

Infusion Fluid Monitoring System Using Arduino Microcontroller and Internet of Think (IoT) to Increase Work Efficiency of Nurses in Hospital

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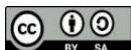
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ABSTRACT

The occurrence of embolism and infiltration is still a significant problem in intravenous fluid therapy. An innovative product is needed to help nurses work properly. This study aimed to analyze the accuracy of digital monitoring programs for intravenous fluids in improving the work efficiency of nurses in hospitals. Research and Development design was employed in this study with the ADDIE Model approach. The digital system used an Arduino Microcontroller, Internet of Think, and displayed in an Android application. The study was conducted for three months; sixty-five, nurses from the General Hospital participated by purposive sampling technique. Each participant was given a questionnaire and logbook of infusion handling time. Data were analyzed by algorithm system, independent t-test, and paired t-test. The study showed that the accuracy of the infusion for 1 minute, 15 minutes, and 30 minutes is 99.5%. Most of the nurses were easy to use program application (77.14%), worked more efficiently (77.68%), decreased the average infusion handling time (4.06 minutes), and had a difference in the average time before and after the program implementation ($p=0.002$). Digital intravenous fluids monitoring systems can improve the work efficiency of nurses in hospitals. The application can be applied and become an innovative product reference for nursing.

Keywords: digital; infusion; internet of things; microcontroller; nurse

INTRODUCTION

The complexity of the infusion problem that is currently still at the ordinary clinical level requires nurses' attention. Nurses still must do strict inspections or control so that things do not happen desired for the patient's condition. Some of the problems that often occur are increased blood flow to the infusion tube, or what can be called infiltration, the presence of air in the infusion tube, or what can be called Air Embolism, and infusion that runs out but it's late for the action of replacing the injection by the nurse. Infiltration problems occur because nurses must be on time to replace the fluid. The infusion runs out, the infusion tube is folded, and the position of the infusion needle is the parallel or higher height of the infusion fluid (Schnock KO et al., 2017). The incidence of infiltration from the data of Infusion Nursing Society in patients hospitalized due to lack of control on infusion occurred as much as 63-78% (Potter & Perry, 2011).

The danger of infiltration in the infusion tube, if not treated quickly, can form a blood clot (blood clotting/thrombosis). Thrombosis, when released, can circulate in the bloodstream and cause obstruction. Thrombosis can also block small blood vessels in the body and cause pulmonary and air embolism. Causes of air embolism are the infusion fluid that is replaced late and turbulence in the tube and liquid bottle. As well as with the mechanism of thrombosis, air embolism in the infusion tube can block blood flow. Venous air embolism (VAE) is a potential complication of surgical procedures and central venous access. There are several reports in the literature on VAE during the in-hospital use and placement of primary venous access. VAE may be introduced through disruption in the integrity of the venous circulation during insertion, maintenance, or removal of intravenous or central venous catheters. VAE impacts pulmonary circulation, respiratory and cardiac function, systemic inflammation, and coagulation, often with severe or fatal consequences. When VAE enters arterial circulation, air emboli affect cerebral blood flow and the central nervous system. Early recognition and treatment reduce the clinical sequelae of VAE.

An organized team approach to therapy, including clinical simulation, can facilitate preparedness for VAE (Brul & Priellipp, 2017). The infusion fluid monitoring system in the Hospital is still performed manually by medical personnel. There is still much fluid in infusions that nurses do not adequately monitor. Often happen patient's family informs the nurse that the IV is running out. That matter results in delays in replacing the infusion fluids that have run out of content. The initial assessment is very important in determining appropriate nursing diagnoses, planning nursing actions, and carrying out nursing actions. (Agussalim, Adnan, & Niswar, 2016; Dinda, Sulityorini, Rahmawati, 2022).

Understaffed nurses are also a problem in changing intravenous fluids. Based on the results of the survey at the General Hospital of Bangli in 2019 was described several issues regarding intravenous therapy via infusion at 45% infiltration, air embolism at 56.5%, and exhausted infusion but too late for action infusion replacement by nurses at 42%, takes an average of 12 minutes for infusion problem solving (Bangli General Hospital, 2019).

