



Assessment on Application Effect of Intelligent Pressure Ulcer Information Management System Software

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Abstract

Background: We aimed to apply the intelligent pressure ulcer information management system software to hospitalized patients with pressure ulcer and to evaluate its application effect.

Method: Fifty patients hospitalized in the Third Xiangya Hospital of Central South University, Changsha, China, a grade-A tertiary hospital from March 2021 to May 2021 were grouped into the control group. For these subjects, conventional electronic forms were used to report and manage pressure ulcer information. Another 50 patients with pressure ulcer were selected as the experimental group who were hospitalized the same hospital from June 2021 to August 2021. They were managed with Intelligent Pressure Ulcer Information Management System Software.

Results: The effects of the two management methods were assessed by comparing the reporting time, the degree of pressure ulcer healing 1 week after the occurrence of pressure ulcer and after discharge, and the nurse satisfaction. The reporting time and Design-R scores 1 week after the occurrence of pressure ulcer and after discharge were significantly lower than those of the control group ($P < 0.05$).

Conclusion: The pressure ulcer information management system makes the reporting process simple and convenient, which saves the reporting time, improves the accuracy of the pressure ulcer staging. It achieved the guidance for various stages of pressure ulcer treatment program, the use of dressing guidance, improved the accuracy of pressure ulcer treatment program, which is worthy of clinical reference.

Keywords: Pressure ulcer; Management; Intelligent system

Introduction

Pressure ulcer is a global health problem and the prevalence has remained high. The 2013-2014 international pressure ulcer survey showed that the incidence of pressure ulcer is 4.1% in patients with self-care ability and 16.3% in patients with

incontinence (1). Pressure ulcer brings many adverse effects on patients' quality of life, such as increased pain, sense of isolation, fear and anxiety (2, 3). Meanwhile, it also affects the diagnosis, treatment and recovery of the primary disease,



extends the hospital stay of patients, increases the hospitalization cost, increases the economic burden of society and family, and may even endanger the patients' life (4-6).

Pressure ulcer management should involve various aspects, such as prevention, treatment, and feedback, which is a continuous process. Before the implementation of information management, hospitals report pressure ulcer mainly through document records and printed forms, which was not easy to file. The phenomenon of re-reporting and omission caused by bed or department transfer occurred from time to time, which brought difficulties to the continuous management of pressure ulcer. In recent years, there were some newly published policies in China, such as China Nursing Career Development Plan (2016-2020) (7), Notice on Printing and Distributing the Guiding Opinions on Promoting the Reform and Development of the Nursing Service Industry (8). These policies point out that the construction of nursing informatics needs to be strengthened, and the model of nursing service should be innovative, so as to improve nursing efficiency and management efficacy.

Based on this, our hospital designed a pressure ulcer information management system that is easy to operate and includes various functions, including risk assessment, pressure ulcer staging and treatment guidance, feedback on treatment efficacy, and assessment of the degree of pressure ulcer healing. The clinical application effect is now reported as follows.

Materials and Methods

General information

Patients with new or external pressure ulcer admitted to The Third Xiangya Hospital of Central South University from March 2021 to August 2021 were selected as the subjects by cohort sampling method. Inclusion criteria for subjects: 1) Greater than 18 years of age; 2) Patients with Braden score ≤ 12 ; 3) Patients with hospital stay of 7 days. Exclusion criteria for subjects: 1) Patients whose family members refused the treatment for pressure ulcers; 2) Patients who

died or abandoned the treatment due to accident or disease progression. A total of 100 patients who met the above criteria were included in the study, and were divided into control group (March 2021 to May 2021) and experimental group (June 2021 to August 2021) according to the admission order.

The study was approved by the hospital ethics committee (N0:2020-S411).

The control group was reported and managed with conventional electronic forms for pressure ulcer information, which was conducted as the following process: Pressure ulcer managers carried out a comprehensive examination for the patients with pressure ulcers, assessed the risk of pressure ulcer with Braden rating scale and made corresponding records, and reported the information of the patients with the Registration Form of Pressure Ulcer Occurred in Other Hospitals or the Registration Form of Newly Occurred Pressure Ulcer in the Hospital. The pressure ulcer managers changed the medication regularly according to the 2019 "Pressure Ulcer/Pressure Injury Prevention and Treatment: Clinical Practice Guidelines" guidelines (10), filled in the situation of the skin, therapeutic care measures and the cure after transferring regularly. The experimental group was managed with the Intelligent Pressure Ulcer Information Management System Software. The software was designed for the researcher's master's degree (10), and then it was upgraded by the information department of the hospital to integrate the electronic nursing medical record system of the hospital. The main functional modules of the software include: login module, reporting module, staging and treatment guidance module, assessment module, consultation module, information query and management module.

