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Editorial

Global strategies for preventing type 2 diabetes: A public health perspective

The global diabetes tsunami has reached alarming proportions, with over 10 per cent of the adult global population and an estimated 537 million people affected by the disease in 2021, according to the International Diabetes Federation (IDF)¹. A majority (>90%) of these individuals suffer from type 2 diabetes mellitus (T2DM), a metabolic disorder characterized by insulin resistance (IR) and a progressive loss of pancreatic β -cell function, leading to chronic hyperglycemia. The diabetes-epidemic carries immense human and economic costs, making the development of prevention strategies of paramount importance. This editorial on this World Diabetes Day explores key global strategies to prevent T2DM and their applicability in India, where rapid urbanization, lifestyle changes, and genetic predispositions have accelerated the diabetes crisis.

The global prevalence of overweight/obesity is ~2 billion, with an expected doubling of this figure by 2035 and an anticipated global healthcare expenditure burden of four trillion dollars to manage adiposity-related chronic diseases, especially T2DM². A definite association can be observed between the obesity pandemic and the adoption of fast-food culture in society, along with the invention of computers and television towards the latter half of the 20th century, creating an obesogenic environmental repertoire³. The most affected demographic to this epidemic is children and adolescents, where the obesity rates have skyrocketed, currently ~400 million with an anticipated doubling time within the next decade.

The global rise in T2DM can be attributed to several interrelated factors. These include urbanization, sedentary lifestyles, unhealthy diets, increasing obesity rates, and ageing populations. Urbanization particularly has played a key role, as it is associated with changes in physical activity patterns, dietary habits, and work environments that are more sedentary. In India, the dietary shift towards highly processed, calorie-dense, and nutrient-poor foods, combined with

reduced physical activity, has created a 'diabetogenic' environment.

Effective T2DM prevention strategies must tackle modifiable risk factors, including unhealthy diets, physical inactivity, and obesity. These strategies can be divided into primary prevention, aimed at preventing T2DM in at-risk individuals, and secondary prevention, which focuses on early detection and management of prediabetes to prevent progression to T2DM. Lifestyle interventions targeting diet, physical activity, and weight management are the most effective strategies for preventing T2DM. A balanced diet rich in fruits, vegetables, whole grains, and lean proteins and low in processed sugars and fats is essential. A wide range of dietary interventions can help create a negative energy balance to promote weight loss and diabetes reversal/remission^{4,5}. Hypocaloric diets, as per an individual's sociocultural aspects of food practices, are likely to be palatable, and thus, more sustainable, leading to significant and lasting weight loss. Specialized approaches such as time-restricted eating and intermittent fasting have shown promise in improving adiposity and addressing metabolic dysregulation⁴. Regular physical activity improves insulin sensitivity and helps in maintaining a healthy weight. The World Health Organization (WHO) recommends at least 150 min of moderate-intensity physical activity per week for adults⁶. Although lifestyle changes offer a straightforward solution for achieving the goal, implementing these changes often becomes a herculean task due to the significant behavioural adjustments required^{4,7}. However, intensive lifestyle interventions (ILI) have been proven to be associated with the prevention of T2DM in disease-prone individuals and remission/reversal of diabetes in affected ones, as observed in multiple large studies^{7,8}. Therefore, the first step in preventing and managing T2DM is the behavioral intervention to promote regular physical activity and healthy dietary habits.

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A variety of evidence-based physical activity interventions are available to promote diabetes prevention and management⁹. The exercise programme should be tailored to each patient based on the patient's age, comorbidities and social circumstances. Individually tailored physical activity programmes provided by exercise counsellors have been found to be cost-effective and successful in achieving the therapeutic goals in a good proportion of patients¹⁰. Psychological interventions such as setting personal goals, demonstrating exercise behaviour, and providing reminders of health benefits and consequences have been shown to empower patients and improve long term adherence to exercise programmes¹¹.

Various diabetes prevention programmes (DPP) designed to prevent or achieve remission of T2DM have been implemented worldwide, based on ILI, which involves structured dietary plans and physical activity interventions. Studies have demonstrated that comprehensive lifestyle changes can reduce the risk of developing T2DM by up to 58 per cent among high-risk individuals. Another recent study from the United Kingdom (UK) demonstrated that total diet replacement (TDR) led to a 9.3 per cent average weight loss (10.3 kg) over 12 months, with 32 per cent of participants achieving T2DM remission, linked to a mean weight loss of 14.4 per cent (15.9 kg)¹².

Given that the roots of obesity and T2DM often stem from unhealthy lifestyle habits formed in childhood, ideally, DPP should begin in schools. While large-scale early interventions have shown limited impact on childhood obesity, significant reductions in measures of adiposity, such as waist circumference and fasting insulin, suggest these efforts may help lower future T2DM incidence—a pressing global health concern¹³.

While imposing strict dietary restrictions in modern societies may be impractical, various government-led fiscal policies can encourage healthier eating habits. Measures such as sugar taxes and additional levies on foods with high fat or sugar content, along with sweetened beverages, have been shown to reduce obesity and T2DM¹⁴. These policies, strongly supported by the World Health Organization (WHO), have been implemented by many governments worldwide and have had significant impacts, including quality-adjusted life years¹⁵.

