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Sodium Counting System in Mass Catering for Therapeutic Diet Preparation

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***Abstract*— Sodium is a well-known substance to enhance food taste, but the intake must be restricted, especially for patients who require a low-sodium diet. The amount of added salt in cooking can be optimized and controlled by calculating the total sodium in the ingredients used. This process is cumbersome for hospital meal catering, in which food is prepared based on the number of daily orders and specific diets. The existing solution uses a spreadsheet for calculating the amount of sodium, which is vulnerable to errors and not user-friendly. This paper presents a systematic system that can monitor and control the amount of sodium during meal preparation for hospital catering. The system consists of two main parts: a desktop application and an automated salt dispenser. The application keeps track of sodium usage based on the final ingredient list and the meal plan, thus allowing the catering officer to check the feasibility of changing the sodium amount needed for cooking without doing any manual calculations. The application is then integrated with a salt dispenser to ensure the salt amount used in the cooking is as intended. The successful implementation of this system supports Malaysia's 2021–2025 salt reduction strategy to prevent and control Non-Communicable Diseases (NCD). It is also consistent with SDG 3: Good Health and Well-Being, which calls for a global decrease in salt intake of 30%.**

***Keywords*— Sodium control; salt dispenser; mass catering; desktop application.**

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I. Introduction

Mass catering in therapeutic diet preparation at hospitals is a specialized service that provides tailored meals to patients with specific dietary needs. The process begins with assessing each patient's nutritional requirements, considering their medical condition and dietary restrictions. A team of dietitians, chefs, and catering officers collaborates to design and prepare meals that meet the prescribed therapeutic diets. While the primary focus is on meeting the specific dietary requirements, meals should be tasty to enhance the overall dining experience for patients, promoting better appetite and reducing food waste. The study conducted by Chik et al. [1] has highlighted that plate waste generation, a type of food waste, is significantly influenced by temperature and taste. These findings align with another study by Osman et al. [2], which revealed patient dissatisfaction with the taste of hospital food. According to the staff, it is because salt usage can be little to none and sometimes not used, depending on the prescribed diet. The government hospital in Malaysia follows the hospital diet manual published in 2016, which also suggests that a low-sodium diet is prepared without salt and avoids ingredients high in sodium [3].

Dietitians from Sultanah Fatimah Specialist Hospital (HPSF) Muar have emphasized that food taste can be better by optimizing sodium content in cooking. To help resolve the concern about food waste and patient dissatisfaction with the food served, the Department of Food Service and Dietetics (DFSD) of HPSF created a D-Salt calculator using a spreadsheet [4]. The calculator helps them appropriately decide and maximize the use of salt and high-sodium ingredients in mass cooking. It adopts the sodium point system introduced by Malaysia's Ministry of Health (MOH) in the Salt Reduction Strategy to Prevent and Control Hypertension policy. According to the sodium point system, each individual may consume a maximum of 10 sodium points daily, where 1 point of sodium is equivalent to 200 mg. The D-Salt Calculator aims to ensure that patients consume a maximum of eight sodium points daily, as the sodium points may come from natural foods and unprocessed, uncooked, or unprepared items.

The spreadsheet requires a user to fill in the blank template shown in Fig. 1 before allowing others to use the calculator. They may create separate menu pages for each day using the template. According to Fig. 1, several pages have been created to differentiate each day's menu.

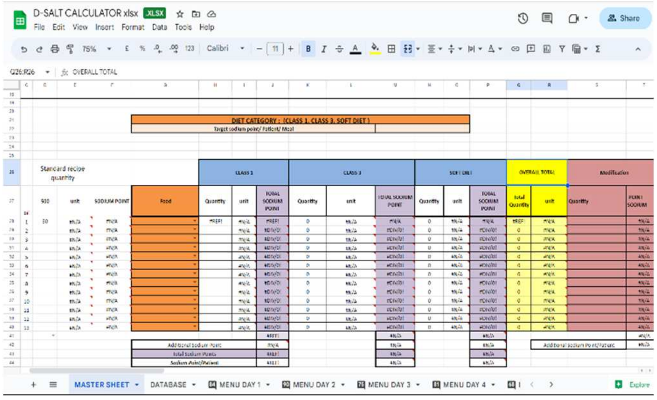

Fig. 1 Blank template of D-Salt Calculator [4]

When menu pages are ready, the user may update the number of patients for each class in the table illustrated in Fig. 2. Apart from updating the number of patients. The table also allows users to revise the menu and sodium point's target for each menu.

CLASS 1									
NUMBER OF PATIENTS	MEAL TIME	MENU	TARGET *SODIUM POINT*	*TOTAL SODIUM POINTS/* SERVING	MENU	TARGET *SODIUM POINT*	*TOTAL SODIUM POINTS/ SERVING*	*SODIUM POINT/ PATIENT/ MEAL TIME*	TOTAL SODIUM POINT/ PATIENT/ DAY
70	LUNCH	Soy sauce chicken with tomatoes	1.0	73	FRIED JAPANESE MUSTARD	1.7	113	2.7	6.6
20	TEA TIME	TOAST PUDDING & CUSTARD SAUCE	1.1	19				1.0	
45	DINNER	GRILLED KUZI CHICKEN	1.50	64	FRIED CURLY MUSTARD	0.85	27	2.0	*sodium point balance*
20	BREAKFAST	WHOLEMEAL BUN	1	19				1.0	1
TOTAL TARGET SODIUM POINT/ PATIENT/ DAY									7.2

Fig. 2 Interface to update no. of patients, menu, and sodium point target [4]

Additionally, the D-Salt Calculator enables users to optimize the sodium content of each meal using the pink column of the spreadsheet section shown in Fig. 3. The yellow column suggests the quantity of each ingredient based on the updated number of patients. For example, if the standard recipe requires 100 pieces of chicken for 100 people, the yellow column updates the quantity of chicken to 120 when there are 120 patients.

