Preprints.org

Review

Not peer-reviewed version

How Artificial Intelligence Technology can be Used to Treat Diabetes

Syed Adnan Jawaid * and Jamshir Qureshi *

Posted Date: 30 January 2024

doi: 10.20944/preprints202401.2049.v1

Keywords: How Artificial Intelligence Technology can be Used to Treat Diabetes, AI used to treat diabetes, AI cure of diabetes, Aritifical Intelligence cure of diabetes, AI, Artificial Intelligence, AI useful for health, Artificial Intelligence useful for health

Preprints.org is a free multidiscipline platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Review

How Artificial Intelligence Technology Can Be Used to Treat Diabetes

Syed Adnan Jawaid and Jamshir Qureshi

University: University of Maryland – College Park; adnan.jawaid@hotmail.com (S.A.J.); jamshirqureshi@gmail.com (J.Q.)

Abstract: ***Background***: The research is conducted against the backdrop of the rising incidence of diabetes and the demand for novel approaches to improve patient outcomes. With the goal of revolutionizing conventional methods and addressing the changing healthcare landscape, the study concentrated on the application of AI technology in diabetes treatment. ***Objective***: Examining the various ways AI can be used in diabetes care and assessing how it can enhance automated screenings, tailored treatment recommendations, predictive modeling, and patient self-management were the main goals of the study. ***Result***: The findings demonstrated how well AI works to anticipate a patient's unique reaction to a therapy, assist medical personnel in making decisions, and give patients more control over their own care. Artificial intelligence (AI)-powered solutions showed promise in improving real-time monitoring and encouraging patient adherence, supporting a comprehensive strategy for managing diabetes. ***Conclusion***: The research indicates that artificial intelligence (AI) has great potential to change the way diabetes is treated. However, it also highlights the need for more research, ethical issues, and validation of AI. The results advocate for joint efforts to ensure responsible and patient-centered technology innovation in diabetes care and encourage the integration of AI with new technologies.

Keywords: How Artificial Intelligence Technology can be Used to Treat Diabetes; AI used to treat diabetes; AI cure of diabetes; Aritifical Intelligence cure of diabetes; AI; Artificial Intelligence; AI useful for health; Artificial Intelligence useful for health

1. Introduction

Millions of people worldwide are impacted by diabetes, a chronic metabolic disease that has become a major global healthcare burden. The International Diabetes Federation (IDF) reports that 374 million people have impaired glucose tolerance and 463 million people between the ages of 20 and 79 have diabetes [1]. It is anticipated that by 2045, the number of individuals with diabetes would have increased to an estimated 693 million. With 8.8% of people worldwide estimated to have diabetes in 2017, it is projected that this percentage will increase to 10% by 2045, providing alarming evidence of the diabetes epidemic's rapid growth [2].

Diabetes-related complications have a major impact on rates of morbidity and mortality. Effective intervention is essential for prompt detection and prevention in addition to therapy. Despite a startling 10% of worldwide health spending (US$760 billion) going toward diabetes care, half of adult patients with the disease go misdiagnosed, making diabetes management an extremely difficult task [3]. Artificial Intelligence (AI) is emerging as a disruptive force in this context, with applications in patient self-management tools, clinical decision support, automated retinal screening, and predictive population risk stratification [4].

Artificial Intelligence (AI) is a field of study within computer science that aims to develop systems that can handle complexity and analyze data. It has the potential to change the way that diabetes is treated completely [5]. The introduction of wearables, smartphones, and other gadgets by technology advancements has made it possible to track and monitor patient symptoms and illness status continuously. The development of tools and devices that improve overall care and treatment

© 2024 by the author(s). Distributed under a Creative Commons CC BY license.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

outcomes, as well as the efficient handling of data, make AI application in diabetes management appealing [6].

The application of AI in diabetes care encompasses three primary areas: diabetes patients, healthcare providers, and healthcare systems. AI expands the patient's understanding of self-care, facilitates decision-making for healthcare professionals, and maximizes the use of available resources in healthcare systems. Notably, credible institutions like the American Diabetes Association (ADA) and the US Food and Drug Administration (FDA) have endorsed AI in diabetes care, highlighting the increasing acceptance and recognition of AI's role in improving healthcare outcomes [6].

The purpose of this paper is to give a broad overview of the various ways that artificial intelligence is being used to prevent, diagnose, and treat diabetes. AI is revolutionizing diabetes care in a number of areas, such as clinical decision support, automated retinal screening, predictive population risk assessment, and patient self-management tools [7]. We hope to shed light on the paradigm change that artificial intelligence (AI) is bringing to the field of diabetes management by investigating the technical underpinnings and uses of AI in diabetes care.

A number of AI-based strategies have been implemented in the treatment of diabetes, taking advantage of technology developments to surpass conventional approaches to diagnosis and follow-up. One AI method that is widely applied in the treatment of diabetes is case-based reasoning (CBR). One well-known example of CBR is the 4 Diabetes Support System, which uses data from previous interactions to identify and suggest remedies for blood glucose control issues automatically [8].

Digital support for diabetes treatment has been developed in large part thanks to machine learning and deep learning techniques including decision trees, artificial neural networks, and support vector machines. Automated blood glucose variability screening, risk assessment, and diabetes patient identification are made easier by these procedures. With its variety of methods, machine learning facilitates precise risk assessment and the identification of high-risk individuals, which helps with early intervention and prevention strategies [9].

Artificial neural networks are essential for connecting and interpreting heterogeneous data in order to provide tailored diabetes diagnosis solutions. Various methodologies, including support vector regression (SVR), have been utilized to develop hypoglycemia predictors, which notify medical professionals to take appropriate action when patients exhibit dangerously low blood glucose levels [10].

An automated method for diagnosing diabetic retinopathy, a major diabetic complication, has been created using deep learning algorithms. Convolutional neural networks (CNN)-based automated retinal screening provides a practical and reliable means of identifying and tracking diabetic retinopathy [11].

In patients with type 2 diabetes mellitus, supervised machine learning-based clinical decision support tools help forecast the short- and long-term HbA1c responses following insulin initiation. By identifying clinical factors impacting patient responses, these technologies can create more individualized diabetes care [12].

