Global Prevalence of Metabolic Disorders, Associated Factors and Management

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Abstract

Metabolic disorders, including diabetes, obesity, metabolic syndrome, and dyslipidemia, have become significant global health concerns due to their rising prevalence and association with increased morbidity and mortality. These disorders contribute to the growing burden of noncommunicable diseases (NCDs), which are now among the leading causes of death worldwide. The increasing incidence of metabolic disorders is driven by a complex interplay of genetic, behavioral, environmental, and socioeconomic factors. Rapid urbanization, sedentary lifestyles, unhealthy dietary patterns, and socioeconomic disparities have exacerbated the problem, particularly in low- and middle-income countries where healthcare access is limited.

This study was conducted through an extensive literature review, synthesizing data from peerreviewed journals, global health reports, and epidemiological studies to assess the prevalence, associated risk factors, and management strategies for metabolic disorders across different populations. The findings indicate that while genetic susceptibility plays a role, lifestyle and environmental factors remain the most significant contributors to metabolic disorders. Industrialization and urban living have led to an increased intake of processed foods high in refined sugars and unhealthy fats, contributing to obesity and insulin resistance. Additionally, reduced physical activity and prolonged sedentary behavior have further heightened the risk of metabolic dysfunction.

Effective management of metabolic disorders requires a comprehensive and multidisciplinary approach that includes early screening, lifestyle interventions, pharmacological treatments, and public health policies aimed at prevention. Innovations in medical technology, such as digital health tools, telemedicine, and personalized medicine, have enhanced the early diagnosis and treatment of these conditions. However, challenges persist in many regions, particularly those with healthcare inequities, limited resources, and a lack of awareness about preventive measures. Strengthening healthcare infrastructure, implementing public health initiatives, and promoting education on healthy living are crucial steps toward reducing the global burden of metabolic disorders.

This review provides a detailed analysis of the epidemiology of metabolic disorders, explores their key determinants, and evaluates the effectiveness of current and emerging management strategies. Addressing these challenges through evidence-based policies, global collaborations, and improved healthcare access is essential for mitigating the long-term impact of metabolic disorders and enhancing overall population health.

Keywords: Prevalence, Metabolic Disorders, Associated Factors, Management *Words count:* 339

INTRODUCTION

A metabolic disorder refers to a condition that adversely affects the body's ability to process and distribute essential macronutrients, including proteins, fats, and carbohydrates (Zakir et al., 2022). Metabolic disorders may arise when atypical chemical reactions within the body disrupt the standard metabolic processes, consequently heightening the risk of conditions such as heart disease, stroke, and diabetes, while also leading to imbalances in essential substances necessary for maintaining health (Garg et al., 2022). These conditions typically manifest as both congenital and acquired metabolic disorders, capable of altering the entire physiology of the human body. Metabolic disorders can be inherited, referred to as inborn errors of metabolism, or they may develop over the course of an individual's life (Akkol & Aschner, 2022).

Types of Metabolic Disorders

The term "metabolic disorders" encompasses conditions such as hypertension (HTN), type 2 diabetes mellitus (T2DM), hyperlipidaemia (HLD), obesity, and, more recently, non-alcoholic fatty liver disease (NAFLD). Many of these conditions co-occur, share common risk factors, and are linked to heightened risks of disability, cancer, and premature mortality (Chew et al., 2023). MetS represents a significant global health challenge, necessitating extensive, sustained interventions aimed at addressing critical modifiable risk factors. The characteristics of the environments in which individuals reside, such as residential neighbourhoods, possess the capacity to shape health-related lifestyle factors across entire populations over extended periods. Consequently, it becomes essential to examine the effects of environmental attributes on metabolic syndrome (MetS), particularly in light of the pressing global trends of urbanisation, densification, pollution, and gentrification. This necessitates a thorough understanding of their potential implications for health outcomes, including MetS and its various components (Barnett et al., 2022).

Incidence and Prevalence of Metabolic Disorders

The widespread occurrence of obesity and associated metabolic disorders constitutes a significant public health challenge in developing nations (Bhurosy & Jeewon, 2014). This condition is a precursor to numerous life-threatening noncommunicable diseases, such as cardiovascular disease and type 2 diabetes, which are primary contributors to premature mortality on a global scale (Leitner et al., 2017). The global incidence of metabolic disorders appears to rise in tandem with the incidence of obesity, as evidenced by data from The National Health and Nutrition Examination Survey (NHNES), which reported an increase in the prevalence of metabolic syndrome among adults from 25.3% to 34.2% in 2012 within the United States (Saklayen, 2018). While the prevalence of metabolic syndrome peaked at the dawn of the 21st century in the United States, it later experienced a decline due to advancements in the early identification and management of dyslipidaemia and hypertension, even as obesity rates continued to rise (Mozaffarian et al., 2015).

