Journal of Technology Informatics and Engineering (JTIE)
Vol. 5 No. 2 August 2026
E-ISSN: 2961-9068; P-ISSN: 2961-8215, Pages 314-333
DOI: https://doi.org/10.51903/jtie.v5i2.550

Intelligent IoT-based Alert System for Monitoring Drip of Intravenous Fluids (IV) and Reverse Blood Flow

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Abstract

Intravenous (IV) therapy is widely used in hospitals for administering fluids, medications, and nutrients, yet conventional manual monitoring may lead to delayed intervention, fluid depletion, reverse blood flow, and other patient-safety risks. This study proposes an Intelligent IoT-Based IV Drip System (IBIVDS) for real-time monitoring of IV fluid levels and reverse blood flow. The system integrates a NodeMCU ESP8266 microcontroller, load-cell weight sensor, LCD, buzzer, and Node-RED platform, supported by Arduino IDE, FreeRTOS, Python, HTML, JavaScript, and Django. The system continuously monitors IV fluid status and automatically sends alerts to healthcare personnel when predefined thresholds are reached. Notifications are generated at 50% remaining fluid and again at 20%, with the latter accompanied by an audible buzzer alert. Experimental evaluation showed that the proposed system achieved an average notification delay of approximately 0.01 min, substantially lower than the approximately 1 min delay reported for the baseline Smart Infusion Pump System under comparable conditions. The system also provides room and patient identifiers to facilitate rapid clinical response. The novelty of this study lies in integrating real-time IV level monitoring, reverse blood-flow prevention, multi-threshold alerting, and remote IoT-based notification within a single low-cost monitoring framework. The findings indicate that IBIVDS can improve the responsiveness, reliability, and consistency of IV therapy monitoring while reducing dependence on continuous manual observation.

Keywords: *Internet of Things (IoT); Intravenous Fluid Monitoring; Reverse Blood Flow; Patient Safety.*

I. INTRODUCTION

Intravenous (IV) drip monitoring systems, primarily used in hospitals and healthcare facilities, are vital in the supervision and control of the flow of fluids and medications to patients via IV lines. These systems are designed to ensure the safe and accurate administration of treatments in diverse healthcare settings, for example, home care, clinics, and hospitals of different levels. IV drip monitoring systems help healthcare providers observe the infusion rate, allowing them to monitor how quickly fluids and medications are delivered, ensuring patients receive the correct amount at the appropriate time. They also track the total volume infused to avoid complications like over-hydration or dehydration (Karthik et al., 2023).

IV therapy is a method commonly used in hospitals and healthcare facilities to dispense medications directly into the veins of the patient (Sonkar et al., 2022; Joseph et al., 2019). This approach allows fluids containing vitamins, minerals, or drugs to be administered through an infusion or injection, quickly reaching the bloodstream at a controlled pace. The intravenous (IV) route is the fastest method for distributing fluids and medications throughout the body, surpassing

Received in May 2026; Revised in June 2026; Acceptedin July 2026; Published in August 2026

other approaches like oral administration. This makes it particularly advantageous in emergencies or situations demanding swift intervention (*What Is IV Therapy?*, 2024). A standard IV setup includes a solution bag or bottle, a drip chamber to help monitor flow rate, a roller clamp to adjust the flow, and a cannula secured with adhesive. Traditional IV monitoring in healthcare environments, such as hospitals, clinics, and home care, depends highly on the manual collection of patient data. Healthcare providers are required to manually check and record vital details, such as infusion rates, fluid levels, and the patient's status. This manual approach is often time-intensive and prone to inaccuracies, which could delay the identification of potential problems. Additionally, since monitoring typically occurs intermittently rather than continuously, there may be a lag in detecting changes in the patient's condition, potentially delaying critical interventions (Venkat et al., 2023).

As noted in (Vinan-Vega et al., 2019), many hospitals rely on manual IV drip monitoring by medical staff, who must frequently check drip levels, making the process labor-intensive and demanding constant attention. Although IV drips are highly effective, they come with potential complications. If not regularly monitored and replaced, an IV drip bottle can lead to blood backflow and the production of air bubbles in blood bottles, which may result in severe outcomes like heart attack, respiratory failure, or stroke. Additionally, (Vinan-Vega et al., 2019), reported that even minimal air entry, at rates of approximately 20 ml/sec, can cause patient discomfort, while higher rates between 70-150 ml/sec can be fatal. This issue is further compounded by the rapid growth in population, which has resulted in an inadequate ratio of medical staff to patients. This shortage of healthcare personnel increases the risks associated with IV therapy, as fewer staff members are available to monitor and manage patients' IV needs effectively.

To tackle these challenges, numerous studies (Joseph et al., 2019) have investigated the application of the Internet of Things (IoT). IoT involves a network of physical objects, such as network devices, vehicles, and buildings, that are equipped with electronics, software, and sensors, enabling them to gather and transmit data (Joseph et al., 2019). This technology allows for the remote monitoring and control of objects using existing network infrastructure, seamlessly connecting the physical world with computer-based systems (Joseph et al., 2019). IoT simplifies processes, automates routine tasks, improves quality of life, and saves both time and money (Joseph et al., 2019). This technology has been incorporated in various research studies, i.e., (Venkat et al., 2023) introduced an IoT-based system for monitoring IV drips and ensuring patient welfare. This system can monitor IV flow, detect issues, and notify attendants. However, the study was deficient in interactive interfaces, well-defined visual displays, and informative content that could assist patients in understanding their treatment. Another study, as noted in (Karthik et al., 2023), proposed a wireless IV monitoring system using ZigBee technology. This system is capable of sending up to three alerts to health professionals (i.e., nurses and doctors), when necessary while also monitoring the infusion flow rate and detecting any anomalies. Nevertheless, the researchers did not implement AI and machine learning technologies to analyze data from IV bag monitoring systems to predict potential complications.

Despite the widespread use of advanced automated devices to ensure patient safety, monitoring patients during IV therapy remains a challenging task (Sonkar et al., 2022). Many healthcare facilities still rely on manual monitoring for these processes. As a result, there is a need for a system that alerts medical staff about the drip level in the Fimos bottle being administered through the patient's vein and provides real-time updates on the patient's condition. Additionally, monitoring patients in hospitals continuously throughout the day is a demanding and time-consuming task. In some situations, doctors and nurses can be overwhelmed with other responsibilities, making it challenging to monitor each patient effectively. As a result, this can lead to various complications. It is crucial that health-related tasks are carried out with high accuracy to maintain the system's effectiveness. One such task in hospitals is the administration of saline or IV fluids. If the intravenous drip system is not checked properly and promptly, it can lead to issues such as fluid backflow and, in severe cases, blood loss or death.

Therefore, to reduce the challenges associated with IV treatment, it is essential to improve present capabilities by integrating advanced technological solutions that tackle the issues within the healthcare sector. The Internet of Things (IoT) can significantly contribute to averting these issues. IoT is a network that enables the gathering and transferring of data via different hardware devices, sensors, and processors, all interconnected to form an intelligent system to minimize the difficulties associated with IV treatment. Additionally, there is a need to enhance our present capabilities by adopting advanced technological solutions that address the challenges in the healthcare sector. The IoT can play a key part in surmounting these limitations as a network that facilitates the collection and transmission of data through several appropriate hardware, sensors, and microprocessors, all interconnected to form an intelligent system (Otanasap et al., 2022).