2. Artificial Intelligence Techniques in Diabetes Care

Diabetes mellitus is a complicated range of disorders resulting from glucoregulatory system dysfunction that is becoming a major global health issue. The International Diabetes Federation estimates that 425 million individuals worldwide were affected by the disease in 2017, and they expect this number to rise significantly over the next several decades [13]. Diabetes's severe consequences, which are marked by chronic hyperglycemia, might lower life expectancy and increase death.

Different treatment modalities are required for the three primary subtypes of diabetes: type 1 diabetes (T1D), type 2 diabetes (T2D), and gestational diabetes (GDM). While individuals with T1D must only use external insulin, those with T2D frequently develop insulin resistance and may need to take insulin doses externally [14]. Furthermore, the combination of insulin with placental hormones during pregnancy results in gestational diabetes. For diabetes to be effectively managed,

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

prompt diagnosis, patient education for self-management, and ongoing medical care are necessary to reduce long-term risks and avoid acute complications [15].

The field of diabetes management is seeing a revolution in the use of artificial intelligence (AI). The paradigm of diabetes care has changed as a result of the incorporation of technology like continuous glucose monitoring devices and the creation of artificial pancreas systems [16]. The utilization of artificial intelligence (AI) algorithms for tailored medical aid and sophisticated analysis has been spurred by the exponential growth of electronic data from diabetes patients. AI's usefulness in improving diabetes care is shown by its ability to recognize common therapeutic assistance like artificial pancreas systems and continuous glucose monitoring [17].

Applications of artificial intelligence (AI) in diabetes span a wide range of approaches that fall into three main categories: information exploration and discovery, knowledge acquisition, and knowledge-based reasoning. Computers can learn automatically thanks to learning techniques like support vector machines, deep learning, and artificial neural networks [18]. In databases, knowledge discovery is investigating and developing algorithms that retrieve important data by using methods like grouping and classification. Making exact inferences from knowledge requires applying logical strategies like rule-based and case-based reasoning [19].

AI has a clear impact on diabetes treatment in a number of areas, including as decision assistance, tailored therapy, and early diagnosis. There has been a notable increase in the use of AI in diabetes care, as evidenced by the literature, which also shows that AI has the potential to offer useful tools for managing the growing amount of patient data [20].

With its ability to provide early diagnosis, individualized treatment regimens, and decision assistance, artificial intelligence (AI) is quickly becoming a vital component of diabetes care. The use of artificial intelligence (AI) in diabetes management is expected to increase as the incidence of the disease rises worldwide. This will lead to better patient outcomes and more effective healthcare systems [21].

3. Transformative Impact of Artificial Intelligence on Diabetes Care

Advanced artificial intelligence (AI) technologies are driving a fundamental revolution in the healthcare industry. There's never been a greater pressing demand for interactive and personalized health solutions, with over 30 million Americans alone being diagnosed with type 2 diabetes. Advanced customisation with several layers that goes beyond physiological and biological characteristics to include the complex features of lifestyle, behavior, culture, behaviors, and motivations is critical to the future of health [22].

Understanding patients holistically enables caregivers to customize interventions based on scientific information obtained from medical publications and recommendations. This is known as personalization in healthcare. This sophisticated approach is especially important when it comes to diabetes, as patient results can be greatly impacted by tailored care. This degree of customisation is made possible in large part by AI, which transforms the way medical professionals identify, treat, and assist patients [23].

Systems like IBM's Watson Health and DynoSense Corp.'s remote health monitoring demonstrate one noteworthy use of AI in diabetic health monitoring. These platforms use artificial intelligence (AI) to evaluate enormous volumes of patient data, offering advice on medical choices and forecasting changes in health that might call for intervention [24]. By providing individualized illness prevention and management through ongoing monitoring utilizing phone sensors and connected health devices, Lark Health Coach, an AI platform for chronic diseases, goes above and beyond. Lark's one-on-one text-based communication resembles sympathetic therapy and assists patients in making better decisions [25].

Moreover, the search for new drugs is greatly aided by AI and machine learning. These technologies improve safety and efficacy assessments of drugs and provide mechanistic insights into diseases such as diabetes [26]. They also make it easier to identify people who might be good candidates for clinical trials. Drug development that can use a larger chemical space could lead to novel compound design and long-term improvements in medical science [27].

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

AI is having a revolutionary effect on diabetes care in a number of areas, including improved clinical practices, medication discovery, and remote monitoring and personalized health solutions [28]. AI has the ability to enhance patient outcomes dramatically, advance medical research, and usher in a new era of preventive and customized treatment as it develops further and is integrated into healthcare. Without a doubt, artificial intelligence will play a significant role in diabetes care in the future, providing a window into a more effective, patient-focused, and technologically sophisticated healthcare environment [29].

4. Challenges and Ethical Considerations in the Integration of AI in Diabetes Care

Artificial intelligence (AI) has great potential for improving the treatment of diabetes, but there are a number of drawbacks and moral dilemmas that must be carefully considered. It is imperative to address these concerns in order to ensure the responsible and successful implementation of AI in diabetes management as the healthcare landscape changes in tandem with technological advancements [30].

AI algorithms' propensity for bias is one of the main problems. Large datasets are used to train machine learning models, and if these datasets contain biased data, the AI system may reinforce or even worsen already-existing healthcare disparities. This may lead to unequal access to tailored treatments, diagnostic resources, and treatment suggestions in diabetes care. To guarantee just and equitable healthcare delivery, developers and medical professionals must constantly evaluate and reduce bias in AI systems [31]. The era of AI-driven healthcare raises severe issues about data security and privacy. AI systems can benefit much from patient data, especially sensitive information on diabetes management. As these systems gather, handle, and evaluate enormous volumes of private health information, it becomes critical to have strong cybersecurity safeguards. Finding the right balance between using patient data to provide individualized care and protecting individual privacy is a difficult undertaking that calls for strict laws, open procedures, and safe infrastructure [32].