Approximately one-fourth of the general population in Europe and Latin America is documented to exhibit metabolic syndrome (Scuteri et al., 2014; Cleven et al., 2022; Szypowska et al., 2023). In 2019, there were about 43.8 million instances of Type 2 Diabetes Mellitus (T2DM), 18.5 million cases of Hypertension (HTN), and 1.2 billion cases of Non-Alcoholic Fatty Liver Disease (NAFLD), with a consistent rise in mortality from 2000 to 2019, exhibiting the greatest absolute

burden in obesity (Chew et al., 2023). In 2021, among five common metabolic diseases, hypertension had the greatest burden (226 million), compared to T2DM (75 million). The highest absolute burden continues to be found in the most populous countries of the world, particularly India, China, and the United States, whilst the highest relative burden was mostly concentrated in Oceania Island states. The burden of these metabolic diseases has continued to increase over the past three decades but has varied in the rate of increase (Zhang et al., 2024).

Africa and the Middle East have a greater prevalence of hypertension than the rest of the globe, accounting for around one-quarter of overall fatalities. Alarmingly, the region has one of the highest diabetes prevalence rates, and obesity remains alarmingly high among females in the region (Malekpour et al., 2023). Research has thoroughly examined the incidence of MetS in Nigeria, revealing rates that fluctuate between 12.1% and 54.3% (Adegoke et al., 2009; Siminialayi et al., 2010; Adejumo et al., 2017; Amadi et al., 2022). Simultaneously, the worldwide incidence of chronic non-communicable diseases (NCDs), such as diabetes mellitus (DM) and hypertension (HT), is increasing at an alarming rate, with forecasts indicating that annual fatalities attributed to NCDs could rise to 52 million by 2030, a significant increase from 36 million in 2008 (WHO, 2012). Metabolic syndrome has transcended its previous association solely with adults; it is now increasingly recognised in children and adolescents as well. In the year 2020, it was observed that 3% of children and 5% of adolescents worldwide exhibited characteristics indicative of metabolic syndrome. The prevalence of metabolic syndrome appears to be marginally elevated among children in low-income nations, indicating that a country's economic status does not serve as a reliable predictor of metabolic syndrome (Noubiap et al., 2022).

Factors Contributing to Metabolic Disorders

The predominant contributors to metabolic syndrome and its underlying mechanisms are attributed to environmental factors. Unhealthy dietary patterns characterised by elevated consumption of fats and sugary foods serve as precursors to metabolic risk factors, including hypertension, obesity, and impaired glucose tolerance. Consequently, westernised dietary habits that encompass fast foods, fish, and high-fat or sugary foods are associated with increased systolic and diastolic blood pressure readings (Alamnia et al., 2023). Recent data indicate that heightened intake of refined or quickly absorbed carbohydrates, such as syrups, biscuits, and cakes, is significantly linked to MetS, Diabetes Mellitus II, and cardiovascular diseases (Shastun et al., 2016). This category of carbohydrates is distinguished by a significant glycaemic load (GL)—a metric that encompasses both the amount and the quality of dietary carbohydrates—which may elevate the risk of coronary heart disease through the exacerbation of glucose intolerance and dyslipidaemia (Al-Qawasmeh & Tayyem, 2018). Conversely, whole grains are rich in various nutrients, including fibre and minerals, which have demonstrated a positive impact on elements of MetS, such as body weight, fasting glucose or insulin resistance, blood pressure, high-density lipoprotein cholesterol, and triglycerides (Al-Qawasmeh & Tayyem, 2018).

