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The Accuracy of Artificial Intelligence to Support Multimodal Management and Prediction of Gestational Diabetes

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Abstract: Gestational Diabetes Mellitus (GDM) is characterized as any degree of glucose intolerance that manifests during pregnancy and typically resolves postpartum. Diagnosis is commonly made through an Oral Glucose Tolerance Test (OGTT); however, there are notable inconsistencies in diagnostic criteria and treatment thresholds both nationally and internationally. The onset of GDM generally occurs in the late second or early third trimester, with potential complications including fetal macrosomia, which may lead to difficult labor, and neonatal hypoglycemia due to excess insulin production in the infant's pancreas. Furthermore, certain studies suggest that GDM may delay fetal brain development, resulting in long-term neurological impairments. Although artificial intelligence (AI) models have only recently emerged as a potential solution in various medical fields, their application continues to raise concerns, particularly regarding the use and storage of personal data. Machine Learning (ML), a subset of AI, utilizes multivariate classification methods, also known as supervised pattern recognition approaches, which are designed to identify patterns and correlations among multiple variables to categorize them into specific groups or classes. In this context, we are describing here. Thus, artificial intelligence has not yet demonstrated its full clinical potential in the management of gestational diabetes mellitus (GDM). Current applications remain limited in their impact on improving patient outcomes, largely due to methodological heterogeneity and the early stage of implementation. Still, AI has shown considerable promise in the domain of predictive modeling, particularly through its ability to process large volumes of clinical and biochemical data. This analytical capacity enables the identification of complex patterns and correlations that can support the accurate early prediction of GDM, potentially allowing for earlier intervention and personalized care strategies. Future research should focus on validating these predictive models in larger, diverse populations and integrating them into clinical workflows under appropriate regulatory and ethical frameworks.

Keywords: gestational diabetes; artificial intelligence; management; prediction.

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1. Introduction

Gestational Diabetes Mellitus (GDM) is characterised as any degree of glucose intolerance that manifests during pregnancy and typically appears postpartum. Diagnosis is commonly established through an Oral Glucose Tolerance Test (OGTT); however, there are notable inconsistencies in diagnostic criteria and treatment thresholds both, nationally and internationally. The onset of GDM generally occurs in the late second or early third trimester, with potential complications including foetal macrosomia, which may lead to difficult labour, and neonatal hypoglycaemia due to excess insulin production in the infant's pancreas. Furthermore, certain studies suggest that GDM may delay foetal brain development, resulting in long-term neurological impairments.

Although artificial intelligence (AI) models have only recently emerged as a potential solution in various medical fields, their application continues to raise concerns, particularly regarding the use and storage of personal data. Machine Learning (ML), a subset of AI, utilises multivariate classification methods, also known as supervised pattern recognition approaches, which are designed to identify patterns and correlations among multiple variables to categorise them into specific groups or classes. While ML techniques have been extensively employed in fields such as metabolomics, proteomics, and genomics, the use of predictive models for gestational diabetes, based on clinical and biochemical data, has been on the rise since 2019. The healthcare sector has been at the forefront of adopting such technologies, with ML playing a pivotal role in medical advancements. ML's capability to process complex medical data facilitates disease prediction and treatment, drug development, patient record management, and the creation of clinical decision support systems for patient screening (Kaur et al., 2018).

This study aims to conduct a comprehensive review of various AI models currently used in the management of gestational diabetes.

2. Methods

This section outlines the methodology used to identify, select and review the articles included in this literature research.

The literature search was conducted using academic databases and open-access platforms offered by the university, including PubMed, Elsevier, and Google Scholar. Inclusion criteria were based on the relevance of article titles and the presence of specific keywords such as *gestational diabetes* and *artificial intelligence*. A consistent search strategy was applied across all platforms, utilising the combined keywords *gestational diabetes AND artificial intelligence*. Only studies published from 2010 onwards were considered for inclusion in order to ensure the relevance and contemporaneity of the data reviewed.