Taking into account the results of AI-assisted judgments in diabetes management raises the question of accountability. Deciding who is responsible for an adverse incident or wrong diagnosis that results from a recommendation made by an AI system becomes complicated. To handle potential liabilities and guarantee patient safety, it is crucial to set up procedures for ongoing monitoring and evaluation in addition to clear lines of accountability [33].

Moreover, continuous education and training for medical professionals is required to apply AI in diabetes management. The ability to comprehend, evaluate, and enhance ideas produced by artificial intelligence is essential for fostering productive partnerships between human knowledge and machine learning. To improve the synergy between AI and human-led healthcare, medical curriculum should incorporate AI knowledge, and healthcare workers should receive ongoing training [34].

It's important to think about how AI will affect society when it comes to diabetes care. Even if cutting-edge technologies could lead to better results, there's a chance they could make healthcare inequities worse. Promoting health equity requires making sure that AI-driven solutions are available to all facets of the population, irrespective of their geography or socioeconomic standing [35].

There are advantages and disadvantages to integrating AI into the treatment of diabetes. Overcoming these obstacles calls for a multifaceted strategy that includes continual education, ethical standards, legal frameworks, and technological advancements. The healthcare sector can fully utilize AI to transform diabetes treatment and provide patients with individualized, effective, and fair care by carefully navigating these issues [36].

5. Applications of Artificial Intelligence (AI) in Diabetes Care

With its cutting-edge applications, artificial intelligence (AI) is bringing in a new age in healthcare and changing the face of diabetes care. Artificial intelligence (AI) is revolutionizing this quickly developing profession by helping to identify risks, provide tailored care, and deepen our understanding of issues associated with diabetes. Artificial Intelligence (AI) in diabetes care can potentially improve patient outcomes, maximize resource use, and improve patient experiences [37].

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

Although managing glucose levels is still a major goal in diabetes care, a comprehensive strategy is required due to the condition's complexity. By focusing on the treatment of extra risk factors including blood pressure (BP) and cholesterol, especially low-density lipoprotein (LDL) cholesterol, AI applications are setting new standards. For people, macrovascular events such as cardiovascular disease (CVD) are serious problems [38].

The difficulty is in tailoring treatment plans while taking the unique needs and intricacies of each patient into account. Guidelines for measurements including HbA1c, blood pressure, and low-density lipoprotein (LDL) cholesterol suggest certain targets, such as those offered by the American Diabetes Association (ADA). But the individualization criteria are complicated, which causes professionals to become confused. By using large datasets to assess hazards, AI systems help determine individualized treatment targets based on patient profiles and risks [39].

A paradigm shift has occurred in recent guidelines, which now advocate particular glucose-lowering drugs depending on comorbid conditions such atherosclerotic cardiovascular disease (ASCVD) and chronic kidney disease (CKD). The difficulty is striking a balance between treating microvascular events that increase morbidity and mortality and preventing CKD and CVD. In order to navigate this complexity, AI-driven insights are crucial, offering a data-driven foundation for decision-making [40].

The dynamic nature of diabetes-related risk is recognized thanks largely to AI applications. Over time, risk factors change, and the length of diabetes mellitus and age become essential indicators. Even following an ischemia event, there are significant shifts in the risk environment. AI models that use large datasets to provide precise risk assessment let clinicians modify treatment plans in response to patients' changing risk profiles [41].

Over time, risk prediction models—risk engines—have changed. The groundwork was established by classic instances such as the UKPDS Risk Engine and the Framingham Risk Engine. Still, constraints like drawing from particular populations have created more recent, flexible models. One notable contemporary risk engine is the Building, Relating, Assessing, and Validating Outcomes (BRAVO) model [42]. One notable feature of the ACCORD trial data-based BRAVO model is its ability to perform micro-simulations at the patient level. In contrast to conventional models, BRAVO takes body weight fluctuations into account, takes the effects of hypoglycemia into account, and provides a worldwide viewpoint adjusted for a range of demographics [43]. With its ability to forecast both macrovascular and microvascular problems, it offers a more comprehensive picture of the consequences of diabetes. The utility of the BRAVO paradigm is multidimensional. It makes risk stratification easier, allowing medical professionals to divide patients into high-, medium-, and low-risk categories [44]. It supports the establishment of personalized targets for risk variables and directs treatment choices in clinical practice. The model is also a useful tool for determining how cost-effective pharmacological interventions and legislative reforms are [48].

The mechanics behind clinical trial outcomes are better-understood thanks to AI-driven models like BRAVO. They evaluate the effect of risk factor reduction on long-term outcomes and make reliable predictions about the advantages shown in trials. The model's adaptability is demonstrated by its ability to examine policy changes and the cost-effectiveness of interventions such as the Diabetes INSIDE Program [45].

Bravo is a potent tool for therapy optimization because of its capacity to replicate clinical trials with different medication combinations. It enables evidence-based decision-making by offering insights into the long-term advantages and hazards of interventions. The model facilitates the comparison of various treatment choices and the planning of successful clinical trials by extrapolating short-term efficacy data onto long-term results [46].

The future of diabetes care has a lot of interesting potential as AI develops. More precise individualization of therapy is anticipated as a result of the incorporation of AI into standard clinical practice and continuous improvements in risk prediction models. The BRAVO model is a significant advancement in the understanding of the complexities of diabetes outcomes, and its uses go beyond clinical settings to include medication development and healthcare policy [47].

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

In summary, artificial intelligence (AI) applications—such as the BRAVO model—transform diabetes treatment. These developments create new opportunities for better patient outcomes and raising the standard of diabetes treatment overall by paving the path for a more individualized, data-driven approach to risk prediction and management [49].

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

6. Artificial Intelligence Revolutionizing Diabetes Management

Diabetes is at the vanguard of this technological transformation since new opportunities for improving the management of chronic illnesses have been created by the integration of artificial intelligence (AI) in healthcare. AI is a subfield of computer science that aims to develop tools or systems for handling complexity in a variety of applications and data analysis. AI has been especially focused on precision-based knowledge in the healthcare industry, with great potential for improvements in natural language processing, population health, and medicine [50].