The sedentary lifestyle represents a significant modifiable risk factor for metabolic syndrome, as research indicates that sedentary behaviour directly influences metabolism, bone mineral density, and vascular health (Tremblay et al., 2010). Prolonged periods of inactivity can exacerbate chronic health conditions. One consequence of a sedentary lifestyle is the emergence of metabolic disorders, marked by elevated triglyceride levels, reduced high-density lipoprotein cholesterol levels, a reversible decline in insulin sensitivity across various organs, diminished cardiopulmonary adaptability, and an accumulation of liver fat alongside dyslipidaemia. These factors collectively contribute to metabolic disturbances and alterations in body composition

(Davies et al., 2018). The rationale behind this is that extended periods of inactivity can result in diminished contractile activity of skeletal muscle, consequently leading to a reduction in the function of lipoprotein lipase (LPL) within the muscle (Hamilton, 2017). The sedentary lifestyle contributes to the heightened risk of metabolic disorders through two primary mechanisms. Firstly, the lack of physical activity diminishes the physiological engagement of muscle, resulting in reduced lipoprotein lipase (LPL) activity and disturbances in oxidation processes, which adversely affect muscle fibres. Secondly, such behaviour leads to a decline in the body's basal metabolism, frequently coupled with increased food consumption and decreased energy expenditure. This interplay ultimately fosters weight gain and elevates glucose levels, thereby facilitating the onset of Type 2 Diabetes (Same et al., 2015).

Smoking continues to be the foremost contributor to avoidable illness and death on a global scale, accounting for over 8 million fatalities annually (World Health Organisation: WHO, 2023). In the year 2019, the global population of active smokers reached 1.14 billion, collectively consuming 7.41 trillion cigarette-equivalents of tobacco. The consumption of tobacco was responsible for 200 million disability-adjusted life-years and emerged as the predominant risk factor for mortality among males (Reitsma et al., 2021). In 2012, the estimated total global costs associated with tobacco smoking reached around USD 1432 billion, accounting for 1.8% of the annual global GDP (Goodchild et al., 2017). Smoking is broadly acknowledged to be linked with numerous health hazards, such as cancer, cardiovascular disease, and chronic obstructive pulmonary disease. Nevertheless, in spite of this awareness, smoking prevalence continues to be significant in certain countries (Ng et al., 2014). Prior research indicates that smoking may act as a catalyst for metabolic syndrome (MetS), given that the compounds present in tobacco negatively influence the sugar and lipid metabolism of individuals who smoke leading to elevated plasma cortisol levels and insulin resistance which can subsequently result in the accumulation of visceral fat and an increase in waist circumference (Zhong et al., 2024). Smoking serves as an independent risk factor for diminished bone mineral density, while various deleterious substances found in smoking products inflict direct toxicity on organs, glands, and cells, thereby influencing systemic metabolism (Zhong et al., 2024).

Endocrine disruptor compounds (EDCs) encompass a variety of substances that obstruct the hormonal synthesis, metabolism, binding, transport, secretion, and delivery to target organs within the endocrine system (Khalil et al., 2023). Endocrine-disrupting chemicals (EDCs) are ubiquitous in various domains, including the environment, food sources, and manufactured products such as polychlorinated biphenyls. They are also present in plastics, exemplified by phthalates and bisphenol A (BPA), as well as in production goods like fragrance compounds, organobromine flame retardants, and fluorosurfactants. Additionally, combustants contribute to their prevalence, with substances like polychlorinated dibenzodioxins/furans and polyaromatic hydrocarbons. EDCs can also be found in agricultural chemicals, including pesticides and herbicides, alongside metals such as arsenic and cadmium (Darbre, 2018). The rapid pace of urbanisation, coupled with a significant rise in air pollution, complicates the task of isolating the effects of air pollutants from other environmental interactions. Epigenetic research indicates a profound impact of environmental factors on the human genome, where prolonged exposure can lead to epigenetic modifications, including DNA methylation (Khalil et al., 2023). Increasing studies propose that such epigenetic variations, driven by air pollution, contribute to genetic predispositions towards metabolic dysregulation and the subsequent onset of type 2 diabetes mellitus (Khalil et al., 2023). The use of certain medications may increase the risk of the development of the metabolic syndrome by either promoting weight gain or altering lipid or glucose metabolism as many commonly used drugs in clinical practice may interfere with glucose homeostasis and can induce impaired glucose tolerance or dysglycemia in subjects without type-2 diabetes (T2D) or worsen glycemic control in patients with T2D (Scheen, 2023). This adverse event occurs especially in predisposed individuals due to genetic background and/or unfavorable environment on which the deleterious effects of the medication are superimposed. Besides T2D, other metabolic disorders have also been reported, such as dyslipidemia and metabolic syndrome (MetS), most often linked to weight gain (Scheen, 2023).