Thus, to the best of our knowledge, the idea of combining IoT technology, real-time IV drip monitoring, reverse blood flow detection, intelligent alert mechanisms, and remote healthcare monitoring into a single integrated system has not been previously investigated. Motivated by this research gap, this work proposes an Intelligent IoT-Based Alert System for Monitoring IV Drip and Reverse Blood Flow. The proposed system provides real-time monitoring and automated alerts to healthcare providers, including doctors and nurses, enabling timely intervention, ensuring accurate fluid administration, minimizing the risk of complications such as blood backflow and empty IV bags, and ultimately improving patient safety and the overall quality of healthcare delivery.

Motivated by the stated, our work proposes the Intelligent IoT-based Alert System for Monitoring IV Drip and Reverse Blood Flow technology that helps healthcare providers, i.e., doctors and nurses, ensure accurate dosages are administered, reduce the risk of complications, and enhance the total quality of care for patients getting IVs. Therefore, the foremost contributions of this work are as follows:

- We first tailor the IoT sensors and attach them to the IV bag and tubing to monitor key factors, such as fluid flow rate, remaining volume in the bag, and pressure within the system, ensuring accurate and continuous tracking of IV conditions.
- Install the intelligent system with real-time alerts that notify nurses or doctors of abnormalities, such as low IV fluid status or potential obstructions in the IV line, ensuring timely intervention and improving patient care
- Trigger sound alarms and warnings when the IV fluid level reaches a predefined threshold to help nurses and doctors identify possible issues, minimizing the likelihood of medication mistakes and impediments as detailed in our proposed architecture and monitoring system. More explanations on the proposed algorithm are provided in Section III, along with a description of several components or modules used in our proposed system model.
- In Section IV, we conduct numerical simulations to divulge the impact of our proposed approach on the IV drip monitoring system, and more specifically, the results show the outperformance of our proposed framework compared to the other baseline schemes.
- Finally, the conclusion of our study and recommendations for future work are expounded in Section V.

II. LITERATURE REVIEW

As population density rises, healthcare demands also increase, making it essential for individuals to prioritize their well-being (Joseph et al., 2019). This highlights an urgent need for accessible and high-quality healthcare services to meet the diverse needs of people across various socio-economic backgrounds (Rosdi & Huong, 2021a). In response to emergencies in hospitals and medical centers, IV therapy is widely utilized as an effective method for administering fluids and medications directly into a patient's vein (Rosdi & Huong, 2021a). Ensuring patient safety involves careful management of medication dosages and accurate administration methods.

In numerous healthcare settings, nurses typically calculate IV flow rates using mathematical formulas based on fluid volume and infusion time (Patel et al., 2019), with regular monitoring required to ensure accuracy (Rosdi & Huong, 2021a). (Rosdi & Huong, 2021a) indicates that reverse blood flow can be a significant issue during IV therapy, occasionally causing blood loss. Although usually not harmful, this can lead to unnecessary complications. Additionally, the absence of continuous monitoring of IV infusions can result in problems such as air embolisms, especially when the fluid source is depleted. Both gravity-fed and pump-driven infusion systems can introduce air bubbles into the line, with these bubbles potentially expanding due to changes in temperature and pressure (Odenbach et al., 2022). If air enters the bloodstream, it can cause severe complications, including life-threatening air embolisms (Arunvikas et al., 2024; Odenbach et al., 2022; Rifat Kabir et al., 2022; Seol et al., 2023a). Fluctuations in infusion rates can result in either over- or under-administration of medication, posing serious risks to patient safety (Seol et al., 2023b). Therefore, there is a critical need for an advanced IV monitoring system to enhance patient safety during infusions.

In many hospitals, patient monitoring is often done manually or with basic devices, where temperature checks are periodic, and IV drip rates are visually monitored by staff (Arunvikas et al., 2024). A clinical audit conducted in an Australian tertiary hospital (Yang et al., 2018) involving 332 inpatients revealed that 26% received IV fluids. Of these, 85% had their serum electrolytes and renal function monitored, and fluid balance charts were maintained for 94%. However, only 15% had their body weight recorded, indicating a potential gap in monitoring. Despite some improvements, existing systems are limited. For instance, while systems using load cells, IR sensors, and capacitance-based methods (Ajibola et al., 2018; Chui et al., 2024; Dziadak & Graffstein, 2024; Junaidi et al., 2019; Krishnan et al., 2022; Krishnapriya et al., 2024; Sreekumar et al., 2023) can detect fluid levels and trigger alerts, they often lack remote notification capabilities, especially when medical staff is not in the patient's room.

Sreekumar et al. (2024) developed a control technique that notifies healthcare professionals, including nurses and doctors, when the fluid level in an infusion bag approaches a critical threshold. However, the technique relied heavily on WhatsApp Messenger to send messages to caretakers, which is a limitation. Studies (Bandari, 2022; Venkatesh et al., 2021) utilized deep learning and computer vision to monitor IV drip systems. Notably, (Venkatesh et al., 2021) introduced a minimally invasive, flexible approach with great performance. These approaches used ultrasonic sensors to collect data, which was transferred using Bluetooth or Wi-Fi to a cloud data center.

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The IoT significantly enhances health-monitoring systems in hospitals. By integrating intelligent devices and subsystems, hospitals can reduce operational costs, improve patient care, and ease the workload of medical staff (Joseph et al., 2019). IoT enables the connection of various devices, software, and sensors, facilitating efficient data collection and exchange, and is widely used for remote patient monitoring, especially in busy emergency departments (Dsouza et al., 2021; Ng et al., 2019; Rosli et al., 2019). Additionally, Bharaddwaj et al. (Bharaddwaj et al., 2024) proposed an IoT-based method to monitor drip rates using IR sensors. The system calculates the saline level in the IV bottle, sending an alert to the nurse's phone if the liquid level exceeds a set threshold.

However, the existing systems only monitor the electrolyte level in the IV saline bottle, which increases the risk of reverse blood flow, potentially leading to air embolism and serious harm to the patient if not detected in time (Joseph et al., 2019). This highlights the limitations of manual procedures, especially with drip bottles, where precision is crucial (Anagha, 2020). A smart IV monitoring method was developed using IoT technology (Giaquinto et al., 2020), allowing for the detection of infusion issues like blockages, air bubbles, or disconnections, with instant alerts to medical staff. Additionally, IoT-based wireless IV monitoring systems (Caya et al., 2019; Rosyady et al., 2024; Sreekumar et al., 2024) can inform attendants about IV status in real-time, improving patient care and reducing medical errors (Alamelu & Mythili, 2021). Although the above-highlighted methods are increasingly automated, in the current healthcare system, monitoring tasks are still performed manually (Kumar et al., 2023).

Nonetheless, our proposed system offers an efficient and remote solution for monitoring intravenous fluid levels in drip bags. It features a sensor that detects when the fluid reaches a critical level, triggering alarms with both audio and visual indicators. Additionally, a notification with the relevant unique identifier of the room and patient number is sent to the nurse, allowing for prompt responses without constant manual checks. Therefore, this system is designed to alleviate the time-consuming burden of manual monitoring, minimizing human error and enhancing patient safety. It minimizes risks associated with IV administration by automating fluid level monitoring, ensuring timely interventions, and reducing the likelihood of complications. The proposed system is an affordable, reliable, and straightforward tool for medical personnel, and its implementation will improve patient safety, streamline healthcare processes, and support more efficient healthcare practices, ultimately contributing to better overall healthcare delivery.

