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Obesity and stress rather than the thrifty gene, major risk factors for type 2 diabetes mellitus

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ABSTRACT

Introduction: Type 2 Diabetes Mellitus (T2DM) is becoming one of the main problems identified for public health importance by the World Health Organization (WHO) particularly in developing countries. The exact cause for T2DM unknown for sure but multiple predisposing factors are suggested including overweight, obesity, and sedentary lifestyle and stress.**Objectives:** To systematically review the major risk factors for T2DM giving more emphasis in the developing world. **Methodology:** The search for studies was performed through Google scholar, Medline, Pubmed, Cochrane Library, and Web of Science databases. The keywords that were used to search in the database included “T2DM” AND “predisposing factors” AND “determinants OR risk factor”, relevant articles were included for review. **Results:** Of the fifty-eight study results that met the inclusion criteria; the majority reported stressful life as the risk factor for type2 diabetes mellitus. Other articles noted obesity, out of which some reported obesity linked with the 'thrifty gene' as a risk factor. Furthermore, the remaining reports suggested genetic traits, aging, lack of exercise, and insulin resistance, and infections all contribute to the risk of diabetes. **Conclusion:** Although not everyone with T2DM is overweight, the presence of obesity, lack of physical activity, and stressful life increase the chances of acquiring T2DM. But it is doubtful to accept the thrifty gene hypothesis to play a role in the higher proportion of diabetes. This review highlights the need for a further study focused on finding a new approach to manage and prevent diabetes is recommended.

Keywords: Determinants; Obesity; Prevention; Stress, Thrifty gene; Type 2 diabetes mellitus

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Introduction

Globally an estimated 425million people are diabetic and, this figure is expected to grow to over 600 million by 2045 [1]. Diabetes mellitus is one of the main health challenges, with an estimated 95% of the global diabetic population having type 2 diabetes[2]. Studies reported the burden of diabetes mellitus to increase year to year[3,4] and noted the prevalence of diabetes for all age groups worldwide was estimated to be 2.8% in 2000 and 4.4% in 2030. The rise in the number of diabetes is expected to be high particularly among the urban population in developing countries [5].

The etiology of diabetes is mainly the interaction of environmental and genetic factors [6]. Previous studies noted although multiple risk factors are suggested for the occurrence of T2DM [7]most of these factors are mainly determined by the role genetic and metabolic factors including, ethnicity, family history of diabetes, and previous gestational diabetes, older age, overweight and obesity, unhealthy diet, physical inactivity excess alcoholic drink, and smoking to increase risk [8,9]. On the other hand, scholars propose the thrifty phenotype hypothesis pointing to the epidemiological associations between poor fetal and infant growth and the subsequent development of type 2 diabetes, which produces permanent changes in glucose-insulin metabolism [10]. They also suggested the association of exposure to famine resulting in low birth weight due to nutritional deprivation in utero resulted in the dysfunction of beta-cell expressed as T2DM when those with these genotypes were exposed to an environment with abundant food [11,12].

But the relative contribution of the genetic versus the environmental factors to cause T2DM remained controversial. With this regard, other scholars debated rather than the mere thrifty gene hypothesis, dietary quality, lack of physical exercise, and stressful life play a significant role in increasing the risk of T2DM [13,14]. Recent studies also indicated that there is the coexistence of nutritional deficiencies and over-nutrition associated with physical inactivity, due to urbanization and industrialization [15]. Now a day's developing countries face a rapid change in the nutrition transition and increases in non-communicable diseases [16]. Mass media access and a change in technological advancement facilitate physical inactivity in turn this promotes obesity and the risk of chronic non-communicable diseases [17]. All these conditions increase the prevalence of diabetes in low and middle-income countries [18]. On the other hand, research evidence points out a key role of infectious agents as a possible predictor for diabetes mellitus[1] Identifying the most important risk factors may be important to formulate strategies towards decreasing the prevalence of T2DM, a disease with no definitive cause [19]. Hence, this review article examines the modifiable risk factor for T2DM by reviewing high-quality works of literature/articles. The findings fill an evidence gap to inform policy-makers on the main factors associated with T2DM and to formulate a preventive strategy to halt the incidence.

