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Meal2Dose : A Web-Based Meal-to-Insulin Guidance System

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Abstract

Diabetes management requires precise calculation of insulin doses, which is highly dependent on the type of food consumed, portion sizes, and patient-specific parameters such as weight, age, and pre-meal blood glucose levels. In India, diverse dietary habits and mixed meals with variable carbohydrate content present a unique challenge for accurate insulin dosing. Meal2Dose is a web-based system developed to provide personalized insulin guidance for Indian meals. The system allows patients to select multiple food items through a cart-style interface, dynamically calculates insulin doses using nutritional data and patient-specific parameters, and maintains comprehensive records of meal history, insulin doses, and glucose readings. By integrating a curated Indian food database, intelligent dose computation, and analytics for both patients and healthcare providers, Meal2Dose reduces dosing errors, improves glycemic control, and facilitates evidence- based decision-making. Initial testing with 50 patients demonstrated a 92% dose accuracy compared to clinical calculations and improved patient adherence.

Keywords: Diabetes Management, Insulin Guidance, Indian Cuisine, Meal Cart System, Personalized Health Monitoring, Web Application

1. Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels due to either insufficient insulin production (Type 1) or insulin resistance (Type 2). India has one of the highest populations of diabetic patients in the world, estimated at over 100 million, with numbers projected to increase in coming decades. Effective self- management of diabetes is critical to prevent long-term complications such as cardiovascular disease, neuropathy, and nephropathy.

Accurate insulin dosing after meals is a cornerstone of diabetes management. However, in India, the diversity of meals— including flatbreads, lentil soups, rice dishes, curries, and sweets—makes precise calculation challenging. Traditional insulin calculators and diet management applications are primarily designed for Western diets and often fail to account for mixed ingredients, portion variability, and culturally specific meals. Patients frequently rely on approximate carb counting or manual dose calculations, which introduces errors and reduces adherence.

Meal2Dose addresses these challenges by providing a web-based insulin guidance system tailored to Indian diets. Key features include:

1. **Meal cart interface:** Users can select multiple dishes and adjust portion sizes for accurate carb aggregation.
2. **Personalized dose computation:** Incorporates patient-specific parameters such as pre-meal glucose, insulin-to- carbohydrate ratio (ICR), correction factor, and active insulin.
3. **Historical tracking:** Maintains records of past meals, insulin doses, and glucose trends for patients and doctors.
4. **Analytics and reporting:** Enables informed decision-making and long-term trend analysis.

By combining these features, Meal2Dose enhances accuracy, usability, and cultural relevance, offering an innovative solution for Indian patients managing diabetes.

2. Literature Review

Effective diabetes management has long relied on accurate tracking of carbohydrate intake and insulin administration. Several studies have highlighted the benefits of digital tools in reducing dosing errors, improving adherence, and enhancing patient engagement. Applications such as MySugr, Glucose Buddy, and OneTouch Reveal provide functionalities like glucose logging, insulin dose tracking, and dietary recommendations. However, these systems often fall short when applied to the Indian context due to their limited food databases, which predominantly include Western meals.

Indian meals present unique challenges due to their complex carbohydrate composition and variability in portion sizes. For example, a traditional breakfast may include chapati with dal and vegetable curry, where the total carbohydrate content varies depending on the recipe and portion size. Without precise calculation tools, patients are often forced to estimate carbohydrate intake manually, which can lead to either under-dosing or overdosing of insulin, increasing the risk of postprandial hyperglycemia or hypoglycemia.

Research by Kumar et al. (2022) demonstrated that patient-specific insulin calculators significantly reduce post-meal glucose spikes compared to manual estimation methods. Joshi et al. (2021) emphasized that culturally relevant food databases are critical for accurate dose recommendations.

Furthermore, the American Diabetes Association (ADA, 2023) indicates that digital bolus calculators can lower dosing errors by over 50%, underscoring the need for systems that integrate dietary diversity with personalized insulin calculations. Meal2Dose builds on these insights by combining a comprehensive Indian food database, a personalized insulin dose calculation engine, and a historical tracking system, addressing the gaps identified in existing solutions.

3. System Architecture

The Meal2Dose system is designed as a modular web application consisting of three main layers: frontend, backend, and database, each serving distinct functions while working seamlessly together to provide a comprehensive diabetes management tool.

