Applied Nursing Research 29 (2016) 107–112

Contents lists available at ScienceDirect

Applied Nursing Research

journal homepage: www.elsevier.com/locate/apnr

Reduction in the incidence of pressure ulcers upon implementation of a reminder system for health-care providers[☆,☆☆]

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ARTICLE INFO

Article history:
Received 15 October 2014
Accepted 20 May 2015
Available online xxxx

Keywords:
Pressure ulcer
Electronic health records
Reminder systems
Medical records systems-computerized
Adverse effects

ABSTRACT

Purpose: To measure the clinical impact of the introduction of a reminder system for healthcare professionals to alert patients who are at risk for pressure ulcers (PU).
Methods: This was a pre- and post-test study of patients who were discharged from 6 medical–surgical units of the University Hospital of Fuenlabrada in 2009 and 2010. Beginning in January 2010, implementation of an on-screen list of reminders was automatically updated daily on the units' computers including patient arrival date, last assessment of ulceration risk and location of any PU. The cumulative incidence of PU was measured for patients discharged in 2009 (group A: healthcare professionals were not exposed to on-screen reminder) and 2010 (group B: healthcare professionals were exposed to on-screen reminder list). The relative risk (RR) was estimated. The study was completed with a stratified analysis and binary logistic regression.
Results: In group A, there were 84 cases of PU among 9263 patients discharged (0.9%); whereas in group B, there were 59 cases among 9220 patients discharged (0.6%). The RR of PU for group B/group A was 0.706 ($p = 0.038$). In the logistic regression analysis, after adjusting for study variables, the odds ratio of PU B/A was 0.558.
Conclusion: A list of on-screen reminders at the beginning of a healthcare professional's shift to inform them of patients at risk for developing a PU was effective at reducing the incidence of these clinical burdens.

Introduction

A pressure ulcer (PU) is a lesion on the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear (European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel, 2009). These lesions are common in hospitalized patients (Soldevilla Agreda, Torra i Bou, Verdú Soriano, & López Casanova, 2011; Soldevilla et al., 2006), although there is virtually no data for their frequency. In addition, most are considered preventable (Joanna Briggs Institute of Evidence Based Nursing and Midwifery, 2008) and constitute a major economic problem, with a study in 2007 estimating a cost of 461 million Euros in Spain per year (Soldevilla Agreda, Torra i Bou, Posnett, et al., 2007).

In the context of concern for patient safety and prevention of adverse effects (AE), PUs have become a key factor considered in the analysis of patient safety (Aranaz, Aibar, Vitaller, & Ruiz, 2006). Their occurrence has become an indicator by which to assess the quality of nursing care related to patient safety (S.E.N.E.C.A. Project, 2010). In addition, the National Quality Forum now recommends measures to prevent PU which have been proposed as good practice in our environment (Agencia de Calidad del Sistema Nacional de Salud, 2008).

Several multicenter studies have been conducted in different countries describing the prevalence of PU in hospitals ranging between 0.4 and 39% (Clark et al., 2002; Lyder, 2003; Soldevilla Agreda et al., 2011). Recent studies assessing the prevalence of PU in Spain (Ignacio, 2007), state that the percentage of patients who develop or have pressure sores in Spanish hospitals ranges from 8 to 16%. Focused on the hospital setting, the Seneca project analyzed a random sample of 1344 medical records from 34 hospitals across the NHS and determined a prevalence of 8.6% among medical–surgical patients (S.E.N.E.C.A. Project, 2010). Unfortunately, the data can vary even within the same hospital (Cidoncha Moreno, Camino Campo Martínez, Gamarra-Mayor

☆ Funding: The study is part of project No. PI070873 "Incidents and adverse events related to care. Validation of a tool and the effectiveness of guideline implementation in electronic health", funded by the Institute of Health Carlos III call for aid in the promotion program of biomedical research and health sciences of the Ministry of Health for the implementation of projects under the national plan of I + D + I 2004-2007. Resolution of October 15, 2007.
☆☆ Statement on conflicts of interest: The authors declare they have no conflict of interest for this study.