Nurses need more time to overcome infusion problems so that it has an impact on their work efficiency of nurses. Therefore, it is necessary to develop innovative digital infusion monitoring products. Several studies have been conducted on infusion monitoring tools, such as the Centralized Infusion Fluid Monitoring System Using Digital Image Processing. Designing Infusion-Based Monitoring System Wemos D1 R2 microcontroller. Automatic stopping and infusion monitoring with a telemetry system based on Android (Primahayu, Utaminingrum, Syahugy, 2017; Kusuma & Mulia, 2018; Aziis, 2018). The research is limited to sensitivity testing, and tool validation has yet to reach the user's functional test, in this case, nurses. Therefore, it is necessary to develop a digital infusion monitoring tool using an Arduino microcontroller and the Internet of Things (IoT) to increase the work efficiency of nurses in Hospitals.

METHOD

The study used Research and Development (R&D) design with the ADDIE Model approach (Sugiyono. 2017). The development of the Digital infusion fluid monitoring system consists of five phases based on research design Analysis, Design, Development, Implementation, and Evaluation of learning materials and activities. This model procedure is given below.



- 1) Analyze the need for new product development and the feasibility and requirements of product development.
- 2) A systematic process that starts from designing the concept and content of the product.
- 3) Activities for the realization of product designs that have previously been made.
- 4) Ask questions related to product development goals.
- 5) Provide feedback to product users so that revisions are made according to the evaluation results or need the product still needs to meet.

Figure 1. The ADDIE Model (Microcontroller)

Analysis Phase

The Analysis phase is the basis for all other stages of the instructional design of the digital infusion fluid monitoring model. During this phase, the researcher defines the problem, identifies the source of the problem, and determines the possible solutions. This phase may include specific research techniques such as needs objectives and task analysis. The outputs of this phase often include instructional objectives for addressing problems that have occurred. This output will be an input for developing innovative products (Dick, Carey, & Carey, 1996).

Several problems related to the manual infusion fluid monitoring system will impact issues such as jammed infusion, rising blood to the infusion tube, and empty infusion, which causes infiltration, air embolism, and phlebitis. these conditions affect patient safety and the work efficiency of nurses. Nurses need extra time to tackle these problems.

The application of a system to reduce the risk of injury to patients, namely the process of giving infusion fluids, has been controlled by an infusion pump. This tool can detect the smoothness and volume of infusion drops and warn nurses in the patient room. However, this tool is still very expensive; The price is not affordable by hospitals or small health institutions. The availability of infusion fluid monitoring tools currently needs to be implemented in all inpatient rooms.

Design Phase

Giving infusion to the patient requires very accurate calculations and careful observation based on the existing rules to prevent fatal symptoms in a patient. In Indonesia, infusion monitoring is still done manually. However, in the present moment, it becomes ineffective. House conditions, extensive disease, a large number of patients, and limited medical personnel make manual monitoring infusion can cause problems such as negligence in monitoring that can lead to delays in performing infusion changes. This delay can strikethrough blood to be sucked out infusion hose. The pump Infusion tool was equipped with an optocoupler sensor circuit as a drip number detector entered the body. This tool was also equipped with indicators that tell if the infusion liquid has run out or the droplet was not flowing. The module that was designed was able to work well when there was an error, such as the bottle was empty or the drip was not dropped into the drip chamber, and the counting accuracy of the number of droplets was 96.2% per minute (Wadianto, Zhafirah, & Fihayah, 2016).

The primary devices used in the administration of intravenous fluids consist of 3 parts, such as (a) part of the infusion fluid bottle/bag (solution bag), (b) infusion set section, and (c) infusion needle section (*AboCath*). A sensor is a device that receives a stimulus and responds with signal electricity (Yulkifli, 2013). In this study, sensors used photogate to measure the number of infusions drops per minute. The photogate sensor is a measuring device time that detects an object or objects so that it can be known how long the object time is when blocking the sensor. This sensor consists of a light source and a light detector. Microcontrollers are currently equipped with supporting peripherals to form a complete computer at the chip level. The microcontroller is an IC consisting of RAM, ROM, parallel I/O, a counter, and a clock circuit (Yohandri, 2013).

Arduino consists of various variations, including Arduino Mega, Arduino Uno, and Arduino Pro Mini. Various boards Arduino uses different types of ATmega depending on the specifications. For example, Arduino Uno uses the ATmega328 while the more advanced Arduino Mega 2560 (Arifin et al., 2016). This study uses Arduino Mega 2560 as a microcontroller.