III. RESEARCH METHOD

The section provides a detailed and systematic description of the research work.

A. Intelligent IoT-based IV drip System Architecture

The architecture of an IV drip system refers to the design and components involved in delivering fluids, medications, or nutrients directly into a patient's bloodstream through their veins. This process is typically used in medical settings such as hospitals or clinics, but the system's fundamental design remains the same regardless of its specific application. This section, therefore, presents the proposed novel method. The architecture of an IV (intravenous) drip system can be summarized as a carefully designed system for administering fluids or medications into the bloodstream. It combines simple gravity mechanisms with precise control systems to ensure safety, accuracy, and ease of use. The patient's vein is part of the patient where the catheter is inserted, a simplified line or structure inside the body. Generally, the flow of the IV fluid starts from the IV bag, moves through the tubing, into the drip chamber, through the flow regulator, and finally enters the patient's vein via the catheter, as depicted in Figure 1.

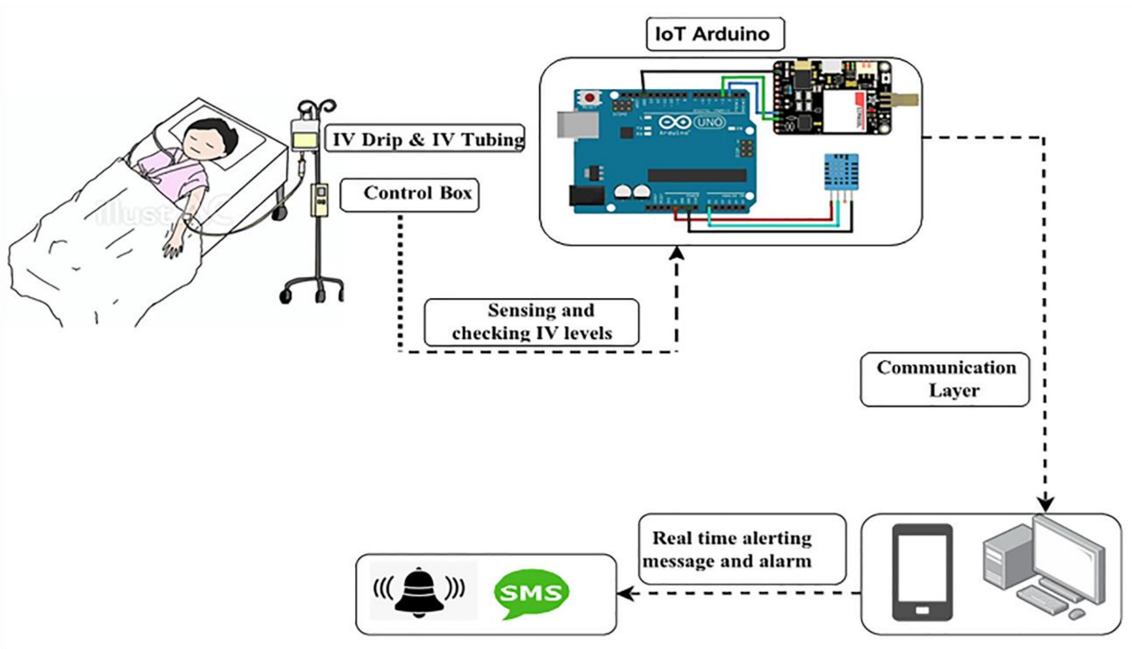

Figure 1. The proposed Architecture for the Intelligent IoT System

As depicted in Figure 1, the proposed system architecture is composed of the following components:

i. Fluid Source (IV Bag or Bottle): It's a plastic or glass container that holds the fluid to be infused (saline, glucose, medications, etc.). Typically, the container is positioned higher than the patient to leverage gravity for fluid flow.

ii. Transport System (IV Tubing): It connects the fluid source to the patient's vein, which includes components like the drip chamber and flow regulator for flow control.

iii. The control box: it involves the sensor system, which provides real-time data and checks IV fluid levels, which are processed by the system's IoT Arduino-based microcontroller

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(NodeMCU). Our experiments calibrated the blood flow sensor using a precision syringe infusion pump to deliver controlled flow rates ranging from 10 to 500 mL/h. The infusion pump served as the calibration reference because of its high flow accuracy (±1%). We generated flow rates of 20, 50, 100, 150, and 250 mL/h and recorded the sensor outputs for each setting. Each measurement was repeated five times to evaluate repeatability.

iv. Communication layer: This happens when the IV fluid level reaches a critical threshold or an air bubble is detected; the system sends an alert to the nurse's mobile phone, including a unique identifier (room number and patient number) based on IV levels. This resolution enables the nurse to attend to the patient promptly without the need for regular physical labels.

B. Intelligent IoT-based IV drip delivery Monitoring System

Figure 2 provides a detailed visualization of how data moves through the system. It breaks down the system's processes into a hierarchy of levels, showing the flow of information and how input data is transformed into output results. This monitoring diagram provides a clear visual representation of the sequence of activities involved in monitoring IV fluid levels and generating alerts in the System. The process of monitoring IV bag fluid levels involves continuously monitoring the fluid level in the bag, analyzing the fluid level by evaluating level data to determine if an alert condition is met, and sending a message (SMS) alert to a healthcare nurse when the fluid level reaches predefined thresholds (i.e., 50% and 20% of the IV fluid in our case). Additionally, another way of alerting is triggering a sound alarm when the fluid level reaches a predefined threshold (i.e., 20% of the IV fluid in our case).

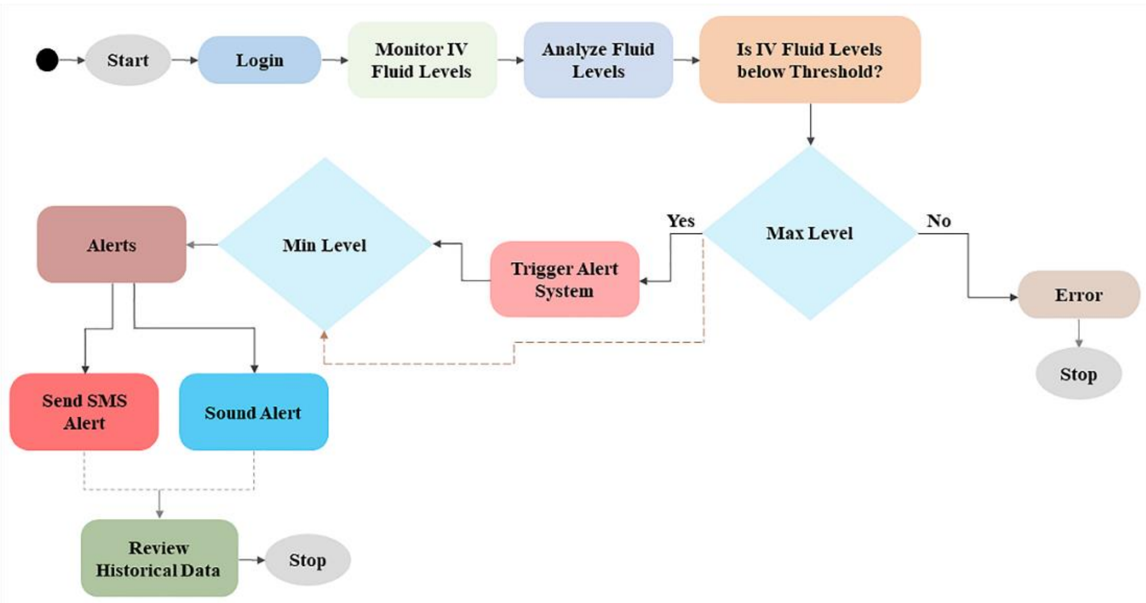

Figure 2. Monitoring of the IV fluid flow

In addition, our proposed Intelligent IoT-Based Alert System for Monitoring Intravenous (IV) Fluid Drips is specifically designed to prevent the IV fluid from running out by sending two alert notifications to the nurse before the bottle is empty. In other words, the system not only monitors the IV fluid level and sends SMS notifications but also prevents the reverse blood flow effect by ensuring that the IV fluid does not become completely depleted before the nurse intervenes.

