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Diabetes Management in Conflict Zones: Epidemiological Insights, Challenges, and Strategic Interventions

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ABSTRACT

Diabetes mellitus is a worldwide concern especially in areas of conflict. This review looks at diabetes epidemiology in these zones and the factors that affect the disease burden and care. Civil wars affect the health care system, which leads to a lack of personnel and services that are critically needed for diabetes management, including blood glucose monitoring and physician visits. Lack of access to medication is rife in war zones which implies that insulin and other necessary diabetes medications are hard to come by and this results to high blood sugar levels and complications such as ketoacidosis and infections. Another big problem is malnutrition. Conflicts lead to food scarcity and limited access to balanced diets that are crucial in managing diabetes. Poor quality food aid exacerbates the problem of blood glucose control. Furthermore, the stress of conflict because of death, displacement and living in fear worsens anxiety which in turn affects diabetes management and blood sugar levels. To meet these challenges, new ideas are needed. Mobile health care can help deliver necessary medical assistance and drugs in the areas affected by conflicts. Policy advocacy is essential to develop policies for diabetic health care needs in these regions. Understanding these factors is vital to developing appropriate interventions and plans, improving diabetes management, and improving the health of vulnerable populations. These strategies are crucial in reducing the effects of conflict on diabetes care and enhancing the well-being of those in the community.

Abbreviations: CGM= Continuous Glucose Monitoring, iPSCs = induced pluripotent stem cells, BCAAs= branched-chain amino acids, RM= regenerative medicine

Keywords: Diabetes, conflict zones, healthcare delivery, medication shortages, bioengineering, policy advocacy

INTRODUCTION

Diabetes mellitus is a major worldwide health problem involving a rise in blood sugar levels due to problems in insulin release, utilization, or both [1]. Diabetes has become a global health phenomenon and its incidence has rapidly increased posing major challenges in terms of health, economy and social consequences [2]. However, this disease is not proportionally distributed with refugees and those in conflict regions experiencing a great deal of difficulty in managing their diabetes [3]. Conflict areas are areas in the society that experience turmoil such as war or civil strife that compromises any social functioning—health care being one of them [4]. Such areas can experience extensive damage to their physical infrastructure, displacement of population, as well as acute shortage of medicines and health care professionals [5]. As such, patients suffering from chronic illnesses, including diabetes, in countries experiencing warfare find it difficult to address their ailments, which make an already poor health situation worse [6]. This paper seeks to provide an extensive review of the existing literature to establish

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the epidemiology and effects of diabetes in conflict regions. This paper explain the various complex barriers to proper diabetes management, by describing such aspects as epidemiology, interruptions to services, medication supply, and diets. Thus, aiming at offering a comprehensive overview of the process, this review seeks to reveal the intricacies of the discussed barriers to diabetes care in conflict-affected populations. Appreciating these challenges can help to design specific prevention and management strategies, as well as policy approaches to minimize adverse effects of diabetes for conflict-affected populations across the world.

METHODS

This narrative review aims at summarizing the current knowledge on the epidemiology and challenges in the management of diabetes in conflict settings. A literature search was performed in PubMed, Scopus, and Google Scholar with keywords including “diabetes in conflict zones”, “healthcare delivery in conflict zones”, and “diabetes management challenges”. The articles were chosen based on their relevance to diabetes incidence, healthcare disturbances in conflicts, lack of medicines, and possible solutions for diabetes care. Some of the major themes discussed include epidemiological factors that affect diabetes prevalence in conflict affected populations, effect of conflict on health care services, medication and management of diabetes and possible solutions and policy directions for improving diabetes management during conflict.

Epidemiology of Diabetes in Conflict Zones

To understand the epidemiology of diabetes in conflict zones, it is necessary to consider factors that affect the occurrence of the disease [7]. This results in changes of lifestyle and dietary practices and increases the chances of getting diabetes [8]. Research has also established that urbanization and changes in the diets of populations in conflict regions especially in Africa and the Middle East have further exacerbated the spread of diabetes among vulnerable groups [9]. Furthermore, stress and trauma that occur during conflict can also have a direct effect on diabetes results [10]. Hormonal changes triggered by stress can affect the blood glucose level and thus affect the management of diabetes with its complications [10]. In addition, limitations in healthcare access and the lack of healthcare continuity compound the difficulties that people with diabetes experience in conflict areas ¹¹.

Impact of Conflict on Diabetes Management

Conflict significantly affects healthcare systems and has adverse effects on the management of chronic diseases [11]. Hospitals, clinics, and medical supply chains are not spared from attacks or destruction during armed conflicts, which hampers the availability of diabetes medications and care services [12]. Health workers are compelled to abandon their posts in war-affected areas, which undermines the availability of healthcare workers and weakens the ability to address non-communicable diseases [13]. Lack of drugs, especially insulin, is a major problem in the conflict areas [14]. Lack of access to insulin and poor storage and distribution of the product threatens the lives of diabetic patients who need to use insulin regularly [15]. Furthermore, nutritional deficiencies worsen diabetes care struggles as displaced persons consume poor quality diets rich in carbohydrates but poor in micronutrients, which worsens glycemic control and general health [16]. Mental and interpersonal effects can also be seen in diabetes care in conflict areas [17]. Psychological stress due to displacement, loss of income, and lack of knowledge on the future can elevate blood glucose level and compromise on diabetes management [18]. Furthermore, the erosion of social networks and community systems weakens the care delivery system and increases the isolation of persons with diabetes, adding to their burden [19].

Strategies for Managing Diabetes in Conflict Zones

To meet the multifaceted needs of diabetes care in conflict areas, new and flexible approaches to healthcare must be implemented [20]. The use of mobile health care units and telemedicine can be a helpful approach to addressing the problem of accessibility and provide remote consultation and drug delivery to the affected population [21]. International humanitarian aid can fill the gap of medication needs and help to strengthen the local health care systems to continue diabetes management during conflicts [22]. Policy advocacy is crucial for ensuring that diabetes care is integrated into humanitarian responses and for securing funding for basic medications and healthcare services in conflict affected areas [22]. To ensure that diabetes care is included in emergency health programs, there is a need for collaboration between the international organizations, governments, and other stakeholders in the affected regions [23]. Managing diabetes in conflict areas faces several challenges including lack of accessible healthcare, limited availability of drugs, inadequate diet, and psychological pressure [24]. Efficient interventions include flexible healthcare delivery, strong policy recommendations, and global partnership for equitable diabetes care [25]. Sustained efforts should be made to address the effect of conflict on diabetes outcomes and enhance the health of affected communities [25]. This review aims to summarize the current knowledge on the epidemiology, burden, and Care of diabetes in conflict zones. Through this review, the complex interactions between disruptions in healthcare, medication scarcity, and socio-economic factors that affect

individuals with diabetes in conflict areas are revealed, stressing the need for collective action towards solving these problems.

Epidemiology and Impact of Diabetes in Conflict Zones

Diabetes mellitus, a chronic metabolic complication characterized by high blood glucose, has become a major world health concern. In conflict zones, diabetes burden is aggravated by weak health infrastructure, limited access to medicines, and population displacement [24, 25]. This review aims to review the literature on the epidemiology of diabetes in conflict zones and its implications on health care delivery and to highlight the importance of integrated and adaptive health interventions. The rates of diabetes in conflict-affected regions depend on displacement, malnutrition, and stress [26]. For instance, in many parts of Africa, the incidence rate of diabetes is rising, particularly because of urbanization and changes in the people's diets and physical activities [27]. These trends are worsened by conflict because it affects food access and hence people end up being malnourished or being forced to eat unhealthy high calorie and low nutrient food given in the refugee camps which is a risk factor for diabetes [27]. The rates of diabetes are also known to be higher in conflict areas among vulnerable populations such as the elderly, women and those with co-morbidities [28]. Conflict and displacement cause stress, which may lead to the development of diabetes or the exacerbation of diabetes-related conditions due to hormonal fluctuations and changes in daily routines [29]. Furthermore, the limited access to health facilities and drugs plunges the disease to worse [30].