The clinical community has shown a great deal of interest in the use of AI in visually-oriented medical professions like radiology, pathology, ophthalmology, and dermatology. Artificial Intelligence (AI) is being used in both virtual and real-world diabetes treatment. In the virtual realm, artificial intelligence (AI) uses mathematical calculations to improve comprehension through learning; in the physical realm, AI is incorporated into medical gadgets and even care robots [51].

Artificial Intelligence has enormous promise in the treatment of diabetes, providing efficient data processing and the creation of instruments and gadgets for all-encompassing control. However, comprehensive safety plans, health reserves, and procedural protections that address any potential technical system weaknesses are advised in order to guarantee the security of AI-driven technology [52].

The P7 concept outlines the future elements of healthcare, emphasizing:

- Predictive: Utilizing electronic health records and genomic data to determine an individual's susceptibility to specific diseases.
- Personalized: Tailoring treatment to each individual based on their unique characteristics.
- Preventive: Developing strategies to prevent the onset of diseases rather than treating them after occurrence.
- Precise: Using AI tools to precisely identify the cause of diseases and recommend appropriate therapeutic actions.
- Pervasive: Providing healthcare services anytime, anywhere, and in any location.
- Protective: Ensuring the confidentiality of patient information through appropriate health measures.
- Participatory: Actively involving patients in the diagnosis and treatment of their diseases [23].

Numerous artificial intelligence (AI) technologies have been implemented in the diabetes care domain to improve data processing and patient tracking. In order to address the variability in blood glucose levels related to lifestyle factors, machine learning (ML) is essential. Smart algorithms can respond to physiological changes in diabetics and provide tailored suggestions for insulin dosage and meal timing [35].

Precision medicine powered by AI helps medical practitioners shift from strict management procedures to data-driven decision-making. Artificial intelligence (AI) systems have the ability to reanalyze clinical trial data, revealing subgroups that react differently to therapies and providing patients with more individualized and efficient guidance [13].

AI's application of computer vision has the ability to completely automate screening procedures based on clinical picture interpretation at the level of the healthcare system. For example, automated retinal screening has proven to be effective in identifying diabetic retinopathy, which minimizes the need for expert referrals and guarantees prompt intervention for high-risk individuals [26].

Numerous AI methods have been used in the treatment of diabetes, such as:

- Case-Based Reasoning (CBR): A technique used to optimize and customize insulin therapy that solves new challenges by drawing on knowledge from analogous prior experiences.
- Artificial Neural Networks: Used in the analysis of various data sets and the development of customized solutions, particularly in the diagnosis of diabetes.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

- Support Vector Regression: Used to create models for predicting hypoglycemia and to provide alerts for preventive action when blood glucose levels are dangerously low [28].

AI is being used in a wide range of diabetes management applications, including automated retinal screening, home monitoring, feature detection, diagnosis support, clinical decision support, and patient self-management. With the use of wearable technology, patients can monitor their heart rate, activity level, and other physiological parameters at home. Deep learning algorithms enable automated retinal screening, which guarantees effective identification of diabetic retinopathy [27].

AI helps with diabetic dosage accuracy by reminding patients to take their medications on time. The self-management component gives patients the authority to choose their own daily activities and food. AI programs have also been created to forecast how type 2 diabetic patients would react, both immediately and over time, to the beginning of insulin [50].

AI is transforming diabetes care by providing cutting-edge options for tracking, diagnosing, and customizing care. AI has a significant impact on patient care, from automated retinal screening and precise dose reminders to machine learning algorithms that assist medical personnel in making decisions. AI-driven technology enables prompt and focused interventions as patients actively participate in their care. But before widespread clinical adoption, privacy and security issues must be resolved. Future research on AI's potential for controlling chronic diseases, including diabetes, is anticipated, leading to a paradigm shift in healthcare procedures [49].

7. Results

The collaborative investigation of artificial intelligence (AI) in the management of diabetes highlights the technology's revolutionary potential in a number of healthcare domains. AI has emerged as a key factor in transforming diabetes care. AI is described as a computational paradigm that seeks to unravel complexity. AI's dual use in virtual and actual environments redefines conventional methods and presents novel alternatives [3].

With its focus on predictive, customized, preventative, precise, ubiquitous, protective, and participatory features, the P7 healthcare paradigm offers a thorough foundation for comprehending how AI will impact healthcare in the future. AI tackles the personal, professional, and systemic issues related to managing diabetes. Examples include automated retinal examinations for diabetic retinopathy and individualized insulin dosage recommendations made by machine learning algorithms [5].

The application of AI to diabetes care signifies a profound change in medical procedures. AI provides a complete strategy to solve the issues faced by diabetes, ranging from automated screening programs and patient self-management tools to machine learning algorithms aiding healthcare personnel [21].

Artificial Neural Networks, Case-Based Reasoning, and Support Vector Regression are just a few examples of the wide spectrum of AI techniques that demonstrate how flexible AI can be in providing complicated answers for diabetes-related problems. AI is helping to change the way that healthcare is delivered, whether it is through clinical decision support systems that forecast HbA1c reactions or home monitoring using wearable technology [23].

AI-driven developments are improving diabetes treatment and have the potential to change how chronic diseases are treated as long as individuals take an active role in their care. The combined findings paint a picture of a future where artificial intelligence (AI) would likely bring hitherto unseen opportunities but will also necessitate rigorous assessment of privacy and security considerations prior to broad implementation in healthcare settings [46].

AI-driven technology enables prompt and focused interventions as patients actively participate in their care. The future holds more research into AI's potential for managing various chronic diseases, including diabetes. But before widespread clinical adoption, privacy and security issues must be resolved. With the potential to improve results, lower costs, and empower patients and healthcare providers alike, the dynamic field of artificial intelligence in diabetes treatment represents a reinvention of healthcare delivery [16].

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

8. Discussion

The present study has explored the complex field of artificial intelligence (AI) and its significant consequences for the treatment of diabetes, a chronic illness that affects millions of people globally. The investigation covered a wide range of topics, such as the definition and uses of artificial intelligence (AI) in healthcare, the revolutionary potential of AI in the treatment of diabetes, and particular methods and approaches used in this field [22].