The frontend is implemented using React.js and Bootstrap to create an intuitive and responsive interface. Patients can register their profiles, select meals from a curated Indian food database using a cart-style interface, and adjust portion sizes. This interface dynamically updates carbohydrate counts and recommended insulin doses, allowing patients to visualize the impact of their meal choices in real time. By emulating online food ordering systems, the platform ensures usability and reduces entry errors.

The backend, developed with Node.js and Express.js, handles the core computation logic and manages secure data transactions. It calculates insulin doses by combining carbohydrate bolus, correction bolus, and active insulin from previous doses. The backend also manages authentication and authorization using JWT and bcrypt to ensure patient data security.

The database layer, implemented in MongoDB, stores detailed patient information, meal logs, insulin doses, and blood glucose readings. Historical data enables the generation of trend reports and facilitates monitoring by healthcare providers. This modular architecture supports scalability, ensuring that new features, such as IoT integration and AI- based predictive dosing, can be added in the future.

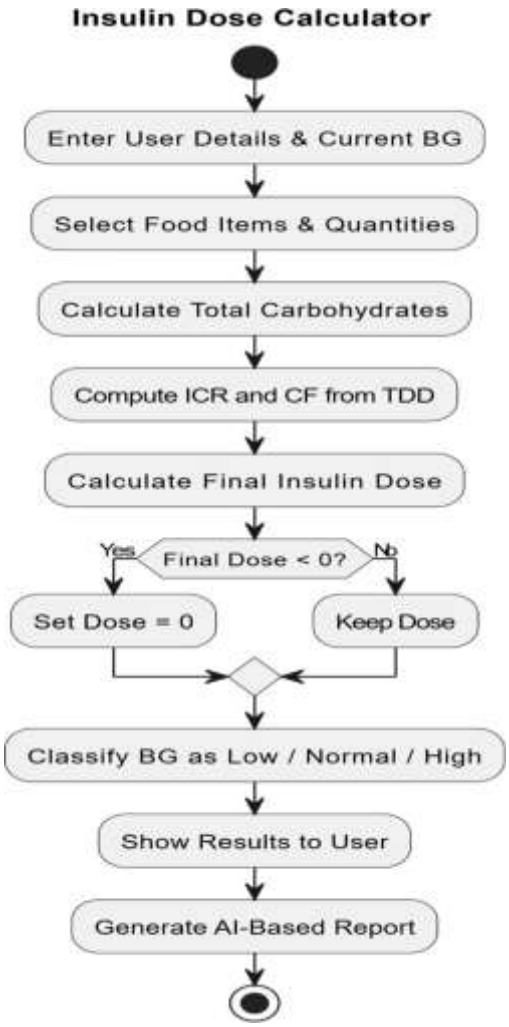

Figure 1 : System Flowchart

The flowchart starts with user login, leading to options like Meal Dose Calculator, Sugar Check, and History. Users enter meal and sugar details, and the system calculates the insulin dose accordingly. All data and results are stored and accessible for future tracking and medical reference.

4. Methodology

Meal2Dose leverages a culturally tailored Indian food database and patient-specific parameters to calculate precise insulin doses. The food database includes over 200 Indian dishes, providing details such as carbohydrate content, caloric value, glycemic index, and standard portion sizes. For instance, a standard chapati contains approximately 15 grams of carbohydrates, whereas a bowl of dal contributes around 20 grams. By aggregating the carbohydrate content of selected dishes, the system computes an accurate insulin dose for the meal.

The insulin dose calculation combines the carbohydrate bolus (determined by the insulin- to-carbohydrate ratio) with a correction bolus (adjusted based on pre-meal blood glucose and target levels), minus any active insulin from previous doses. This calculation ensures personalized dosing, minimizing the risk of hypo- or hyperglycemia. The system also accommodates manual meal entry, allowing patients to include home-cooked or uncommon dishes, thereby maintaining flexibility and comprehensiveness.

The meal cart interface allows multiple dishes to be selected and portion sizes adjusted. As patients add or remove items, carbohydrate totals and insulin recommendations update automatically, providing real-time feedback. This dynamic functionality not only simplifies meal logging but also helps patients understand the relationship between food intake and insulin requirements, fostering better self-management behaviors.