Impact of Conflict on Diabetes Management

Conflicts result in the destruction of health facilities and equipment, thereby limiting diabetic patients' access to essential health care [31]. Health facilities may be damaged or converted for use in managing emergency situations, and this means that there will be fewer facilities for managing chronic diseases³². Health care workers may also leave conflict areas, creating a critical absence of skilled health care personnel [32]. Availability of insulin and other important drugs for diabetes is severely limited in areas affected by conflict [33]. Supply chains can be interrupted, which can lead to shortages that are deadly for insulin-dependent diabetics [34]. Also, the refrigeration needed for the storage of insulin is still a luxury in many areas due to poor infrastructure [35]. Displacement caused by conflict means that people are often relocated to refugee camps where food choices are scarce [36]. It is common to find that the food provided is high in carbohydrates and low in nutrients that are required by the body, which compounds the problem of glycemic control in diabetic patients [37]. Malnutrition and food insecurity also exacerbate diabetes and make the management of the disease difficult, which results in adverse health consequences [38].

Psychological and Social Impacts

Stress due to conflict and displacement can also affect diabetes care and management in a big way [39]. Conflict can cause psychological stress which may impair diabetes self-care due to elevated stress hormones which raise blood sugar levels [40]. Also, social support systems, which are considered essential in chronic disease, are also affected in conflict areas [41]. Table 1 summarises how conflict affects diabetes care in multiple ways, including disruptions in healthcare services, lack of access to medication, nutrition, and psychological social stressors. All of the identified aspects are backed by cited literature, which underlines the challenges of addressing diabetes in conflict-stricken communities.

Strategies for Managing Diabetes in Conflict Zones

In order to manage diabetes in conflict zones, healthcare services must be flexible and sustainable [42]. Mobile clinics and telemedicine can offer remote consultations and check-ups, and international aid can assist in addressing issues with medication and supplies [43]. Education of local healthcare workers and community health volunteers can also help improve the healthcare system [44]. To address diabetes in humanitarian responses, there is a need for advocacy and policies that promote the prioritization of diabetes management [45]. Governments and international organizations should ensure that resources and funding are directed towards diabetes care in conflict prone regions [46]. Policies need to address the availability and affordability of medicines, strengthen healthcare systems, and integrate diabetes care into emergency health programs [47].

Table 2 presents a summary of recommendations for diabetes care in conflict settings with a focus on flexible healthcare systems and strong policy agendas. Every strategy is described with particular actions and objectives to overcome the problems of the conflict environment.

Bioengineering Approaches to Diabetes Management

Medical progress has resulted in new technologies that improve diabetes management by providing better methods of glucose measurement, more efficient insulin administration, and even possible treatments for regeneration of damaged tissues [48]. Insulin pumps allow for continuous subcutaneous insulin delivery, which is more precise and flexible than multiple daily injections [49]. Current insulin pumps such as Medtronic MiniMed and Omnipod are able to mimic the body's natural insulin release by providing basal rates and bolus amounts

during meals [50]. Tubless systems, like the Omnipod, do not require tubing, which enhances the convenience of use and adherence to the treatment [51]. These devices are also programmable and can be operated through a wireless device, thus making the control of insulin easy and convenient [52]. Smart insulin pens use Bluetooth and have dose calculators to ensure that the insulin given to the patient is precise [53]. Some of these pens can record the dosing information and can pair with the application in the smartphones for data analysis, dosage record, and adherence check [54]. Closed-loop systems involve the use of Continuous Glucose Monitoring (CGM) and insulin pumps to develop an automated insulin delivery system [55]. These systems employ complex algorithms to estimate blood glucose levels and regulate insulin administration on a real-time basis, thereby enhancing glycemic control and minimizing the incidence of hypoglycemia [56, 57]. The Medtronic MiniMed 670G, a hybrid closed-loop system has shown better results in clinical trials [58]. CGMS offer immediate glucose level readings to help patients manage their diabetes efficiently [59]. Researches on the sensor technology have enhanced the precision, dependability, and durability of CGM devices [60]. The current generation of CGM systems like the Dexcom G6 and Abbott FreeStyle Libre employ enzyme electrodes and biocompatible materials to improve the calibration and increase the wear time of the sensors [61]. Currently, research is being conducted on non-invasive CGM technologies like optical and transdermal sensors to minimize the need for calibration and invasive procedures⁶¹. Current CGM devices are compatible with mobile applications and cloud technology for ongoing monitoring and data storage [62]. These systems employ artificial intelligence and machine learning techniques to give feedback, patterns and early warning indicators to patients as well as health care givers to make appropriate decisions [63]. Table 3 and Figures 1 and 2 summarises the key aspects of bioengineering developments in diabetes care focusing on the technology and its application in patient care.

Regenerative Medicine and Tissue Engineering

The goal of regenerative medicine is to restore the normal insulin-producing function by either repairing or replacing the damaged pancreatic cells [64]. This approach involves stem cell treatment and islet transplantation. The induced pluripotent stem cells (iPSCs) can be differentiated into insulin-producing beta cells of the pancreas [65]. This approach has the potential of offering a source of functional beta cells for transplantation that is renewable [65]. Current work aims at enhancing the methods of cell differentiation and finding ways of preventing these cells from being attacked by the body's immune system [66]. Islet transplantation is the process of transplanting healthy islets from a donor pancreas into a diabetic patient [67]. The progress in bioengineering has enhanced the methods of islet isolation and encapsulation, which has made the transplanted islets to survive and function optimally [68]. Encapsulation devices form a shield around the islets and enable the islets to function for a longer time without the need for immunosuppression [68]. Bioengineering solutions hold the promise of improved diabetes care through better glucose monitoring, closed-loop insulin delivery, and novel cell-based therapies [68]. These advancements not only help in better glycemic control but also have positive impact on patient's quality of life and decrease the risk of diabetes related complications [69]. Further research and innovation in the field of bioengineering are needed to address the existing challenges and make these advanced therapies more widely available for patients [69, 70].

Food Biochemistry and Nutritional Interventions

Food biochemistry is the branch of biochemistry that deals with the molecular structure of food and chemical reactions that occur during food processing and digestion [71]. This knowledge is used by nutritional interventions to enhance health outcomes through diet [72]. It is essential to know the biochemistry of the macronutrients and micronutrients that are present in foods to design proper dietary recommendations for the prevention and management of diseases [73]. Carbohydrates are the main source of energy [74]. They include the monosaccharides and disaccharides which are the simplest sugars to the polysaccharides which include starch and fiber [75]. Carbohydrate biochemistry determines their digestion, absorption and metabolic effects [74]. Consumption of simple sugars, particularly fructose and glucose, has been identified to be a risk factor for metabolic diseases including obesity, diabetes, and cardiovascular diseases [75]. They quickly raise blood glucose levels, stimulate insulin production, and are a factor in the development of insulin resistance over time [76]. High fiber carbohydrates like whole grains, vegetables, and legumes are recommended because they release energy slowly and have positive impacts on glycemic control [77,78]. Fiber, a type of carbohydrate that is not broken down by digestion, has numerous benefits for the digestive system, blood sugar control, and cholesterol management [79]. Proteins are necessary for the growth, repair and maintenance of tissues in the body [80]. They are made up of amino acids which can be classified as essential and non-essential depending on the fact whether the body can produce them or not [81]. These are the amino acids that cannot be synthesized by the body and therefore must be derived from food. The balance of amino acids plays a role in protein synthesis and health. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