The IoT (Internet of Think) linked to the devices and equipment was allowed to wirelessly measure and transmit the biometric data, location information of medical staff and patients, and the location information of specimens and other items. In addition, IoT technology offers opportunities to collect a variety of personal lifelog data through wearable sensors and mobile applications. In terms of what this does is use the module The ESP 8266 which is connected to the sensor and servo motor and is expected to detect the infusion volume and send the information to the server via the internet so that the monitoring process of the state of the infusion can be done in real-time and the process of changing the infusion can be done quickly and precisely without waiting for the process observation or reporting from the family patient. Other supporting devices used are a buzzer, TFT LCD, motor servo, and battery. Software development using PHP, MySQL, and Firebase. When the infusion condition runs out, an Internet-connected browser will provide voice and data notifications to explain the real condition of the infusion which is then connected via an android smartphone..

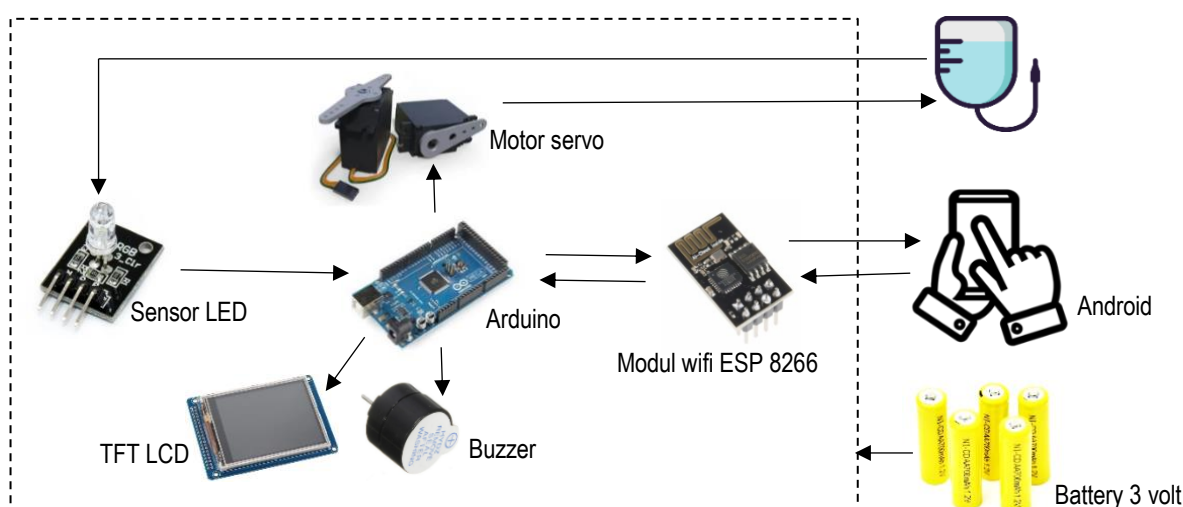


Figure 2. Schematic system

The tool that has been made is validated with a system algorithm test to ensure the tool is valid for 1-minute, 5-minute, and 15-minute calculations in the Nursing Laboratory of Udayana University.

Table 1. Test Results of Digital Infusion Fluid Monitoring System in the Laboratory

No	1 minute				15 minutes				30 minutes			
	Manual	Monitor	Error	% Error	Manual	Monitor	Error	% Error	Manual	Monitor	Error	% Error
1	500 ml	500	0	0	500 ml	500	0	0	500 ml	501	1	0.2
2	500 ml	501	1	0.2	500 ml	503	3	0.6	500 ml	500	0	0
3	500 ml	498	2	0.4	500 ml	502	2	0.4	500 ml	499	1	0.2
4	500 ml	500	0	0	500 ml	500	0	0	500 ml	500	0	0
5	500 ml	500	0	0	500 ml	500	0	0	500 ml	500	0	0
6	500 ml	499	1	0.2	500 ml	500	0	0.2	500 ml	499	1	0.2
7	500 ml	502	2	0.4	500 ml	498	2	0.4	500 ml	502	2	0.4
8	500 ml	500	0	0	500 ml	500	0	0	500 ml	500	0	0
9	500 ml	497	3	0.6	500 ml	500	0	0	500 ml	497	3	0.6
10	500 ml	499	1	0.2	500 ml	497	3	0.6	500 ml	499	1	0.2
11	500 ml	500	0	0	500 ml	500	0	0	500 ml	500	0	0
12	500 ml	500	0	0	500 ml	498	2	0.2	500 ml	500	0	0
Mean				0.16				0.20				0.14

Description of measurement error: Every 500 ml = 100%, 100 ml = 20%, 50 ml = 10%, 5 ml = 1%, 1 ml = 0.2 %. Sending data every 24 seconds and auto refresh monitoring web page every five once a second, with a percentage of total measurement error (0.5%) of the manual measurement results. Accuracy system (99.5%), so in this system, the process of sharing the data was successfully carried out because the data have a load cell against the infusion is successfully saved in MySQL database.

