Journal of Rare Cardiovascular Diseases
ISSN: 2299-3711 (Print) | e-ISSN: 2300-5505 (Online)
www.jrcd.eu
RESEARCH ARTICLE

Educated to Nourish: The Role of Quality Education and Nutrition in Preventing Diabetes Mellitus

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Article History
Received: 28.02.2025
Revised: 25.03.2025
Accepted: 27.04.2025
Published: 02.05.2025

Abstract: Quality education is essential for individual and societal growth, helping people identify their skills and achieve measurable goals. It should be accessible to all, regardless of caste, color, or creed. Individual Education Programmes (IEPs) help streamline tasks and reduce distractions. Governments must prioritize funding and resources to ensure education up to the undergraduate level, as it benefits both individuals and society in the long run. Nutrition, recognized by the UN as a fundamental human right, includes access to nutrient-rich food, clean water, and sanitation. Malnutrition and hidden hunger can lead to severe health issues. The government's mid-day meal program is a key step in combating childhood malnutrition by meeting one-third of a child's daily nutritional needs. Zero hunger aims to eliminate food insecurity through education, food aid, empowerment, and healthcare access. It can be achieved by ensuring sustainable food systems, year-round food availability, reduced waste, and eliminating stunting in young children. Diabetes mellitus can be managed and prevented through lifestyle and dietary changes. Proper diet, exercise, and medication are crucial, and preventive measures can significantly reduce the global burden of diabetes-related mortality.

Keywords—Quality education, Individual Education Plan, Nutritional needs, SDG-Zero hunger, Diabetes Mellitus.

INTRODUCTION

Education is a basic right of every child just like food, water and shelter. Quality education is assumed to be a boon to all the children across the world despite caste, colour or creed. Critical thinking skill of a learner can be enhanced by strengthening the concepts and the contents of a particular topic. Critical thinking is always linear, convergent, analytical and judgmental whereas creative thinking is divergent, generative, random, innovative and expansive. Hunger can be tackled only through nutrition. Proper nutrition provides the necessary fuel for the body to function properly, and an adequate diet can help control hunger and maintain a healthy weight. Eating a well-balanced diet with an appropriate balance of macronutrients (such as carbohydrates, protein, and healthy fats) and micronutrients (such as vitamins and minerals) can help control hunger and the risk of metabolic disease such as diabetes and chronic diseases like heart disease and kidney disease. When proper nourishment is provided for the population, sustainable development goal of zero hunger can be easily achieved.

The topics on quality education, health, and zero hunger provides a comprehensive understanding of the current state of research, key findings, challenges, and potential solutions in these crucial areas. The literature on quality education often explores the importance of education in promoting economic development, reducing inequality, and improving overall well-being. Common areas of focus include the social determinants of health, access to healthcare, the role of education in health outcomes, and the impact of lifestyle factors. Literature on zero hunger is often centered around sustainable development goals, with a primary focus on ending hunger and achieving food security.

Quality Education

Education emancipates the intellect, unleashes the imagination, and serves as a foundational element for self-respect. It stands as the cornerstone of prosperity, unlocking a realm of opportunities that empowers each individual to actively contribute to the advancement of a progressive and healthy society.

Quality education refers to the standard of teaching and learning in schools, colleges, and universities. It involves providing students with relevant knowledge, skills, and values necessary for their personal and professional growth. The quality of education is evaluated based on various factors such as the quality of teaching, facilities, resources, and student outcomes. A good quality education can improve a person's chance of success in life and contribute to the overall development of a society.

Quality of teaching should improve based on individual need of a student. The areas of strength of a class have to be identified by the facilitator. There is a difference between the three concepts like personalization, differentiation and individualization. Personalization is learner-centered but the others like differentiation and individualization are teacher-centered. The teacher has to set SMART (Specific, Measurable, Attainable, Realistic and Time-bound) and relevant goals for a learner. Individualized Education Programmes (IEP) are used to measure a child's progress in a more systematic way. The

goals should be specific but not vague or general. The measurement can be done using standardized tests.

Quality education is a critical factor in the professional development of a nation, playing a pivotal role in enhancing global competitiveness (Tarman, 2017). Employability rate influences quality education directly or indirectly so that the outcome also improves (Fomunyam, 2018). Enhancing employability has a positive impact on the quality of education as it fosters the development of skills and competencies crucial for success in the workplace. Budiharso and Tarman (2020) examined that "the working condition of academic institutes is a main factor that affects the quality of education to a great extent." More specific findings of this study indicate that the teachers and principals are the major controlling factors in an institute and are responsible for the provision of education to the students. When positive working conditions are not maintained, key employees may experience distress, and this distress can result in a deterioration of education quality. In the lack of favorable working conditions, essential staff may undergo distress, which can lead to a decline in the quality of education. Niknam and Thulasiraman (2020) highlighted that educational institutions are interested in having a personalized learning system for the students that adjusts the pedagogy, curriculum, and learning environment so that their learning needs and preferences can be met.