				VERIFICATION 3/29/22 PASS					
				DINNER: POTATO SOY CHICKEN (SOFT DIET)					
				Target *Sodium Point*/ Patient/ Meal				2.2	
				NUMBER OF PATIENTS		120			
	Quantity				SOFT DIET			MODIFICATION	
No.	100	unit	*SODIUM*	Food	Quantity	unit	TOTAL SODIUM	Quantity	*SODIUM*
1	100	pcs	0	Chicken	120.0	pcs	0		0
2	600	g	0	Onion	720.0	g	0		0
3	150	g	0	Garlic	180.0	g	0		0
4	50	g	0	Ginger	60.0	g	0		0
5	1000	ml	160	Sweet soy sauce (20	1200.0	ml	192	1000	-32
6	2	g	0	Star anise	2.4	g	0		0
7	500	g	0	Potato	600.0	g	0		0
8	1000	g	0	Tomatoes	1200.0	g	0		0
9	30	g	0	Lemongrass	36.0	g	0		0
10	50	g	0	Cornflour	60.0	g	0		0
11	300	ml	0	Cooking oil	360.0	ml	0		0
12	3000	ml	0	Water (3000ml)	3600.0	ml	0		0
13	3	packet	60	Fine Salt (10g)	3.6	packet	72	5	28.00
							264		-4
				Additional Sodium Point			-4.00		
				Total *Sodium Point*			260		
				***Sodium Point*/Patient**			2.17		
				Target *Sodium Point*/meal:			**264**		
				Sodium Point balance			4		
				Max added salt allowed (g)			2		

Fig. 3 Interface to adjust sodium amount [4]

Based on Fig. 3, the yellow column suggested a 3.6 packet of salt for the menu, but the user modified it to five in the pink column. Since adding 1.4 salt packets equals 28 sodium points, the "SODIUM" pink column automatically adjusts the additional sodium amount to 28. The cell beside the one labeled "Sodium Point balance" turns green, indicating that users can still add sodium to the recipe. Otherwise, the cell will turn red to show that the maximum sodium limit has been reached.

Although the taste of the food has reportedly improved, the manual sodium optimization and calculation process is inconvenient, lacks user-friendliness, and is prone to human error. Users must understand the functionality of each table, which can be a challenge. The calculator is also vulnerable to errors, as users can modify the content of each cell. The functionalities available for different users are undistinguishable, which may lead to unauthorized edits. Therefore, the current solution needs improvement to streamline the process of meal planning and sodium control.

To simplify the optimization and calculation of sodium content and make it accessible to dietitians, chefs, and catering officers involved in therapeutic diet preparation, we propose the implementation of a Sodium Counting System by leveraging Internet of Things (IoT) technology. The system consists of two parts: i) a desktop application for recipe standardization and sodium content control. ii) a salt dispenser that dispenses the amount of salt according to the desktop application.

After a comprehensive search of academic databases, most software found for hospital food service usage was related to meal ordering [5]–[9]. The implementation of electronic food service management systems has increased over the past ten years to support food procurement, food preparation, meal ordering and delivery, allergen management, and food service model transformations [5]. For example, Bedside-spoken meal ordering systems (BMOS), web-based systems, and electronic menus (e-menus) using bedside TV screen systems are the new menu systems aimed at replacing the paper form of meal ordering. BMOS requires staff to visit each patient at the bedside, discuss menu choices, and record orders on a mobile device. This increases the need for personnel and resources and improves patient engagement and nutrition intake [10]. Other systems, such as web-based [6], [9], and e-menus [7], offer greater patient control but may not be suitable for all patients depending on factors like hospital infrastructure and patient preferences.

Apart from the meal ordering system, a digitized service platform called DiDiER was developed to increase requests for dietary counseling, improve service providers' workflow, and personalize dietary plans for patients with increased health risks due to malnutrition and food allergies [11]. The system provides a cloud-based service platform for nutritionist usage and a secure home cloud equipped with an intelligent sensors system for patients. The project highlights its feature of storing patients' data locally in a personal home cloud, giving full authority to the patients on which data to share with the nutritionist. The papers reviewed in this section have specific roles and provide benefits for healthcare in improving patient satisfaction towards meal ordering and enhancing the workflow of the dietary counseling service. However, none of the mentioned software has sodium-counting functionalities. Therefore, it shows a research gap and the need for further research and development of sodium counting software.

Three desktop applications were also evaluated to determine vital features for accurate sodium counting and efficient meal planning. The apps are Sodium in Foods, SideChef: Recipes+Meal Planner, and Sodium Tracker & Counter. The Sodium in Foods app helps blood pressure patients track sodium intake with over 8,000 foods labeled with sodium content in milligrams [12]. The app also includes health tools like BMI and Macronutrient calculators, allowing users to mark favorite foods and maintain grocery lists. However, it does not offer meal planning features, limiting its practicality for this purpose.

The SideChef: Recipes+Meal Planner app offers a range of user-generated recipes with step-by-step instructions, customizable meal plans, and ingredient management tools [13]. However, the quality and accuracy of user-contributed content may vary, and some features are behind a paywall. Internet access is required to use the app, and it may not be suitable for mass catering due to limitations in serving size.