Development Phase

Several developments of tools related to setting and monitoring infusion drops have been carried out such as infusion pumps with relatively high prices. Other developments have also been carried out but there are still weaknesses such as only monitoring the droplets and displaying them on the visual basic system graph. This device is not equipped with a system for regulating the number of drips of intravenous fluids. Some have designed a monitoring and control device for the number of infusions drops with a photodiode sensor as an infusion drop sensor and a micro servo as a droplet rate controller. However, the main controller still used the ATmega16 AVR microcontroller.

After the product design was completed, then consulted with experts to find out the weaknesses of the tools that have been made. Researchers modified the design of the infusion monitoring device based on expert input and expertise. Developing a digital infusion fluid monitoring tool involves several scientific fields such as the electrical team, the Udayana University informatics team, the Vocational Education School, and expert nurses who work in hospitals.

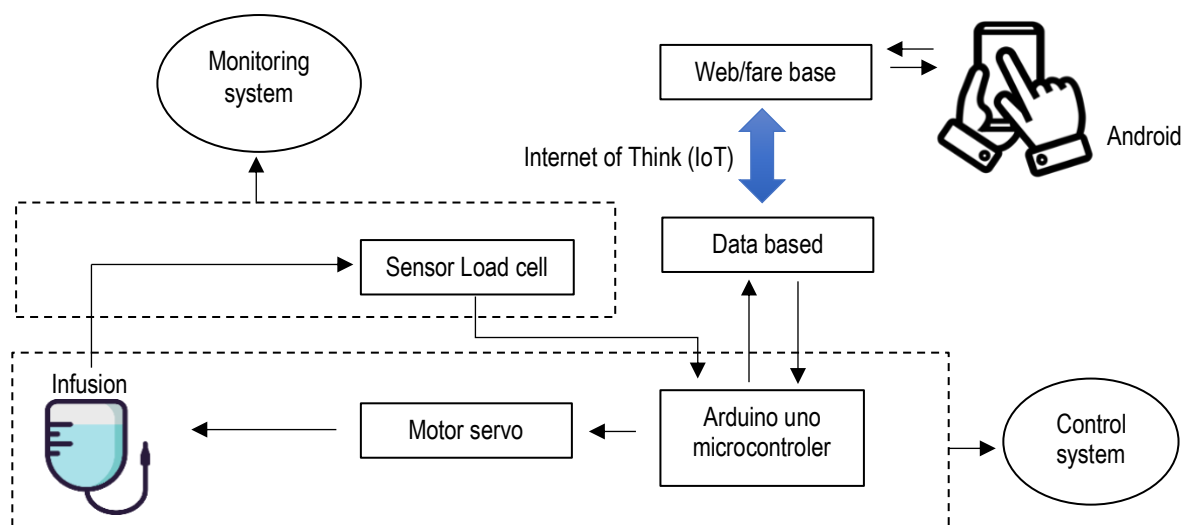


Figure 3. Digital Infusion Fluid Monitoring System

The schematic circuit of the system is shown in Figure 3. Arduino Uno is the control center of the loadcell sensor and servo motor. Arduino Uno is a microcontroller with an ESP8266 WIFI module widely used for designing the Internet of Things (IoT) based tools.

Implementation Phase

Initial trials were conducted by simulation using the method prototype in a limited group. Testing was carried out in a nursing laboratory on a mannequin. The initial test aimed to determine the validity or sensitivity of the digital infusion fluid monitoring device. The next program is to do a trial in a real setting in the Hospital to get information on whether the prototype is more efficient compared to a conventional system.

The pretest-posttest with the control group design was used to determine the effect of using the tool on nurses as users in increasing hospital work efficiency.

The research was conducted at the General Hospital of Bangli. Research data collection was carried out for three months. The sample in this study was 65 Nurses at the General Hospital of Bangli region, with a purposive sampling technique. Each participant was given a questionnaire regarding sociodemographics, infusion handling time, and perception of the application program to measure the work efficiency of nurses based on the time of handling infusion problems.