1) Login module: In the pressure ulcer information management system, users are pressure ulcer managers and system administrator, and the system grants different rights to the users according to their identity. When the users log in, the system identifies their identity and assigns the permission according to their name and password that they entered.

2) Reporting module: Patients' general information can be entered into the system by entering patients' information in the electronic medical record interface. After successful input, it will be displayed in the list box for patients' information. The pressure ulcer report includes four parts: Patients' general information, conditions of pressure ulcer, pathogeny of pressure ulcer, and therapeutic regimes. When reporting pressure ulcer, pressure ulcer reporting can be completed by entering complete and correct patients' information into the report. Since the pressure ulcer reporting module involves a large amount of information to input, in order to prevent users from entering wrong data or missing data to input, the system will check the information before the user submits the report. When the format of the information entered by the user is incorrect or the information is missed by the user, the system will give a corresponding reminder.

3) Staging and treatment guidance module: It is the core function part of the pressure ulcer information management system, which can be divided into four functional sub-modules: pressure ulcer site selection, pressure ulcer stage identification and guidance, therapeutic regime guidance and dressing guidance. After uploading the patients' photos about pressure ulcer, automated identification of patients' pressure ulcer stage can be called on the image recognition function of the system after clicking the AI staging identification button. After AI identification, the staging identification results will be prompted and displayed in the software, and the staging guidance interface will pop up according to the results. The user can confirm the correctness of the staging in the system again according to the identification results and staging guidance of the AI identification, which can be corrected or supplemented manually. After the user completes the pressure ulcer staging, the system is able to automatically select the treatment regime and the recommended dressing suitable for the current patient. The treatment options and recommended dressings for pressure ulcers referred to the "Prevention and Treatment of

Pressure Ulcers/Pressure Injuries: Clinical Practice Guidelines, 2019 edition".

4) Assessment module: ① Pressure ulcer risk assessment adopts the most widely used Braden pressure ulcer scoring scale. After pressure ulcer managers input the data, the system automatically calculates the scores and the total score, and makes the corresponding risk level. The system warns the assessment results, if the pressure ulcer risk degree is high risk and extreme risk, the system will mark the patients as high-risk patients, their pressure ulcer information will be sent to the high-risk patients table. Every time the user visits the system or every 48 hours, the system will intelligently prompt the pressure ulcer managers to re-assess the patient. ② The degree of pressure ulcer healing is assessed with the Design-R scale. After pressure ulcer managers input the data, the system will automatically calculate each score and the total score, guide pressure ulcer managers for timely assessing the pressure ulcer healing. The historical assessment records of the current assessed patients can be viewed.

5) Consultation module: In addition to the manual application for consultation, every time there is an update of patients' data in the system or every 24 hours, the system will automatically scan the database of patients' pressure ulcer assessment form. When the risk level of the patients assessed is higher than the preset risk index of the system, the system will list the patients who need to initiate the pressure ulcer consultation in time to the user. After determining the consultation for the patients, users can input the contents into the consultation contents, consultation requirements and consultation opinions at the bottom of the interface. Furthermore, users can also choose a document as the consultation content and upload it to the consultation record.

6) The information query module searches the patients' files stored in the database through keyword screening. Users can enter one or more keywords for screening, such as name, gender, admission number, ward and so on. After finding

the specific patient, users can view the pressure ulcer report of the selected patient, evaluate and consult the patient.

The specific process is: Pressure ulcer managers conducted a comprehensive examination for the patients with pressure ulcers. For patients with pressure ulcer, the information of pressure ulcers was input into the software with the Report of Pressure Ulcer Occurred in Other Hospitals or the Report of Newly Occurred Pressure Ulcer in the Hospital. The types of pressure ulcer were distinguished by the system, and were filled into the corresponding form, respectively. On each form, there are automatic selection of pressure ulcer parts on manikin map, upload of pressure ulcer pictures, automatic identification and staging of pressure ulcer pictures, intelligent guidance for pressure ulcer treatment regime and dressing selection. Pressure ulcer managers saved the relevant information and submitted it to the pressure ulcer team and the nursing department. If the information was incomplete or wrong, the pressure ulcer team or nursing department will return the data for re-entry until the patient's pressure ulcer heals and the data was exported and archived.