C. *Calculation of the flow rate of IV fluids*

When dealing with intravenous (IV) drips, healthcare professionals often need to calculate the flow rate of fluids (or medications) into the patient's bloodstream. The primary goal is to ensure the proper amount of fluid is delivered over a given period. Three important parameters are essential for IV infusion therapy, namely, volume in mL, time, and drop factor.

i. *Flow rate for both gravity and pump-based IV systems:* We calculate the flow rate in drops per minute (gtt/min), i.e., in the gravity-fed IV systems, where the force of gravity delivers the fluid, the flow rate is typically calculated in drops per minute (gtt/min).

$$FR\left(\frac{gtt}{\min}\right) = \frac{VI(mL)}{T(\min)} \times DF(gtt/mL) \quad (1)$$

Where $VI(mL)$ represents the volume infused in milliliters, which represents the amount of fluid you plan to administer, $T(\min)$ denotes the time over which the infusion should occur in minutes, and $DF(gtt/mL)$ is the drop factor that represents the number of drops that make up 1 milliliter of fluid, which usually takes values of 10, 15, 20, or 60 drops per milliliter.

ii. *Infusion rate for medication:* To calculate the medication infused based on the concentration in the fluid, which is required to be delivered at a precise dosage, the formula was applied,

$$DIR(mg/\min) = \frac{TDD(mg)}{T(\min)} \times \frac{VIVF(mL)}{TVIVS(mL)} \quad (2)$$

Where $DIR(mg/\min)$ is the drug infusion rate, $TDD(mg)$ is the total drug dose (mg), which is the total amount of medication to be infused. $T(\min)$, i.e., the infusion time in minutes, and $VIVF(mL)$ presents the volume of the IV solution containing the drug. $TVIVS(mL)$ presents the total volume of the IV solution in milliliters, i.e., the overall solution in which the medication is dissolved.

iii. *Calculate the time to infuse a given volume:* The volume to be infused and the flow rate and its determined using

$$T(hrs/\min) = \frac{VI(mL)}{FR(mL/hr)} \quad (3)$$

$T(hrs/\min)$ is the time in hours or minutes, $VI(mL)$ is the volume to be infused in milliliters, and $FR(mL/hr)$ presents the flow rate in milliliters per hour.

D. System Requirements

In this innovative healthcare system, the Arduino Uno microcontroller serves as the central processing unit that acts as the core intelligence of our setup. The primary focus of this project is monitoring the hospital's IV drip as depicted on Figure 3.

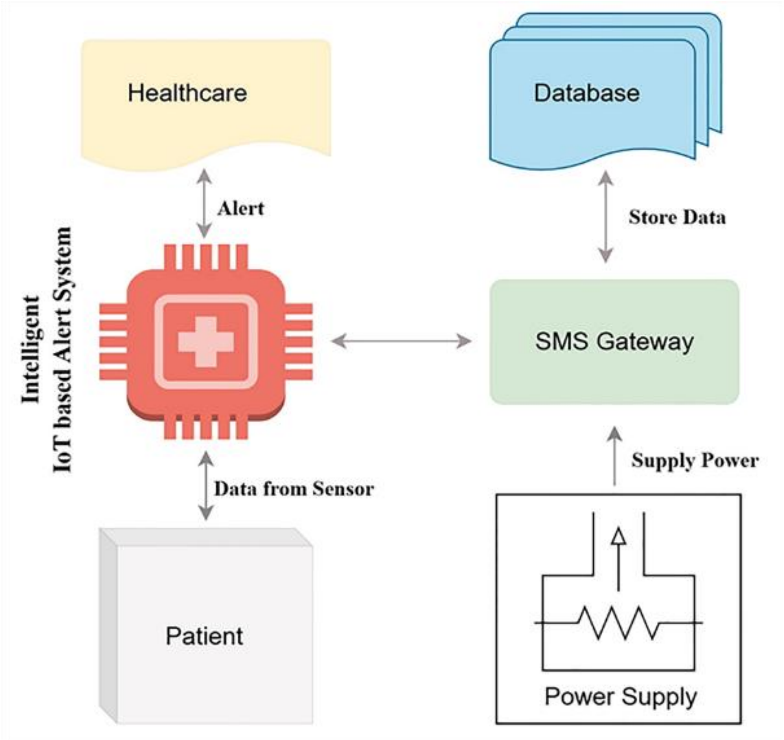

Figure 3. Intelligent-Alert-SMS-System

E. Components Description

Table 1 comprises the system requirements, including our proposed model's hardware and software technologies.

Table 1: System Requirements.

Hardware	Software
Node MCU	Arduino IDE
LCD Display	FreeRTOS
Weight sensor (Loard cell)	Node-RED
Buzzer	Python, HTML
Power Supply	JavaScript, CSS
Smart Phone	Django, VS Code

Several components or modules have been used to realize this project.

a) NodeMCU: The NodeMCU is a microcontroller with built-in Wi-Fi functionality; it is based on the ESP8266. It serves as the brain of the system, processing input from the sensors and sending data to the cloud or issuing commands to connected devices. The NodeMCU is illustrated on Figure 4.

Figure 4. Node-MCU

Figure 5. LCD

b) LCD (Liquid Crystal Display): As depicted on Figure. 5, the LCD is used to display real-time information about the IV bag's status, such as the fluid level. It provides a visual interface for users (medical staff), allowing them to easily monitor the system without needing external devices.

c) Weight Sensor: The weight sensor is crucial for measuring the weight of the IV bag, which directly correlates with the remaining fluid level. The sensor continuously monitors the weight and sends data to the NodeMCU, triggering alerts when certain thresholds are met (e.g., send the first alert when the fluid level is at 50% and the second alert once the fluid level is below 20%). The Weight Sensor is depicted in Figure 6.