Evaluation Phase

This phase measures the efficiency of the digital drip monitoring tool instructions. Researchers analyzed changes in work efficiency in handling infusion therapy problems before and after the program's installation. Researchers also compared the work efficiency of nurses between the intervention group and the control group.

The evaluation must occur throughout the instructional design process – in phases, between phases, and after implementation. Data from the evaluation is used to make decisions about using innovative products for monitoring infusion fluids developed so that they can be downstream to the medical device industry and health care facilities.

RESULT

Table 2. Nurses' Distribution and Perceptions of Digital Infusion Fluid Monitoring System (n=65)

Variables of Sociodemographic among Intervention Group	f (%)	Nurses' Perception of Digital Infusion Fluid Monitoring System		Variables of Sociodemographic among Control Group	f (%)
		Easy (%)	Difficult (%)		
Gender				Gender	
Male	11 (31.4)	9 (81.8)	2 (18.2)	Male	9 (31.4)
Female	24 (68.6)	18 (75)	6 (25)	Female	21 (68.6)
Education				Education	
Vocational Nurse	15 (42.8)	10 (66.6)	5 (33.4)	Vocational Nurse	10 (33.3)
Bachelor of Nurse	20 (57.2)	17 (85)	3 (15)	Bachelor of Nurse	20 (66.7)
Marital status				Marital status	
Married	23 (65.7)	17 (73.9)	6 (26.1)	Married	21 (70)
Not married yet	12 (34.3)	10 (83.3)	2 (16.7)	Not married yet	9 (30)
Employment status				Employment status	
Government employees	20 (57.2)	17 (85)	3 (15)	Government employees	15 (50)
Contract	12 (34.3)	10 (66.6)	5 (33.4)	Contract	15 (50)
Length of working				Length of working	
<5 years	12 (34.3)	10 (83.3)	2 (16.7)	<5 years	12 (40)
>5 years	23 (65.7)	17 (73.9)	8 (22.8)	>5 years	18 (60)
Total	35 (100)	27 (77.14)	8 (22.8)	Total	30 (100)

Based on Table 2. It can be explained that of the 35 participants in the intervention group, as many as 27 people (77.14%) found it easy to apply the digital nursing diagnosis enforcement program, the Male gender (81.8%) while the female (75%). Based on the level of education, nurses' perceptions mostly stated that they were easy at the bachelor level nurses (85%), with unmarried status (73.9%), government employees (85%), and a working period of < 5 years (83.3%).

In the control group, most of the participants were female (68.6%), bachelor-level nurses (66.7%), married status (70%), government employees (50%), and working period > 5 years (60%).

Table 3. Work Efficiency of Nurses in Providing Nursing Interventions to Overcome Infusion Problem

Variables of Sociodemographic among Intervention Group	Work in monitoring and handling infusion problem				
	Efficient (%)	Less efficient (%)	Odd ratio (OR)	95% CI	p-value
Gender					
Male	11 (72.6)	4 (27.4)	2.662	1.985-8.022	0.174
Female	17 (85.8)	3 (14.2)	Ref.		
Education					
Vocational Nurse	10 (83.1)	2 (16.9)	3.511	0.212-6.261	0.008*
Bachelor of Nurse	18 (78.2)	5 (21.8)	Ref.		
Marital status					
Married	16 (80.0)	4 (20.0)	0.517	0.023-5.510	0.320
Not married yet	12 (80.0)	3 (20.0)	Ref.		
Employment status					
Government employees	9 (81.1)	2 (18.9)	Ref.	2.014-12.744	0.011*
Contract	19 (72.8)	5 (21.2)	2.502		
Length of working					
<5 years	10 (83.1)	2 (16.9)	Ref.	4.152-9.098	0.000*
>5 years	18 (77.6)	5 (21.4)	5.393		
Total	28 (77.68)	7 (22.32)			

Based on Table 3, it can be explained that most of the female participants (85.8%) have efficient performance compared to male participants; there is no significant relationship between gender and nursing work efficiency. Participants with bachelor's education perform more efficiently than participants with vocational education (83.1%). There is a relationship between the level of education and the work efficiency of nurses for nursing care; nurses with a bachelor's level of education can be 3.5 times more efficient than the level of vocational education. Both married and unmarried participants performed efficiently (80%), but statistically, there was no significant relationship between marital status and nurse work efficiency. In terms of employment status, both government employees and contract, most have efficient performance (81.1%) and (72.8%); statistically, there is a relationship between employment status and work efficiency; government employees and nurses have the potential to be 2.5 times more efficient compared to nurses who are contract status. There is a significant relationship between the length of work and the work efficiency of nurses; statistically, nurses with a length of working > 5 years have a 5.3 times more efficient performance compared to those with a length of working < 5 years after the intervention.