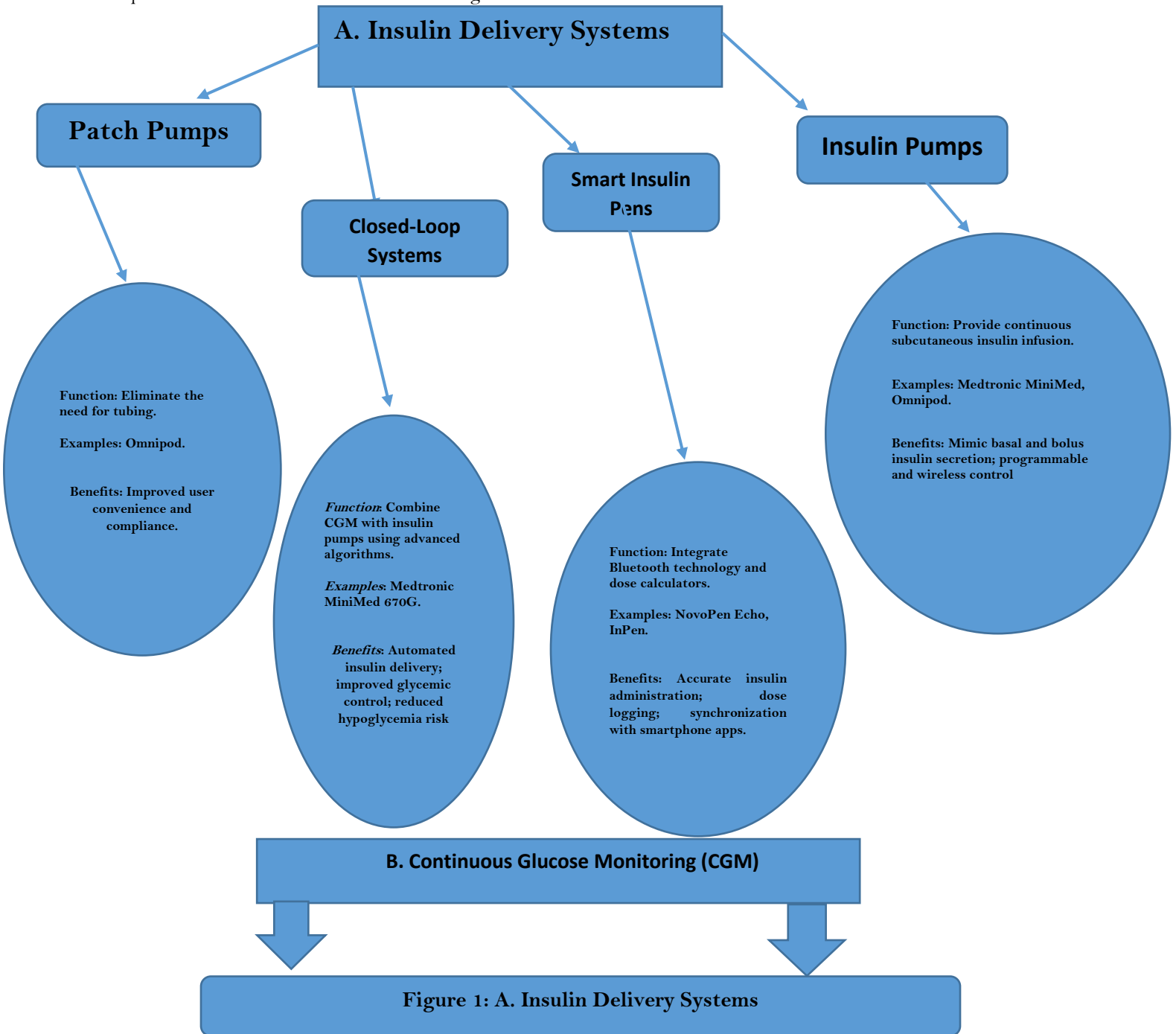
For example, branched-chain amino acids (BCAAs) are involved in muscle protein synthesis and energy metabolism during exercise [82]. The quality of dietary protein is determined by its amino acid content and the ability to be broken down by the body [83]. Animal proteins from meat, dairy, and eggs are of higher biological value than plant proteins from beans and grains; however, different plant proteins can be consumed together to meet all the body's amino acid requirements [84]. Fats and oils are essential in energy storage, cell membrane structure, and cell signaling [85]. It is divided into saturated, unsaturated (monounsaturated and polyunsaturated), and trans fatty acids. Omega-3 and omega-6 are polyunsaturated fats that cannot be synthesized by the body and must be taken in through the diet [86]. They also have significant impacts on inflammation, cell membrane stability, and brain activity [87]. Saturated and trans fats are considered to be unhealthy and increase the risk of cardiovascular disease while unsaturated fats are protective [88]. Fish oils contain Omega-3 fatty acids which helps reduce inflammation and is good for the heart [89]. They are organic compounds that are required for various metabolic functions in the human body [90]. Vitamins are organic compounds which are required for metabolism. For instance, vitamin D is essential for calcium uptake and bone health while vitamin C has an anti-oxidant function and is involved in collagen formation [91]. Iron, calcium and magnesium are some of the minerals that are important in the body for various reasons [92]. Iron is required for oxygen transport, calcium for bone formation, and magnesium for enzyme activity [93]. Nutritional interventions are used to correct nutrient deficiencies, control diseases, and prevent diseases. It is possible to prevent deficiencies of vitamins and minerals by providing food with these nutrients [94]. For example, iodine is added to salt to prevent goiter and flour is fortified with folic acid to decrease neural tube defects in newborns [95]. According to the public health guidelines, one should consume food that is complicated and contains fruits, vegetables, whole grains, lean proteins, and healthy fats [96, 97]. These guidelines are based on the biochemical concept of nutrients and their effects on health [98]. New developments in nutrigenomics make it possible to tailor diets according to one's genetic makeup [99]. This approach is designed to improve health by individualizing diet according to genetic profile and metabolic potential [100]. The knowledge of the biochemistry of food is important to designing proper nutrition interventions as depicted in table 4. Through understanding the molecular mechanisms of nutrient interactions, it is possible to develop dietary interventions that support health, prevent illness, and improve well-being. Further research should be conducted to unravel the intricate link between food biochemistry and human health, thus opening the door for novel dietary approaches and individualised nutrition guidelines [101].

Pharmacological Innovations and Accessibility

Over the years, pharmaceutical breakthroughs have enhanced the treatment of diseases, provided new treatment options, and improved the lives of patients with diverse illnesses [102]. However, it is also important to note that the enjoyment of these innovations is still a major challenge [103]. The concept of accessibility can be defined in terms of affordability, availability, and equitable distribution, all of which play a role in determining the extent to which these innovations can improve global health [104]. Molecular stratification of patients according to genetic, environmental, and lifestyle factors has dramatically altered the therapeutic index of treatments [105]. Precision medicine enables treatment strategies for diseases such as cancer based on the molecular basis of the disease, including the specific mutations that cause the disease to progress [106]. Biopharmaceuticals such as monoclonal antibodies and gene therapies are new ways of treating diseases that were hitherto considered untreatable [107,108,109]. Such therapies may produce better results but are more costly to manufacture and distribute [110]. This exposes new treatments to patients faster and at a lower cost than the traditional drug development process [111]. For instance, the use of antivirals for new indications including COVID-19 has provided fast track therapeutic solutions in the course of global health crises [112]. Expenses related to the new treatments restrain their availability mainly in impoverished areas and for the rare diseases [113]. It is important to note that other strategies like tiered pricing and licensing are instrumental in achieving affordability without damping innovation incentives [114]. Cold chain storage of biologics and gene therapies presents operational challenges in the regenerative medicine (RM) settings [115]. These are vital in the provision of resources and services to all the people across the globe [116]. Differences in the regulatory framework between countries can also impact the availability of new treatment options [117]. Coordinating the approval systems and encouraging mutual recognition arrangements can help make new therapies more easily accessible [118]. Pharmaceutical firms, governments and non-governmental organizations can effectively manage resources and minimize the cost by joint investment and risk sharing [119, 120]. Encouraging the transfer of knowledge and technology to the developing regions helps in developing the local production capacities and hence, decreases the reliance on foreign suppliers, thus making it more easily available [121]. Proper implementation of health economics studies will help in the pricing and reimbursement of new products in the market, thus guaranteeing availability of innovations in

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the market and encouraging further research and development [122]. Pharmacological advancements offer significant potential for enhancing the health of people across the globe, but their potential cannot be fully unlocked without increased access. Issues of affordability, distribution and regulation cannot be tackled without the participation of all stakeholders and innovative policies. Thus, the healthcare community can guarantee that the new pharmacological discoveries will be available to all patients, regardless of where they live or their social status. The findings from table 5 highlight the need to foster teamwork and come up with new policies and strategies that will make it possible for all people to access the benefits of pharmacy in all the regions and income levels. Through affordability, distribution and policies, the healthcare profession can enhance the role of pharmaceutical advancements in enhancing health standards across the world.