Figure 6. Weight-Sensor

Figure 7. Buzzer

d) The Buzzer: it acts as an auditory alert system. It sounds an alarm when certain conditions are met. Regarding our project, when the IV bag reaches a critical fluid level, i.e., below 20%, it starts sounding to alert the medical staff(s). The system's immediate SMS notification allows the nurse/doctor on duty to take urgent action. The Buzzer is depicted in Figure 7.

e) The Power Supply: This is a component that provides electrical energy to power electronic circuits or devices. Since some components in the developed system require current during transmission, it is crucial to have a stable power supply.

f) Arduino IDE: We developed the system using the NodeMCU software, which we programmed to monitor the IV fluid level and trigger alerts when necessary. The code structure comprises the following parts, including weight measurement (the weight sensor continuously sends data to the NodeMCU, which calculates the percentage of fluid remaining in the IV bag), the alert system (i.e., the two thresholds were programmed at 50% of the fluid level and 20%, respectively). When the fluid level drops to 50%, an SMS alert is sent, followed by another when the level reaches 20%. Each alert is sent only once for each condition to prevent redundant notifications. Finally, the buzzer and LCD Display Control (the buzzer gives sound whenever the fluid reaches the critical level, which has been set from 20% to below, and the LCD continuously updates to show the current fluid level.

g) FreeRTOS: This is an open-source real-time operating system for micro controllers. It has capabilities to provide multitasking, inter-task communication, and timing functions. FreeRTOS has been incorporated in our developed system since it is very suitable for real-time applications in IoT-BASED systems.

h) Node-RED: This is a flow-based development tool for visual programming that simplifies the wiring of hardware devices, APIs, and online services. Node-RED was very useful for rapid prototyping and integration of IoT-BASED systems.

i) Various Technologies: the system involved working with different technologies such as:

Python: for programming the logic and integrating hard-ware components.

HTML: HyperText Markup Language was used to structure the content of the web page and to create elements such as Titles and headings, shown for IV bag data.

CSS: Cascading Style Sheet to style the interface to make it clean, readable, and professional. It used to control and fonts (e.g., blue for high fluid), Layout, and responsive design for Mobile/Computer screen.

JavaScript: used to add interactivity to the page. It was Used for dynamically updating the level without reloading the page, handling alert pop-ups when the IV fluid is low, fetching real-time data (from Django and sensors), Fetching percentage when the page loads, fetching IV bag percentage from the server without refreshing the page, Updating the bag fill high, Updating the label inside the bag.

Django: used to render HTML templates using its template engine, the structure of the frond-end pages was dynamically generated by Django. Additionally, JavaScript on the front-end uses fetch () to request the latest IV percentage and the Django responds with a JSON object containing the data.

VS Code: Unlike heavier IDEs, VS Code is lightweight and run efficiently and runs on systems with average hardware which made it quick prototyping and testing without slowing down my machine.

F. Hardware integration

The proposed smart blood transfusion monitoring system integrates a NodeMCU (ESP8266) microcontroller as the central processing unit, interfacing with a weight sensor, an LCD, a buzzer, a regulated power supply, and IoT communication modules to enable real-time monitoring and alerting. The weight sensor continuously measures the IV blood bag weight, from which the remaining fluid volume is computed and processed by the NodeMCU. The processed information is displayed on the LCD, while predefined threshold values trigger a one-time SMS notification at 50% remaining fluid and activate both SMS and audible buzzer alerts when the fluid level falls below 20%, thereby preventing redundant notifications and facilitating timely clinical intervention.

The system firmware was developed using the Arduino IDE, where sensor acquisition, threshold evaluation, alert generation, and wireless communication algorithms were implemented. To ensure reliable real-time performance, FreeRTOS was employed to support multitasking, enabling concurrent execution of sensor sampling, display updates, alarm control, and network communication. Additionally, Node-RED was integrated as the IoT platform for data routing, visualization, and remote monitoring, allowing healthcare personnel to access transfusion status and receive alerts through cloud-connected services.

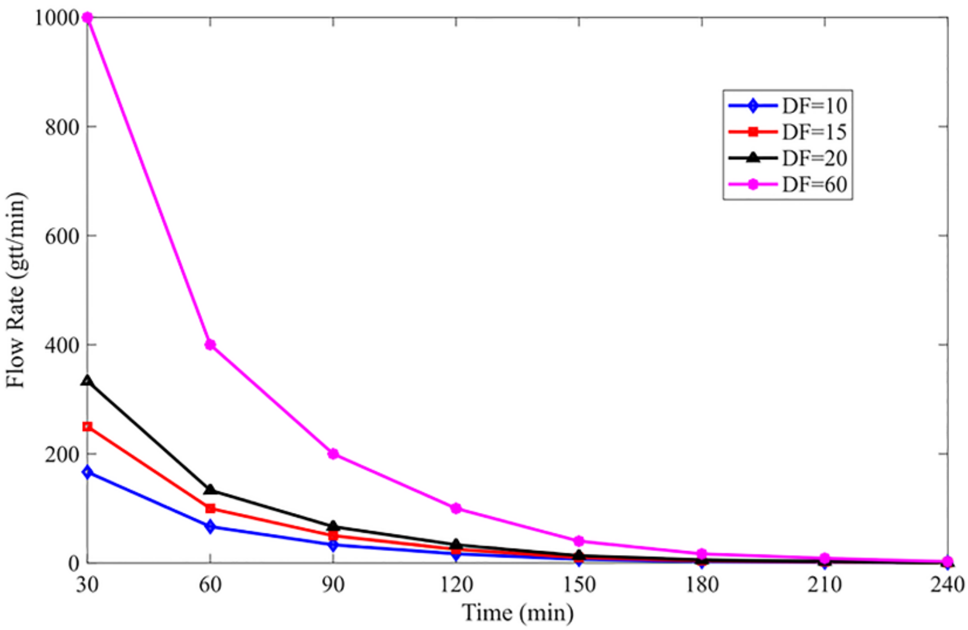

Figure 8. Flowrate

IV. SIMULATION RESULTS AND DISCUSSIONS

In this section, simulation results are executed to demonstrate the outperformance of our proposed Intelligent IoT-based Alert System for Monitoring Drip of Intravenous Fluids (IV) and Reverse Blood Flow. Firstly, the relationship between the flow rate of IV drip versus time consumed is depicted on Figure 8. It is noticed that as time goes by, the flow of the IV drip keeps reducing. This is because the flow rate is directly proportional to the volume of IV drip and inversely proportional to the time over which infusion occurs, as per equation (1). Therefore, the more the time increases, the more the flow rate reduces.