Skill areas of learners can be affected by learning disabilities like receptive and expressive language skills, auditory or phonological processing, visual processing, memory, metacognition, organizational skills and social skills. So certain techniques and strategies can be used to overcome these learning difficulties of a learner. Multi-sensory technique is a way of teaching that engages more than one sense at a time. This includes use of pictures, use of coloured highlighters, paired reading approach, memory clue technique, graphic organizers, models etc. The study conducted by Raghupathi and Raghupathi (2020) alerts the governments across countries to improve the educational interventions, to reduce health disparities by reducing inequality. The effects of education are at the grass roots, creating better overall self-awareness on personal health and making healthcare more accessible.

In a global context, substantial evidence indicates a robust connection between education and health, encompassing factors such as health behaviors, risky environments, and the utilization of preventive services. Moreover, we find that a substantial element of this effect is causal. Education does not exert its influence on health in isolation from other variables, making it challenging to evaluate their individual effects. Income is another very important factor that interacts in many important ways with education as it influences on health. Investigations empirically have found that the effect of education on health is greater than the effect of income. Individuals with an extended period of formal education typically exhibit enhanced health, well-being, and healthier behavioral patterns. Education is an important pathway for improving health and well-being of individuals. It reduces health care, dependency, lost earnings and sufferings too. Education also promotes sustainable healthy lifestyle supporting the development of the individual, family and the community. Compelling evidence suggests that beliefs regarding health and healthcare, influenced by socio-demographic factors such as education, play a crucial role in shaping health behaviors. Randomized controlled trials on the efficacy of interventions has demonstrated that education has the potential to change health beliefs and behaviors if designed and delivered appropriately (Feinstein, 2003).

Food and Nutrition

Food and nutrition systems refer to the infrastructure and systems in place to ensure an adequate and healthy food supply. This includes food production, distribution, and storage systems, as well as government policies and programs to promote healthy eating and reduce food insecurity. Food and nutrition systems are critical to global health and well-being and are influenced by a variety of factors, including economic, social, and environmental.

Health represents the primary outcome of the food and nutrition system, although not all aspects of health and disease etiology can be attributed to dietary factors. Adequate levels of nutrients contribute to health by supporting and enhancing physiological functions; however, imbalances, whether in excess or deficiency, may result in illness. Nutrients can interact with various factors, either facilitating physiological processes that uphold health or, conversely, exacerbating disease processes by impeding repair, causing damage, or promoting the progression of illness. Positive health outcomes encompass growth, development, maintenance, repair, energy provision, and resilience against physical, biological insults, and pathogens causing diseases. Conversely, adverse health outcomes may manifest as acute, chronic, or mental illnesses, diminished performance, and the breakdown of functional capabilities. Nutrients have a distinct role to play in managing health and disease. Disease can occur due to various reasons like toxicity of a nutrient or physical, chemical and microbial contaminants of food (Sobal et al., 1998).

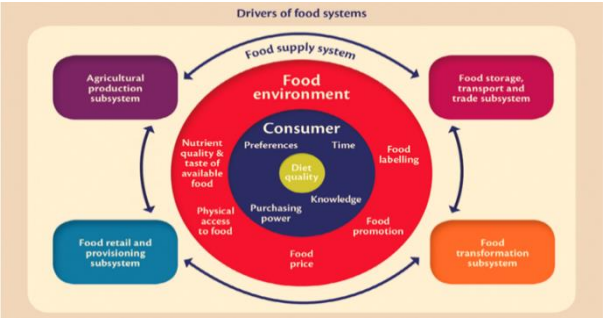

Fig. 1 – Linkages between food systems, food environment and diet quality

Source: Global Panel on Agriculture and Food Systems for Nutrition (Glopan, 2016)

Figure 1 illustrates the drivers of the food system that comprises of Food supply system such as - a. Food storage, transport and trade subsystem b. Food transformation subsystem c. Food retail and provisioning subsystem d. Agricultural production subsystem. These influences the Food environment which includes a. Quality of nutrient and taste on food b. Physical access to food c. Price of available food d. Food promotion and e. Food labelling. The supply system and the food environment have a direct impact on the consumers' a. Preferences b. Time c. Knowledge and d. Purchasing power. These drivers influence the diet quality available to the common population. The long-term drivers of nutritional crisis are climatic change, rapid urbanization, income growth, globalization of diets and competition of natural resources.