Prior research indicates that socio-economic disparities and demographic variations correlate with an uneven distribution of health and disease across high-, middle-, and low-income nations (Allen et al., 2017). The metabolic syndrome (MS), characterised by a constellation of metabolic risk factors linked to cardiovascular (CV) disease and type 2 diabetes (T2D), exhibits a similar pattern, as its prevalence demonstrates an inverse relationship with socio-economic status (SES). Reduced income and educational attainment correlate with an increased incidence of multiple sclerosis, whereas elevated socioeconomic status serves as a mitigating factor (Adedoyin et al., 2013; Blanquet et al., 2015; Khambaty et al., 2020), potentially beginning in early adolescence (Yang et al., 2017), although its advantageous impact may ultimately wane with advancing age (Yang et al., 2018). Socioeconomic status correlates with nutritional status, emotional or physical stress, unhealthy behaviours, and various psychosocial factors, all of which are linked to the onset of metabolic syndrome, a significant risk factor for cardiovascular disease (Chung et al., 2021).

Moreover, although environmental factors are regarded as the primary contributors to metabolic syndrome and its underlying mechanisms, one must not overlook the significance of genetic influences. Research indicates that offspring of obese parents exhibit a greater propensity for obesity compared to their healthy counterparts (Swarup et al, 2024). Epidemiologic studies indicate that environmental factors during foetal development and the early postnatal period significantly impact disease risk and pathogenesis in adulthood. Consequently, the mother's lifestyle, along with intrauterine and postnatal nutrition, is crucial in understanding the aetiology and pathogenesis of metabolic syndrome (Swarup et al, 2024).

Management of Metabolic Disorders

Metabolic diseases emerge from a complex interaction of genetic, environmental, and lifestyle influences, such as a high-calorie diet, insufficient physical activity, and inherent genetic predispositions (Cao, 2014). The various factors underscore the essential importance of interdisciplinary collaboration in managing these issues. Failure to address them may lead to serious complications associated with metabolic diseases, such as heart disease, kidney disease, and nerve damage (Clemente-Suárez et al., 2023). Therefore, a variety of approaches, such as lifestyle modifications, systemic pharmacological treatments, and surgical procedures, are often employed to prevent and manage metabolic diseases have not come without their challenges, particularly concerning potential adverse effects. For example, antidiabetic medications such as metformin, sulfonylureas, alpha-glucosidase inhibitors, thiazolidinediones, DPP-4 inhibitors, and SGLT-2 inhibitors frequently present gastrointestinal side effects, which may include anorexia, nausea, flatulence, dyspepsia, vomiting, and diarrhoea (Xu et al., 2023). Moreover, specific medications may lead to hypoglycemia, weight gain, and genital infections (Maruthur et al., 2016; Bonnet & Scheen, 2016; Gallwitz, 2016).

Consequently, lifestyle modifications ought to be prioritised as the initial therapeutic approach for the prevention and management of metabolic diseases, well in advance of pharmacological

interventions. Dietary modifications are crucial, particularly with the Mediterranean Diet, which is a plant-based regimen distinguished by a substantial consumption of vegetables, including leafy greens, fruits, whole-grain cereals, pulses, legumes, nuts, and extra virgin olive oil (EVOO) as the primary fat source. This dietary approach has been recommended as a potential intervention for MetS, as it mitigates excessive adiposity and the inflammatory responses associated with obesity (Franquesa et al., 2019). Furthermore, the Dietary Approaches to Stop Hypertension (DASH) diet, recognised for its numerous health benefits stemming from its nutritional composition and distribution, presents a viable alternative. This diet is abundant in vegetables and fruits, leading to elevated intake of potassium, magnesium, and fibre. These nutrients have been demonstrated to play a significant role in blood pressure regulation, glucose metabolism, and insulin response (Akhlaghi, 2019). Moreover, it exhibits restrictions in sodium and fat content, particularly saturated fatty acids (SFA), which are significantly associated with cardiovascular disease (Akhlaghi, 2019).

Although the significance of diet and weight loss has been thoroughly established, the importance of physical activity is often neglected by both healthcare professionals and individuals (Montesi et al., 2013). Engaging in physical activity yields beneficial outcomes for all facets of metabolic syndrome and the associated cardiovascular risks, which are fundamental in the onset of cardiometabolic diseases. For instance, brisk walking is deemed especially suitable, as it is accessible to a wide demographic, incurs no additional expenses, and presents a minimal risk of injury (Montesi et al., 2013). The impact of exercise and leisure time physical activity ranges from prevention to treatment of the diverse elements of metabolic syndrome, in addition to influencing mood and enhancing quality of life.