In the field of healthcare, artificial intelligence is defined as a subfield of computer science that focuses on developing tools or systems that can analyze data and manage complexity in a variety of settings. The main objective is to use AI's ability to interpret complex data and provide solutions that reduce complexity and enhance results. As AI develops further, its application in healthcare holds promises of transforming medicine, population health, and natural language processing [26].

Diabetes is a complicated and common chronic illness that is used as a focal point for AI integration in healthcare. The discussion has demonstrated the dual nature of virtual and physical applications of AI in diabetes management. In the virtual realm, artificial intelligence is used to do mathematical operations that improve comprehension through education. The physical side, on the other hand, deals with the incorporation of AI into medical equipment, which includes the potential for care robots [2].

AI's potential to treat diabetes represents a paradigm change. The implications go beyond conventional methods, providing creative ways to tackle the complexities of managing diabetes all at once. AI has a revolutionary impact on diabetes treatment, from precision-based information to reimagining prevention and intervention management tactics [8].

The P7 concept, which outlines the aspects of healthcare that AI is expected to have a substantial impact on in the future, was introduced in the talk. Predictive, individualized, preventive, and precise approaches to healthcare are highlighted in this conceptual framework. The idea also supports widespread access to healthcare services, safeguards for the privacy of patient data, and patient participation in diagnosis and treatment decisions [16].

This comprehensive strategy represents a break from traditional healthcare models and a move in the direction of a paradigm that is more patient-centric, data-driven, and preventive. These ideas are supported by the use of AI, which provides healthcare personnel with tools and techniques to give interventions that are more focused and efficient [23].

AI is being used in diabetes treatment in a variety of ways that affect people with diabetes, medical professionals, and the larger healthcare system. AI offers ways for people with diabetes to manage the lifestyle-related variability in blood glucose levels. The 'Digital Bolus Calculator,' as an example of machine learning algorithms, adjusts insulin dosage based on each person's unique physiology [34].

Clinical decision-making benefits from a paradigm change for healthcare providers. Data-driven precision medicine replaces inflexible management regimens by allowing reanalysis of clinical trial data to find subgroups that react differently to interventions. Patients will receive more focused and useful information thanks to this refined approach [19].

The use of AI in "computer vision" has the potential to completely automate screening processes that depend on clinical picture interpretation at the level of the healthcare system. For example, automated retinal screening has proven effective in identifying diabetic retinopathy, minimizing the need for expert referrals and guaranteeing prompt treatment for high-risk patients [30].

The varied and dynamic nature of the diabetes care industry is reflected in the application of several AI approaches. To optimize and personalize insulin therapy, Case-Based Reasoning (CBR), an AI technique that solves new issues by learning from analogous prior experiences, has been used. Artificial Neural Networks have applications in diabetes diagnosis due to their capacity to interpret a wide variety of data [40].

Encouragement In order to create hypoglycemia prediction models that can inform physicians for preventive action when patients have dangerously low blood glucose levels, vector regression has been employed. These methods highlight how adaptable AI is to dealing with the various issues that diabetes presents, ranging from risk assessment and preventive measures to customized therapy [51].

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

AI has many uses in managing diabetes, from clinical decision support to at-home monitoring. Wearable technology is essential to at-home monitoring since it allows patients to monitor their heart rate, activity level, and calorie intake, among other physiological parameters. Deep learning algorithms enable automated retinal screening, which guarantees effective identification of diabetic retinopathy [40].

AI is used by clinical decision support systems to forecast patients with type 2 diabetes mellitus's short- and long-term HbA1c reactions following the start of insulin. These instruments aid in identifying clinical factors that impact a patient's response to HbA1c, hence offering significant insights to healthcare practitioners [10].

9. Conclusions

In conclusion, the application of artificial intelligence (AI) to diabetes treatment is a ground-breaking step toward more efficient, individualized, and patient-focused medical care. Artificial Intelligence has several uses, from individualized treatment recommendations and predictive modeling to automated tests and self-management support. These uses highlight how AI has the potential to revolutionize diabetes care at the individual, professional, and systemic levels. The notion of P7 healthcare embodies the significant influence artificial intelligence (AI) can have on the healthcare industry going forward, as it prioritizes predictability, personalization, prevention, precision, pervasiveness, protection, and participation. But as AI develops, privacy issues, ethical issues, and the requirement for thorough validation of AI-driven products must all be prioritized. The broad acceptance and application of AI will depend on finding a balance between innovation and protecting patient rights.

10. Future Implication

AI has a bright future in the treatment of diabetes, and further study is necessary to realize its full potential. To guarantee the accuracy and dependability of AI models for predicting individual reactions to therapy across a range of patient groups, more research is required for model validation and refinement. Long-term research evaluating the practical effects of AI-driven interventions, particularly with regard to patient outcomes and healthcare resource consumption, would be extremely beneficial. Furthermore, investigating how AI may be integrated with cutting-edge technologies like wearables and the Internet of Things (IoT) could improve real-time diabetic support and monitoring. Research ought to concentrate on creating AI tools that support lifestyle modifications, adherence, and patient education in order to enable people to effectively manage their own conditions. The ethical, legal, and social ramifications of artificial intelligence (AI) in diabetes treatment must be navigated by researchers, medical practitioners, and technology developers working together to provide a responsible and patient-centered approach to technological innovation.