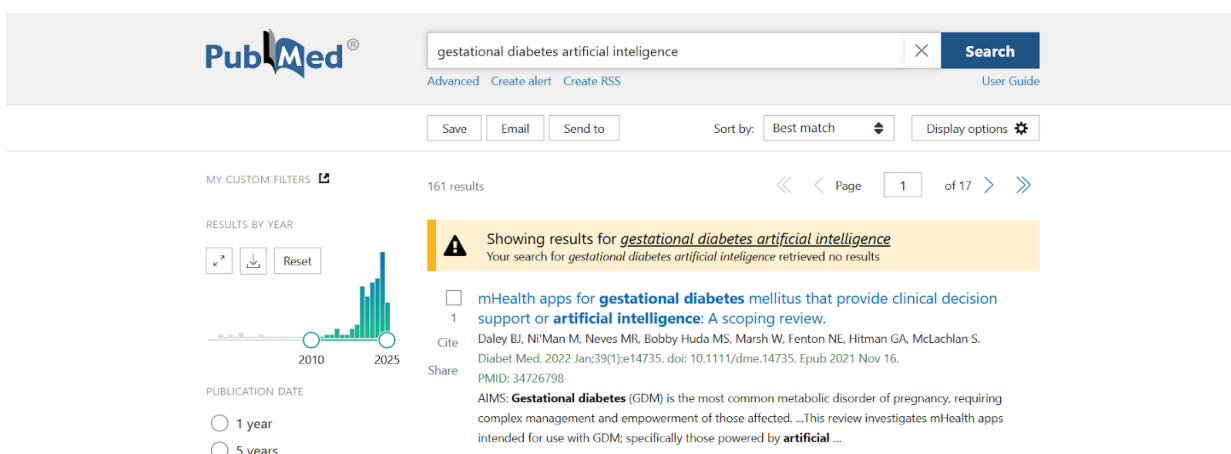


Figure 1. Method of search for relevant articles on PubMed(Original Figure)
<https://pubmed.ncbi.nlm.nih.gov/?term=gestational+diabetes+artificial+intelligence>

Studies that focused exclusively on the diagnostic aspect of gestational diabetes, as well as those representing ongoing research or without final published results, were excluded from this review. The selection process prioritised articles that explicitly incorporated the predefined keywords and demonstrated a clear emphasis on the management and prediction of gestational diabetes. The selection criteria also included articles with similar parameters used to assess glycemic control to ensure the uniformity and the relevance of the results. This approach ensured that the review remained aligned with its objective of examining practical solutions and interventions, rather than early-stage or diagnostic-focused investigations.

3. Results

Following a comprehensive and critical assessment of the selected literature, the findings appear to be highly heterogeneous, largely due to the variability in study design and parameter selection across the reviewed articles. This wide range of results and methodological diversity provided a comprehensive overview of how artificial intelligence (AI) has been integrated into clinical practice and its potential impact on various health-related parameters.

In the context of gestational diabetes mellitus (GDM) management, the literature generally suggests a moderately positive outlook on the use of AI-based tools. One such tool, the *SineDie* application, was utilised by 30 patients diagnosed with GDM. The system recommended initiating insulin therapy in 12 of these cases. At the subsequent clinical evaluation, 41.7% of the recommendations were accepted by clinicians, 29.0% were postponed, and 25.8% were rejected. These outcomes indicate a degree of clinical alignment with AI-generated treatment suggestions, although this alignment was qualified. (Albert et al., 2020)

Another intervention involved subcutaneous insulin administration managed via a continuous glucose monitoring (CGM) system. This approach yielded promising outcomes, with notable reductions in glycated haemoglobin (HbA1c) levels in three individual cases: from 11% to 6.6% after 18 months in the first case, from 7% to 6.6% over 9 months in the second, and from 14% to 6.9% in the third. These results highlight the potential for AI-assisted CGM systems to improve glycaemic control in patients with GDM (Manov et al., 2023).

The *GDM-health* application was assessed in a randomised study involving 203 women, with 98 allocated to the intervention group and 85 to the control group. While there was no statistically significant difference in the rate of change in blood glucose levels between the two groups (-0.16 mmol/L in the intervention group vs. -0.14 mmol/L in the control group per 28 days, $P = 0.78$), participants in the intervention group reported significantly higher satisfaction with care ($P = 0.049$). This suggests that AI-based interventions may enhance the patient experience, even when clinical outcomes remain comparable to standard care (Mackillop et al., 2018).

Finally, the *MobiGuide* system was evaluated as a decision-support tool for GDM management, monitoring multiple daily parameters such as blood glucose, blood pressure, heart rate, and weight. Although no statistically significant differences in clinical outcomes were observed when compared to conventional care, patient feedback indicated high levels of satisfaction with the app's interface and usability. Most users reported a willingness to reuse the application, highlighting the necessity of user-centric approach in the creation of digital health tools (Rigla et al., 2017).

Concerning the predictive capacity of artificial intelligence in the context of gestational diabetes mellitus (GDM), the literature reveals a study focused on early prediction, specifically during the first trimester, using multiple machine learning algorithms.

In this study, a total of 12,304 outpatient cases were included in the development dataset. According to the ADA 2011 diagnostic criteria, 77.6% ($n = 9,543$) of these women were classified as non-GDM, while 22.4% ($n = 2,761$) were diagnosed with GDM. The study aimed to identify risk factors and predictive variables measurable early in pregnancy that could be incorporated into algorithmic models to facilitate timely risk stratification and intervention (Shen et al., 2020).

Table 1. (Information from Table 3 modified from Shen et al., 2020)

ALGORITHMS	ACCURACY	SENSITIVITY	SPECIFICITY	AUCC
SVMd	0.887	0.221	1	0.780
RANDOM FOREST	0.838	0.263	0.936	0.655
ADABOOST	0.882	0.183	1	0.736
kNNE	0.862	0.254	0.965	0.669
NBF	0.878	0.263	0.982	0.774
DECISION TREE	0.841	0.242	0.942	0.614
LR&	0.877	0.258	0.983	0.769
XGBOOSTH	0.882	0.183	1	0.742
GBDT	0.882	0.183	1	0.757

Another study employed alternative predictive models and diagnostic tests to assess the likelihood of developing gestational diabetes. The researchers used a different dataset and implemented various machine learning techniques to improve early prediction accuracy. The performance metrics and comparative analysis of these models are presented in the following table: (Khanna et al., 2024).