METHODS

The published results from high-quality human observational and experimental studies which analyzed the factors associated with T2DM were all included in this literature-based analysis. An electronic search of Medline, Pub Med, Google Scholar, Medline, Cochrane Library, and Web of Science databases published up to the end of 2019 was conducted. The search was done in keywords: ["factors associated with diabetes" OR "diabetes mellitus" AND ["Impacts" OR "factors associated"] AND [Observational studies OR experimental studies]. A function extracting related articles as well as reference lists from research, reviews, and editorials was used during the search process. The full version of the English-language analyzed articles and abstracts of most found papers were available during the selection process. All pieces of literature, including observational studies, systematic review, and Meta-analysis, published in the English language, were included. There

were no limits on the place of the study, and gender. In the primary search, 285 records were found. After the studies/reviews which did not examine the major factors associated with T2DM, duplicated, and the majority of the outdated publications that were published before 2000 were excluded and 190 articles were selected. During the second selection, 58 articles were evaluated as potentially relevant considering factors associated with T2DM. The flow diagram of the article screening and selection process is shown in Fig. 1.

PRISMA 2009 flow diagram

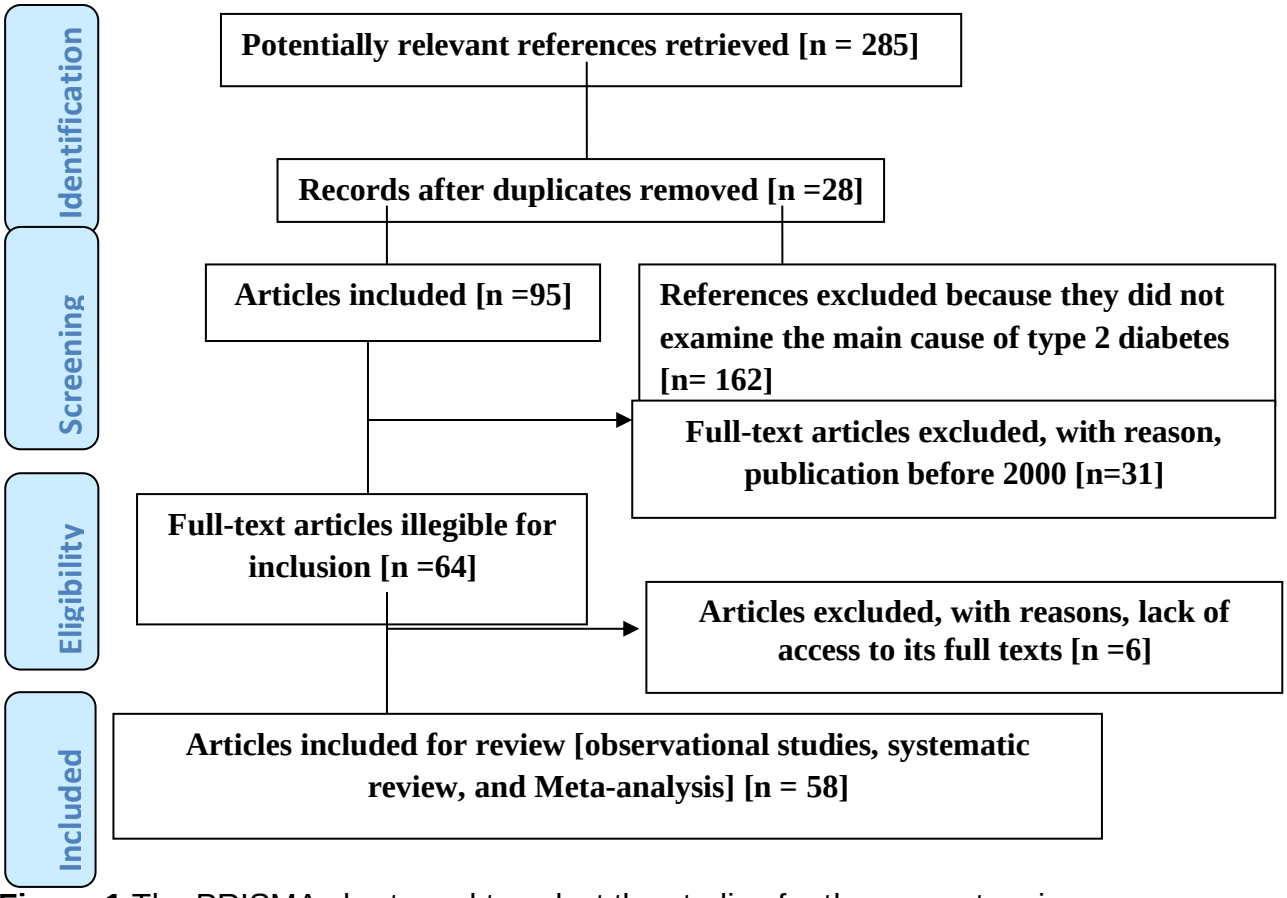

Figure.1 The PRISMA chart used to select the studies for the present review

Result and discussion

Overall from the final articles include for the present review and analysis, fifteen of them noted stressful life as a cause of diabetes, twelve of them were related to the effect of diet and obesity and metabolic syndrome as a factor that increases the risk of T2DM. Likewise, eleven articles propose the thrifty phenotype hypothesis as a risk factor for T2DM of course some articles opposed this hypothesis, five articles suggested the combined effect of genetic traits, aging, lack of exercise, obesity, and insulin resistance all contribute to the risk of diabetes, three articles inadequate fruit in a diet as a predisposing factor for T2DM, five of their alcohol consumption and the remaining eight articles reviewed were about the effects of infections to increase the risk

Although multiple risk factors are suggested, none of these factors is the definitive cause for T2DM. But the results of the final analysis of most articles reviewed, emphasized the interaction between unhealthy diet, obesity, and stressful life as a risk factor for its occurrence. Epidemiological studies suggested that obesity

is among the major risk factor of diabetes and having normal body weight is crucial in the prevention of T2DM, regardless of genetic predisposition [20,21].