After the relevant information was registered, the software would identify the stage of the pressure ulcer and recommend the pressure ulcer treatment plan and dressing. The pressure ulcer managers can prevent and change the dressing for the pressure ulcer according to the pressure ulcer treatment plan recommended by the software. In the case of difficult pressure ulcers that cannot be handled by themselves, pressure ulcer managers can apply for pressure ulcer team consultation in the software. After on-site observation and judgment, the pressure ulcer experts could provide further treatment advice in the pressure ulcer consultation module. The degree of pressure ulcer healing of the patients was assessed by the deputy nurses 1 week after the occurrence of pressure ulcer and after discharge.

In this study, the control and experimental groups used the same pressure ulcer assessment scale and pressure ulcer treatment plan.

Research tools

Patients' risk of pressure ulcer was assessed with the Braden assessment scale developed in 1987 by the two doctors, Braden and Bergstrom (12). It includes perception, humidity, mobility, locomotivity, nutrition and friction/shear force. The score 15~18 means mild risk, 13~14 means moderate risk, 10~12 means high risk, and 9 or less means extreme risk. The scale is widely used, with good reliability and validity.

The Design-R pressure ulcer healing assessment scale (13) was developed by the Academic Committee of Japanese Pressure Ulcer Society in 2002, which was used to evaluate the degree of pressure ulcer healing from seven items including depth, exudate, scope, inflammation/infection, granulation tissue, necrotic tissue and blister. The total score ranged from 0 (healing) to 66 (most severe), with a lower score indicating better healing. Depth was assessed individually and might fluctuate during pressure ulcer healing. Inter-rater reliability > 0.910 (14), ICC=0.960 in Chinese translation (15).

Self-designed satisfaction questionnaires were used to investigate paramedics' satisfaction of use. It includes five aspects: the convenience of operation, the detail of content, the time-consuming of use, the guidance of pressure ulcer nursing and the availability of data for research. All questions were graded by through Likert 5. Higher scores indicates higher user satisfaction.

Data collection

The reporting time was recorded. The effects of the two pressure ulcer management methods were assessed with the Design-R pressure ulcer healing assessment scale for the degree of pressure ulcer healing at 1 week after the pressure ulcer and after discharge. A self-designed satisfaction questionnaire was used to investigate the satisfaction of pressure ulcer managers participating in the project.

Statistical methods

All data available in this study were established with SPSS 20.0 (IBM Corp., Armonk, NY, USA).

According to the types of data, the data were described with the frequency, composition ratio or mean±standard deviation. The relevant information were compared with chi-square or t-test, with a significant level of $P < 0.05$.

Results

The results showed that there were no statistical significance in the differences of gender, age,

marital status, education level, family monthly income per capita, pressure ulcer staging, pressure ulcer category, pressure ulcer site and department between the two groups ($P > 0.05$). The Braden scores before enrollment were compared between the two groups with t-test, and the results showed no statistical significance in the differences. The patients in the two groups were comparable. The relevant details are shown in Table 1 and Table 2.

Table 1: Comparison of the equilibrium between the two groups

<i>Variable</i>	<i>Group</i>	<i>Control Group</i>	<i>Experimental group</i>	<i>Statistical Value</i>	<i>P</i>
Gender	Male	26	27	0.040	0.841
	Female	24	23		
Age (years old)	18-60	22	21	0.041	0.840
	>60	28	29		
Marital status	Married	46	44	0.444	0.505
	Unmarried / divorced / widowed	4	6		
Education	Junior high school and below	33	35	0.184	0.668
	Senior high school and above	17	15		
Family monthly income per capita (yuan)	<2000	26	27	0.162	0.922
	2000-5000	20	20		
	>5000	4	3		
Pressure ulcer staging	1	5	4	0.305	0.998
	2	22	23		
	3	18	17		
	4	3	4		
	Deep tissue damage	1	1		
	No staging	1	1		
Pressure ulcer category	New pressure ulcer	22	21	0.041	0.840
	Pressure ulcer occurred in other	28	29		

		hospitals				
Pressure ulcer site				0.512	0.998	
		Sacroccygeal region	17	18		
		Iliac spine	11	11		
		Hip	9	8		
		Scapular region	6	5		
		Ischial tuberosity	5	5		
		Ankle	1	2		
		Heel	1	1		
Affiliated department				0.424	0.809	
		General internal medicine	21	23		
		Major surgery	22	22		
		ICU	7	526		

Table 2: Comparison of Braden scores between the two groups (score, Mean±SD)

<i>Variable</i>	<i>Control Group</i>	<i>Experimental group</i>	<i>t</i>	<i>P</i>
Braden score	9.13±4.26	9.26±4.04	0.112	5.732

The reporting time of the two groups was compared with *t*-test, and the results showed that the reporting time was (12.75±1.62) min in the conventional electronic form information management group and (4.67±0.55) min in the experimental group, indicating that the reporting

time was significantly lower in the experimental group than that in the control group (*P*<0.05). The degree of pressure ulcer healing was compared between the two groups with *t*-test, and the results are showed in Table 3.