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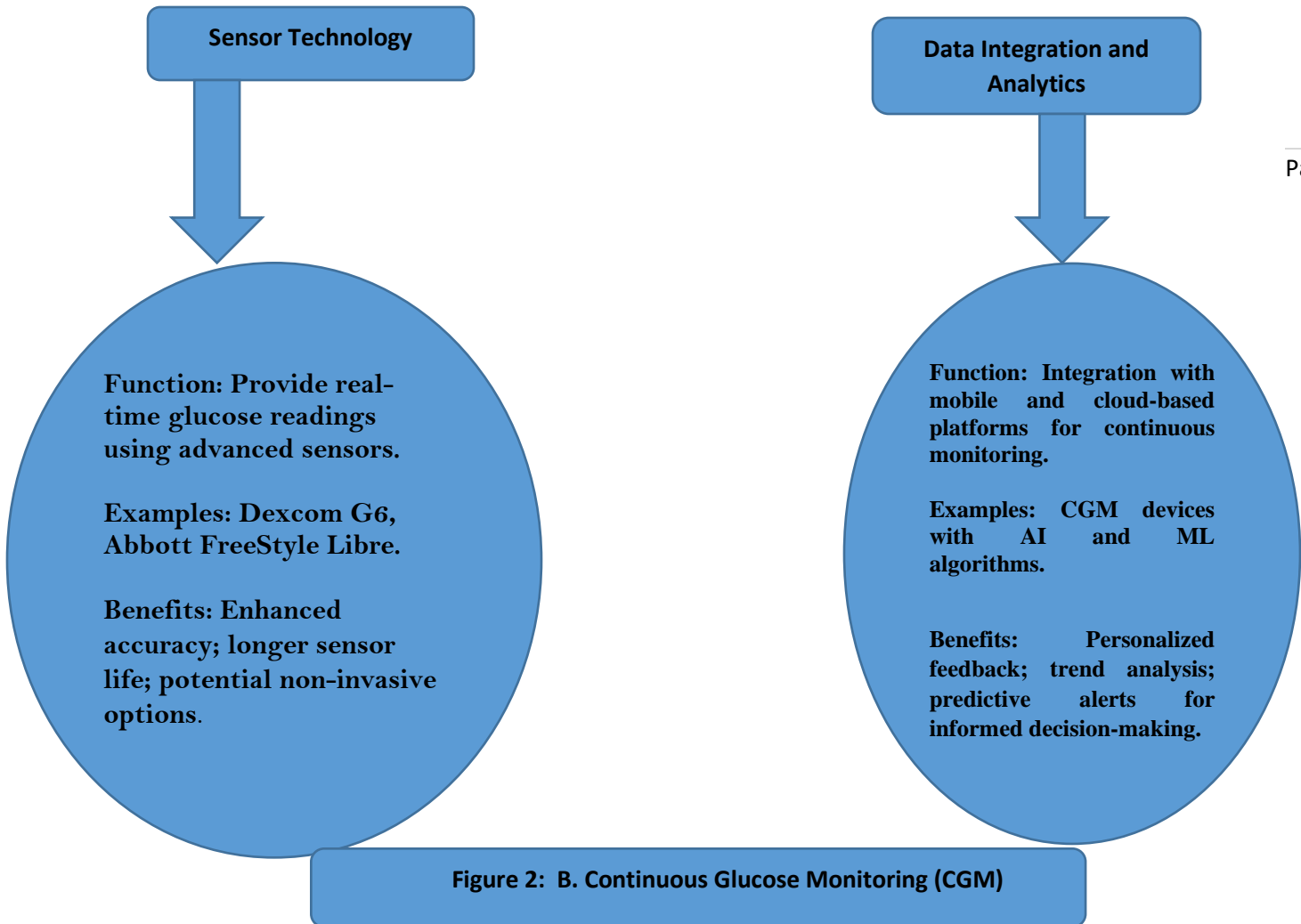


Table 1: Impact of Conflict on Diabetes Management

Impact of Conflict on Diabetes Management	Evidence and Implications
Disruption of Healthcare Services	Conflict usually leads to the destruction of the health care facilities that make it difficult for diabetic patients to access the necessary medical services. Clinics and hospitals may be destroyed or repurposed, which will decrease the access to the services for chronic disease management [31, 32]. Many healthcare workers leave conflict areas, which contributes to the scarcity of personnel in the field of healthcare [32].
Medication and Supply Shortages	Insulin and other critical diabetes medications are not easily available due to disrupted supply chains in conflict areas. This scarcity is dangerous for diabetic patients who rely on insulin, especially because there is often no proper way to store insulin in a cold environment [33, 34, 35].
Nutritional Challenges	Insulin and other critical diabetes medications are not easily available due to disrupted supply chains in conflict areas. This scarcity is dangerous for diabetic patients who rely on insulin, especially because there is often no proper way to store insulin in a cold environment [36, 37, 38].
Psychological and Social Impacts	Stress arising from conflict increases blood glucose levels through the release of stress hormones while loss of social support also worsens diabetes control. Nonadherence to treatment is high in conflict affected populations because of the stress associated with displacement and insecurity [39,40,41].

Table 2: Strategies for Managing Diabetes in Conflict Zones

Strategies for Managing Diabetes in Conflict Zones	Description and Implementation
Adaptation of Health Services	Therefore, in conflict zones, healthcare services need to be flexible and sustainable in managing diabetes. These are mobile clinics and telemedicine for remote consultation and follow-up and international aid to help in medication and supply where there is a shortage. It is also important to train local healthcare workers and community health volunteers to promote quality healthcare [42, 43, 44].
Policy and Advocacy	There is the need to advocate and provide policies for diabetes care in humanitarian response. The international organizations and governments must work together to ensure that sufficient funding and resources are available for diabetes care in conflict zones. It is recommended that policies should be directed at increasing the availability of drugs, enhancing health care systems, and incorporating diabetes care into emergency health care plans [45, 46, 47].

Table 3: Bioengineering Approaches to Diabetes Management

Approach	Description	Examples	Benefits
Insulin Delivery Systems	Sophisticated devices used in the administration of insulin to ensure that the insulin administration is more accurate and has the ability to mimic the normal physiological insulin secretion of the body.	Medtronic MiniMed Omnipod Patch Pump Smart Insulin Pens	Improved glycemic control. Convenience and compliance. Automated insulin delivery [49,50,51].
Continuous Glucose Monitoring (CGM)	Real time glucose monitoring systems that can feed back information and help diabetics manage the condition actively.	Dexcom G6 Abbott FreeStyle Libre	Enhanced accuracy. Extended sensor life. Integration with mobile and cloud platforms [60,61,62].

Table 4: Food Biochemistry and Nutritional Interventions

Category	Description	Biochemical Roles	Dietary Implications	References
Carbohydrates	Primary source of energy, ranging from simple sugars to complex polysaccharides	Provide energy, affect glycemic control, influence insulin release	High intake of simple sugars linked to metabolic disorders; complex carbs and fiber beneficial for health	[76,77,78,79]
Proteins	Essential for growth, repair, and maintenance of body tissues, composed of amino acids	Protein synthesis, muscle repair, energy production	Essential amino acids must be obtained from diet; animal proteins have higher biological value, combining plant proteins can provide all essential amino acids	[80,81,82,83,84]
Lipids	Vital for energy storage, cellular structure, and signaling; include saturated, unsaturated, and trans fats	Energy storage, cell membrane integrity, inflammation regulation	Omega-3 and omega-6 fatty acids should be consumed daily while saturated and trans fats are unhealthy for the heart and unsaturated fats are healthy.	[85,86,87,89]
Vitamins	Organic compounds necessary for metabolic pathways	Metabolic pathways, antioxidant activity, bone health	Calcium for bones and teeth, Vitamin D for absorption of calcium, Vitamin C for synthesis of collagen and antioxidant effect.	[90,91]
Minerals	Inorganic elements essential for various physiological functions	Oxygen transport, bone health, enzymatic reactions	Iron for oxygen transport, calcium for bone health, magnesium for enzymatic functions	[92,93]
Nutritional Interventions	Strategies to address dietary deficiencies and manage chronic diseases	Fortification, supplementation, dietary guidelines, personalized nutrition	Fortification prevents deficiencies, dietary guidelines advise on healthy eating, and personalized nutrition is a diet based on gene type.	[94,95,96,97,98,99,100,101]