Sodium Tracker & Counter specializes in monitoring users' sodium intake and allows them to set daily limits. It offers comprehensive reporting, target setting, and notifications to facilitate consistent sodium monitoring [14]. However, the app relies on the user's manual input for the food database, leading to potential measurement errors. The search feature within the app has a long delay, and maintaining a consistent record of meals can be challenging for users. While Sodium Tracker & Counter is beneficial for individual sodium counting, it may not be suitable for calculating sodium for meal prepping or mass catering purposes. Overall, these reviews provide valuable insights into the strengths and limitations of each app, serving as a valuable resource for an effective Sodium Counting System for mass catering in therapeutic diet preparation.

In developing hand sanitizer dispensers, Das et al. [15] suggest using a light-dependent resistor (LDR) sensor to detect the proximity of human hands instead of an ultrasonic sensor and infrared sensor because both sensors may malfunction when deployed in busy places due to the interference of sunlight and vehicle sound. The dispenser pumps and sprays sanitizer when the laser light inside the detection chamber is interrupted by the user's hand. This condition happens because the distraction of the laser light increases the voltage gain from the LDR sensor. The system also used components such as the L298 Motor driver, Arduino UNO, water pump, and barrel power connector. Their dispenser featured delay timers to prevent wastage, liquid level indicators, and LEDs for pump operation and sanitizer level indication. Apart from the LDR sensor and laser usage, sanitizer level checking can be considered for the salt dispenser development. However, the water pump usage may not be suitable as salt is a fine powder, not liquid, which makes it impossible to be pumped using the pump implemented in this paper.

Arumugam et al. [16] proposed the design of an automated medicine dispenser for the use of pharmacies by incorporating the Arduino Pro mini with RFID technology and a Global System for Mobile Communication (GSM) module. It works by preloading the RFID tag with patient information. The RFID reader is then used to read the information in the RFID tag. The Arduino Pro mini processes these data and controls a gear motor to open the specific medicine tray based on the data processed. The customer gets to know the details of the medication prescribed through an LCD and the billing amount through a mobile phone, which data is transmitted using a GSM module. This proposed design, therefore, automates the workflow of medicine dispensation, which eases the service provider.

Another medicine dispenser, by Philip et al. [17], is developed due to human forgetfulness. The paper proposed the design of an automatic medicine dispenser to remind users of medicine consumption using IoT technology. Instead of waiting for input from the user to dispense medicine, as illustrated in the previous medicine dispenser, this IoT-based medicine dispenser utilizes the RTC (real-time clock) module to output medicine based on the set time. It does not use RFID technology to differentiate multiple medications because it focuses only on one liquid and one solid type. The centrifugal pump and servo motor are controlled respectively by the Arduino Uno to dispense medicine from liquid and pill containers.

The Smart Pet Food Dispenser by Jain et al. [18] automates and optimizes the feeding of pets by combining sensors, motor control, RFID recognition, and a real-time clock. The light sensor allows the dispenser to differentiate between different times of the day and adjust its operations accordingly. The RFID system inclusion to read the pet's tag helps to ensure that only authorized pets receive food from the dispenser. Furthermore, the two integrated infrared sensors in the food container allow the dispenser to measure the food level, and the servo motor used for food dispensing offers control over the amount of food dispensed. Lastly, the RTC implementation enables scheduled and regular feeding times, guaranteeing the pet eats at the proper intervals. Overall, the dispenser has well-thought-out features and functionality. It provides advantages such as consistent portion sizes, overfeeding prevention, and ease for pet owners who could have hectic schedules or need to be away from home a lot.

These dispensers demonstrate innovative approaches to automation and offer practical benefits in their respective domains. The hand sanitizer dispenser promotes hygienic hand sanitization practices, the medicine dispenser streamlines the medication handling process and helps to discipline users to consume medicine, and the pet food dispenser simplifies pet feeding routines. Although none of the dispensers shows a direct application of salt dispensers, the features such as touchless operation, dispensing mechanism and sensor integration can be a reference to identify suitable components for the automated salt dispenser.

II. Materials and Method

This section outlines the steps crucial for the Sodium Counting System development. Fig. 4 illustrates the general flow of this research. The dietitians and catering officers from the HPSF's Food Service and Dietetics Department were interviewed on the processes involved in meal preparation at the hospital. It can be summarized into six activities:

- Receive/Store/Issue: to manage the ingredients in the kitchen
- Packaging: recipe ingredients are packed and labeled

- Preparation: all ingredients for cooking are prepared
- Cooking: Menu and standard recipes are referred
- Serving: Food is served according to the ward and diet class
- Cleaning: all utensils, places, and trays used are cleaned

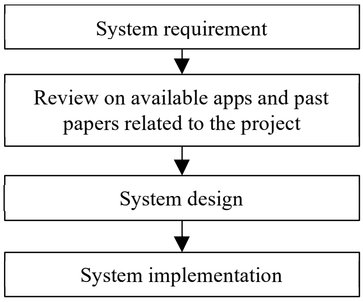

Fig. 4 Flow of project methodology

The scope of the proposed system focuses on the packing and preparation activity. Fig. 5 shows the activities included in the Sodium Counting System. The salt dispensing function is added to the current system to help them prepare salt automatically after controlling the amount.