Previous review articles noted that genetic traits, obesity, and insulin resistance increase the risk of diabetes in the African American community [22]. On a similar venue, the parallel increment rates of obesity and higher prevalence of diabetes among the African American populations were also reported [23]. Few studies argued that although the role of genetics, aging, and ethnicity are reported in developing insulin sensitivity, the contribution of excess body weight, large waist circumference, lack of physical exercise, and smoking played a crucial role behind insulin resistance [24-27]. For this reason, maintaining optimal waist circumference and body weight should be emphasized as an important strategy to reduce insulin resistance and subsequent metabolic diseases[28].

Although a strong relationship of increase in the body mass index with diabetes and insulin resistance was reported; contradicting data was also reported by another study in which healthy metabolic profile and the absence of diabetes risk factors is not protective young adults from the incident of diabetes associated with overweight and obesity [29]. This indicates other hidden factors to be taken into consideration.

Although there have been several well-documented hypotheses for insulin resistance [30]; the suggested factors of insulin resistance among obese individuals include an increase in the amount of nonesterified fatty acids, glycerol, hormones, cytokines, pro-inflammatory markers, and other substances [31]. But the development of diabetes becomes more likely if the dysfunction β-cells of the islet of the pancreas are accompanied by insulin resistance. Based on the available evidence maintaining normal body weight, doing regular physical exercise, and preventing abdominal obesity are among important strategies to prevent T2DM [32].

Researchers are still studying many factors that could make diabetes more common among people of certain ethnicities [33]. Another study evidenced that the risk of T2DM among ethnic minority groups living in Europe compared to Europeans varies by geographical origin [34]. The same study emphasized the need for future research and policy initiatives on T2DM among ethnic minority taking ethnic differences into account.

The occurrence of metabolic syndrome is also one of the leading factors for the occurrence of T2DM [35]. Although the exact cause for the metabolic syndrome is not known for sure, a previous study reported it to have resulted from a complex interaction of genetic, metabolic, socio-economic, and environmental factors [36]. Similar results were also shown in previous studies that lower education level, past smoking, the absence of fruit/vegetables in the diet [37-39]. Additionally, carbonated soft drinks and the consumption of significant amounts of alcohol were risk factors for the occurrence of metabolic syndrome, and this may increase the risk of T2DM [40].