Table 5: Innovations and Accessibility in Pharmacology

Category	Description	Challenges	Strategies for Improvement
Precision Medicine [102,103,104,105,106]	Tailors treatments based on genetic, environmental, and lifestyle factors.	High costs, complexity of implementation	Public-private partnerships, health economics research
Biologics and Advanced Therapies [107,108,109,110]	Includes monoclonal antibodies, gene therapies offering superior efficacy.	High production costs, logistical challenges	Technology transfer, investment in infrastructure
Drug Repurposing [111, 112]	Finding new uses for existing drugs to reduce development time and costs.	Regulatory barriers, patent issues	Harmonizing regulatory processes, promoting mutual recognition agreements
Affordability[113,114]	High costs limit access, particularly in low-income regions.	Financial barriers, inequitable pricing	Tiered pricing, licensing agreements, health economics research
Distribution Infrastructure[115,116]	Maintaining cold chains and logistics for advanced therapies.	Resource limitations, technological constraints	Investments in technology and infrastructure, technology transfer
Regulatory Barriers [117,118]	Variations in regulatory standards across countries.	Delayed access, non-uniform standards	Harmonizing approval processes, mutual recognition agreements
Public-Private Partnerships [119, 120]	Collaboration between stakeholders to optimize resources and reduce costs	Complex negotiations, differing priorities	Shared investments, risk-sharing mechanisms
Technology Transfer [121,122]	Facilitating local production capabilities in developing regions.	Intellectual property issues, capacity building	Promoting local manufacturing, knowledge transfer

CONCLUSION

There are numerous barriers to diabetes care in conflict affected areas such as limited access to healthcare facilities, restricted medication availability, high risk diets, and emotional strain. These challenges affect the diabetic patients in these areas and their health in a very adverse way. Some of the measures that could be taken in order to address the diabetes management in conflict zones include the use of mobile health care units, telemedicine and strong international support and aid. Policy advocacy is crucial to ensure that people with diabetes receive the care they require in humanitarian settings and that sufficient funding is provided. Through eliminating these barriers, it is possible to enhance diabetes care and prevent the occurrence of negative health consequences among conflict-affected individuals.

REFERENCES

1. Brownlee M, Cerami A. The biochemistry of the complications of diabetes mellitus. *Annual review of biochemistry*. 1981 Jul;50(1):385-432.
2. Wisman JD, Capehart KW. Creative destruction, economic insecurity, stress, and epidemic obesity. *American Journal of Economics and Sociology*. 2010 Jul;69(3):936-82.
3. Bavuma CM, Musafiri S, Rutayisire PC, Ng'ang'a LM, McQuillan R, Wild SH. Socio-demographic and clinical characteristics of diabetes mellitus in rural Rwanda: time to contextualize the interventions? A cross-sectional study. *BMC Endocrine Disorders*. 2020 Dec;20:1-0.
4. Wise PH, Shiel A, Southard N, Bendavid E, Welsh J, Stedman S, Fazal T, Felbab-Brown V, Polatty D, Waldman RJ, Spiegel PB. The political and security dimensions of the humanitarian health response to violent conflict. *The Lancet*. 2021 Feb 6;397(10273):511-21.
5. Benjamin E, Bassily-Marcus AM, Babu E, Silver L, Martin ML. Principles and practice of disaster relief: lessons from Haiti. *Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine*. 2011 May;78(3):306-18.
6. Khan Y, Albache N, Almasri I, Gabbay RA. The management of diabetes in conflict settings: Focus on the Syrian crisis. *Diabetes Spectrum*. 2019 Aug 1;32(3):264-9.
7. Lloyd CE, Roy T, Nouwen A, Chauhan AM. Epidemiology of depression in diabetes: international and cross-cultural issues. *Journal of affective disorders*. 2012 Oct 1;142:S22-9.

8. Bendavid E, Boerma T, Akseer N, Langer A, Malembaka EB, Okiro EA, Wise PH, Heft-Neal S, Black RE, Bhutta ZA, Bhutta Z. The effects of armed conflict on the health of women and children. *The Lancet*. 2021 Feb 6;397(10273):522-32.
9. Abyad A. Healthcare, Poverty and Ageing in the Middle East and North Africa. *Aging Across Cultures: Growing Old in the Non-Western World*. 2021:99-124.
10. Mohseni M, Ahmadi S, Azami-Aghdash S, Isfahani HM, Moosavi A, Fardid M, Etemadi M, Ghazanfari F. Challenges of routine diabetes care during COVID-19 era: a systematic search and narrative review. *Primary care diabetes*. 2021 Dec 1;15(6):918-22.
11. Spiegel PB, Checchi F, Colombo S, Paik E. Health-care needs of people affected by conflict: future trends and changing frameworks. *The Lancet*. 2010 Jan 23;375(9711):341-5.
12. Haar R, Rayes D, Tappis H, Rubenstein L, Rihawi A, Hamze M, AlMhawish N, Weis R, Alahmad H, Burbach R, Abbara A. The cascading impacts of attacks on health in Syria: A qualitative study of health system and community impacts. *medRxiv*. 2023:2023-12.
13. Toole MJ, Waldman RJ. The public health aspects of complex emergencies and refugee situations. *Annual review of public health*. 1997 May;18(1):283-312.
14. Godman B, Basu D, Pillay Y, Mwita JC, Rwegerera GM, Anand Paramadhas BD, Tiroyakgosi C, Okwen PM, Niba LL, Nonvignon J, Sefah I. Review of ongoing activities and challenges to improve the care of patients with type 2 diabetes across Africa and the implications for the future. *Frontiers in pharmacology*. 2020 Mar 20;11:108.
15. Jifar WW, Geneti GB, Dinssa SD. The impact of COVID-19 on pharmaceutical shortages and supply disruptions for non-communicable diseases among public hospitals of South West, Oromia, Ethiopia. *Journal of Multidisciplinary Healthcare*. 2022 Jan 1:1933-43.
16. Mozaffarian D. Dietary and policy priorities to reduce the global crises of obesity and diabetes. *Nature Food*. 2020 Jan;1(1):38-50.
17. Fejfarová V, Jirkovská A, Dragomirecká E, Game F, Bém R, Dubský M, Wosková V, Křížová M, Skibová J, Wu S. Does the diabetic foot have a significant impact on selected psychological or social characteristics of patients with diabetes mellitus?. *Journal of Diabetes Research*. 2014;2014(1):371938.
18. Bausch FJ, Beran D, Hering H, Bouille P, Chappuis F, Dromer C, Saaristo P, Perone SA. Operational considerations for the management of non-communicable diseases in humanitarian emergencies. *Conflict and Health*. 2021 Dec;15:1-2.
19. Minore B, Boone M, Katt M, Kinch P, Birch S, Mushquash C. The effects of nursing turnover on continuity of care in isolated First Nation communities. *Canadian Journal of Nursing Research Archive*. 2005 Jan 1:86-100.
20. Nuche-Berenguer B, Kupfer LE. Readiness of Sub-Saharan Africa Healthcare Systems for the New Pandemic, Diabetes: A Systematic Review. *Journal of diabetes research*. 2018;2018(1):9262395.
21. Riaz O, Malik A. Strengthening health systems: innovations in telemedicine and rural access in Pakistan. *Pakistan Research letter*. 2023 Aug 31;1(02):78-88.
22. Harvey P. International humanitarian actors and governments in areas of conflict: challenges, obligations, and opportunities. *Disasters*. 2013 Oct;37:S151-70.
23. Chin MH, Goddu AP, Ferguson MJ, Peek ME. Expanding and sustaining integrated health care—community efforts to reduce diabetes disparities. *Health promotion practice*. 2014 Nov;15(2_suppl):29S-39S.
24. Bendavid E, Boerma T, Akseer N, Langer A, Malembaka EB, Okiro EA, Wise PH, Heft-Neal S, Black RE, Bhutta ZA, Bhutta Z. The effects of armed conflict on the health of women and children. *The Lancet*. 2021 Feb 6;397(10273):522-32.
25. Epping-Jordan JE, Pruitt SD, Bengoa R, Wagner EH. Improving the quality of health care for chronic conditions. *BMJ Quality & Safety*. 2004 Aug 1;13(4):299-305.
26. Kohrt BA, Carruth L. Syndemic effects in complex humanitarian emergencies: A framework for understanding political violence and improving multi-morbidity health outcomes. *Social Science & Medicine*. 2022 Feb 1;295:113378.
27. Mbanya JC, Motala AA, Sobngwi E, Assah FK, Enoru ST. Diabetes in sub-saharan africa. *The lancet*. 2010 Jun 26;375(9733):2254-66.
28. Kohrt BA, Carruth L. Syndemic effects in complex humanitarian emergencies: A framework for understanding political violence and improving multi-morbidity health outcomes. *Social Science & Medicine*. 2022 Feb 1;295:113378.