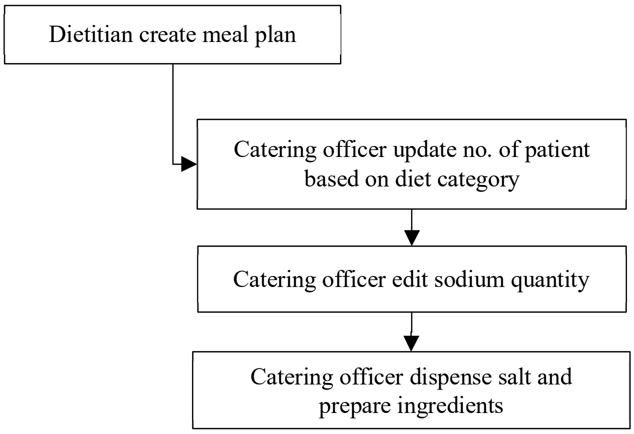

Fig. 5 Activities Involved in Sodium Counting System

Through visits to the DFSD of HPSF Muar, we also learned to use the D-Salt calculator and observe the work involved at the department. Table I shows the user requirement for the sodium counting system.

TABLE I
SYSTEM REQUIREMENT FOR SODIUM COUNTING SYSTEM IN MASS CATERING FOR THERAPEUTIC DIET PREPARATION

No.	System requirement	Justification
1	The app should be compatible with desktop	To allow them to use the existing desktop provided at the department.
2	The app should differentiate user roles	To control access to app features and functionalities
3	The catering officer should not have access to all features	So that the catering officer can focus on the activities in Fig. 5 (update no. of patients, edit sodium quantity, dispense salt) and not have access to edit the meal plan
4	The app should provide a friendly user interface	To help users understand and use the app easily
5	The app should have a meal-planning function.	To allow dietitians to plan and target total sodium points consumed by the patients.
6	The app should allow the user to update the number of patients	To avoid the overproduction of food
7	The app should allow users to control and check the amount of sodium suitable to be added for cooking.	To allow sodium maximization.
8	The dispenser should only dispense the amount of salt indicated by the apps and does not allow manual dispensing.	To restrict salt usage in the kitchen

The IoT framework incorporates four main components: the sensors and actuators, connectivity, data processing, and user interface [17]. Connectivity allows the system to pass information between the components available. Fig. 6 shows the features of IoT connectivity technologies in terms of data rate, coverage, and latency [19].

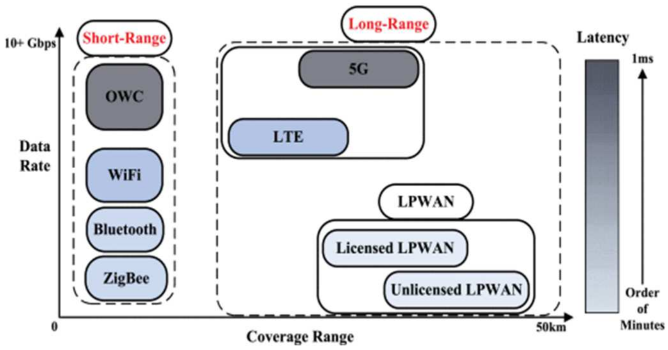

Fig. 6 Illustration of features of the IoT connectivity technologies in terms of data rate, coverage, and latency [19]

Based on Fig. 6, the connection methods can be classified based on coverage range. Bluetooth, ZigBee, Wi-Fi, and OWC have a short coverage range, which supports connectivity within a small area. Cellular and LPWAN support wide-area communication as they have a higher coverage range. It also shows that 5G, LTE, OWC, and Wi-Fi has higher data rate and offers lower latency compared to Bluetooth, ZigBee, and LPWAN technologies. Specific criteria like data rate, latency, coverage, power, reliability, and mobility should be considered to choose an appropriate IoT connectivity. These requirements coincide with one another and could affect the system's performance.

The wide application of Bluetooth connectivity in IoT-based projects [20]–[23] shows that the option is popular. Apart from being easy to implement, Bluetooth can send data up to a distance of 700 cm [21], which is enough for our system. Fig. 7 shows the system architecture of the Sodium Counting System for Mass Catering in Therapeutic Diet Preparation. It incorporates a desktop application, a salt dispenser, a Bluetooth connection, and local storage.

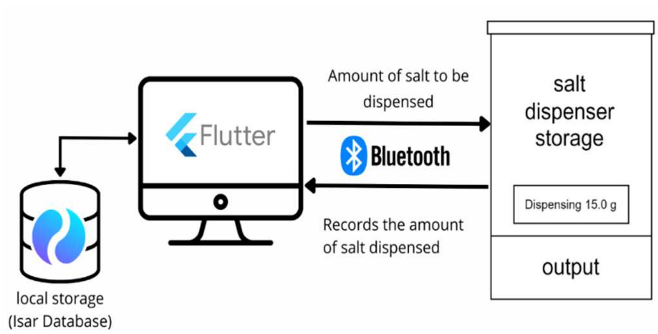

Fig. 7 System Architecture of Sodium Counting System

The desktop application serves as the user interface, allowing hospital staff to manage sodium usage in food preparation, customize meal plans, standardize recipes, and control the salt dispenser. The application is developed specifically for desktop use to provide a familiar and accessible platform for the staff to perform their tasks effectively. The salt dispenser plays a crucial role in storing and dispensing salt accurately. It is connected to the desktop application via Bluetooth, enabling wireless communication between the two components. The dispenser consists of a salt container and a dispensing mechanism triggered by the desktop application, ensuring precise dispensing of the desired amount of salt for each meal. A Bluetooth connection is employed to transmit data and commands between the desktop application and the salt dispenser to establish reliable communication. This approach is chosen over Wi-Fi due to potential connectivity challenges in hospital environments. The Bluetooth connection enables the application to send instructions for salt dispensing and receive real-time status updates from the dispenser, ensuring efficient coordination between the components. By incorporating these components and technologies, the Sodium Counting System may streamline sodium control, enhance meal planning, and improve the overall efficiency of therapeutic diet preparation in mass catering settings.