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http://dx.doi.org/10.1016/j.apnr.2015.05.018
0897-1897/

Martínez, & Alonso Castillo, 2003; Sebastián Viana, Herranz, Navalón Cebrián, Lema Lorenzo, & Nogueiras Quintas, 2009).

Prevention through multifactorial and multidisciplinary interventions is the most effective and ethical way to address PU (Niederhauser et al., 2012). To implement effective preventive measures, it is necessary to identify the patients at risk for developing a PU, which can be accomplished with the use of a rating scale devised by Norton, Exton-smith, and Mc Laren (1962). Data collected in electronic health records can be structured to improve the information available to clinicians and optimize decision-making processes to improve clinical practice and avoid or reduce errors and AEs. In this context, there have been several studies of the role of computer screen reminders and alerts.

For example, Cochrane found 28 studies that evaluated the effects of different reminders on the computer screen, such as those to prescribe specific drugs, to warn about drug interactions, to provide vaccinations, or to order specific tests. These reminders resulted in small to moderate benefits, with improvements close to 4% (Shojania et al., 2009).

Another assessment included 32 studies about computer-generated reminders delivered on paper to healthcare professionals. These studies examined reminders to order screening tests, to provide vaccinations, to prescribe specific medications, or to discuss issues with patients and achieved moderate improvement in professional practices, with a median improvement of processes of care of 7.0% (Arditi, Rège-Walther, Wyatt, Durieux, & Burnand, 2012).

A recent Cochrane review about interventions for implementation of thromboprophylaxis in hospitalized medical and surgical patients at risk for venous thromboembolism, included a total of 55 studies. In this report, alerts, such as computerized reminders or stickers on patients' charts were associated with a risk difference of 13%, signifying an increase in the proportion of patients who received prophylaxis (Kahn et al., 2013).

Additional studies have tested reminders for decision making in the prevention of thromboembolism (Kucher et al., 2005), to establish the pattern of acetylsalicylic acid upon release, to remember pneumococcal and/or influenza vaccinations, heparin prophylaxis (Dexter et al., 2001), measuring the extent of cardiovascular risk (Holt et al., 2010), management of clinical guidelines (Gandhi et al., 2003), management of prescriptions (Bogucki, Jacobs, Hingle, & Clinical Informatics Outcomes Research Group, 2004), or the reduction of AE related to peripheral venous access (Sebastian-Viana et al., 2012).

There is moderate quality evidence that computer-generated reminders and alerts to healthcare professionals achieve moderate improvement in process of care; but, there are some studies that show that there is no clinical benefit (Bayoumi et al., 2014).

There have been previous studies on computerization of clinical guidelines and protocols for different clinical situations, such as PU (Willson et al., 1995; Zielstorff et al., 1997). Nevertheless, only a few studies have examined the use of on-screen reminders in clinical practice and its clinical effect for patients with regard to prevention of AE, including PU. Understanding improved clinical outcomes and decreased frequency of PU relates to the implementation of preventive measures in patients at risk. To this end, our study was designed to measure the clinical impact of a system of on-screen reminders based on electronic clinical records, to inform healthcare professionals about patients who are at risk for developing a PU.

Materials and methods

This study was conducted at 6 medical–surgical units of the Fuenlabrada Hospital, a mid-size hospital in Madrid with 406 beds. Here, we reviewed the electronic records to track AE, including records of monitoring and prevention of PU in the hospital units. These records were structured and normalized, and in subsequent implementations, the determination of their impact (PU originated during hospital stay). From these records, we developed an automated query in structured query language (SQL) which prepares a list of all patients admitted to the unit (list of reminders). This list of reminders included the date of admission, the last assessment of PU risk, the status of current PUs, and the last recorded location and extent of PU. Beginning in January 2010, data were presented in an on-screen format and the list of reminders updated automatically each time the computer was turned on.

