliver more comprehensive and informed care. Incorporating family health mapping, assessment protocols, and population-focused strategies ensures that nursing practice aligns with public health priorities. By combining evidence-based screening approaches with culturally grounded education, community health nurses can play a transformative role in reducing the prevalence of undiagnosed T2DM and improving health outcomes in high-risk communities [33–35].

Conclusion

Early detection of undiagnosed type 2 diabetes mellitus (T2DM) among obese adults is a critical public health priority, especially in communities where family history and consanguinity significantly elevate metabolic risk. The interplay of genetic predisposition, shared household environments, and culturally rooted marriage patterns creates clusters of high-risk individuals who may remain undiagnosed for years without targeted community-based interventions. Obesity further compounds this vulnerability by driving insulin resistance, central adiposity, and silent metabolic dysfunction.

Community health nursing stands at the forefront of addressing this challenge. Through comprehensive risk assessments, anthropometric measurements, point-of-care testing, and culturally sensitive

education, nurses can identify individuals at greatest risk and facilitate early referral and treatment. Their continuous engagement with households enables them to overcome barriers related to health literacy, stigma, cultural norms, and limited healthcare access. By integrating family history mapping and awareness of consanguinity into routine assessments, community health nurses enhance the accuracy and reach of screening efforts.

Ultimately, strengthening community-level screening programs, empowering families with knowledge, and embedding preventive practices within local cultures can substantially reduce the burden of undiagnosed T2DM. When prevention and early detection are approached through a culturally informed, family-centered, and evidence-based nursing lens, communities are better equipped to identify risk early, adopt healthier behaviors, and prevent the long-term complications of diabetes.

References

1. International Diabetes Federation. *IDF Diabetes Atlas*. 10th ed. Brussels: International Diabetes Federation; 2021.
2. American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2024. *Diabetes Care*. 2024;47(Suppl 1):S16-S33.
3. Cho NH, Shaw JE, Karuranga S, et al. IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045. *Diabetes Res Clin Pract*. 2018;138:271-281.
4. Kahn SE, Hull RL, Utzschneider KM. Mechanisms linking obesity to insulin resistance and type 2 diabetes. *Nature*. 2006;444(7121):840-846.
5. Meigs JB, Cupples LA, Wilson PW. Parental transmission of type 2 diabetes: The Framingham Offspring Study. *Diabetes*. 2000;49(12):2201-2207.
6. Bener A, Hussain R. Consanguineous marriages and their effect on common adult diseases: Studies from an endogamous population. *Ann Hum Biol*. 2006;33(1):1-12.
7. Hamamy H. Consanguineous marriages: Preconception consultation in primary health care settings. *J Community Genet*. 2012;3(3):185-192.
8. World Health Organization. *WHO Guideline on Screening for Type 2 Diabetes and Prediabetes*. Geneva: WHO; 2022.
9. International Diabetes Federation. *IDF Diabetes Atlas*. 10th ed. Brussels: International Diabetes Federation; 2021.
10. Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults, 1980–2013: A systematic analysis. *Lancet*. 2014;384(9945):766-781.
11. Cowie CC, Rust KF, Byrd-Holt DD, et al. Prevalence of diabetes and impaired fasting glucose in adults in the U.S. population: NHANES 1999–2002. *Diabetes Care*. 2006;29(6):1263-1268.
12. Al-Lawati JA, Barakat MN, Al-Lawati AM, Mohammed AJ. Population-based study of diabetes and impaired fasting glucose in Oman: Prevalence and associated risk factors. *Oman Med J*. 2012;27(6):470-476.
13. Jayawardena R, Ranasinghe P, Byrne NM, Soares MJ, Katulanda P, Hills AP. Prevalence and trends of the diabetes epidemic in South Asia: A systematic review and meta-analysis. *BMC Public Health*. 2012;12:380.
14. Kahn SE, Hull RL, Utzschneider KM. Mechanisms linking obesity to insulin resistance and type 2 diabetes. *Nature*. 2006;444(7121):840-846.
15. Després JP. Body fat distribution and risk of cardiovascular disease: An update. *Circulation*. 2012;126(10):1301-1313.
16. Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults, 1980–2013: A systematic analysis. *Lancet*. 2014;384(9945):766-781.
17. Meigs JB, Cupples LA, Wilson PW. Parental transmission of type 2 diabetes: The Framingham Offspring Study. *Diabetes*. 2000;49(12):2201-2207.
18. Lyssenko V, Laakso M. Genetic screening for the risk of type 2 diabetes: Worthless or valuable? *Diabetes Care*. 2013;36(Suppl 2):S120-S126.

19. Stern MP. Diabetes and cardiovascular disease: The "common soil" hypothesis. *Diabetes*. 1995;44(4):369-374.
20. Bener A, Hussain R. Consanguineous marriages and their effect on common adult diseases: Studies from an endogamous population. *Ann Hum Biol*. 2006;33(1):1-12.
21. Hamamy H. Consanguineous marriages: Preconception consultation in primary health care settings. *J Community Genet*. 2012;3(3):185-192.
22. Al-Gazali L, Hamamy H, Al-Arrayad S. Genetic disorders in the Arab world. *BMJ*. 2006;333(7573):831-834.
23. World Health Organization. *WHO Guideline on Screening for Type 2 Diabetes and Prediabetes*. Geneva: WHO; 2022.
24. Lindström J, Tuomilehto J. The diabetes risk score: A practical tool to predict type 2 diabetes risk. *Diabetes Care*. 2003;26(3):725-731.
25. Selvin E, Steffes MW, Gregg E, Brancati FL, Coresh J. Performance of HbA1c for the classification and prediction of diabetes. *Diabetes Care*. 2011;34(1):84-89.
26. Després JP. Body fat distribution and risk of cardiovascular disease: An update. *Circulation*. 2012;126(10):1301-1313.
27. World Health Organization. *Global Report on Diabetes*. Geneva: WHO; 2016.
28. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med*. 2002;346(6):393-403.
29. Renzaho AMN, Mellor D, Boulton K, Swinburn B. Effectiveness of prevention programmes for obesity and chronic diseases among immigrants to developed countries: A systematic review. *Public Health Nutr*. 2010;13(3):438-450.
30. World Health Organization. *People-Centred Care: A Policy Framework*. Geneva: WHO; 2015.
31. Yates T, Davies MJ, Gray LJ, et al. Levels of physical activity and relationship with markers of diabetes and cardiovascular disease risk in 5474 white European and South Asian adults screened for diabetes. *Prev Med*. 2010;51(3-4):290-294.
32. Hamamy H. Consanguinity and other marriage patterns in the Middle East: Implications for genetic disease and screening. *Community Genet*. 2007;10(1):1-9.
33. International Council of Nurses (ICN). *The Role of the Nurse in Public Health*. Geneva: ICN; 2009.
34. American Diabetes Association. Standards of Medical Care in Diabetes—2024. *Diabetes Care*. 2024;47(Suppl 1):S1-S168.
35. World Health Organization. *Framework for Integrating Noncommunicable Disease Prevention and Control into Primary Health Care*. Geneva: WHO; 2018.