The current state of global food systems raises concerns as they predominantly prioritize quantity over quality, hindering efforts to promote healthy and affordable food choices consistent with optimal nutrition outcomes. Rather than supporting consumers in achieving optimal health, the trend leans towards the opposite. While agricultural productivity has surged, and the threat of famine has diminished, the focus on quantity has led to a proliferation of low-quality diets.

Over recent decades, there have been improvements in dietary access for many, accompanied by a rise in the consumption of highly processed and energy-dense foods. For instance, the sale of ultra-processed foods and beverages in middle-income countries has surpassed high-income countries. Despite progress, low-quality diets are prevalent globally. The health status of children is a major concern with obesity, cardio-vascular diseases, diabetes, hypertension and hypercholesterolemia on the rise. One part of the population is affected with metabolic diseases due to loaded nutrients like saturated fat, sodium while the other half of the population is struggling to meet the daily required needs. Addressing this challenge requires a concerted effort from policy makers, private sector leaders, and other stakeholders. Key areas of focus include:

1. Dietary Shifts: Encouraging a transition towards balanced and nutritious diets is crucial to combat the rise of diet-related diseases.
2. Policy Interventions: Governments must enact policies that promote healthier food choices, discourage the consumption of ultra-processed foods, and support sustainable agricultural practices.
3. Consumer Education: Raising awareness about the nutritional impact of dietary choices empowers individuals to make informed decisions regarding their diets.
4. Public-Private Collaboration: Collaboration between the public and private sectors are vital for creating innovation in the food industry which can enable the sectors to develop and implement policies related to health.
5. Sustainable Agriculture: Promoting diverse and sustainable agricultural practices, supporting local farmers, and reducing harmful practices contribute to enhancing the nutritional quality of food.
6. Food Labeling and Transparency: Governments should make it mandatory for producers to give nutritional information on all food packaging. This will enable the common public to make healthy choices.
7. Global Co-operation: To improve global nutrition, international collaboration is necessary. This will enable global sectors to share their best practices, research, and resources.

A multifaceted approach involving various stakeholders, including governments, businesses, and consumers, is essential to reshape food systems. By prioritizing quality over quantity, we can work towards ensuring healthier diets for all and creating a sustainable and positive shift in the global food landscape.

Recognized as a potent and well-established catalyst, quality education is instrumental in fostering sustainable development. To obtain manifold advantages for the broader population, quality education extends across diverse educational settings.

Quality education and healthcare are crucial components of a thriving society as they directly impact the physical, mental, and social well-being of individuals. Quality education enables people to think critically, so as to promote cultural richness, to become productive members of society. It offers access to information, expands opportunities, and opens doors to better career prospects, thereby decreasing poverty and inequality. On the other hand, quality healthcare ensures preventative measures, prompt diagnosis, and effective treatment, improving overall health outcomes and reducing mortality rates. To improve social and economic development, investment in these sectors cannot be overemphasized.

Zajacova, and Lawrence (2018) concluded that less educated adults report worse general health, more chronic conditions and more functional limitations and disabilities. Education impacts health through economic factors, health behaviors, social-psychological pathways and access to health care.

Sustainable Development Goal-Zero Hunger

According to FAO, IFAD, UNICEF, WFP & WHO, over 820 million people worldwide (or 1 in 9 people) suffer from hunger. In 2018, an estimated 149 million children under the age of five years had stunted growth, which is a feature of undernutrition characterized by suboptimal height-for-age. Similarly, the prevalence of overweight in children under five years old has risen to 40.1 million, with almost half occurring in Asia and one-quarter in Africa. Due to COVID-19 pandemic there is a disruption in the food system, as a result of which food security is hindered. With micronutrient deficiency, these issues increasingly co-exist within the same communities, thus forming the triple burden of malnutrition (Headey et al., 2020).