A. Software Design

The software design categorizes user roles of the desktop app into two categories: dietitian and catering officer. Each user role has different access to the desktop app's features. Table II shows the features available in the desktop app based on the user role.

TABLE II
FEATURES AVAILABLE BASED ON USER ROLE

Features	**Roles**	
	Dietitian	**Catering Officer**
Manage and standardize the recipe.	✓	
Customize meal plan	✓	
Add diet category	✓	
Update no. of patient.	✓	✓
Adjust sodium content	✓	✓
Dispense salt	✓	✓

The dietitian role has access to all of the desktop app's features, providing them with comprehensive control over the desktop app. They can manage and control the sodium content in food, customize meal plans, standardize recipes, adjust the salt dispenser, and update the number of patients. On the other hand, the catering officer role has a more focused set of features essential to their responsibilities. They can adjust the sodium content in the food, dispense salt using the salt dispenser, and update the number of patients regularly. Fig. 8 shows the designed flow for the desktop app.

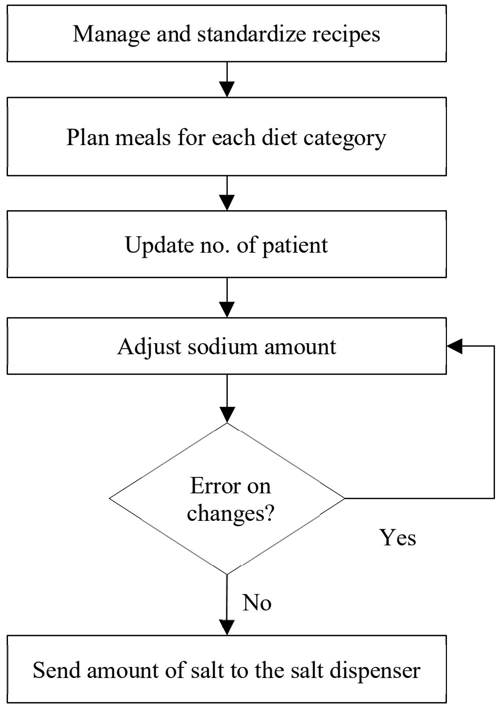

Fig. 8 Desktop app flow

Materials and tools used for the desktop app development:

- Flutter
  Flutter offers a rich set of UI components and widgets, enabling developers to create visually appealing and interactive user interfaces. The framework's "hot reload" feature allows for real-time code changes and instant updates to the app's interface, providing a faster development and debugging process [24]. The Sodium Counting System leverages Flutter's customizable UI elements to design an intuitive and user-friendly interface.
- Visual Studio Code
  Using VS Code for coding app offers a familiar and efficient coding experience with its user-friendly interface and extensive community support [25]. It integrates seamlessly with Flutter's development tools, allowing smooth workflow.
- Supabase
  It provides several authentication options, including email and password-based authentication, third-party providers, and social login integrations (like Google and Facebook) [26]. Sodium Counting System utilizes Supabase to achieve secure and reliable user authentication.
- Isar Database
  The desktop application, developed using the Flutter framework, utilizes the Isar Database as the local storage component. Leveraging the Isar Database provides the application with fast querying capabilities,

allowing quick data retrieval based on specific criteria or conditions [27].

- Draw.io
  A free and open-source cross-platform graph drawing software developed by Seibert Media [28]. We initially used this tool to design the user interface of the desktop app.
- Canva
  An online graphic design tool for creating beautiful assets and visual representations [29]. We used it to improve the UI design and present a clearer idea to the stakeholders.

B. Hardware Design

This section presents the design and materials used for the Sodium Counting System's automatic salt dispenser. The overall flow of the designed salt dispenser is provided in Fig. 9. Once the salt dispenser is powered on and connected to the desktop app via Bluetooth, it will check whether there is a value of the salt amount received from the desktop app. The salt dispenser will prompt the user to refill the storage if the salt left is below the minimum level set. The salt dispenser proceeds to dispense when there is enough salt storage. Otherwise, it will prompt the user to refill if the salt storage is below the minimum level set.

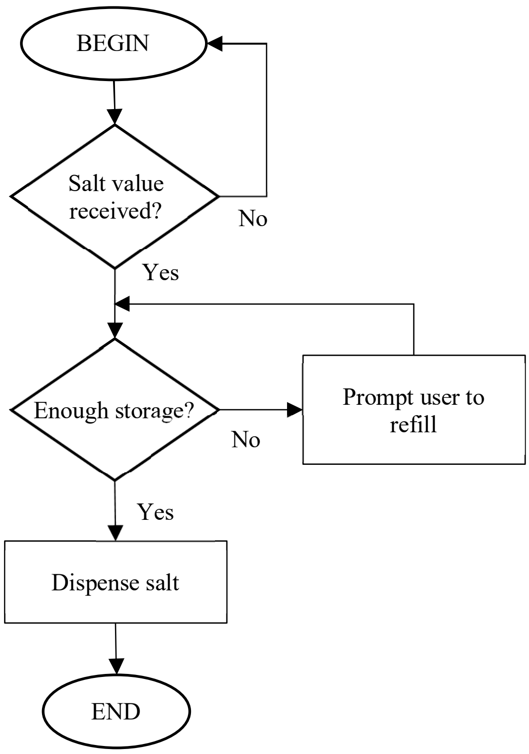

Fig. 9 Salt dispenser flow

Materials and tools used to develop the salt dispenser:

- Arduino Integrated Development Environment (IDE)
- DOIT ESP32 DEVKIT V1 Board
  The development board is based on the ESP32 microcontroller, and it supports wireless connectivity for Wi-Fi, Bluetooth Classic, and Bluetooth Low Energy (BLE) [30]. It is chosen due to the low cost, ease of use, wireless connectivity, and Arduino compatibility.
- Load cell and HX711 modules
  Two load cells, one with a 20 kg capacity and another with a 5 kg capacity, along with their respective HX711 modules, are utilized to measure the salt amount available in the storage of the dispenser and the weight of salt dispensed, respectively.
- Ultrasonic sensor
  An ultrasonic sensor is integrated into the salt dispenser to determine if a cup or container is present, ensuring that salt dispensing occurs only when a cup is detected.
- LCD I2C
- LED RGB module
- Servo motor SG90
- Buzzer
- Power supply
  The voltage regulator module, switch, and 9V rechargeable battery ensure a reliable power supply to the salt dispenser. The voltage regulator module regulates the input voltage to 5V to provide stable power to the system. The switch allows convenient on/off control, conserving battery power when not in use. The 9V rechargeable battery is used, as it is suitable to operate the salt dispenser.

Physical testing, taring, and calibration are done to avoid getting false readings from the load cells. The cables, load cells, and connections to HX711 are inspected. According to the datasheets, the precision of the 5kg load cell is 0.02%F.S, while the 20kg load cell is 0.05%F.S. Before connecting the load cells with another part of the circuit, the load cells are tested, and the readings are compared with a digital scale of 10kg capacity and a precision of 1 gram. A maximum of 500 g load is used. The 5kg load cell has the same reading as the digital scale for every test compared to the 20 kg load cell. It is because the 20kg load cell reads a higher value better. The less accuracy of the 20kg load cell in reading load with small values can be tolerated because it will only need to check a minimum of 5kg.

III. Results and Discussion

A. Desktop App- PlanPrep

With the help of the Desktop app – PlanPrep, the sodium maximization process, and dispensing can be automated. The desktop app featured four main screens: Prep Meal page, Plan Meal page, Standard Recipes page, and Salt Dispenser page. Following the software design, the PlanPrep app allows dietitians to access all the screens or pages. However, for the catering officer, the Plan Meal page is not accessible, and on the Standard Recipe Page, they can only view the available recipes. Fig. 10 shows the Plan Meal page, where the dietitian can plan meals or manage the diet categories. When designing a meal plan, the dietitian can add menus for different diet categories, specifying the meal time and day. During meal planning, if the total sodium point of the meals throughout the day exceeds eight points of sodium, the app will prompt the user to adjust the plan, ensuring adherence to the prescribed limits. This prescribed limit is eight since the dietitian from HPSF Muar suggested it as the maximum sodium consumption amount allowed for each patient.

The Plan Meal page's app bar has a button for the dietitian to choose which day to plan the meal. The mini navigation bar of the page lists all the diet categories available. It also has a button to edit the diet category at the bottom. From Fig. 10, the dietitian chose to create a meal plan for Class 2. They added "Fried Kuey Teow" for breakfast and "Corn rice and red-cooked chicken" for lunch. The total sodium is unavailable because the meal plan is not complete. A "Duplicate this plan" is also provided on the page, so the dietitian can easily copy the same menus for other diet categories they want.

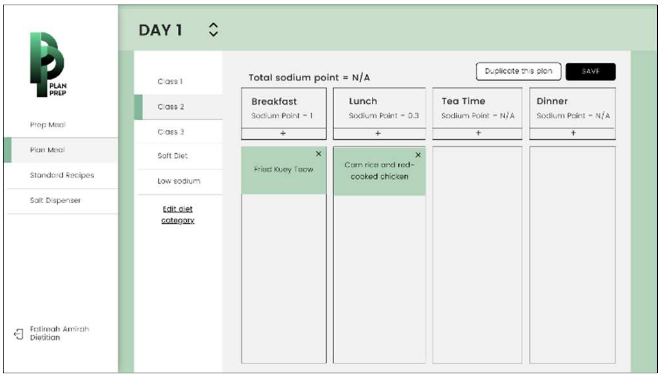

Fig. 10 Plan Meal page of PlanPrep app

Alternatively, selecting the Standard Recipe page allows the dietitian to perform various actions such as viewing, creating, editing, or deleting recipes. When creating a new recipe, the dietitian is prompted to provide essential details such as the recipe name, mealtime, serving size, and ingredients, as shown in Fig. 11.

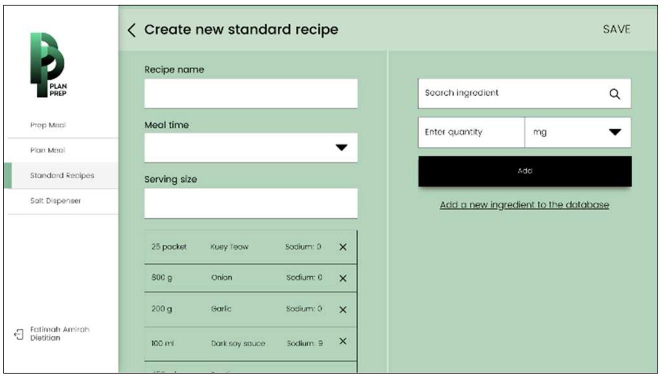

Fig. 11 Standard Recipe page of PlanPrep app

To add ingredients to the standard recipe, the dietitian may search for it on this page by using the Search ingredient function and entering its quantity. The added ingredients are listed below the serving size's text field with their quantity and sodium content. If the searched ingredient is unavailable, the dietitian may add it to the database by clicking the text button under the "Add" black button.

Furthermore, both users, dietitians, and catering officers, can view the records of salt dispenser usage after logging in to the app, providing valuable insights into the sodium utilization process. Based on Fig. 12, the Salt Dispenser page displays the record of the salt dispenser usage with the date, time, and amount of salt dispensed.