Table 4. An Analysis of The Digital Infusion Fluid Monitoring System on The Work Efficiency of Nurses in Hospitals

		mean	n	Standard Deviation	Standard Error Mean
Pair 1	Pre_intervention	10.5667	30	1.75	0.320
	Post_intervention	6.1333	30	1.47	0.270
Pair 2	Pre_control	10.6667	30	2.90	0.530
	Post_control	10.6333	30	2.95	0.539

	Mean	Standard Deviation	95% CI	t	df	p-value	p-value*
Pre_intervention-post_intervention	4.060	2.37	3.547-5.319	10.231	29	0.002	0.000*
Pre_control-post_control	0.033	2.79	-1.011-1.077	0.065	29	0.948	

Based on Table 4, it can be explained that the average time needed by nurses to overcome the problem of infusion therapy before intervention was 10.56 minutes, and after the intervention, 6.13 minutes and in the control group, the average time needed by nurses to overcome the problem of infusion therapy before the intervention was 10.66 minutes after the intervention was 10.63 minutes. There was a decrease in time in the intervention group by 4.06 minutes, while in the control group, it decreased by 0.03 minutes. There was an effect of giving a digital infusion program on the work efficiency of nurses ($p=0.002$) in the control group ($p=0.948$). The results showed differences between the intervention and control groups ($p=0.000$).

DISCUSSION

Digital development of infusion fluid monitoring systems is a relatively good and cost-efficient design option. To design a fluid monitoring system, centralized infusion required several components. The selection of the Arduino microcontroller and the use of the Internet of Things (IoT) is very relevant following the latest developments. Microcontrollers are currently equipped with supporting peripherals to form a complete computer at the chip level; simply the microcontroller is an IC consisting of. ESP 8266 is a WiFi module that has become increasingly popular with hardware developers lately. Apart from the very high price affordable, this versatile WiFi module has is SOC (System on Chip), so we can do programming directly to ESP8266 without the need for a microcontroller addition. Another advantage is that this ESP8266 can run the role of Adhoc access points and clients simultaneously (Mehta, 2015). Arduino microcontrollers, wifi, and IoT modules can be found in various health equipment that can support the performance of nurses in Hospitals.

Internet of things process on monitoring successfully done this is proven by internet can be used for continuous observation on infusion conditions in the field. The process of sharing data that converts the infusion condition was successful because infusion conditions can be recorded in the database MySQL and accessed via the web. In 12 tests, an error rate of 0.5% was obtained, which means the load cell sensor has a small error rate in detecting the infusion volume or an accuracy rate of 99.5%. The study results are relevant to using infusions in hospitalized patients accompanied by supervision and monitoring regular check-ups by nurses. The Wemos D1 R2 Microcontroller can be used as a tool to monitor Infusions that are almost running out and need to be replaced immediately and also the observation of the number of infusion drops required by the patient. The IOT based patient monitoring system has been successfully developed. This system able to measure the body temperature and respiratory rate and the measured data sent wirelessly to android apps using IOT platform. In hospitals, while the opportunities and challenges of the Internet of Things (IoT) applications are continuously increasing, research on what IoT services are actually in demand in hospitals has yet to be conducted. This study conducted a survey of working hospital nurses to confirm the demand for IoT services. There is a continuous increase in challenges and opportunities in IoT applications. IoT can also address fitness management, private health, chronic disease supervision, elderly care, and pediatric care. We develop a novel system that offers secure integration of a smart hospital environment with the help of IoT and AI. The safety issues, privacy, adoption barriers, and gaps in the existing smart systems are addressed (Hadis et al., 2020; Kang et al., 2019; Valanarasu, 2019). The accuracy of measuring medical devices helps nurses anticipate health problems faced by patients in hospitals.