29. Odhaib SA, Mansour AA, Khalifa SF, Shegem N, Thannon W, Abi Saad M, Abdulrazaq H, Belkhadir J, Sandid M, Masood SN. Impact of humanitarian crises on diabetes care in Iraq and Syria—IDF-MENA region. *Journal of Diabetology*. 2022 Dec 1;13(Suppl 1):S38-47.
30. Balakrishnanpillai J, Kesavadev J, Saboo B. Harmony in Health: A Narrative Review Exploring the Interplay of Mind, Body, and Diabetes with a Special Emphasis on Emotional Stress. *Journal of Diabetology*. 2024 Apr 1;15(2):123-30.
31. Hill-Briggs F, Adler NE, Berkowitz SA, Chin MH, Gary-Webb TL, Navas-Acien A, Thornton PL, Haire-Joshu D. Social determinants of health and diabetes: a scientific review. *Diabetes care*. 2021 Jan;44(1):258.
32. Chauhan V, Secor-Jones S, Paladino L, Sardesai I, Ratnayake A, Stawicki SP, Papadimos TJ, O'Keefe K, Galwankar SC. Emergency departments: preparing for a new war. *Journal of Emergencies, Trauma, and Shock*. 2022 Oct 1;15(4):157-61.
33. Murphy A, Biringanine M, Roberts B, Stringer B, Perel P, Jobanputra K. Diabetes care in a complex humanitarian emergency setting: a qualitative evaluation. *BMC health services research*. 2017 Dec;17:1-0.
34. Koliaki C, Tentolouris A, Eleftheriadou I, Melidonis A, Dimitriadis G, Tentolouris N. Clinical management of diabetes mellitus in the era of COVID-19: practical issues, peculiarities and concerns. *Journal of clinical medicine*. 2020 Jul 18;9(7):2288.
35. Kehlenbrink S, Ansbro É, Besançon S, Hassan S, Roberts B, Jobanputra K. Strengthening diabetes care in humanitarian crises in low-and middle-income settings. *The Journal of Clinical Endocrinology & Metabolism*. 2022 Sep 1;107(9):e3553-61.
36. George J, Adelaja A. Forced displacement and agriculture: implications for host communities. *Sustainability*. 2021 May 20;13(10):5728.
37. Awuchi CG, Echeta CK, Igwe VS. Diabetes and the nutrition and diets for its prevention and treatment: a systematic review and dietetic perspective. *Health Sciences Research*. 2020;6(1):5-19.
38. Nelson K, Cunningham W, Andersen R, Harrison G, Gelberg L. Is food insufficiency associated with health status and health care utilization among adults with diabetes?. *Journal of General Internal Medicine*. 2001 Jun;16:404-11.
39. Greene-Cramer B, Summers A, Lopes-Cardozo B, Husain F, Couture A, Bilukha O. Noncommunicable disease burden among conflict-affected adults in Ukraine: a cross-sectional study of prevalence, risk factors, and effect of conflict on severity of disease and access to care. *PLoS One*. 2020 Apr 21;15(4):e0231899.
40. Kalra S, Jena BN, Yeravdekar R. Emotional and psychological needs of people with diabetes. *Indian journal of endocrinology and metabolism*. 2018 Sep 1;22(5):696-704.
41. Hassan G, Ventevogel P, Jefeé-Bahloul H, Barkil-Oteo A, Kirmayer LJ. Mental health and psychosocial wellbeing of Syrians affected by armed conflict. *Epidemiology and psychiatric sciences*. 2016 Apr;25(2):129-41.
42. Slama S, Kim HJ, Roglic G, Boulle P, Hering H, Varghese C, Rasheed S, Tonelli M. Care of non-communicable diseases in emergencies. *The Lancet*. 2017 Jan 21;389(10066):326-30.
43. Harris B, Ajisola M, Alam RM, Watkins JA, Arvanitis TN, Bakibinga P, Chipwaza B, Choudhury NN, Kibe P, Fayehun O, Omigbodun A. Mobile consulting as an option for delivering healthcare services in low-resource settings in low-and middle-income countries: A mixed-methods study. *Digital Health*. 2021 Aug;7:20552076211033425.
44. Woldie M, Feyissa GT, Admasu B, Hassen K, Mitchell K, Mayhew S, McKee M, Balabanova D. Community health volunteers could help improve access to and use of essential health services by communities in LMICs: an umbrella review. *Health policy and planning*. 2018 Dec 1;33(10):1128-43.
45. Bausch FJ, Beran D, Hering H, Boulle P, Chappuis F, Dromer C, Saaristo P, Perone SA. Operational considerations for the management of non-communicable diseases in humanitarian emergencies. *Conflict and Health*. 2021 Dec;15:1-2.
46. Ansbro ÉM, Biringanine M, Caleo G, Prieto-Merino D, Sadique Z, Perel P, Jobanputra K, Roberts B. Management of diabetes and associated costs in a complex humanitarian setting in the Democratic Republic of Congo: a retrospective cohort study. *BMJ open*. 2019 Nov 1;9(11):e030176.
47. Mercer T, Chang AC, Fischer L, Gardner A, Kerubo I, Tran DN, Laktabai J, Pastakia S. Mitigating the burden of diabetes in Sub-Saharan Africa through an integrated diagonal health systems approach. *Diabetes, metabolic syndrome and obesity: targets and therapy*. 2019 Oct 31:2261-72.
48. Szunerits S, Melinte S, Barras A, Pagneux Q, Voronova A, Abderrahmani A, Boukherroub R. The impact of chemical engineering and technological advances on managing diabetes: Present and future concepts. *Chemical Society Reviews*. 2021;50(3):2102-46.