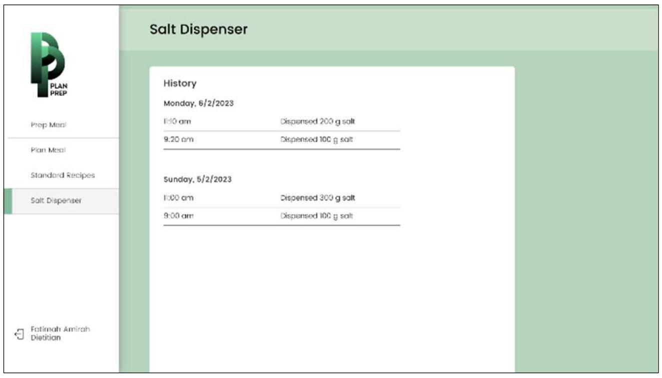

Fig. 12 Salt Dispenser page of PlanPrep app

Fig. 13 shows the Prep Meal page with only three options on the navigation menu bar as the catering officer logs in to the app. The Prep Meal page facilitates the meal preparation process, ensuring consistent execution in line with the planned menus and dietary requirements. Based on Fig. 13, the catering officer can see a table of meal plan summaries for the day. Catering officers can use the white button at the app bar to update the number of patients and the black button to go to the Prep Ingredient page.

Fig. 13 Prep Meal page PlanPrep app

Fig.14 presents the Prep Ingredient page for lunchtime. A list of the menus that should be cooked for lunch is displayed at the side navigation bar. When the catering officer chooses to prepare "Soy sauce chicken with tomatoes", for example, the Prep Ingredient page lists the ingredients required for the meal. Ingredients containing sodium have a button at the side for users to adjust their amount. The app will check the feasibility of the changes and warn the user if the changes are unsuitable. Once the app is error-free and warning-free, it will enable the Dispense Salt button, and the user can click it to dispense salt through the salt dispenser.

The PlanPrep app is tested and compared with the D-Salt Calculator by the DFSD of HPSF Muar. We found that the PlanPrep app holds several benefits. Firstly, the changes from rows and columns to a beautiful and organized interface have improved the user experience because they can understand the app easily. For example, the function for estimating the maximum sodium for cooking has become clear to the catering officer. The risk of unauthorized editing of the standard recipes, meal plan, and ingredient amount has been reduced, as authorized users are the only user entitled to access the PlanPrep app.

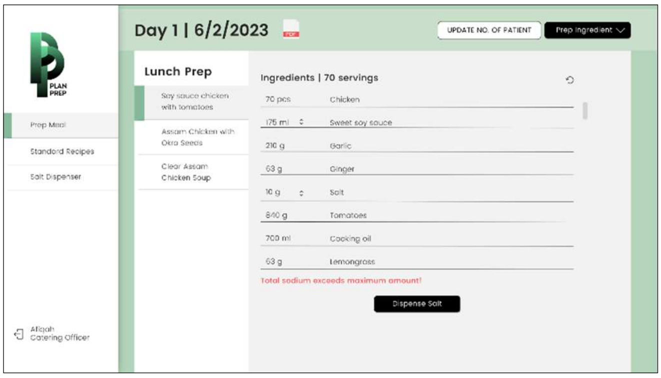

Fig. 14 Prep Ingredient page of PlanPrep app

The PlanPrep development also makes integration with other systems, such as the Salt Dispenser, possible. Upon using the PlanPrep app, the user agreed that more options are available with the app compared to the D-Salt Calculator, as previously, they only used rows and columns, limiting their ability to control the data presentation. To summarize the findings, Table III is presented.

TABLE III
COMPARISON OF D-SALT CALCULATOR AND PLANPREP APP

Feature	D-Salt Calculator	PlanPrep app
Security	Vulnerable	More secure
User experience	Difficult to use	Easy to use
Integration with other systems	Difficult to integrate	Easy to integrate
Scalability	Limited	Scalable

The PlanPrep app differs from reviewed software [12]–[14] in several significant ways. First, it incorporates a meal plan feature. Dietitians can create meal plans tailored to specific dietary requirements and restrictions. Additionally, the app's automated calculations streamline the controlling process of the sodium content in meals. By automating calculations, the PlanPrep app reduces the potential for human error and improves the precision and consistency of sodium measurement and control. The flexibility of serving sizes is another important feature. Unlike existing software, which restricts serving size [13], the PlanPrep app allows dietitians to determine the standard serving size based on their expert judgment.

B. Salt Dispenser

The preparation process of salt for mass cooking is automated with the help of the salt dispenser. The salt dispenser featured several functionalities such as weighing salt, displaying status on LCD, detecting the presence of a cup, and opening the dispenser's outlet to achieve the primary function of the dispenser, dispensing salt. Fig. 15 shows the prototype of the Salt Dispenser. The proposed hardware design is installed on a rice dispenser to demonstrate the functionalities of the salt dispenser.