The transmitter, receiver, and chambers must be placed in a straight line for droplets to be detected by the infrared sensor. An infrared sensor using a photodiode can detect the presence of droplets in the drip infusion chamber because the photodiode's responsibility for detecting infrared light is better than a phototransistor. An infrared sensor can detect infusion fluid drips by seeing the difference in the sensor output voltage when the drop is passed, and the drop is not passed. The sensor used to measure infusion drops per minute is photogate and to measure the infusion volume is a load cell. Motor Servo Tower Pro SG90 is used as automatic drip control and Arduino mega is used as a brain for this instrument. The display uses a TFT LCD and using buzzer for alarm warning. The accuracy of infusion drops per minute system is 0.97 with an error of 1.25% and the accuracy of infusion volume is 0.978 with an error 1.944% (Natalia, Nandang, & Riandita. 2016; Fauziyyah & Yohandri, 2020)

Monitoring infusion through technology can reduce the risk of pain compared to conventional. The results showed that the majority of nurses had a positive attitude towards technology development and saw it as an important part of the nursing profession in the future. Overall, nurses consider that the integration of IoT technology has a significant influence in helping nurses work and increasing work efficiency. Nurses also consider that the adoption of IoT technology in health services can improve patient safety. However, there are also some negative aspects of using technology in health services. The implementation of the smart pumps reduced the annual consumption of IV solutions to 8994 units (18%) and 3649 liters (22.3%). From an institutional perspective and with a probability of 0.63, the use of MedNet™ technology proved to be a lower-cost alternative (17.1% saved) with respect to the conventional infusion systems (Rosas, 2019).

The majority of respondents (77.14%) found it easy to apply to the program. Most nurses (77.86%) felt worked more efficiently. Education level, employee status, and length of work are the dominant factors related to the work efficiency of nurses. Bachelor's education level 3.5 times feel more efficient than vocational education, a Government employee's status 2.5 times feel more efficient than contract employees, work period of more than five years 5.3 times feel more efficient than work period of fewer than five years. The simple way of working affects the work efficiency of nurses (Nursalam, 2015). A comparison between the ward and non-ward nurses showed that individuals working inwards had a high patient demand for care-related IoT services, and individuals working in non-ward departments demonstrated a high demand for IoT services to improve work efficiency (Nabella, 2021).

Implementing a digital monitoring program for intravenous fluids can improve the work efficiency of nurses in hospitals ($p=0.002$). Decrease the average working time in monitoring and handling infusion problems by 4.0666 minutes, the difference in the average time between the intervention and control groups ($p=0.000$). The use of computer/digital-based information technology affects the performance of nurses in hospitals. The Means and Infrastructure variables affect employee efficiency at the Teluk Pinang Health Center (Selviani, 2019; Swedarma, 2019). Most nurses have good perceptions or thoughts about technology-based caring. Nurses have a contribution in demonstrating the use of technological competence. (Rohmawati et al., 2021)

As part that the variable SIMRS and network technology have a significant effect on the efficiency of employee performance at Jombang Hospital. the use of SIMRS and network technology contributed 86.7% to the efficiency of employee performance (Saptono, 2015). The scoping review results can be used as a basis for further research in digital technology and nursing care. The field of technologies for informal and formal care has already been explored in terms of acceptance, effectiveness, and efficiency (AEE), and presented a structured overview of the methods used, target settings, fields of support and target groups of these technologies and provide databased indications which technologies appear to be promising for further research. Given the broad field and large number of potentially relevant technologies, producing a concise capture, systematization, and summary of all information was indeed challenging research (Krick et al., 2019).

The development of technology in an organization can make a relative advantage, with compatible technology, able to minimize the complexity in the field so that it has innovative characteristics to face every challenge. Efficiency can be achieved by implementing a Hospital Information System that is oriented to the business process needs of each Hospital. Need adjustment of business processes with Hospital Information Systems can support hospitals to have a competitive advantage and be able to compete (Fadilla & Setyonugroho, 2021). Nurses can utilize sophisticated medical devices in health to improve the quality of health services to the patients in hospitals.

CONCLUSION

The realization of an infusion fluid monitoring system using an Arduino Microcontroller and the Internet of Think (IoT) with a simple display is a relatively good and cost-efficient design option. Most nurses felt worked more efficiently in providing nursing interventions to overcome infusion problems. Implementing the digital monitoring program for intravenous fluids can improve the work efficiency of nurses in hospitals. The results of this study can be replicated and developed, especially for hospital management, and take advantage of digitalization to increase professionalism and community satisfaction.

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