"Achieving the Sustainable Development Goals cannot be without ending hunger and malnutrition and without having sustainable and flexible, climate-compatible husbandry and food systems that deliver for people and earth. The world has made substantial progress in reducing hunger and undernutrition over the past decade. Global rates of hunger have fallen and now affect around one in ten people and the chance of children who are chronically undernourished has declined to around one in four." Similar progress means lower suffering, lower mortality rates and better life chances for hundreds of millions of families and their children. Still, despite these earnings, malnutrition in all its forms presently affects one in three people worldwide, far beyond the 795 million who experience hunger on a diurnal base and this situation is rapidly getting worse. Sustainable Development Goal 2 (SDG 2) calls for a global effort to align food production and consumption with local contexts, ensuring that everyone has access to a sustainably produced, nutritious diet that aligns with other SDGs. As the deadline approaches in just a decade, progress towards achieving the SDGs, including target 2.2, has been progressing at a sluggish pace. Among the targets of the Sustainable Development Goals (SDG), target 2.2 focuses on ending malnutrition among under-five children, by reducing stunting, wasting and overweight by 2030 (Mensi and Udenigwe, 2021).

The SDGs encompass 17 goals, of which target 2 seeks to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. Goal 2 targets to create a world free of hunger by 2030.The global issue of hunger and food insecurity has shown an alarming increase since 2015, as the factors including the pandemic, conflict, climate change, and deepening inequalities are the main reason.

By 2022, approximately 735 million people or 9.2% of the world's population – found themselves in a state of chronic hunger – a staggering rise compared to 2019. This data underscores the severity of the situation, revealing a growing crisis. In addition, an estimated 2.4 billion people faced moderate to severe food insecurity in 2022. This classification signifies their lack of access to sufficient nourishment. This number escalated by an alarming 391 million people compared to 2019 (The Sustainable Development Goal 2 – dashboard, 2023).

Figure 2. Sustainable Development Goal 2 – dashboard

Source: The Sustainable Development Goal 2 – dashboard (2023)

The ongoing rise in hunger and food insecurity, driven by an intricate interplay of factors, requires urgent attention and concerted global initiatives to address this pressing humanitarian issue. Pervasive hunger and malnutrition pose obstacles to sustainable development, creating a cycle that individuals find challenging to break free from. Insufficient nourishment results in less productive individuals who are susceptible to diseases, hindering their ability to earn more and enhance their livelihoods. About 2 billion people in the world do not have regular access to safe, nutritious and sufficient food. In 2022, 148 million children had stunted growth and 45 million children under the age of five were affected by wasting.

Achieving food security demands a comprehensive approach that spans various dimensions – encompassing social protection measures, ensuring the availability of safe and nutritious food, particularly for children, and transforming food systems to foster a more inclusive and sustainable global environment. There will need to be investments in rural and urban areas and in social protection so poor people have access to food and can improve their livelihoods (United Nations-SDG Summit, 2023).

In order to realize the goal of achieving zero hunger by 2030, urgent and coordinated action, along with policy solutions, is crucial. These actions should address deeply rooted inequalities, transform food systems, invest in sustainable agricultural practices, and mitigate the impact of conflicts and pandemics on global nutrition and food security. Each one has the power to enact positive changes in various aspects of our life – at home, at work and within the community by endorsing local farmers or markets, making sustainable food choices, advocating for widespread access to good nutrition and combating food waste.

Definition of Diabetes Mellitus

Diabetes mellitus is the collective term for heterogeneous metabolic disorders whose main finding is chronic hyperglycaemia. It is a chronic disease. The cause is either a disturbed insulin secretion or various grades of insulin resistance or usually both.

Globally diabetes is considered a major threat to health systems. "An estimated 537 million people are living with diabetes worldwide in 2021, with around 18.7 million people living in low-income and middle-income countries (LMICs) (IDF Diabetes Atlas, 2021)."

Prevalence and Trends of Diabetes Mellitus

This paper reviews the types of diabetes and its prevalence worldwide. The prevalence of the disease among urban and rural population is also highlighted. The ethnic and socio-economic status of a population has a direct role in contributing to the occurrence of the metabolic disease, diabetes mellitus. Apart from these, the risk factors have a greater role to play in contributing to the occurrence of the disease.

Current Estimates of Global Diabetes Mellitus Prevalence

The estimated prevalence of diabetes among adults (20 to 79 years) in the year 2000 was found to be 151 million i.e., 4.6% of the world's population during that time. It is alarming to notice that the occurrence has tripled at present. Nearly 537.5 million (10.5%) of the world's population is affected with diabetes (Kumar et al., 2024).

Regional Variations in Diabetes Prevalence (In America, Europe, Africa, Asia)

The IDF Diabetes Atlas (2021) had published that in South-East Asia (SEA) nations for at least 20 years the incidence of diabetes is on the rise, and current estimates have revealed that the rise will be higher than 12.8% by 2045.