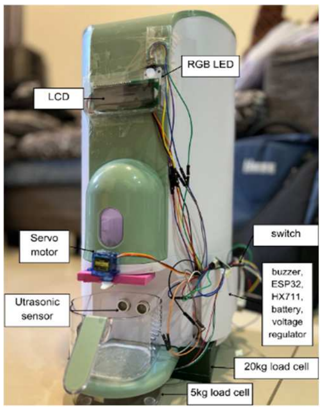

Fig. 15 Prototype of automatic salt dispenser

This salt dispenser functions as described in Table IV. The weight of salt in storage is measured by the 20kg load cell, while the weight of salt dispensed is measured by the 5kg load cell. The LCD I2C displays 'READ', and the RGB LED will be green-colored to indicate that the dispenser is ready after checking that salt storage is sufficient and the device is connected to the app over Bluetooth. Else, the visual indications change as described in Table IV. Next, the motor will only rotate to dispense salt when salt data is received from the app, salt storage is sufficient, and a cup is present. While the dispensing process occurs, the system will check the cup's presence and the salt's weight in storage to rotate the motor and close the opening of the dispenser whenever required. Lastly, the dispensing process is completed by having the motor close the outlet of the salt dispenser, an LCD to display 'COMPLETE', an LED to be green, a buzzer to play sound, and an ESP32 to send the weight of dispensed salt to the app.

The salt dispenser is distinguishable from the reviewed dispensers [15]–[18]. Firstly, the salt dispenser features an ultrasonic sensor instead of LDR sensors, as used in the prior hand sanitizer dispenser, to detect the presence of cups or other containers. This is because the place to put the salt dispenser is less busy and has fewer distractions. Next, the salt dispenser incorporates a load cell to measure the salt left in the dispenser's storage. As consumers can clean the container in the future, this approach helps maintain cleanliness and hygiene. The previous system, the Smart Pet Food Dispenser by Jain et al. [18], used two infrared sensors inside the container for measuring and observing storage, which is a downside for maintaining cleanliness. Apart from the differences, the salt dispenser follows the available dispensers by including a servo motor to control its opening.

Salt dispenser integration with the PlanPrep app created a seamless system that enhances sodium counting and dispensing efficiency and accuracy. The salt dispenser, equipped with sensors, actuators, and an ESP32 microcontroller, communicates with the PlanPrep app via Bluetooth connection. This integration enables real-time data exchange between the app and the dispenser, facilitating precise control over sodium measurement and dispensing.

TABLE IV
THE OUTCOME FROM SALT DISPENSER

Condition	Outcome
Salt storage is less than 5kg	• LED = red • LCD = "Please refill"
The salt dispenser is not connected to the PlanPrep app	• LED = red • LCD = "Please pair with desktop"
Salt storage is more than 5kg, and the device is connected to the PlanPrep app	• LED = green • LCD = "READY"
Data received over Bluetooth, salt storage is more than 5kg, and the cup is within 2cm from the ultrasonic sensor	• LED = blue • LCD = "Dispensing (the data received in gram)" • The motor is rotated to dispense salt
Salt dispensed is equal to or more than data received from PlanPrep	• LED = green • LCD = "COMPLETE" • The motor is rotated to close the opening of the dispenser • Buzzer plays sound • Weight of dispensed salt is sent to the PlanPrep app
Data is received over Bluetooth, but salt storage is less than 5kg	• LED = red • LCD = "Please refill"
Data was received over Bluetooth, but the cup is not within 2cm from the ultrasonic sensor	• LED = red • LCD = "Place cup" • The motor is rotated to close the opening of the dispenser

IV. CONCLUSION

In conclusion, the Sodium Counting System for Mass Catering in Therapeutic Diet Preparation presents a comprehensive and efficient solution to address the challenges faced by healthcare facilities in providing tailored meals to patients with specific dietary needs. Through the integration of IoT technology, the system simplifies the sodium counting process, enhances user-friendliness, and reduces the potential for human error.

The developed desktop application, PlanPrep, facilitates meal planning, recipe management, and sodium calculation, empowering dietitians and catering officers to optimize sodium usage and enhance the taste of hospital food. Estimating the maximum amount of salt to be added in mass cooking has become more straightforward, and the work involved has become simpler. The desktop application usage also accommodates the staff's preference for hospital-provided devices and improves data security by storing data on the device's local storage. The created salt dispenser also ensures that the sodium levels used during meal preparation are as intended.

PlanPrep app and salt dispenser also have some limitations. Firstly, as the PlanPrep app is dependable on local storage, the data cannot be synchronized if the app is to be installed on multiple desktops. It also has a high possibility of data loss. For the salt dispenser, as the salt is a fine powder, it keeps blocking the outlet of the dispenser. Users may need to remove the blockage manually, adding more work to them. Lastly, the LCD screen has a small viewing area of 2.5 x 0.64 inches, which makes the statements displayed on the LCD hard to read and sometimes not visible when the room is brighter than the backlight of the LCD.

Therefore, this system can be improved by finding a way to synchronize the app's data on the cloud without requiring much Internet. Secondly, a more suitable outlet could be developed for the current salt dispenser. An LCD with a bigger screen can also be considered to help the user see the salt dispenser's instructions. New functionalities or features for the app can also be an opportunity for further investigation. The current version of the desktop application, PlanPrep, provides essential functionalities for meal planning, recipe management, and sodium calculation. However, future research can focus on incorporating additional features to enhance user experience and efficiency. For example, the app could include a comprehensive nutritional analysis module that considers factors like calories, vitamins, and minerals. Integration with barcode scanning technology or recipe recommendation algorithms could also be explored to streamline the recipe creation process and expand the available recipe database.

While this project focuses on therapeutic diet preparation in hospitals, future work can consider adapting the Sodium Counting System to other mass catering settings. Elderly care centres, school canteens, and restaurants also face the challenge of providing tailored meals for individuals with specific dietary needs. Research can explore the customization of the system to cater to these different contexts, considering the unique requirements and operational constraints of each setting. This expansion would improve the overall quality of food service and nutritional management in diverse mass-catering environments. By exploring these areas of future research, advancements can be made to enhance the functionality, usability, and applicability of the Sodium Counting System, benefiting a broader range of users and mass catering settings.

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