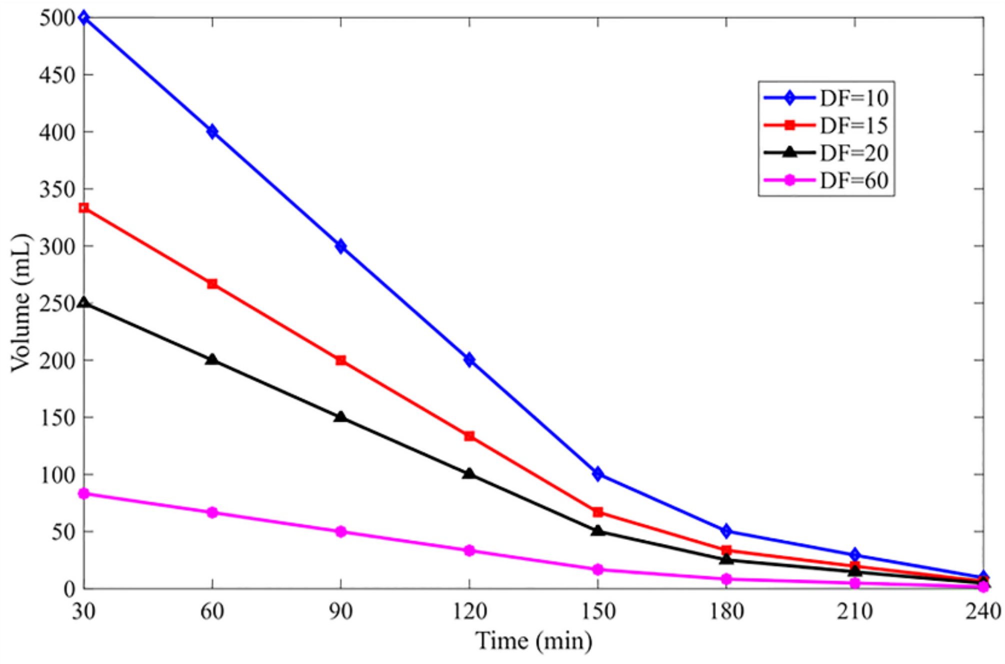

Figure 9. Volume

Additionally, by varying the drop factor (DF) of the IV drip from 10, 15, 20, and 60, it is noticed that increasing the drop factor boosts up the flow rate since they are directly proportional. In Figure 9, the volume of infused IV drip is illustrated with respect to the time over which infusion occurs. It is accurately observable that the more time increases, the more the volume of IV drip decreases. Furthermore, altering DF from 10, 15, 20, 60, obviously abates the volume flow of IV drops. This is because they are inversely proportional.

To evaluate the performance of our proposed work (intelligent IoT-based IV drip system) labeled as IBIVDS, we compare our algorithm with the work done in (Rosdi & Huong, 2021b) known as Smart Infusion Pump System for Remote IV labeled as SIPS, under comparable experimental conditions in Figure 10. For a fair comparison, both systems were evaluated using the same IV bag capacity (500 mL), identical notification thresholds, and the same network environment. The notification lagging time was measured as the difference between the actual time at which the IV level reached the predefined threshold and the time at which the notification was received by the healthcare provider.

The reported values represent the average of N repeated experimental trials. By comparing our proposed IBIVDS algorithm with the SIPS, the experimental results indicate that IBIVDS achieves a lower notification lagging time with respect to the actual time. During the experiment of our IoT-based IV system, a lagging time between the actual time and the IBIVDS notification time of approximately 0.01 min was observed, which is **s**ubstantially lower than the approximately 1 min lagging time reported for SIPS (Rosdi & Huong, 2021b). These findings suggest that the proposed system provides faster notification delivery under the evaluated experimental conditions.

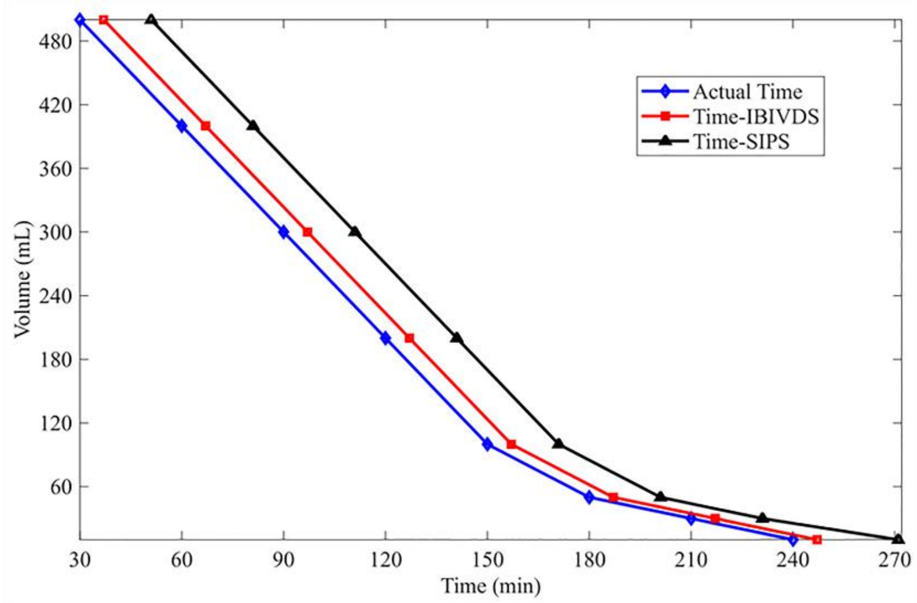

Figure 10. Time

Figure 11. Notification at 50% of IV

Furthermore, our proposed scheme – IBIVDS sends notifications twice (at 250mL which is 50% of the IV drip level, and at 100 mL, which 20% of the IV drip level) to the nurse together with with the relevant unique identifier of room and patient number, allowing for prompt responses

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without constant manual checks. Additionally, Figure. 11 and Figure. 12 show the real-time notifications sent to the nurse through the developed interface that allows the medical staff to check the system status.