Table 3: Comparison of Design-R score between the two groups (points, Mean±SD)

	<i>Design-R score (except for depth)</i>		<i>t</i>	<i>P</i>
	Control Group	Experimental group		
One week after the onset of pressure ulcer	13.75±3.62	8.34±2.11	13.66	<0.01
After discharge	4.26±0.52	2.12±0.34	5.43	0.0325

Comparison of paramedics’ satisfaction between the two groups

A satisfaction survey was conducted on 15 paramedics participant The results showed that the satisfaction of pressure ulcer information management system software was better than that of the control group in terms of the

convenience of operation, the detail of content, the time-consuming of use, the guidance of pressure ulcer nursing and the availability of data for research, respectively (*P*<0.05), as shown in Table 4.

Table 4: Comparison of paramedics' satisfaction between the two groups (points, Mean±SD)

<i>Variable</i>		<i>Control Group</i>	<i>Experimental group</i>	<i>t</i>	<i>P</i>
Convenience of operation		3.55±0.32	4.01±0.36	-2.440	<0.05*
Detail of content		3.44±0.31	4.25±0.41	-2.869	<0.05*
Time-consuming use	of	3.32±0.29	4.31±0.38	-2.893	<0.05*
Guidance of pressure ulcer nursing		3.22±0.28	4.45±0.44	-3.621	<0.05*
Availability of data for research		3.25±0.29	4.55±0.45	-4.893	<0.05*

Discussion

The reporting time in the experimental group was significantly lower than that in the control group. Compared with uploading pressure ulcer information using the conventional electronic form, the pressure ulcer information management system software designed in this study can realize the functions of automatic import and input of patients' pressure ulcer information or that needing to be reported and uploading to the superior pressure ulcer management department after submitting by clicking. Paramedics do not need to write more words, and for the filling of structured modules, the typesetting in the writing form does not need to be considered, which makes the record simpler and faster, and simplifies the workflow (15). WANG's study (16) showed 91.04% of the caregivers believed that the pressure ulcer management software was time-saving. In addition, according to the examinations by affiliated department, pressure ulcer type, pressure ulcer stage and pressure ulcer site, the superior pressure ulcer management department can quickly obtain the corresponding information so as to take effective intervention and treatment measures.

After ensuring that the differences in factors that may affect pressure ulcer healing were balanced among patients in the two groups, the study found a significantly lower Design-R score 1 week after the onset of pressure ulcer and after discharge in the experimental group, indicating

that the patients in the experimental group healed better than those in the conventional electronic form group. A large sample and large-scale investigation study proved that the lack of knowledge and inconsistent nursing measures of clinical nurses restricted the results of pressure ulcer prevention (17). The software designed in this study realizes the functions of automatic selection of pressure ulcer site, automatic uploading of pressure ulcer pictures, identification and automatic staging of pressure ulcer pictures, guidance of pressure ulcer treatment regime and intelligent guidance of pressure ulcer dressing, which can greatly reduce the error caused by manual identification and improve the scientific nature of the treatment regime. Therefore, paramedics can timely adjust patients' treatment regimes according to the relevant information to accelerate the wound healing in patients. The pressure ulcer prevention and management ability of nurses at different levels has been improved to different degrees and the average accuracy of protection measures to 94.25% after the application of Pressure ulcer management software (16). The treatment guidance module of this software can improve the understanding of paramedics on the knowledge of pressure ulcer, which has great practical value in the context of the general lack of knowledge related to pressure ulcer among paramedics.

According to the results of the satisfaction survey on paramedics, the satisfaction of the pressure ulcer information management system software was better than the conventional for information

management in terms of the convenience of operation, the detail of content, the time-consuming of use, the guidance of pressure ulcer nursing and the availability of data for research, The same results were also demonstrated earlier (18) in which nurses' experience satisfaction for the Software for the safety management of intraoperative acquired pressure ulcers was 98.39%. The difference is that intelligent pressure ulcer management system has added picture recognition, which can show pressure ulcers more intuitively and help to identify pressure ulcers. Nursing staff can implement the prevention measures prompted by system one by one, which can reduce the impact of incomplete protection and improper prevention caused by lack of experience. So, it is easier for the nursing staff to understand and accept the relevant protection standards, and improving the work initiative and efficiency.. In addition, with the systematic information management, the pressure ulcer related information can be inquired, counted and exported at any time, which is more conducive to the development of relevant scientific research, and even can provide reference for the management department to allocate the corresponding medical resources, with great promotion value.