49. Potti LG, Haines ST. Continuous subcutaneous insulin infusion therapy: a primer on insulin pumps. *Journal of the American Pharmacists Association*. 2009 Jan 1;49(1):e1-7.
50. Thomas A, Heinemann L. Algorithms for automated insulin delivery: an overview. *Journal of Diabetes Science and Technology*. 2022 Sep;16(5):1228-38.
51. Bowen JL, Allender CJ. A comparative pulse accuracy study of two commercially available patch insulin infusion pumps. *European Endocrinology*. 2016 Aug;12(2):79.
52. Daly A, Hovorka R. Technology in the management of type 2 diabetes: present status and future prospects. *Diabetes, Obesity and Metabolism*. 2021 Aug;23(8):1722-32.
53. Steenkamp D, Eby EL, Gulati N, Liao B. Adherence and persistence to insulin therapy in people with diabetes: impact of connected insulin pen delivery ecosystem. *Journal of Diabetes Science and Technology*. 2022 Jul;16(4):995-1002.
54. Ware J, Hovorka R. Closed-loop insulin delivery: update on the state of the field and emerging technologies. *Expert review of medical devices*. 2022 Nov 2;19(11):859-75.
55. Marks BE, Williams KM, Sherwood JS, Putman MS. Practical aspects of diabetes technology use: Continuous glucose monitors, insulin pumps, and automated insulin delivery systems. *Journal of clinical & translational endocrinology*. 2022 Mar 1;27:100282.
56. Dassau E, Cameron F, Lee H, Bequette BW, Zisser H, Jovanović L, Chase HP, Wilson DM, Buckingham BA, Doyle III FJ. Real-time hypoglycemia prediction suite using continuous glucose monitoring: a safety net for the artificial pancreas. *Diabetes care*. 2010 Jun 1;33(6):1249-54.
57. Marcus Y, Eldor R, Yaron M, Shaklai S, Ish-Shalom M, Shefer G, Stern N, Golan N, Dvir AZ, Pele O, Gonen M. Improving blood glucose level predictability using machine learning. *Diabetes/Metabolism Research and Reviews*. 2020 Nov;36(8):e3348.
58. Collyns OJ, Meier RA, Betts ZL, Chan DS, Frampton C, Frewen CM, Hewapathirana NM, Jones SD, Roy A, Grosman B, Kurtz N. Improved glycemic outcomes with Medtronic MiniMed advanced hybrid closed-loop delivery: results from a randomized crossover trial comparing automated insulin delivery with predictive low glucose suspend in people with type 1 diabetes. *Diabetes Care*. 2021 Apr 1;44(4):969-75.
59. Reddy M, Oliver N. The role of real-time continuous glucose monitoring in diabetes management and how it should link to integrated personalized diabetes management. *Diabetes, Obesity and Metabolism*. 2024 Mar;26:46-56.
60. Cappon G, Acciaroli G, Vettoretti M, Facchinetti A, Sparacino G. Wearable continuous glucose monitoring sensors: a revolution in diabetes treatment. *Electronics*. 2017 Sep 5;6(3):65.
61. Lee I, Probst D, Klonoff D, Sode K. Continuous glucose monitoring systems—Current status and future perspectives of the flagship technologies in biosensor research. *Biosensors and Bioelectronics*. 2021 Jun 1;181:113054.
62. Villena Gonzales W, Mobashsher AT, Abbosh A. The progress of glucose monitoring—A review of invasive to minimally and non-invasive techniques, devices and sensors. *Sensors*. 2019 Feb 15;19(4):800.
63. Freckmann G, Mende J. Continuous glucose monitoring: data management and evaluation by patients and health care professionals—current situation and developments. *Journal of Laboratory Medicine*. 2018 Dec 19;42(6):225-33.
64. Giordano C, Brennan M, Mohamed B, Rashidi P, Modave F, Tighe P. Accessing artificial intelligence for clinical decision-making. *Frontiers in digital health*. 2021 Jun 25;3:645232.
65. Peloso A, Citro A, Zoro T, Cobianchi L, Kahler-Quesada A, Bianchi CM, Andres A, Berishvili E, Piemonti L, Berney T, Toso C. Regenerative medicine and diabetes: targeting the extracellular matrix beyond the stem cell approach and encapsulation technology. *Frontiers in endocrinology*. 2018 Aug 31;9:445.
66. Maxwell KG, Millman JR. Applications of iPSC-derived beta cells from patients with diabetes. *Cell Reports Medicine*. 2021 Apr 20;2(4).
67. Shi Y, Zhao YZ, Jiang Z, Wang Z, Wang Q, Kou L, Yao Q. Immune-protective formulations and process strategies for improved survival and function of transplanted islets. *Frontiers in immunology*. 2022 Jul 12;13:923241.
68. Nanji SA, Shapiro AJ. Advances in pancreatic islet transplantation in humans. *Diabetes, Obesity and Metabolism*. 2006 Jan;8(1):15-25.
69. Jacobson EF, Tzanakakis ES. Human pluripotent stem cell differentiation to functional pancreatic cells for diabetes therapies: Innovations, challenges and future directions. *Journal of biological engineering*. 2017 Dec;11:1-3.
70. Fuchs S, Ernst AU, Wang LH, Shariati K, Wang X, Liu Q, Ma M. Hydrogels in emerging technologies for type 1 diabetes. *Chemical reviews*. 2020 Dec 28;121(18):11458-526.

71. Shahidi F, Pan Y. Influence of food matrix and food processing on the chemical interaction and bioaccessibility of dietary phytochemicals: A review. *Critical Reviews in Food Science and Nutrition*. 2022 Aug 11;62(23):6421-45.
72. Ohlhorst SD, Russell R, Bier D, Klurfeld DM, Li Z, Mein JR, Milner J, Ross AC, Stover P, Konopka E. Nutrition research to affect food and a healthy lifespan. *Advances in nutrition*. 2013 Sep 1;4(5):579-84.
73. Chen Y, Michalak M, Agellon LB. Focus: Nutrition and food science: Importance of nutrients and nutrient metabolism on human health. *The Yale journal of biology and medicine*. 2018 Jun;91(2):95.
74. Lee D, Son HG, Jung Y, Lee SJ. The role of dietary carbohydrates in organismal aging. *Cellular and Molecular Life Sciences*. 2017 May;74:1793-803.
75. Plaza-Díaz J, Martínez Augustin O, Gil Hernandez A. Foods as sources of mono and disaccharides: biochemical and metabolic aspects. *Nutr Hosp*. 2013 Jul 1;28(Supl 4):5-16.
76. Rippe JM, Angelopoulos TJ. Added sugars and risk factors for obesity, diabetes and heart disease. *International Journal of Obesity*. 2016 Mar;40(1):S22-7.
77. Henquin JC. Triggering and amplifying pathways of regulation of insulin secretion by glucose. *Diabetes*. 2000 Nov 1;49(11):1751-60.
78. Sarda FA, Giuntini EB, Nazare JA, Koenig D, Bahia LR, Lajolo FM, Menezes EW. Effectiveness of carbohydrates as a functional ingredient in glycemic control. *Food Science and Technology*. 2018 Nov 14;38:561-76.
79. Chanmuang S, Nguyen QA, Kim HJ. Current research on the effects of non-digestible carbohydrates on metabolic disease. *Applied Sciences*. 2022 Apr 8;12(8):3768.
80. Hou Y, Yin Y, Wu G. Dietary essentiality of “nutritionally non-essential amino acids” for animals and humans. *Experimental Biology and Medicine*. 2015 Aug;240(8):997-1007.
81. Takahashi T, Toda E, B Singh R, De Meester F, Wilczynska A, Wilson D, R Juneja L. Essential and non-essential amino acids in relation to glutamate. *The Open Nutraceuticals Journal*. 2011 Nov 18;4(1).
82. Nie C, He T, Zhang W, Zhang G, Ma X. Branched chain amino acids: beyond nutrition metabolism. *International journal of molecular sciences*. 2018 Mar 23;19(4):954.
83. Wolfe RR, Rutherford SM, Kim IY, Moughan PJ. Protein quality as determined by the Digestible Indispensable Amino Acid Score: evaluation of factors underlying the calculation. *Nutrition reviews*. 2016 Sep 1;74(9):584-99.
84. Poutanen KS, Kärnlund AO, Gómez-Gallego C, Johansson DP, Scheers NM, Marklinder IM, Eriksen AK, Silventoinen PC, Nordlund E, Sozer N, Hanhineva KJ. Grains—a major source of sustainable protein for health. *Nutrition Reviews*. 2022 Jun 1;80(6):1648-63.
85. De Carvalho CC, Caramujo MJ. The various roles of fatty acids. *Molecules*. 2018 Oct 9;23(10):2583.
86. Meyer BJ, Mann NJ, Lewis JL, Milligan GC, Sinclair AJ, Howe PR. Dietary intakes and food sources of omega-6 and omega-3 polyunsaturated fatty acids. *Lipids*. 2003 Apr;38(4):391-8.
87. Lordan R, Tsoupras A, Zabetakis I. Phospholipids of animal and marine origin: Structure, function, and anti-inflammatory properties. *Molecules*. 2017 Nov 14;22(11):1964.
88. Kousparou C, Fyrilla M, Stephanou A, Patrikios I. DHA/EPA (Omega-3) and LA/GLA (Omega-6) as bioactive molecules in neurodegenerative diseases. *International Journal of Molecular Sciences*. 2023 Jun 27;24(13):10717.
89. Wall R, Ross RP, Fitzgerald GF, Stanton C. Fatty acids from fish: the anti-inflammatory potential of long-chain omega-3 fatty acids. *Nutrition reviews*. 2010 May 1;68(5):280-9.
90. Godswill AG, Somtochukwu IV, Ikechukwu AO, Kate EC. Health benefits of micronutrients (vitamins and minerals) and their associated deficiency diseases: A systematic review. *International Journal of Food Sciences*. 2020 Jan 7;3(1):1-32.
91. Yuan P, Cui S, Liu Y, Li J, Du G, Liu L. Metabolic engineering for the production of fat-soluble vitamins: advances and perspectives. *Applied microbiology and biotechnology*. 2020 Feb;104:935-51.
92. Haussler MR, Whitfield GK, Kaneko I, Haussler CA, Hsieh D, Hsieh JC, Jurutka PW. Molecular mechanisms of vitamin D action. *Calcified tissue international*. 2013 Feb;92:77-98.
93. Haftek M, Abdayem R, Guyonnet-Debersac P. Skin minerals: key roles of inorganic elements in skin physiological functions. *International Journal of Molecular Sciences*. 2022 Jun 3;23(11):6267.
94. Prashanth L, Kattapagari KK, Chitturi RT, Baddam VR, Prasad LK. A review on role of essential trace elements in health and disease. *Journal of Dr. YSR University of Health Sciences*. 2015 Apr 1;4(2):75-85.
95. Berti C, Faber M, Smuts CM. Prevention and control of micronutrient deficiencies in developing countries: current perspectives. *Nutrition and Dietary Supplements*. 2014 May 29:41-57.