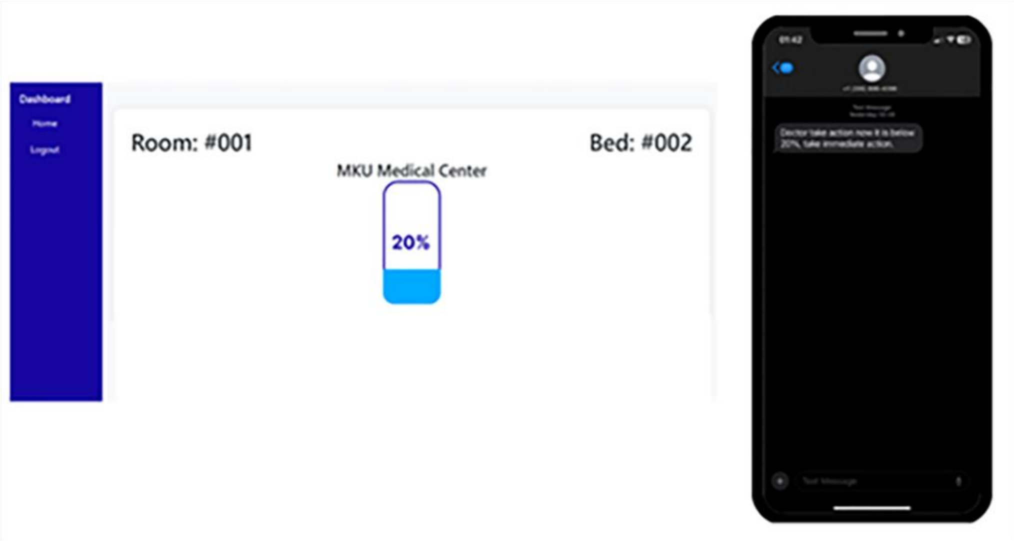

Figure 12. Notification at 20% of IV

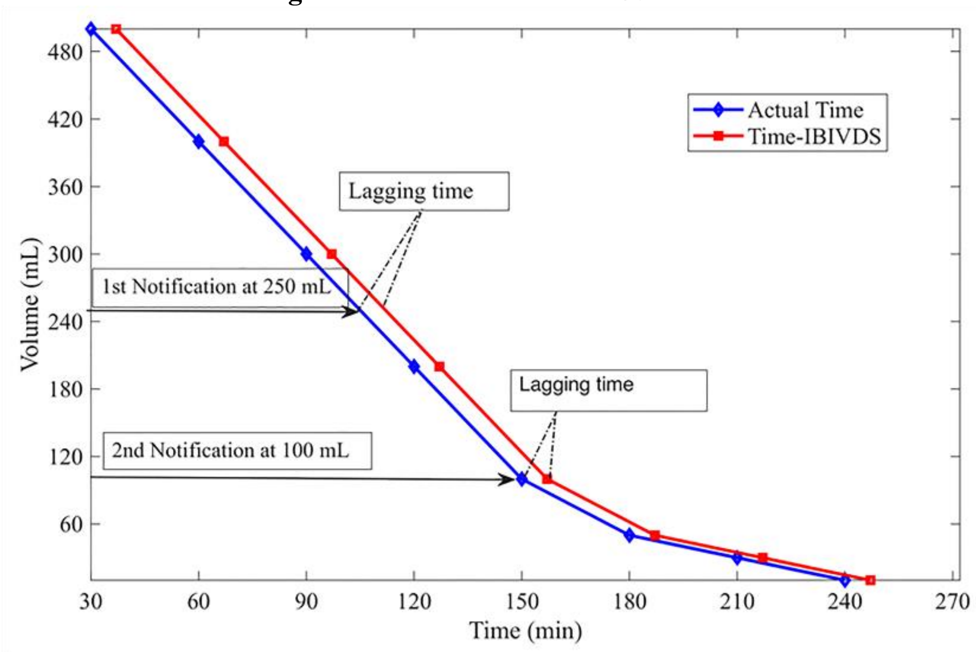

Figure 13. Lagging

Moreover, the notification lagging time between the actual time and the IBIVDS notification time is depicted in Figure 13, where the average lagging time recorded across the experimental trials was 0.01 min. Although the comparison is limited to notification delay, by comparing it with (Rosdi & Huong, 2021b), our proposed IBIVDS lagging time is considerably lower than the approximately 1 min reported in (Rosdi & Huong, 2021b). Therefore, within the scope of the evaluated metric (notification lagging time), the proposed IBIVDS demonstrates improved performance over the SIPS approach.

V. CONCLUSION AND FUTURE PERSPECTIVES

Our work proposed an Intelligent IoT-based Alert System for Monitoring Drip of Intravenous Fluids (IV) and Reverse Blood Flow. Objectively, the proposed system was able to address the challenge of manual monitoring of the administration of intravenous (IV) fluids, medications, and nutrients in most hospitals, which can sometimes lead to lapses in attention and pose serious risks to patients in our healthcare facilities. Consequently, in the scenario where a nurse overlooks the IV drip levels or forgets to replace an empty bottle, there is a significant risk of blood flowing back into the IV line and air becoming trapped in the line, which can lead to fatal consequences for the patient. Therefore, our model contributed to the implementation of a system that uses an Arduino-based nodeMCU, liquid crystal display, weight sensors, buzzer, Arduino IDE, FreeRTOS, and nodeRED, to name a few.

The results affirm that our model to be able to send two SMS alert/notification to the nurse's smartphone (i.e., the room and patient number) when the IV fluid level reached a threshold (i.e., 50% of the IV bottle), and a notification together with a buzzer ring are sent when IV fluid level reached a critical threshold (i.e., 20% of the IV bottle) or an air bubble was detected. This enables the healthcare staff to attend to the patient promptly without needing regular physical checks. In future work, some factors and metrics can be considered, namely, power management, notification reliability, packet delivery ratio, response time under varying network conditions, system accuracy, scalability, and energy consumption, to provide a more comprehensive performance assessment and to offer more extensive customization options to meet the unique needs of patients.

DATA AVAILABILITY

The data generated and analyzed during this study are available from the corresponding author upon reasonable request. The experimental and simulation data supporting the findings are derived from the developed IoT-based IV monitoring system and associated performance evaluations.

REFERENCES

Ajibola, O. O. E., Sunday, O. O., & Eyehorua, D. O. (2018). Development of automated intravenous blood infusion monitoring system using load cell sensor. *Journal of Applied Sciences and Environmental Management*, *22*(10), 1557. https://doi.org/10.4314/JASEM.V22I10.04

Alamelu, J. V., & Mythili, A. (2021). *Smart Infusion Pump Control: The Control System Perspective*. 199–211. https://doi.org/10.1007/978-3-030-68723-6_10

Anagha. (2020). *IoT Based Intravenous Flow Monitoring System*.

Arunvikas, V., Pravesh, S., Shafni, J., & Sumitra, V. (2024). Patient Monitoring System on Intravenous Fluid. *Proceedings of the 2024 10th International Conference on Communication and Signal Processing, ICCSP 2024*, 1561–1565. https://doi.org/10.1109/ICCSP60870.2024.10543827

Bandari, S. (2022). IV Drip Monitoring and Control System. *International Journal for Research in Applied Science and Engineering Technology*, *10*(6), 3383–3386. https://doi.org/10.22214/IJRASET.2022.44635

Bharaddwaj, A., Kulal, L. K., Ananya, G. R., Manjunath, A., Gayathri Devi, B., & Venkatarangan, M. J. (2024). Drip Monitoring System for Patient Care at Hospitals. *Proceedings of CONECCT 2024 - 10th IEEE International Conference on Electronics, Computing and Communication Technologies*. https://doi.org/10.1109/CONECCT62155.2024.10677122

Caya, M. V., Cosindad, M. U., Marcelo, N. I., Santos, J. N. M., & Torres, J. L. (2019). Design and Implementation of an Intravenous Infusion Control and Monitoring System. *2019 IEEE International Conference on Consumer Electronics - Asia (ICCE-Asia)*, 68–72. https://doi.org/10.1109/ICCE-ASIA46551.2019.8941599

Chui, H. C., Xu, Y., Wang, Z., Zhang, X., Li, R., & Qin, K. R. (2024). Flow Rate Sensor inside Infusion Tube. *Inventions 2024, Vol. 9, Page 89*, *9*(4), 89. https://doi.org/10.3390/INVENTIONS9040089

Dsouza, M. M., Musthafa, M. S., & Shariff, M. U. (2021). *Design and Fabrication of Flow Meter for Intravenous Infusion Tube*.

Dziadak, B., & Graffstein, P. (2024). Capacitive measurement of infusion fluid volume. *Przeglad Elektrotechniczny*, *5*, 258–262. https://doi.org/10.15199/48.2024.05.49

Giaquinto, N., Scarpetta, M., Ragolia, M. A., & Pappalardi, P. (2020). Real-time drip infusion monitoring through a computer vision system. *IEEE Medical Measurements and Applications, MeMeA 2020 - Conference Proceedings*. https://doi.org/10.1109/MEMEA49120.2020.9137359

Joseph, S., Francis, N., John, A., Farha, B., & Baby, A. (2019). Intravenous Drip Monitoring System for Smart Hospital Using IoT. *2019 2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies, ICICICT 2019*, 835–839. https://doi.org/10.1109/ICICICT46008.2019.8993241

Junaidi, Yusuf, A. S., Iffah, P. Y. D., Pauzi, G. A., Surtono, A., Suciyati, S. W., Warsito, Triyana, K., & Khairurrijal. (2019). Flow Rate and Volume Control of Fluid Based on Arduino for Synthesis of Silver Nanowires. *Journal of Physics: Conference Series*, *1338*(1). https://doi.org/10.1088/1742-6596/1338/1/012018

Karthik, A., SaranTeja, B., Ajay, R., & SwethaPriyanka, J. (2023). IoT Intravenous Bag Monitoring and Alert System. *Asian Journal of Convergence in Technology*, *9*(1). https://doi.org/10.33130/AJCT.2023V09I01.007