Despite the numerous prevention strategies, the global prevalence of obesity continues to rise. Therefore,

pharmacological interventions might often be necessary to address the issues of obesity and diabetes (diabetes consequent to adiposity)^{3,16}. Appropriate use of drug therapy is essential, especially when lifestyle interventions fail, and significant comorbidities of obesity such as fatty liver, sleep apnoea, hypertension and dyslipidemia are coexistent to reduce the risk of cardiovascular disease (CVD) and improve quality of life (QoL). A variety of anti-obesity drugs are currently available, with newer options under development. The most effective medications include phentermine-topiramate, semaglutide, and tirzepatide, in ascending order of effectiveness^{17,18}. When appropriately used with lifestyle interventions, these therapeutic agents often help to markedly reduce adiposity and reverse/prevent T2DM and the associated comorbidities^{17,18}. However, we must be mindful of the prohibitive costs of these newer agents in resource-poor settings.

When ILI and pharmacotherapy fail, bariatric surgery may be necessary for effective weight loss and prevention/remission of T2DM^{19,20}. Long-term follow up data suggests that bariatric surgery offers superior outcomes in maintaining weight loss, improving metabolic comorbidities, and reducing complications and mortality compared to standard care. Therefore, a thorough discussion of the benefits and potential risks of bariatric interventions should be done when conventional options fail.

Digital health technologies, such as mobile health apps and telemedicine, can be leveraged to provide education, lifestyle counselling, and monitoring for individuals at risk of T2DM. Children and adolescents are particularly vulnerable to the negative influences of modern life, such as sedentary behaviour, unhealthy eating habits, fast food culture, digital media, and increased use of electronic devices for social interaction and consuming nutrient-poor, calorie-dense foods³. Since obesity and its related metabolic consequences often originate from unhealthy lifestyles adopted during childhood and adolescence, prevention efforts must begin early. While genetics, psychosocial factors, and environmental influences can further exacerbate these issues, strategies should focus on mitigating the harmful impacts of an obesogenic environment. Given that children's dietary and physical habits are shaped largely by parental influence in the early years and reinforced through school environments, educating parents and teachers on creating healthier spaces for children is essential. Updating school health programmes and curricula is essential to fostering a

healthy childhood, which can help prevent obesity and its metabolic consequences^{3,21}.

The metabolic complications of obesity and T2DM tend to be more severe in children due to the unique nature of adipose tissue biology at this age. As a result, aggressive management, combining ILI with medical treatment, is often necessary to prevent T2DM in youth^{3,22}. When medical management is insufficient, bariatric surgery may be considered²³.

India, often referred to as the 'Diabetes capital of the world', currently has 101 million people (11.4% of the population) living with diabetes and an additional 136 million (15.3%) with prediabetes²⁴. The Indian subcontinent accounts for 17 per cent of the global diabetes burden. Given the exponential rise in diabetes prevalence, India is expected to reach the projected figure of 135 million diabetes cases much earlier than the IDF's estimate for 2045. This alarming situation calls for urgent social, political, governmental and public health actions to prevent the catastrophic economic and health consequences. To effectively tackle this challenge, educational efforts must respect India's unique cultural and social habits, promoting healthy lifestyles without disrupting religious or socio-cultural norms. In India, where carbohydrate-rich diets and sugar consumption are prevalent^{25,26}, public health campaigns promoting traditional dietary patterns, including consumption of legumes, whole grains, and vegetables, could be a culturally acceptable approach. Peer-support lifestyle interventions can also be explored.

Prompt governmental actions, such as implementing sugar taxes and levies on energy-dense foods and beverages, are essential to encourage healthier eating habits, as seen in other countries¹⁴. Professional and public health organizations should lead these efforts by coordinating with social, political, and governmental bodies to implement effective diabetes prevention strategies. In India, the 'Diabetes Community Lifestyle Improvement Programme' (D-CLIP) demonstrated that structured lifestyle interventions can effectively reduce diabetes incidence in high-risk populations²⁷. Workplace wellness initiatives can help mitigate diabetes risk, and several multinational corporations have successfully implemented these programmes. In India, introducing nationwide school health programmes focused on nutrition and physical activity could help combat rising childhood obesity and future T2DM cases. In rapidly urbanizing regions of India, integrating health-promoting infrastructure

into urban planning is crucial for diabetes prevention. In densely populated urban centers like Mumbai and Delhi, improving access to safe and affordable spaces for physical activity could have a significant impact. Walkable neighbourhoods, public parks, bike lanes, and local markets with affordable fresh produce are examples of environmental changes that can foster healthier communities. Mass media campaigns, social media initiatives, and community outreach programmes can be used to educate the public on the importance of adopting and maintaining a healthy lifestyle. In India, where mobile phone penetration is high, the use of digital tools for diabetes prevention (mobile apps, SMS-based health education programmes, and telemedicine platforms) could have a wide-reaching impact, especially in rural and underserved areas.

Screening programmes, particularly in primary care settings, can help identify individuals with impaired glucose tolerance or IR, enabling targeted interventions. In India, where healthcare resources are limited, and IR is more prevalent even at lower body mass index (BMI) levels, cost-effective screening tools and community-based health workers can be vital in reaching high-risk populations²⁸. Studies show that programmes like the DPP are less effective in Indian populations, as evidenced by studies from Tamil Nadu and Kerala^{27,29}. Integrating such community-based initiatives into national health strategies along with anti-obesity pharmacotherapy and bariatric interventions could significantly curb the growing type 2 diabetes epidemic. On this World Diabetes Day, it is imperative that the Indian medical community, alongside governments, healthcare providers, and communities, lead efforts to create supportive environments for healthier living and diabetes prevention for future generations.

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