Urban-Rural differences in Diabetes Prevalence

Kobo et al. (2022) concluded that the Age-Adjusted Mortality Rate (AAMR) was higher in rural areas when compared to urban areas in the USA over the past two decades. In urban areas, there was a significant decrease in the AAMR than the rural areas. The AAMR was low among females compared to males in both urban and rural areas.

Projected Future Trends in Diabetes Prevalence eg. 2030, 2040…

It is estimated by Kumar et al. (2024) that by the year 2030, 643 million people will be affected by diabetes globally and it might increase to 783 million by 2045.

Classification of Diabetes Mellitus

The classification of Diabetes mellitus is clearly given in Table 1.

Table 1: Classification of Diabetes Mellitus

Type of Diabetes	Occurrence	Description of the Condition
Type 1 diabetes or Juvenile Diabetes or Insulin Dependent Diabetes Mellitus (IDDM) **Latent autoimmune diabetes in adults (LADA)**	Develops at a younger age	β-cell destruction that leads to an absolute insulin deficiency due to autoimmune β-cell destruction (Li et al., 2022)
Type 2 diabetes or Adult onset Diabetes or Non-insulin Dependant Diabetes Mellitus (NIDDM)	Develops at an older age	Predominant insulin resistance with a relative insulin deficiency. It is often associated with other diseases or complications (ADA, 2024)
Gestational diabetes	Develops during the III trimester of pregnancy	It occurs or is diagnosed for the first time during pregnancy
Maturity Onset Diabetes of the Young [MODY]	Adolescence or early adulthood	It is associated with mutations in a specific gene (e.g., HNF1A, HNF4A, and GCK) (Li et al., 2022)

RISK FACTORS OF DIABETES

Diabetes mellitus, especially type 2, is a complex disease with multiple risk factors. The most important risk factors include obesity, physical inactivity, unhealthy diet, genetic predisposition, and certain medical conditions. Both modifiable and non-modifiable factors contribute to the development of diabetes.

Age

Qin et al. (2021) conducted a study with 6171 respondents who developed diabetes. It was clear from the study that lifestyle risk factors increased the occurrence of diabetes with age in adults aged 40 to 55 years (9.9%). The occurrence was found to increase by 29.7% among adults above 75 years.

Obesity and Overweight

When the BMI is 25 and above it is a leading risk factor for developing type 2 diabetes (Evangelou et al., 2018). Fazeli et al. (2020) concluded that effect of age is statistically significant ($p<0.0001$, Poisson regression) particularly after the age of 40 years in the occurrence of diabetes mellitus. It has been found that occurrence of diabetes among people who are more than 70 years with normal BMI are similar those who are in their 30s.

Physical Inactivity

When physical activity was introduced into a sedentary lifestyle, the prevalence of type 2 diabetes mellitus (T2DM) decreased by 3.3–9.2%, the incidence decreased by 4.2–11.5%, and diabetes-related mortality decreased by 1.9–5.2%. The occurrence of diabetes mellitus can be reduced by an intervention through reducing smoking, increasing physical activity and reducing obesity (Awad et al., 2019).

Family History

It was clear from the study done by Tsui et al. (2022) that family history was one of the contributing factors for diabetes. The prevalence ranged from 39.1% to 85.3%, with family history reported among mother was common with 32.5%. The researchers also insisted that change in the lifestyle pattern can delay the occurrence of diabetes with better control on cardiometabolic risk factors.

Unhealthy Diet

Increased consumption of processed meat, sugary beverages, decreased intake of whole grains, low level of education, decreased physical activity, increased sedentary lifestyle, binge eating, excessive intake of alcohol and excessive smoking were contributors of increased risk of T2DM. Alteration in the dietary pattern will reduce the risk of T2DM (Bellou et al., 2018).

The modifiable factors contributing to diabetes mellitus can be altered by change in the lifestyle pattern whereas non-modifiable factors cannot be changed. The modifiable and non-modifiable factors are tabulated in Table 2.