References

1. Mishra, D. K.; Shukla, S. ROLE of ARTIFICIAL INTELLIGENCE in DIABETES MANAGEMENT. *International Journal of Engineering Technologies and Management Research* **2020**, *7* (7), 80–88. https://doi.org/10.29121/ijetmr.v7.i7.2020.728.
2. Chaki, J.; Thillai Ganesh, S.; Cidham, S. K.; Ananda Theertan, S. Machine Learning and Artificial Intelligence Based Diabetes Mellitus Detection and Self-Management: A Systematic Review. *Journal of King Saud University - Computer and Information Sciences* **2020**. https://doi.org/10.1016/j.jksuci.2020.06.013.
3. Shao, H.; Shi, L.; Lin, Y.; Fonseca, V. Using Modern Risk Engines and Machine Learning/Artificial Intelligence to Predict Diabetes Complications: A Focus on the BRAVO Model. *Journal of Diabetes and its Complications* **2022**, *36* (11), 108316. https://doi.org/10.1016/j.jdiacomp.2022.108316.
4. Tehrani, N. HOW PERSONALIZED ARTIFICIAL INTELLIGENCE IS ADVANCING TREATMENT of DIABETES. *International Journal of Scientific and Education Research* **2018**, *2* (01).
5. Contreras, I.; Vehi, J. Artificial Intelligence for Diabetes Management and Decision Support: Literature Review. *Journal of Medical Internet Research* **2018**, *20* (5), e10775. https://doi.org/10.2196/10775.
6. Ellahham, S. Artificial Intelligence: The Future for Diabetes Care. *The American Journal of Medicine* **2020**, *133* (8). https://doi.org/10.1016/j.amjmed.2020.03.033.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

7. Nimri, R.; Battelino, T.; Laffel, L. M.; Slover, R. H.; Schatz, D.; Weinzimer, S. A.; Dovc, K.; Danne, T.; Phillip, M. Insulin Dose Optimization Using an Automated Artificial Intelligence-Based Decision Support System in Youths with Type 1 Diabetes. *Nature Medicine* **2020**, *26* (9), 1380–1384. https://doi.org/10.1038/s41591-020-1045-7.
8. Kerr, D.; Axelrod, C.; Hoppe, C.; Klonoff, D. C. Diabetes and Technology in 2030: A Utopian or Dystopian Future? *Diabetic Medicine* **2018**, *35* (4), 498–503. https://doi.org/10.1111/dme.13586.
9. Rashid, M. M.; Askari, M. R.; Chen, C.; Liang, Y.; Shu, K.; Cinar, A. Artificial Intelligence Algorithms for Treatment of Diabetes. *Algorithms* **2022**, *15* (9), 299. https://doi.org/10.3390/a15090299.
10. Vu, G. T.; Tran, B. X.; McIntyre, R. S.; Pham, H. Q.; Phan, H. T.; Ha, G. H.; Gwee, K. K.; Latkin, C. A.; Ho, R. C. M.; Ho, C. S. H. Modeling the Research Landscapes of Artificial Intelligence Applications in Diabetes (GAPRESEARCH). *International Journal of Environmental Research and Public Health* **2020**, *17* (6), 1982. https://doi.org/10.3390/ijerph17061982.
11. Zhang, Y.; Shi, J.; Peng, Y.; Zhao, Z.; Zheng, Q.; Wang, Z.; Liu, K.; Jiao, S.; Qiu, K.; Zhou, Z.; Yan, L.; Zhao, D.; Jiang, H.; Dai, Y.; Su, B.; Gu, P.; Su, H.; Wan, Q.; Peng, Y.; Liu, J. Artificial Intelligence-Enabled Screening for Diabetic Retinopathy: A Real-World, Multicenter and Prospective Study. *BMJ Open Diabetes Research and Care* **2020**, *8* (1), e001596. https://doi.org/10.1136/bmjdrc-2020-001596.
12. Sosale, B.; Aravind, S. R.; Murthy, H.; Narayana, S.; Sharma, U.; Gowda, S. G. V.; Naveenam, M. Simple, Mobile-Based Artificial Intelligence Algorithm in the Detection of Diabetic Retinopathy (SMART) Study. *BMJ Open Diabetes Research and Care* **2020**, *8* (1), e000892. https://doi.org/10.1136/bmjdrc-2019-000892.
13. Chitara, H.; Patel, R.; Bhatt, Prof. T. Diabetes Diseases Diagnosed Support System Using Artificial Intelligence. *SSRN Electronic Journal* **2020**. https://doi.org/10.2139/ssrn.3554212.
14. Naveed, I.; Muhammad Farhat Kaleem; Karim Keshavjee; Aziz Guergachi. Artificial Intelligence with Temporal Features Outperforms Machine Learning in Predicting Diabetes. *PLOS digital health* **2023**, *2* (10), e0000354–e0000354. https://doi.org/10.1371/journal.pdig.0000354.
15. Xie, Y.; Lu, L.; Gao, F.; He, S.; Zhao, H.; Fang, Y.; Yang, J.; An, Y.; Ye, Z.; Dong, Z. Integration of Artificial Intelligence, Blockchain, and Wearable Technology for Chronic Disease Management: A New Paradigm in Smart Healthcare. *Current Medical Science* **2021**, *41* (6), 1123–1133. https://doi.org/10.1007/s11596-021-2485-0.
16. Ghouali, S.; Onyema, EM.; Guellil, MS.; Wajid, M. A.; Clare, O.; Cherifi, W.; Feham, M. Artificial Intelligence-Based Teleopthalmology Application for Diagnosis of Diabetics Retinopathy. *IEEE Open Journal of Engineering in Medicine and Biology* **2022**, 1–11. https://doi.org/10.1109/OJEMB.2022.3192780.
17. Li, S.; Zhao, R.; Zou, H. Artificial Intelligence for Diabetic Retinopathy. *Chinese Medical Journal* **2021**, *135* (3), 253–260. https://doi.org/10.1097/cm9.0000000000001816.
18. Ji Won Chun; Kim, H.-S. The Present and Future of Artificial Intelligence-Based Medical Image in Diabetes Mellitus: Focus on Analytical Methods and Limitations of Clinical Use. *Journal of Korean Medical Science* **2023**, *38* (31). https://doi.org/10.3346/jkms.2023.38.e253.
19. Kerr, D.; Klonoff, D. C. Digital Diabetes Data and Artificial Intelligence: A Time for Humility Not Hubris. *Journal of Diabetes Science and Technology* **2018**, *13* (1), 123–127. https://doi.org/10.1177/1932296818796508.
20. Oka, R.; Nomura, A.; Yasugi, A.; Kometani, M.; Gondoh, Y.; Yoshimura, K.; Yoneda, T. Study Protocol for the Effects of Artificial Intelligence (AI)-Supported Automated Nutritional Intervention on Glycemic Control in Patients with Type 2 Diabetes Mellitus. *Diabetes Therapy* **2019**, *10* (3), 1151–1161. https://doi.org/10.1007/s13300-019-0595-5.
21. Nimri, R.; Phillip, M.; Kovatchev, B. Closed-Loop and Artificial Intelligence–Based Decision Support Systems. *Diabetes Technology & Therapeutics* **2023**, *25* (S1), S-70-S-89. https://doi.org/10.1089/dia.2023.2505.
22. Pieczynski, J.; Kuklo, P.; Grzybowski, A. The Role of Telemedicine, In-Home Testing and Artificial Intelligence to Alleviate an Increasingly Burdened Healthcare System: Diabetic Retinopathy. *Ophthalmology and Therapy* **2021**, *10* (3), 445–464. https://doi.org/10.1007/s40123-021-00353-2.
23. Wu, Y.; Min, H.; Li, M.; Shi, Y.; Ma, A.; Han, Y.; Gan, Y.; Guo, X.; Sun, X. Effect of Artificial Intelligence-Based Health Education Accurately Linking System (AI-HEALS) for Type 2 Diabetes Self-Management: Protocol for a Mixed-Methods Study. *BMC public health* **2023**, *23* (1), 1325. https://doi.org/10.1186/s12889-023-16066-z.
24. Nayak, A.; Vakili, S.; Nayak, K.; Nikolov, M.; Chiu, M.; Sosseinheimer, P.; Talamantes, S.; Testa, S.; Palanisamy, S.; Giri, V.; Schulman, K. Use of Voice-Based Conversational Artificial Intelligence for Basal Insulin Prescription Management among Patients with Type 2 Diabetes: A Randomized Clinical Trial. *JAMA Network Open* **2023**, *6* (12), e2340232. https://doi.org/10.1001/jamanetworkopen.2023.40232.
25. Pelayes, D. E.; Mendoza, J. A.; Folgar, A. M. Artificial Intelligence Use in Diabetes. *Latin American Journal of Ophthalmology* **2022**, *5*. https://doi.org/10.25259/LAJO_4_2022.
26. Chauhan, S.; Kerr, A.; Keogh, B.; Nolan, S.; Casey, R.; Adelfio, A.; Murphy, N.; Doherty, A.; Davis, H.; Wall, A. M.; Khaldi, N. An Artificial-Intelligence-Discovered Functional Ingredient, NRT_N0G5IJ, Derived from Pisum Sativum, Decreases HbA1c in a Prediabetic Population. *Nutrients* **2021**, *13* (5), 1635. https://doi.org/10.3390/nu13051635.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