Table 2. (Information from Table 4 modified from Khanna et al., 2024)

MODEL	Accuracy	Precision	AUC
LOGISTIC REGRESSION	0.89	0.83	0.94
DECISION TREE	0.93	0.99	0.92
RANDOM FOREST	0.88	0.95	0.98
XGBOOST	0.93	0.86	0.94
SVM (POLY)	0.85	0.82	0.83
KNN	0.95	0.99	0.97
ADABOOST	0.89	0.85	0.92
EXTRATREES	0.72	0.67	0.84
LIGHT GBM	0.93	0.88	0.93
CATBOOST	0.96	0.95	0.95
STACK	0.96	0.99	0.96
HARD VOTING CLASSIFIER	0.93	0.89	0.93
SOFT VOTING CLASSIFIER	0.93	0.89	0.93

4. Discussion

Although the majority of studies did not demonstrate a significant improvement in the clinical management of gestational diabetes mellitus (GDM) through AI-based interventions, the evidence suggests that such tools may represent a viable alternative for patients with limited or delayed access to specialised medical care. Nonetheless, the importance of regular medical oversight and timely therapeutic adjustments by qualified healthcare professionals remains paramount. This is particularly relevant given the current global regulatory frameworks, which impose strict limitations on the decision-making authority of AI systems compared to licensed medical practitioners.

The limited number of studies included in this review, in contrast to other more extensive reviews, is partly due to the relatively recent evolution of legal and ethical standards surrounding the use of AI in healthcare. Only in recent years have regulatory bodies begun to revise legislation to allow increased autonomy for AI-based systems in medical decision-making. This shift has catalysed the development of novel data analysis models and clinical applications.

Currently, artificial intelligence in medicine remains in its early stages of implementation. However, current data indicate that AI-generated results are approaching the effectiveness of traditional clinical practice in certain domains. The most notable strength of AI systems lies in their capacity to process and analyse large volumes of data rapidly, uncovering statistically significant patterns and correlations that may be difficult to detect through conventional means.

These capabilities position AI as a powerful complementary tool in clinical decision-making, with the potential to enhance diagnostic accuracy, streamline patient monitoring, and optimise individualised treatment plans, provided that its use is guided by robust clinical governance and ethical oversight.

An alternative approach could involve genetic testing of the mother during the first trimester of pregnancy, followed by DNA sequencing to identify genes associated with susceptibility to gestational diabetes. Given the large number of both specific and nonspecific genes across different ethnic groups, artificial intelligence could assist in more accurately estimating the risk of developing gestational diabetes. Among the genes identified in relation to gestational diabetes mellitus, TCF7L2, MTNR1B, CDKAL1, IRS1, and KCNQ1 are the most common candidate genes, while other genes appear to be specific to certain ethnic populations.

With the advancement of DNA sequencing technologies and gene identification methods, research should be oriented towards identifying specific genes and reaching a consensus in this regard, as the use of AI could enable faster analyses and clearer results.

Currently, the diagnosis, assessment of treatment effectiveness, and management of the disease are primarily based on measuring HbA1C levels. The quantification of glycated haemoglobin offers the most reliable and comprehensive reflection of long-term blood glucose control, making it an essential indicator in monitoring the patient's overall metabolic balance. For this reason, HbA1C should be used in future research to standardise results and enable the formulation of coherent and comparable conclusions.

5. Limitations

One of the most significant limitations encountered in this review relates to the selection of studies addressing the management of gestational diabetes mellitus (GDM). Each study utilised different blood-based biomarkers as reference parameters, making direct comparisons and result correlation across studies challenging. This methodological heterogeneity precluded the synthesis of unified conclusions regarding the efficacy of artificial intelligence (AI) tools in clinical management.

Furthermore, the findings related to GDM management may be affected by subjectivity, attributable both to the paucity of eligible studies included in the analysis and the variability in interpretation when comparing outcomes across diverse experimental designs.

Another important limitation arises from the relatively recent integration of AI into the field of obstetric endocrinology. The short period of time during which AI has been applied to this pathology has resulted in a limited number of published studies and, correspondingly, small patient populations within individual cohorts. This limits the generalisability and robustness of the results.

Finally, this review also inherits the limitations fundamental in each of the individual studies analysed, including biases in study design, limited follow-up duration, lack of external validation, and potential inconsistencies in the data collection process.

6. Conclusions

In conclusion, artificial intelligence has not yet demonstrated its full clinical potential in the management of gestational diabetes mellitus (GDM). Current applications remain limited in their impact on improving patient outcomes, largely due to methodological heterogeneity and the early stage of implementation.

AI has shown considerable promise in the domain of predictive modeling, particularly through its ability to process large volumes of clinical and biochemical data. This analytical

capacity enables the identification of complex patterns and correlations that can support the accurate early prediction of GDM, potentially allowing for earlier intervention and personalised care strategies. Future research should focus on validating these predictive models in larger, diverse populations and integrating them into clinical workflows under appropriate regulatory and ethical frameworks.

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