Table 2. Modifiable and Non-Modifiable Factors of Diabetes Mellitus

Modifiable Factors	Non-Modifiable Factors
Obesity (Evangelou et al., 2018)	**Age** (Evangelou et al., 2018)
Physical inactivity (Awad et al., 2019)	**Family history/Genetics (**Tsui et al., 2022)
Unhealthy diet Bellou et al. (2018)	**Ethnicity (**Egede et al., 2016)
Smoking (Faou et al., 2022)	**Sex (**Qin et al., 2021)
Hypertension (Qin et al., 2021)	**History of gestational DM**
Dyslipidemia (Kalra and Raizada, 2023)	

Global Burden of Diabetes-Related Morbidity and Mortality

Lin et al. (2020) made it clear that "globally, metabolic risks (high BMI) and behavioral factors (inappropriate diet, smoking, and low physical activity) contributed the most attributable death and disability-adjusted life-years (DALYs) associated with diabetes. These estimations could be useful in policy-making, priority setting, and resource allocation in diabetes prevention and treatment."

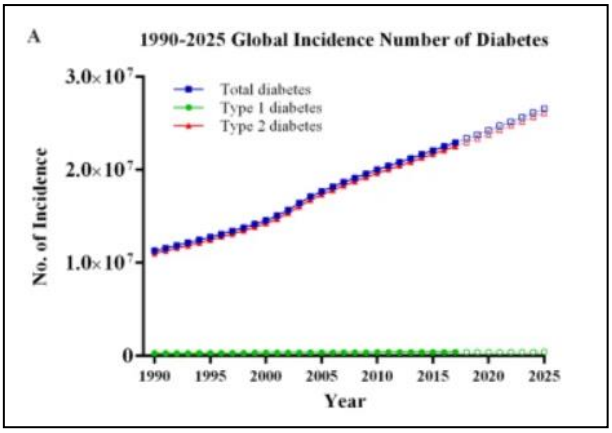

Fig 3 Global burden of diabetes mellitus from 1990 to 2025. (A) Incidence number
Source: Lin et al. (2020)

The global disease burden of diabetes kept on increasing from 1990 to 2017 as shown in Fig. 1. Globally, the incidence of diabetes increased from 11.3 million in 1990 to 22.9 million in 2017, with a 102.9% increase. It is clear from the graph that the incidence is likely to increase from the year 2020 to 2025 too (Lin et al., 2020).

Implications of rising diabetes and the public health policy
Hossain et al. (2024) insisted that governments should collaborate with World Health Organization (WHO) to improve healthcare accessibility. The healthcare should also include frequent diabetes screenings for the general population aged ≥ 45 years and people with increased risk of family history. A WHO initiative to provide access to care that are affordable and to help in prevention of metabolic disease is "The Global Diabetes Compact." Four metrics were studied namely, structural system or policy level, processes of care, behaviours and biomarkers such as glycated haemoglobin (HbA1c) and health events and outcomes. These metrics will pave way to chart out policies, make changes in health care access etc., to achieve the goals of the Global Diabetes Compact. This will provide broad range of health benefits for people with diabetes (Gregg et al., 2023).

Management of Diabetes
Diabetes can be managed with three important factors like diet, exercise and drugs (given in Figure 4). Among these factors one factor is not superior to the other factor. They are interdependent on each other.

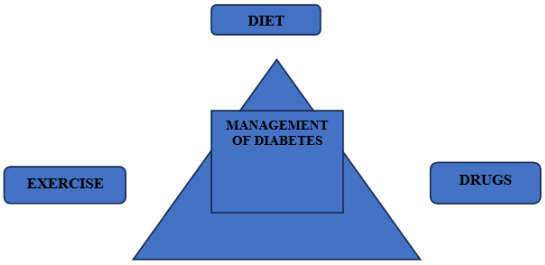

Fig 4. Management of Diabetes

Diet and Diabetes
Diet plays an important role in managing diabetes. There are various dietary patterns to manage the dietary composition of glycemic control and reducing diabetes risk. A strict dietary pattern can maintain the metabolic conditions but the percentage of improvement varies from person to person. It is crucial to plan a diet for these patients according to their taste, likes and dislikes, economic factors, traditions etc.

Dietary Patterns and Diabetes Management
The best dietary pattern to be followed by a diabetic patient is small meals at regular intervals. On consuming large meals at a time will increase the blood sugar level. The release of glucose can be controlled.

Mediterranean and Plant-Based Diets
Mediterranean diets include fruits, vegetables, whole grains, legumes, nuts and healthy fats. These food groups maintain glycemic response, weight loss and decrease the risk of complications associated with diabetes like cardiovascular diseases. Martin-Pelaez (2020) pointed that mediterranean diet helps to slow the progression of diabetes and prevent it on the longer

run. They have anti-inflammatory, antioxidant and gut microbiota effect. Toi et al (2020) reviewed sixty systemic reviews and meta-analyses and suggested that mediterranean and dietary approach to stop hypertension diets significantly reduced the risk of type 2 diabetes mellitus. Since the risk of cardiovascular disease will be high for patients suffering from T2DM, Becerra-Tomas et al. (2020) suggested the beneficial effect of Mediterranean diet on diabetes and the reduction of mortality rate among patients with diabetes.