27. Nimri, R.; Amir Tirosh; Muller, I.; Shtrit, Y.; Kraljević, I.; Montserrat Martín Alonso; Miličić, T.; Banshi Saboo; Deeb, A.; Athanasios Christoforidis; Marieke den Brinker; Lutgarda Bozzetto; Andrea Mario Bolla; Krčma, M.; Rabini, R. A.; Shadi Tabba; Adriani Vazeou-Gerasimidi; Giulio Maltoni; Giani, E.; Idit Dotan. Comparison of Insulin Dose Adjustments Made by Artificial Intelligence-Based Decision Support Systems and by Physicians in People with Type 1 Diabetes Using Multiple Daily Injections Therapy. *Diabetes Technology & Therapeutics* **2022**, *24* (8), 564–572. https://doi.org/10.1089/dia.2021.0566.
28. Kulzer, B. Wie Profitieren Menschen Mit Diabetes von Big Data Und Künstlicher Intelligenz? *Der Diabetologe* **2021**, *17* (8), 799–806. https://doi.org/10.1007/s11428-021-00818-9.
29. Ahmed, M. G.; Zaghloul, I.; Abd El Fattah, M. T. A Survey on Personalization of Diabetes Treatment Using Artificial Intelligence Techniques. *Benha Journal of Applied Sciences* **2023**, *8* (5), 229–236. https://doi.org/10.21608/bjas.2023.202990.1140.
30. Suwarno, I. Artificial Intelligence Algorithm for Diabetes Detection: Systematic Literature Review. *Indonesian Community on Optimization and Computer Application* **2023**, *1* (1), 41–52.
31. Goldstein, C. A.; Berry, R. B.; Kent, D. T.; Kristo, D. A.; Seixas, A. A.; Redline, S.; Westover, M. B. Artificial Intelligence in Sleep Medicine: Background and Implications for Clinicians. *Journal of Clinical Sleep Medicine* **2020**, *16* (4), 609–618. https://doi.org/10.5664/jcsm.8388.
32. Sridhar, G. R.; Gumpeny Lakshmi. Artificial Intelligence in Medicine: Diabetes as a Model. *Studies in big data* **2021**, 283–305. https://doi.org/10.1007/978-981-16-0415-7_14.
33. Xue, Y.; Chen, C.; Tan, R.; Zhang, J.; Fang, Q.; Jin, R.; Mi, X.; Sun, D.; Xue, Y.; Wang, Y.; Xiong, R.; Lu, H.; Tan, W. Artificial Intelligence-Assisted Bioinformatics, Microneedle, and Diabetic Wound Healing: A "New Deal" of an Old Drug. *ACS applied materials & interfaces* **2022**, *14* (33), 37396–37409. https://doi.org/10.1021/acsami.2c08994.
34. Schaarup, J. F. R.; Aggarwal, R.; Dalsgaard, E.-M.; Norman, K.; Dollerup, O. L.; Ashrafian, H.; Witte, D. R.; Sandbæk, A.; Hulman, A. Perception of Artificial Intelligence-Based Solutions in Healthcare among People with and without Diabetes: A Cross-Sectional Survey from the Health in Central Denmark Cohort. *Diabetes Epidemiology and Management* **2023**, *9*, 100114. https://doi.org/10.1016/j.deman.2022.100114.
35. Grauslund, J. Diabetic Retinopathy Screening in the Emerging Era of Artificial Intelligence. *Diabetologia* **2022**. https://doi.org/10.1007/s00125-022-05727-0.
36. Raman, R.; Dasgupta, D.; Ramasamy, K.; George, R.; Mohan, V.; Ting, D. Using Artificial Intelligence for Diabetic Retinopathy Screening: Policy Implications. *Indian Journal of Ophthalmology* **2021**, *69* (11), 2993–2998. https://doi.org/10.4103/ijo.IJO_1420_21.
37. Guzman Gómez, G. E.; Burbano Agredo, L. E.; Martínez, V.; Bedoya Leiva, O. F. Application of Artificial Intelligence Techniques for the Estimation of Basal Insulin in Patients with Type I Diabetes. *International Journal of Endocrinology* **2020**, *2020*, 7326073. https://doi.org/10.1155/2020/7326073.
38. Daley, B. J.; Ni'Man, M.; Neves, M. R.; Bobby Huda, M. S.; Marsh, W.; Fenton, N. E.; Hitman, G. A.; McLachlan, S. MHealth Apps for Gestational Diabetes Mellitus That Provide Clinical Decision Support or Artificial Intelligence: A Scoping Review. *Diabetic Medicine* **2021**, *39* (1). https://doi.org/10.1111/dme.14735.
39. Vyas, S.; Gupta, S.; Tarar, S.; Omarov, B.; Pant, B.; Bangare, J. L.; Bhowmik, T. Investigation of Diabetes Care in Elder Individuals Using Artificial Intelligence. *Journal of Food Quality* **2022**, *2022*, 1–7. https://doi.org/10.1155/2022/8760032.
40. Huang, J.; Yeung, A. M.; Armstrong, D. G.; Battarbee, A. N.; Cuadros, J.; Espinoza, J. C.; Kleinberg, S.; Mathioudakis, N.; Swerdlow, M. A.; Klonoff, D. C. Artificial Intelligence for Predicting and Diagnosing Complications of Diabetes. *Journal of Diabetes Science and Technology* **2022**, *17* (1), 224–238. https://doi.org/10.1177/19322968221124583.
41. Ashrafzadeh, S.; Hamdy, O. Patient-Driven Diabetes Care of the Future in the Technology Era. *Cell Metabolism* **2019**, *29* (3), 564–575. https://doi.org/10.1016/j.cmet.2018.09.005.
42. Huang, X.; Wang, H.; She, C.; Feng, J.; Liu, X.; Hu, X.; Chen, L.; Tao, Y. Artificial Intelligence Promotes the Diagnosis and Screening of Diabetic Retinopathy. *Frontiers in Endocrinology* **2022**, *13*. https://doi.org/10.3389/fendo.2022.946915.
43. Qaraqe, M.; Erraguntla, M.; Dave, D. AI and Machine Learning in Diabetes Management: Opportunity, Status, and Challenges. *Multiple Perspectives on Artificial Intelligence in Healthcare* **2021**, 129–141. https://doi.org/10.1007/978-3-030-67303-1_11.
44. Porcher, S. Measuring Artificial Intelligence Capabilities and Readiness. *Academy of Management Proceedings* **2020**, *2020* (1), 13168. https://doi.org/10.5465/ambpp.2020.13168abstract.
45. Chen, M.; Yang, J.; Zhou, J.; Hao, Y.; Zhang, J.; Youn, C.-H. 5G-Smart Diabetes: Toward Personalized Diabetes Diagnosis with Healthcare Big Data Clouds. *IEEE Communications Magazine* **2018**, *56* (4), 16–23. https://doi.org/10.1109/MCOM.2018.1700788.
46. Cambuli, V. M.; Marco Giorgio Baroni. Intelligent Insulin vs. Artificial Intelligence for Type 1 Diabetes: Will the Real Winner Please Stand Up? *International Journal of Molecular Sciences* **2023**, *24* (17), 13139–13139. https://doi.org/10.3390/ijms241713139.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 January 2024 doi:10.20944/preprints202401.2049.v1