Conclusion

Intelligent pressure ulcer management system designed in this study not only realizes the entry, report, query, statistics and export of the information, but also realizes pressure ulcer risk assessment, automatic selection of pressure ulcer pictures, identification and automatic staging of pressure ulcer pictures, intelligent guidance of pressure ulcer dressing, which saves the reporting time, and improves the degree of pressure ulcer healing in patients. Additionally. However, due to the limitation of objective factors, such as funds and time, this study only conducted the preliminary design of software, and only preliminarily applied on hospitalized patients with pressure ulcer in a grade-A tertiary hospital.

There are still questions on how to adapt to different electronic information systems while ensuring information security, and how to fully integrate with the hospital's electronic medical record information system, which can be further developed and promoted in the future.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Lachenbruch C, Ribble D, Emmons K, VanGilder C (2016). Pressure Ulcer Risk in the Incontinent Patient: Analysis of Incontinence and Hospital-Acquired Pressure Ulcers from the International Pressure Ulcer™ Prevalence Survey. *J Wound Ostomy Continence Nurs*, 43(3):235-241.
2. Rabadi MH, Vincent AS (2011). Do vascular risk factors contribute to the prevalence of pressure ulcer in veterans with spinal cord injury? *J Spinal Cord Med*, 34(1):46-51.

3. Charalambous C, Vassilopoulos A, Koulouri A, et al (2018). The Impact of Stress on Pressure Ulcer Wound Healing Process and on the Psychophysiological Environment of the Individual Suffering from them. *Med Arch*, 72(5):362-366.
4. Kottner J, Hahnel E, Lichterfeld-Kottner A, Blume-Peytavi U, Büscher A (2018). Measuring the quality of pressure ulcer prevention: A systematic mapping review of quality indicators. *Int Wound J*, 15(2):218-224.
5. Morel J, Herlin C, Amara B, et al (2019). Risk factors of pelvic pressure ulcer recurrence after primary skin flap surgery in people with spinal cord injury. *Ann Phys Rehabil Med*, 62(2):77-83.
6. Rasero L, Simonetti M, Falciani F, et al (2015). Pressure Ulcers in Older Adults: A Prevalence Study. *Adv Skin Wound Care*, 28(10):461-464.
7. National Health and Family Planning Commission of the People's Republic of China (2017). National Nursing Development Plan (2016-2020). *China Nursing Management*, 017(001):1-5.
8. Tian Y, Zhang Y, Yu Z, et al (2019). Status of application of nursing information systems in developed countries in Europe and America. *Journal of Medical Informatics*, 40(11):13-18.
9. European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel, Pan Pacific Pressure Injury Alliance. Prevention and treatment of pressure ulcers/injuries: clinical practice guideline. EPUAP/NPIAP/PPPIA: 2019.
10. Guo LP (2017). Design and application of pressure ulcer intelligent management system software. Changsha: Central South University.
11. Bergstrom N (1987). The Braden Scale for predicting pressure sore risk. *Nurs Res*, 36(2):205-210.
12. Xiaohong Z, Takashi N, Lijuan H, et al (2013). Reliability and validity of the Chinese version of DESIGN-R, an assessment instrument for pressure ulcers. *Ostomy Wound Manage*, 59(2):36-43.
13. Sanada H, Moriguchi T, Miyachi Y, et al (2004). Reliability and validity of DESIGN, a tool that classifies pressure ulcer severity and monitors healing. *J Wound Care*, 13(1):13-18.
14. Yan T (2015). Reliability and validity of the Chinese version of the pressure ulcer healing status evaluation and classification scale DESIGN-R. Qingdao University.
15. Abranches D, O'Sullivan D, Bird J (2019). Nurse-led Design and Development of an Expert System for Pressure Ulcer Management. Extended Abstracts of the 2019 CHI Conference.
16. Wang H, Sun H, Xu C (2013). Applying pressure ulcer management software to constructing standardized pressure ulcer prevention and treatment system. *Chinese Journal of Nursing*, 48(12): 1104-1107.
17. Hulsenboom MA, Bours GJ, Halfens RJ (2007). Knowledge of pressure ulcer prevention: a cross-sectional and comparative study among nurses. *BMC Nurs*, 9(6): 2.
18. Zhao J, Wu Y, Yang Y (2021). Study on the application of safety management software for intraoperative acquired pressure ulcers. *Chinese General Practice Nursing*, 19(15): 2109-2111.