Dietary Approaches for Managing Metabolic Disorders in Nigeria

Dietary interventions play a crucial role in preventing and managing metabolic disorders, particularly in Nigeria, where rapid urbanization and lifestyle changes have contributed to increased consumption of processed foods and a decline in traditional diets (Olatunbosun et al., 2019). The adoption of healthier dietary habits rooted in indigenous foods can help mitigate the rising burden of diabetes, obesity, and hypertension.

1. Promoting Traditional Nigerian Diets: Nigeria has a variety of nutrient-dense, locally available foods that can help manage metabolic disorders. Encouraging the consumption of these foods can aid in blood sugar regulation, weight management, and cardiovascular health. Whole Grains: Replacing refined grains like white rice and white bread with brown rice, millet, sorghum, and acha (fonio) has been shown to improve glycemic control and reduce the risk of type 2 diabetes. Legumes and Nuts: Foods such as beans, groundnuts, and locust beans (iru) provide high fiber and plant-based proteins, which improve insulin sensitivity and cardiovascular health. Vegetables and Fruits: Dark green leafy vegetables like fluted pumpkin (ugu), bitter leaf, and okra are rich in fiber and antioxidants, which support metabolic health. Fiber-rich fruits such as pawpaw, guava, and oranges help regulate blood sugar levels and improve digestion. Healthy Protein Sources: Fish (e.g., mackerel, tilapia, catfish) is a good source of omega-3 fatty acids, which can reduce inflammation and improve lipid profiles (Ajani et al., 2018).

2. Reducing Processed and Refined Foods: The shift towards processed and energy-dense foods has contributed to the rising prevalence of metabolic disorders in Nigeria. To address this issue: Limiting White Rice and Processed Flour Products: Brown rice and whole wheat options should be prioritized over refined carbohydrates, which contribute to insulin resistance. Reducing Sugary Beverages: High consumption of sugar-sweetened beverages like soft drinks and processed fruit

juices has been linked to obesity and diabetes in Nigeria. Alternatives such as hibiscus tea (zobo) and kunu (fermented millet drink) without excessive sugar can be encouraged. Avoiding Excessive Salt and Artificial Seasonings: Processed seasoning cubes, which are high in sodium, contribute to hypertension and should be replaced with natural herbs and spices such as ginger, garlic, and turmeric (Olowe et al., 2021).

3. Encouraging Healthier Cooking Methods: Cooking methods can significantly impact the nutritional value of foods. Healthier cooking practices include: Grilling, Boiling, and Steaming: Instead of deep-frying foods like akara and plantain chips, grilling or steaming proteins and vegetables can reduce unhealthy fat intake. Using Fiber-Rich Swallow Options: Traditional swallows such as amala (made from yam or plantain flour) and fufu made from unprocessed cassava provide slow-digesting carbohydrates, which help in blood sugar management (Ademola et al., 2021).

4. Adapting Global Dietary Guidelines to Nigerian Foods

Mediterranean Diet Approach: The Mediterranean diet, which emphasizes whole grains, lean proteins, and healthy fats, can be adapted using Nigerian foods. Local alternatives such as using palm oil in moderation, consuming nuts and seeds, and increasing vegetable intake can mimic the benefits of this diet. DASH Diet (Dietary Approaches to Stop Hypertension): The DASH diet, known for lowering blood pressure, can be adapted to Nigerian foods by encouraging the consumption of potassium-rich foods like plantains and reducing sodium intake from processed foods (Adebiyi et al., 2020).

5. Public Health and Policy Interventions

Community Nutrition Education: Raising awareness in schools, markets, and religious institutions about the benefits of traditional, whole-food diets can encourage healthier choices (Eze et al., 2021). School and Workplace Nutrition Programs: Implementing meal programs that promote healthy Nigerian dishes can help prevent metabolic disorders from a young age (Adediran et al., 2019).