47. Contreras, I.; Bertachi, A.; Biagi, L.; Oviedo, S.; Ramkissoon, C.; Vehi, J. *Chapter 14 - Artificial intelligence-based decision support systems for diabetes*. ScienceDirect. https://www.sciencedirect.com/science/article/abs/pii/B9780128171332000148 (accessed 2024-01-21).
48. Yang, R.; Liu, C.; Li, Q.; Wang, W.; Wu, B.; Chen, A.; Wang, B.; Li, W.; Chen, J. Artificial Intelligence Based Identification of the Functional Role of Hirudin in Diabetic Erectile Dysfunction Treatment. *Pharmacological Research* **2021**, *163*, 105244. https://doi.org/10.1016/j.phrs.2020.105244.
49. Khan, I.; Agarwal, R. Can ChatGPT Help in the Awareness of Diabetes? *Annals of Biomedical Engineering* **2023**, *51* (10), 2125–2129. https://doi.org/10.1007/s10439-023-03356-1.
50. Josep Vehí; Mujahid, O.; Contreras, I. Artificial Intelligence and Machine Learning for Diabetes Decision Support. *Springer eBooks* **2022**, 259–272. https://doi.org/10.1007/978-3-030-99728-1_13.
51. Olivia Li, J.-P.; Liu, H.; Ting, D. S. J.; Jeon, S.; Chan, R. V. Paul.; Kim, J. E.; Sim, D. A.; Thomas, P. B. M.; Lin, H.; Chen, Y.; Sakomoto, T.; Loewenstein, A.; Lam, D. S. C.; Pasquale, L. R.; Wong, T. Y.; Lam, L. A.; Ting, D. S. W. Digital Technology, Tele-Medicine and Artificial Intelligence in Ophthalmology: A Global Perspective. *Progress in Retinal and Eye Research* **2020**, *82* (1), 100900. https://doi.org/10.1016/j.preteyeres.2020.100900.
52. Cedeno-Moreno, D.; Vargas-Lombardo, M. *Mobile Applications for Diabetes Self-Care and Approach to Machine Learning*; International Association of Online Engineering, 2020.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.