96. Kancherla V, Tsang B, Wagh K, Dixon M, Oakley Jr GP. Modeling shows high potential of folic acid-fortified salt to accelerate global prevention of major neural tube defects. *Birth Defects Research*. 2020 Nov;112(18):1461-74.
97. Cena H, Calder PC. Defining a healthy diet: evidence for the role of contemporary dietary patterns in health and disease. *Nutrients*. 2020 Feb;12(2):334.
98. Snetselaar LG, de Jesus JM, DeSilva DM, Stoody EE. Dietary guidelines for Americans, 2020–2025: understanding the scientific process, guidelines, and key recommendations. *Nutrition today*. 2021 Nov 1;56(6):287-95.
99. Toro-Martín D, Arsenault BJ, Després JP, Vohl MC. Precision nutrition: a review of personalized nutritional approaches for the prevention and management of metabolic syndrome. *Nutrients*. 2017 Aug;9(8):913.
100. Aruoma OI, Hausman-Cohen S, Pizano J, Schmidt MA, Minich DM, Joffe Y, Brandhorst S, Evans SJ, Brady DM. Personalized nutrition: translating the science of nutrigenomics into practice: proceedings from the 2018 American College of Nutrition Meeting. *Journal of the American College of Nutrition*. 2019 May 19;38(4):287-301.
101. Narduzzi L, Agulló V, Favari C, Tosi N, Mignogna C, Crozier A, Del Rio D, Mena P. (Poly) phenolic compounds and gut microbiome: new opportunities for personalized nutrition. *Microbiome Research Reports*. 2022;1(3).
102. Falzone L, Salomone S, Libra M. Evolution of cancer pharmacological treatments at the turn of the third millennium. *Frontiers in pharmacology*. 2018 Nov 13;9:421926.
103. George G, McGahan AM, Prabhu J. Innovation for inclusive growth: Towards a theoretical framework and a research agenda. *Journal of management studies*. 2012 Jun;49(4):661-83.
104. Bigdeli M, Jacobs B, Tomson G, Laing R, Ghaffar A, Dujardin B, Van Damme W. Access to medicines from a health system perspective. *Health policy and planning*. 2013 Oct 1;28(7):692-704.
105. Wang RC, Wang Z. Precision medicine: Disease subtyping and tailored treatment. *Cancers*. 2023 Jul 28;15(15):3837.
106. Dugger SA, Platt A, Goldstein DB. Drug development in the era of precision medicine. *Nature reviews Drug discovery*. 2018 Mar;17(3):183-96.
107. Kesik-Brodacka M. Progress in biopharmaceutical development. *Biotechnology and applied biochemistry*. 2018 May;65(3):306-22.
108. Stanimirovic DB, Sandhu JK, Costain WJ. Emerging technologies for delivery of biotherapeutics and gene therapy across the blood–brain barrier. *BioDrugs*. 2018 Dec;32(6):547-59.
109. Desoubieux G, Reichert JM, Sleeman M, Reckamp KL, Ryffel B, Adamczewski JP, Sweeney TD, Vanbever R, Diot P, Owen CA, Page C. Therapeutic monoclonal antibodies for respiratory diseases: Current challenges and perspectives, March 31–April 1, 2016, Tours, France. In *MAbs 2016 Aug 17 (Vol. 8, No. 6, pp. 999-1009)*. Taylor & Francis.
110. Aijaz A, Li M, Smith D, Khong D, LeBlon C, Fenton OS, Olabisi RM, Libutti S, Tischfield J, Maus MV, Deans R. Biomufacturing for clinically advanced cell therapies. *Nature biomedical engineering*. 2018 Jun;2(6):362-76.
111. Kiriiri GK, Njogu PM, Mwangi AN. Exploring different approaches to improve the success of drug discovery and development projects: a review. *Future Journal of Pharmaceutical Sciences*. 2020 Dec;6:1-2.
112. Sultana J, Crisafulli S, Gabbay F, Lynn E, Shakir S, Trifirò G. Challenges for drug repurposing in the COVID-19 pandemic era. *Frontiers in pharmacology*. 2020 Nov 6;11:588654
113. Adachi T, El-Hattab AW, Jain R, Nogales Crespo KA, Quirland Lazo CI, Scarpa M, Summar M, Wattanasirichaigoon D. Enhancing equitable access to rare disease diagnosis and treatment around the world: a review of evidence, policies, and challenges. *International journal of environmental research and public health*. 2023 Mar 8;20(6):4732.
114. Lybecker KM, Freeman RA. Funding pharmaceutical innovation through direct tax credits. *Health Economics, Policy and Law*. 2007 Jul;2(3):267-84.
115. Heidt B, Siqueira WF, Eersels K, Diliën H, van Grinsven B, Fujiwara RT, Cleij TJ. Point of care diagnostics in resource-limited settings: A review of the present and future of PoC in its most needed environment. *Biosensors*. 2020 Sep 24;10(10):133.
116. Eccleston-Turner M, Upton H. International collaboration to ensure equitable access to vaccines for COVID-19: the ACT-Accelerator and the COVAX facility. *The Milbank Quarterly*. 2021 Jun;99(2):426-49.
117. Danzon PM, Wang YR, Wang L. The impact of price regulation on the launch delay of new drugs—evidence from twenty-five major markets in the 1990s. *Health economics*. 2005 Mar;14(3):269-92.

118. Detela G, Lodge A. EU regulatory pathways for ATMPs: standard, accelerated and adaptive pathways to marketing authorisation. *Molecular Therapy-Methods & Clinical Development*. 2019 Jun 14;13:205-32.
119. Ncube BM, Dube A, Ward K. Establishment of the African Medicines Agency: progress, challenges and regulatory readiness. *Journal of pharmaceutical policy and practice*. 2021 Dec 1;14(1):29.
120. Verbaanderd C, Rooman I, Huys I. Exploring new uses for existing drugs: innovative mechanisms to fund independent clinical research. *Trials*. 2021 May 4;22(1):322.
121. Fu X. Foreign direct investment, absorptive capacity and regional innovation capabilities: evidence from China. *Oxford development studies*. 2008 Mar 1;36(1):89-110.
122. Jönsson B, Hampson G, Michaels J, Towse A, von der Schulenburg JM, Wong O. Advanced therapy medicinal products and health technology assessment principles and practices for value-based and sustainable healthcare. *The European journal of health economics*. 2019 Apr 1;20:427-38.

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