Government Regulations: Policies aimed at reducing the availability of unhealthy processed foods and subsidizing healthier alternatives can play a key role in dietary management (Ogunbode et al., 2022). Dietary modifications tailored to Nigeria's traditional food culture can serve as an effective approach to managing metabolic disorders. Emphasizing whole grains, legumes, vegetables, and lean proteins while reducing processed foods, sugar, and unhealthy fats can significantly improve metabolic health. Public health initiatives and policies that support sustainable dietary changes will be essential in reducing the burden of metabolic diseases in Nigeria.

Recommendations

While lifestyle interventions demonstrate efficacy in enhancing metabolic markers, their implementation within communities faces significant hurdles related to feasibility and cost. These factors represent the principal obstacles in converting evidence into practical application at the community level. The delivery of such interventions is characterised by stringent and closely monitored formats, emphasising individualised approaches rather than group settings, and necessitating the involvement of qualified professionals, such as registered dietitians and exercise trainers (Mamun et al., 2020). Consequently, alongside lifestyle interventions, a robust model for addressing MetS would necessitate a community-oriented approach to ensure cost-effectiveness and sustainability. This would encompass strategies such as promoting awareness of healthy living, which includes diet, exercise, smoking cessation, and alcohol reduction, as well as establishing connections with healthcare facilities upon diagnosis to mitigate the risk of

cardiovascular diseases (Okube et al., 2022). These interventions possess the potential to be economically viable, widely accessible, and sustainable, as they can engage individuals beyond traditional healthcare environments, effectively addressing diverse populations. The following recommendations outline strategies for policymakers, healthcare providers, and communities

Enhance Public Health Policies:

Governments should implement policies that promote healthy dietary practices and active lifestyles. Examples include taxing sugary beverages, subsidizing healthier food options, and designing urban spaces that encourage physical activity.

Increase Public Awareness and Education:

Community-based education programs can improve awareness about the risks of metabolic disorders and the benefits of healthy lifestyles. Tailored health promotion campaigns should target vulnerable populations and emphasize the importance of balanced nutrition and regular exercise.

Improve Healthcare Access and Early Detection:

Strengthening healthcare systems, particularly in low- and middle-income countries, is essential. This includes investing in early screening and diagnostic services to facilitate prompt intervention and reducing disparities in healthcare delivery.

Promote Multidisciplinary Research:

Increased funding for research into the genetic, environmental, and socioeconomic determinants of metabolic disorders can lead to more effective, personalized treatment strategies. Collaborative research initiatives should explore innovative therapies, including precision medicine and digital health solutions.

Integrate Lifestyle Interventions with Medical Management:

Healthcare providers should advocate for comprehensive treatment plans that combine lifestyle modifications with pharmacological and, when necessary, surgical interventions. Developing patient-centered approaches that consider individual risk factors and cultural contexts can enhance adherence and outcomes.

Foster Public-Private Partnerships:

Collaboration between the public sector, private industry, and non-governmental organizations can facilitate the development of sustainable programs aimed at reducing the burden of metabolic disorders. These partnerships can support community initiatives, research, and the dissemination of best practices.

Conclusion

The association between lifestyle, environmental factors and metabolic diseases varies and it is complicated, emphasising the critical need to address these factors. To tackling metabolic diseases necessitates a collaborative effort from people, communities, and governments. Prioritising environmental health can also help pave the path for a healthier future while also reducing the burden of metabolic disorders.

The rising global prevalence of metabolic disorders is a clear indication of a multifaceted public health challenge that spans across continents and socioeconomic strata. The interplay between

genetic predispositions, lifestyle factors such as poor dietary habits and physical inactivity, and socioeconomic determinants underscores the complexity of these conditions. Effective management of metabolic disorders requires an integrated approach. Lifestyle modifications remain the cornerstone of prevention and treatment, supported by pharmacological therapies and, when necessary, surgical interventions. The promising advances in precision medicine and digital health offer new avenues for tailored, patient-specific strategies that could significantly improve outcomes. Moreover, coordinated global efforts-compassing robust public health policies, improved access to healthcare services, and community-based initiatives are essential. Collaborative initiatives among governments, researchers, and healthcare professionals can help address socioeconomic disparities, enhance early diagnosis, and promote sustained lifestyle changes to combat the epidemic.

In summary, while the burden of metabolic disorders continues to grow, a comprehensive strategy that combines preventive measures, advanced treatment modalities, and supportive public policy holds the promise of reducing their impact on global health. Continued research and coordinated global action are imperative for mitigating the long-term effects of these complex and interrelated conditions.

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