The interrelationship between alcoholism and diabetes is reported by a review article explaining the link between the effects of a disruption of glucose homeostasis and insulin resistance [41], which are affected by the altered appetite that regulates the peptides and neurotrophic factors [42]. On the other hand, a moderate amount of alcohol is reported to play a role in preventing the incidence of diabetes and lowering the mortality risk among diabetic individuals. But these benefits may be varied according to age, gender, body mass index, ethnics and type of alcohol drink [43]. Similarly, scholars evidenced that compared with beer or other distilled liquor, wine was reported to be associated with a significant decrease risk of T2DM [44]. These findings support the recommendation of the functional benefit of wine in the Mediterranean diet [45].

Previous studies noted that metabolic syndrome is an important risk factor for T2DM and it might

be useful as a practical tool to predict these major metabolic disorders. The risk of T2DM can be high among individuals with multiple cardiovascular disease risk factors [46-48]. On the other hand, it is reported that metabolic syndrome predicts diabetes independently of other factors[49].

Whether it's related to work, relationships, or some other aspect of your life, stress is another suggested factor for T2DM. Many of the final articles reviewed; reported emotional stress to play a role in the etiology of T2DM [50-52]. Inline, a review article by Lloyd and colleagues [53] documented depression as a risk factor for the development of T2DM emphasizing stressful experiences might affect diabetes, in terms of both its onset and its complication. Furthermore, other reviewed articles suggested that not only depression but also general emotional stress, anxiety, sleeping problems, anger, and hostility have an association with an increased risk for the development of T2DM [50]. There are different causes for stress, among the various causes; immigration is one of the reported factors for stress in one's life [54]. Immigrants are expected to experience considerable stress, which may arise from a variety of sources including, ethnicity, gender and socioeconomic[55], language difficulties[56] separation from family and social networks[57], and greater exposure to racism and discrimination not previously experienced in one's country of birth [58]. In due course, continued stress exposure was reported to play a vital role in increasing the risk of disease risk [59, 24]. A study among African children emphasized frequent exposure to stressful life events in childhood to increase the risk of diabetes in their adult life [60]. Inline, a population-based, study in Finland evidenced those individuals who are exposed to extremely stressful life events and high workload had an increased risk of having a metabolic syndrome and insulin resistance as well [52]. The same studies noted life events perceived as stressful, particularly those related to finance and work, maybe a signal for poor metabolic health. In another review article, it is evidenced that stressful life events are related to poor metabolic control among diabetic older adolescents who are diabetic [61]. A recent longitudinal study using causal modeling documented that majority of the effect of the estimate of stress on diabetes risk is not mediated by the traditional risk factors of hypertension, physical activity, smoking, diet quality, and body mass index [62]. To date existing literature-based evidence showed although the impact of lifestyle changes including dietary modification on disease risk has been extensively studied, associations of psychosocial stress and disease risk do not get adequate attention [63,51]. This implicates the need for further trials on diabetic prevention and clinical care.

The other suggested factor to play a role in the incident of T2DM is the thrifty phenotype hypothesis which states early growth restriction as a result of adaptation to environmental deprivation [10, 11]. However, scholars claimed that the thrifty phenotype hypothesis fails to explain why environmentally induced changes are lost so early in development [15]. This is because the pre-conditions for the evolution of thrifty fetal programming are restricted if the correlation between in utero and lifetime conditions is poor. Such a correlation is not observed in natural courses of famine. Baig and colleagues [12] claimed that if there is fetal programming for thriftiness, it could have evolved in anticipation of social factors affecting nutrition that can result in a positive correlation.

On the other hand, the thrifty gene hypothesis is opposed by claiming this hypothesis is deeply flawed [64, 12]. Some of these scholars suggested alternatives, based on the central notion that genetic drift rather than positive selection was a dominant factor, may be called the 'drifty gene' hypothesis [11]. This alternative gives a possible explanation that the change in the frequency of an existing gene variant in a population is due to chance. In the context of the identified pieces of evidence mentioned above, it is doubtful to accept the thrifty gene hypothesis played a role

in the higher proportion of diabetes among black Americans[65].