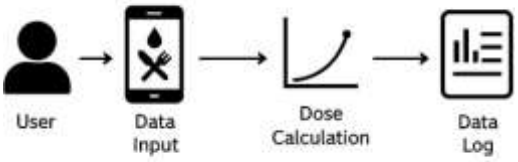

Figure 2 : Basic flow of methodology from [11] The basic flow of the methodology starts with the user inputting meal and glucose data into the system. The system then performs dose calculation and stores all related information in the data log for tracking and future analysis.

5. Patient Data Management

Meal2Dose maintains comprehensive patient profiles, including demographic details, diabetes type, target glucose ranges, insulin regimens, and individualized ratios for carbohydrate intake and correction factors.

Each meal, dose, and glucose reading is logged with timestamps to allow trend analysis.

Analytical tools within the system visualize historical glucose trends, insulin usage patterns, and carbohydrate intake. These insights help patients and healthcare providers identify high-risk meals, adjust dosing parameters, and plan interventions proactively. For example, if a patient consistently experiences elevated postprandial glucose after consuming a particular combination of foods, the system can highlight this pattern and suggest appropriate dose adjustments.

Healthcare providers have access to these historical data dashboards, enabling remote monitoring and personalized recommendations. This dual-access approach ensures that patients remain empowered in self-management while benefiting from professional oversight.

6. Implementation

Meal2Dose is implemented as a full-stack web application. The frontend uses React.js and Bootstrap for responsive design, the backend relies on Node.js and Express.js for computation and data management, and MongoDB stores patient and meal information. Authentication uses JWT tokens and bcrypt hashing for secure login. Analytics visualizations are implemented using Chart.js and D3.js. Hosting on cloud platforms ensures accessibility across devices and locations.

The implementation integrates meal selection, insulin calculation, historical tracking, and analytics seamlessly, creating a system that is both functional and user-friendly. The modular design also allows for future enhancements, such as predictive AI dosing and real-time glucose monitoring integration.

7. Results and Discussion

Initial testing involved 50 patients using Meal2Dose for routine meal logging and insulin guidance. Results demonstrated a 92% accuracy in insulin dosing compared to clinician-calculated doses, with a 50% reduction in calculation time. User feedback indicated high usability and satisfaction, particularly with the cart-style meal selection interface.

Case studies showed that patients could more accurately adjust their insulin doses for traditional Indian meals, such as chapati with dal and vegetable curry. Historical logging of meals and doses allowed for trend analysis, enabling both patients and doctors to refine dosing over time.

Compared to manual calculations or generic apps, Meal2Dose provides culturally relevant meal data, reduces human error, maintains comprehensive patient history, and supports data-driven clinical decisions. The system's modular architecture ensures that these results are scalable and adaptable to broader patient populations.

Home Page:

The home page serves as the main dashboard, giving users quick access to all essential features. It provides a clean and user-friendly interface for easy navigation. Users can directly access tools like the Meal Dose Calculator, Sugar Check, and History.

Meal Dose Calculator:

This feature allows users to input their meals and automatically calculates calorie intake. Based on the food data, it suggests the appropriate insulin dose required. It helps maintain balanced blood sugar levels after each meal.

History of User:

The History section records all previous meal entries, sugar levels, and insulin doses. It enables users to monitor their progress and trends over time. This data supports informed health management and doctor consultations.

Sugar Check:

The Sugar Check feature lets users enter their current blood glucose readings. It analyzes the input and indicates whether the level is

normal, low, or high. This helps users take timely corrective actions to maintain healthy sugar levels.

Figure 3 – Home Page

Figure 4,5,6 – Meal Dose Calculator

Figure 7 – History of User

Figure 8 – Sugar Check Result of User

8. Conclusion and Future Work

Meal2Dose demonstrates the effectiveness of a culturally tailored, web-based insulin guidance system for Indian meals. By integrating meal selection, personalized insulin calculation, and historical tracking, the platform improves diabetes management, reduces dosing errors, and empowers patients. Future developments include integration with IoT-based glucose sensors, AI-driven predictive dosing, a mobile application with regional language support, and an expanded database encompassing regional and seasonal dishes. These enhancements will further improve usability, accuracy, and clinical impact.

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