Low carbohydrate Diet

Goldenberg et al. (2021) reviewed that low carbohydrate diets may lead to remission of diabetes by six months without causing any adverse effect on the patients. But they also pointed out certain limitations such as efficacy, safety and satisfaction of the low carbohydrate diet for a long period of time among the patients. Blood glucose management and reduction in the risk of cardiovascular diseases are supported by low carbohydrate, high protein diet (Matwiejczyk et al., 2023). Churuangsuk et al. (2021) argued that long-term impact is required to assess glycemic control and its complication when the patients are on low carbohydrate diet

Low Glycemic Index Diet

It has been found that low glycemic index dietary patterns are more effective for managing glycemic levels and also reduce the risk of cardiovascular disease (Matwiejczyk et al., 2023). The foods that have an effect on Type 2 Diabetes Mellitus (T2DM) is depicted clearly through Figure 5.

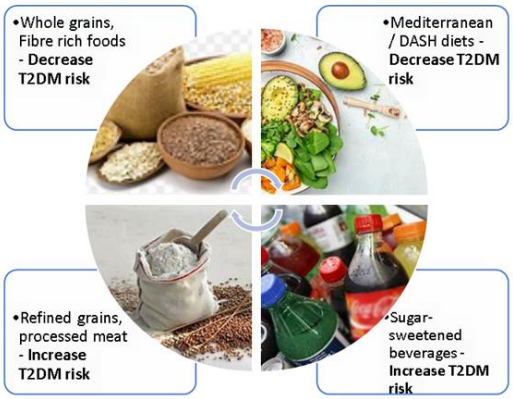

Fig 5. Effect of Dietary Factors on the Risk of Diabetes

Exercise and Diabetes

Exercise is a pillar in the prevention and management of both type 1 and type 2 diabetes. The quality of life of people with diabetes can be enhanced by regular physical activity as it manages blood sugar and reduces cardiovascular risk. The degree of benefit depends on the type, intensity and combination of exercise modalities.

To reduce the burden of T2DM, lifestyle modifications should be emphasized for patients who are at risk (Toi et al., 2020). A significant risk factor for T2DM is obesity. Even it can be managed by diet, exercise and changes in lifestyle pattern. These factors can improve blood glucose levels and the action of insulin in the body (Chandrasekaran and Weiskirchen, 2024).

Mechanism of Action through Glucose Uptake and Insulin Sensitivity

Exercise improves glucose uptake in skeletal muscle. It is crucial for maintaining glucose homeostasis in people with type 2 diabetes (Hulett et al., 2022). Mthembu et al. (2022) reported based on the evidence "that interventions like physical exercise and caloric restriction, within duration of approximately 2 to 4 months, can improve insulin sensitivity." By preventing sedentary behaviour blood glucose can be improved among type 2 diabetes mellitus patients (Sgrò et al., 2021). The skeletal muscle glucose uptake requires a concert of events and it is pictorially represented in Figure 6.

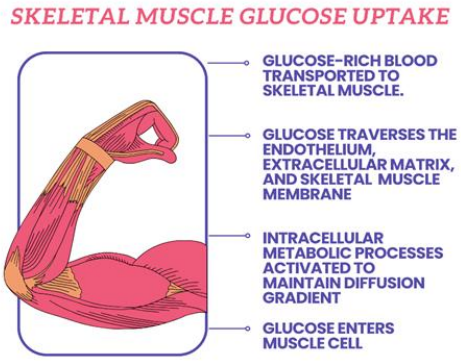

Fig 6. Uptake of Skeletal Muscle Glucose

Exercise reduces inflammation by altering levels of exerkines and cytokines and they contribute to metabolic health. Longer physical activity programs will improve metabolism (García-Hermoso et al., 2022). Indulging in medium to vigorous intensity of regular exercise can definitely improve sensitivity of insulin, thereby controlling blood glucose levels and reducing the risk factors of cardiovascular diseases. It also maintains body weight and reduce the complications associated with type 2 diabetes mellitus (Amanat et al., 2020).

In a study conducted by Magkos et al. (2020), it was concluded that type 2 diabetes remitted in approximately 80% of obese patients for a long time. This was achieved by restriction of carbohydrate and increased physical activity. Weight loss for these patients was around 15 Kg due to strict calorie restriction.