Similarly, scholars noted that may be individuals with a thrifty phenotype, having small bodies and specialized metabolisms adapted to cope with poor-quality diets, get into T2DM if instead, they find themselves growing up in a wealthy society to which they are poorly adapted. But this speculation is debated as it might be regarded as hateful [38]. It could be seen as encouraging the rich to look self-satisfied with their impoverished fellow human beings.

The findings of other reviewed articles suggested ethnicity as the other factor in the increased risk of T2DM [66, 67, 22, 33]. Inline, a cohort that compared black and white participants noted an increased risk of incident T2DM among black women and men. However, after adjusting for modifiable risk factors during young adulthood, no longer statistically significant [68]. On a similar venue, a review by Golden and colleagues documented that genetic susceptibility has not been uniform among the world's racial/ethnic groups[69]. The same study provided the evidence in the USA; in which ethnicity is associated with many other risk factors for type 2 diabetes, including being obese, diet, and socioeconomic status, although studies in this area are inadequate.

Besides the role of the genetic factors in the genesis of diabetes, other external environmental factors are also known to be the cause. Few studies revealed the association of viral infection with diabetes [70, 71]. Though the exact mechanisms involved are not known for sure, it is clear that several viruses can directly affect β cells of the pancreas to decrease or inhibit insulin synthesis [72]. Additionally, it is emphasized the role of infections to contribute to insulin resistance should be considered as a risk factor for T2DM [73, 2]. These studies noted that among biological agents possibly linked to diabetes mellitus, the gut microbiome [a variety of microbes that are both helpful and potentially harmful], and the hepatitis C virus, are mainly discussed. Similarly, a shred of supporting evidence reported by recent studies pointing out the bidirectional relationship between Covid-19 and diabetes, showing both to increase the risk of incidence of diabetes among COVID 19 survivors and increased risk of severe disease outcome from Covid-19 [74,75]. The pathophysiologies on the occurrence of diabetes on COVID survivors is due to the coronavirus entering islets of the pancreas using angiotensin-converting enzyme 2 [ACE2] as its receptor and damages islets causing acute diabetes[76,77]. Based on this fact it is predictive that the toll of diabetes may be increased during post COVID period.

Therefore, it is clear to see that although the predictor for T2DM is not conclusive, any or all of the suggested risk factors are believed to increase its incidence. This emphasizes the need for further trials to fill the literature gap and improve the prevention and clinical practice.

The major strength of this review was the gathering of the latest research on the major predictors of T2DM. Included studies provided existing literature evidence on the suggested causes and hypotheses for T2DM. Moreover, it provides useful information on the literature gap needing further study and evidence for prevention approaches for T2DM. However, this systematic review still had limitations to be acknowledged, it failed to run a meta-analysis due to the study quality and high heterogeneity of included studies. High heterogeneity hindered this review to provide more information for further analysis.

Conclusion

From the present review, it was possible to learn that almost all available studies conducted in various parts of the world revealed no definitive cause for T2DM reported, and multiple risk factors are suggested for the occurrence of T2DM. It can be concluded that the proposed thrifty phenotype hypothesis lacks soundness to show association with T2DM. This paper identified several risk factors for T2DM out of these having normal body weight, and a healthy lifestyle pattern including decreased stress

levels could lead to decreased risk for T2DM. Our findings indicated the need for specific strategies for public health interventions to reduce the future incidence of T2DM. Interventions for the promotion of physical activity and a healthy lifestyle and dietary pattern combined with interventions against the increased incidence of obesity could halt the increase in the toll of T2DM incidence in near future. Future implementation research should focus on identifying efficient strategies to modify lifestyles and predisposing factors including dietary patterns that lead to overweight, obesity, and stress alleviation approaches are recommended. Further studies to identify a better approach to managing and preventing diabetes are recommended.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

ZT developed the review parameters and secured support. He also undertook partial literature search, data extraction, and analysis. SA made a detailed and extensive literature search and involved a synthesis of the findings. Both authors read and approved the final manuscript.

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