Krishnan, G. H., I Kumaraswamy, I. K., Umashankar, G., T Sudhakar, T. S., E V, J., Kavitha S, K. S., & Sandhya J, S. J. (2022). IoT Based Automated Saline Drip and Hand Movement Detection System for Critical Care Patients. *Biosciences Biotechnology Research Asia*, *19*(4), 955–962. https://doi.org/10.13005/BBRA/3044

Krishnapriya, V. S., Suresh, N., Srilakshmi, S. R., Abhishek, S., & Anjali, T. (2024). Intelligent and Real-Time Intravenous Drip Level Indication. *Lecture Notes in Networks and Systems*, *789 LNNS*, 777–790. https://doi.org/10.1007/978-981-99-6586-1_52

Kumar, M. V., Sundar, R. G., Manoharan, K., Kalamani, C., & Soumiya, S. (2023). IoT based Smart Intravenous Fluids (IV) Drip Monitoring and Reverse Blood Flow Prevention System. *IDCIoT 2023 - International Conference on Intelligent Data Communication Technologies and Internet of Things, Proceedings*, 16–20. https://doi.org/10.1109/IDCIOT56793.2023.10053449

Ng, M. Y., Ibrahim, N., & Norsidek, N. I. F. (2019). *Measurement of body temperature and heart rate for the development of healthcare system using IOT platform*.

Odenbach, J., Dhanoa, S., Sebastianski, M., Milovanovic, L., Robinson, A., Mah, G., Rewa, O. G., Bagshaw, S. M., Buchanan, B., & Lau, V. I. (2022). Acute Respiratory Distress Syndrome and Shunt Detection With Bubble Studies: A Systematic Review and Meta-Analysis. *Critical Care Explorations*, *4*(11), E0789. https://doi.org/10.1097/CCE.0000000000000789

Otanasap, N., Kanchanawongkul, V., & Chalermsuk, C. (2022). Design and Development of Saline Infusion Administration System Using IoT. *ASEAN Journal of Scientific and Technological Reports*, *25*(1), 41–49. https://doi.org/10.55164/AJSTR.V25I1.244460

Patel, D. M., Patel, M. V., Sharma, K. H., Kaklotar, J. C., Patel, G. R., & Patel, M. M. (2019). Efficacy and superiority of an innovative method (IM) of intravenous (IV) fluid drip drop rate calculation using IV set and its comparison with conventional methods (CM). *International Journal of Research in Medical Sciences*, *7*(2), 334. https://doi.org/10.18203/2320-6012.IJRMS20190330

Rifat Kabir, M., Shifat Ahmed, S., Chandra Paul, L., Rani, T., & Karaaslan, M. (2022). Development of an Intravenous Fluid Monitoring, Warning, and Reverse Flow Blocking System. *Proceedings of 2022 IEEE International Women in Engineering (WIE) Conference on Electrical and Computer Engineering, WIECON-ECE 2022*, 89–94. https://doi.org/10.1109/WIECON-ECE57977.2022.10150612

Rosdi, M. R., & Huong, A. (2021a). A smart infusion pump system for remote management and monitoring of intravenous (IV) drips. *ISCAIE 2021 - IEEE 11th Symposium on Computer Applications and Industrial Electronics*, 285–288. https://doi.org/10.1109/ISCAIE51753.2021.9431790

Rosdi, M. R., & Huong, A. (2021b). A smart infusion pump system for remote management and monitoring of intravenous (IV) drips. *ISCAIE 2021 - IEEE 11th Symposium on Computer Applications and Industrial Electronics*, 285–288. https://doi.org/10.1109/ISCAIE51753.2021.9431790

Rosli, M. N., Audah, L., Shahida, N., & Shah, M. (2019). IoT Based Security System for a One Bed Hospital Room. *Evolution of Information, Communication and Computing System*, *1*(1), 57–68.

Rosyady, P. A., Habibah, N. U., Baswara, A. R. C., Ihsana, N., Sulistiawan, D., & Dinata, W. R. (2024). Microcontroller-Based Intravenous Fluid Monitoring System Design. *Journal of Applied Engineering and Technological Science (JAETS)*, *5*(2), 649–660. https://doi.org/10.37385/JAETS.V5I2.3230

Seol, J., Lee, S., Park, J., & Kim, K. G. (2023a). Automatic Control System for Precise Intravenous Therapy Using Computer Vision Based on Deep Learning. *IEEE Access*, *11*, 121870–121881. https://doi.org/10.1109/ACCESS.2023.3328568

Seol, J., Lee, S., Park, J., & Kim, K. G. (2023b). Automatic Control System for Precise Intravenous Therapy Using Computer Vision Based on Deep Learning. *IEEE Access*, *11*, 121870–121881. https://doi.org/10.1109/ACCESS.2023.3328568

Sonkar, A., Pal, N., Gupta, H., & Dhanoa, J. K. (2022). Smart Intravenous Drip Monitoring System with Bubble Detection Indicator using IoT. *2022 2nd International Conference on Intelligent Technologies, CONIT 2022*. https://doi.org/10.1109/CONIT55038.2022.9848118

Sreekumar, K., Francis, J., & Prathap, B. R. (2023). Smart Intravenous Infusion Monitoring and Alert System using IoT-based Force Sensitive Resistor and Whatabot API. *Proceedings of IEEE InC4 2023 - 2023 IEEE International Conference on Contemporary Computing and Communications*. https://doi.org/10.1109/INC457730.2023.10262987

Sreekumar, K., Reddy, T. P., & Prathap, B. R. (2024). Enhancing Patient Safety and Efficiency in Intravenous Therapy. *Internet of Things in Bioelectronics*, 171–200. https://doi.org/10.1002/9781394241903.CH9

Venkat, S., Annalakshmi, T., Vanitha, L., Arun Karthik, M., Hari Prakash, N., & Jerin Abhishek, K. (2023). Intelligent Intravenous Fluid Monitoring System For Health Surveillance Applications. *IEEE 9th International Conference on Smart Structures and Systems, ICSSS 2023*. https://doi.org/10.1109/ICSSS58085.2023.10407101

Venkatesh, K., Karia, D., & Arora, M. (2021). Clinical Investigation as an Iteration Tool for the Design of Low-Risk Medical Devices: A Case Study of an IV Drip Monitoring System. *2021 11th IEEE Global Humanitarian Technology Conference, GHTC 2021*, 131–137. https://doi.org/10.1109/GHTC53159.2021.9612491

Vinan-Vega, M. N., Rahman, M. R., Thompson, J., Ruppert, M. D., Patel, R. J., Ismail, A., Mousa, S., & Payne, J. D. (2019). Air embolism following peripheral intravenous access. *Baylor University Medical Center Proceedings*, *32*(3), 433–434. https://doi.org/10.1080/08998280.2019.1609154

What Is IV Therapy? (2024). Retrieved November 3, 2024, from https://www.verywellhealth.com/iv-therapy-5216194

Yang, R., Xiong, R., He, H., & Chen, Z. (2018). A fractional-order model-based battery external short circuit fault diagnosis approach for all-climate electric vehicles application. *Journal of Cleaner Production*, *187*, 950–959. https://doi.org/10.1016/J.JCLEPRO.2018.03.259