Exercise, Diabetes Mellitus and Quality of Life (QoL)

Cai et al. (2017) reviewed from 30 studies that only regular aerobic exercise improved QoL of type 2 diabetes patients and not resistance exercise. But Sabag et al. (2023) confirmed that regular aerobic exercise or combining with resistance training improves QoL among type 2 diabetes patients. Combined aerobic and resistance exercise improves cognition, physical health and metabolic health. These in turn improves the quality of life of type 2 diabetic adults who are in their middle age or old age (Zhang et al., 2023).

Exercise is a highly effective, safe and adaptable strategy for managing and preventing diabetes. From the studies it is recommended that aerobic exercise or resistance training or combination of both significantly improves the blood sugar levels and quality of life.

Drugs and Diabetes

One of the major impacts of controlling diabetes is through drug therapy. Pharmacological interventions help to control blood glucose, reduce complications and consequently quality of life can be improved. For type 2 diabetes mellitus patients, various options on drug are available which tailor for the needs of the patients.

Classes of Diabetic Drugs

Metformin, Glucagon-like peptide-1 receptor agonists (GLP-1 RA), and Sodium-glucose cotransporter inhibitors (SGLT-2i) are effective to treat type 2 diabetes, while novel treatments like the dual GLP-1/glucose-dependent insulinotropic polypeptide (GIP) agonist show promise for reducing glycated hemoglobin and body weight. Metformin is considered as first-line oral treatment for glycemic control (Sibony et al., 2023). Sulfonylureas and benzoic acid derivatives or antihyperglycemic agents such as biguanides, α-glucosidase inhibitors and thiazolidinediones are oral hypoglycemic agents that stimulate beta-cells of the Islets of Langerhans in the pancreas to produce insulin (Mohajan and Mohajan, 2024). DPP4 inhibitors (DPP4i) are another oral hypoglycemic agent that are safe to consume as it has anti-inflammatory action. It also helps to treat diabetes and manages the risk factors (Yin et al., 2022).

Drug delivery systems can improve drug stability so risk of hypoglycemia can be reduced (Zhao et al., 2020). Nanotechnology based approaches offer higher bioavailability by improving the effectiveness of the therapy and compliance of the patient (Padhi et al., 2020).

The outcome of the diabetes treatment can be better if therapies are taken in combination as the impact on glycemic control is better. The comparative effectiveness of the drugs are tabulated in Table 4.

Table 4: Comparative Effectiveness of Drugs

Drugs	Benefits
Metformin	Glycemic control (Sibony et al., 2023)
Glucagon-like peptide-1 receptor agonists (GLP-1 RA)	Cardiovascular protection, weight loss (Sibony et al., 2023)
Sodium-glucose cotransporter inhibitors (SGLT-2i)	Cardiovascular protection, weight loss (Sibony et al., 2023)
Sulfonylureas	Stimulate the secretion of insulin (Mohajan and Mohajan, 2024)
DPP4 inhibitors (DPP4i)	Treats diabetes and manages the risk factors (Yin et al., 2022)

CONCLUSION

Quality education for children makes them more responsible as a citizen. Education can have an impact on the various SDGs like zero hunger, good health and well-being. When health and well-being are taken care, then the incidence of disease condition like diabetes mellitus can be reduced. Diabetes mellitus is a result of metabolic disorders. If it is not treated at the right stage and right time it results in various abnormalities in the blood sugar levels. Type I Diabetes mellitus occurs when the pancreas no longer produces enough amount of the hormone insulin. This ends up in autoimmune destruction of the beta cells of the pancreas that produce insulin. The alpha cells of the pancreas are not as affected as the beta cells. Type II Diabetes mellitus occurs due to autoimmune attacks on the pancreas and/or insulin resistance. The secretion of insulin among type 2 diabetes patients are usually normal but utilisation by the body is poor.

The main aim of managing diabetes is to maintain the metabolism of carbohydrate. Insulin therapy is important to achieve this goal when there is absolute deficiency of insulin. When there is insulin resistance, diabetes can be managed with just diet, drugs and exercise. Apart from managing the insulin secretion, it is also important to manage the acute and chronic complications. Diabetes mellitus will not be a burden if all these are kept under control along with maintaining the blood sugar level.

Conflict of interest

The authors declare that there is no conflict of interest in publication of this paper.

Acknowledgement

The authors are thankful to the Principal and the Staff of Library of Meenakshi Academy of Higher Education and Research for providing facilities and books for this review.

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