Once introduced, we conducted a before–after study to measure and compare the cumulative incidence of PU in medical and surgical patients discharged from the units of study during two time periods: Jan–Dec 2009 (group A—before implementation of reminder list) and Jan–Dec 2010 (Group B—after implementation of the reminder list). Comparisons of the groups were evaluated, taking into consideration the variables of patient gender, age, length of stay, type of patient (medical or surgical), type of discharge and average (payment) weight of "All Patients- Diagnosis-Related Group" (AP-DRG) assigned of patients admitted to the study units (the average weight is based on the average resources used to treat patients in that diagnosis-related group DRG (Mas & Ballater, 2011).

Moreover, we compared the two groups with the mean levels of dependency according to the rubric of levels of dependence developed in project SIGNO II (Brea Rivero & Pérez Polo, 1999; Cortés, 1995; Montesinos, 1988) (project of the Spanish National Institute for Health), and the PU risk measured by the modified Norton scale by Spanish National Institutes of Health (INSALUD) (National Institute for Health, 1996), which are included in electronic medical records. These scales were implemented upon hospital admission, and every 3 or 4 days. This allowed us to compare the homogeneity of dependency levels and the PU risk in both groups.

The rubric of dependency levels collected 16 patient variables with 4 options each. The variables included: age, weight, 4 variables for personal care (hygiene, nutrition, exercise and elimination), 3 communication variables (health education, relationship and consciousness) and 7 variables of technical care (oxygenation, clinical observation, enteral treatments, parenteral treatments, cures, catheters and laboratory tests). Each option was given a score between 1 (the option with least dependence) and 4 (most dependent option). The sum of points gives a scale ranging from 16 to 64 (Fenandez Diez, 2013). Patients were classified by score into 4 levels of dependence:

Level I or minimal care: Patient who can take care of himself, with minimal treatment and does not require routine assessment of vital signs
Level II or medium care: Patients with chronic or sub-acute symptoms, they require assistance for their activities; they have moderate treatment and decreased activity.
Level III or comprehensive care: High dependence on nursing, with frequent observation, incontinent and/or immobile, comprehensive treatment, emotional needs or disconnection environment.
Level IV or very comprehensive care: Total dependency, treatment and continued observation and constant medication, direct care and continuous monitoring of vital signs.

The PU risk was measured using the modified Norton scale by INSALUD. This is a modified version of the scale developed by Norton et al. (1962) and was adapted by INSALUD in 1996 (National Institute for Health, 1996) aimed primarily to operationalize the scores assigned, giving it greater reliability (Bermejo Caja et al., 1998). Like all risk scales, it allows the detection of potentially susceptible patients for which to apply preventive plans. This ordinal scale enables the risk assessment for a patient developing PU and includes 5 variables: physical fitness, mental state, activity level, mobility, and incontinence. Each variable has 4 categories with a score assigned to each of them ranging from 1 to 4, with 1 representing further deterioration of the patient and 4 signifying the best condition of the patient; for example in the incontinence variable: no incontinence = 4 points, occasional incontinence = 3 points, urinary or fecal incontinence = 2 points and urinary and fecal incontinence = 1 points. Thus, the total score of the scale ranges from 5 (patients with further deterioration and at maximum risk of PU) and 20 (best patient condition and minimal risk of PU).

As it is described in the "Guide to nursing care. Pressure ulcers" (National Institute for Health, 1996), this scale allows the classification of patients into three risk levels: no risk: patients with a score > 14, moderate risk: patients with scores 12–14, and very high risk: patients with scores ranging from 5 to 11. For group comparisons and to assess the association of variables, we used Student's t test for quantitative variables and the chi-square test for qualitative variables. To evaluate the effect of an on-screen reminder list in the prevention of PU, we calculated the relative risk (RR) with confidence intervals at 95% (95% CI) by the method of Katz and the absolute risk reduction and number needed to treat (Abraira, 2001; Cook & Sackett, 1995). The NNT is the inverse of the absolute risk reduction and represents the number of patients who should receive the experimental treatment, rather than control treatment, for one additional patient to obtain the benefit (Abraira, 2001). It is, therefore, a measure that allows the comparison of the effectiveness of a treatment.

To estimate the possible effect of other variables included in the study, we performed a univariate analysis. Here, we calculated the cumulative incidence of PU according to gender, age grouped by third quartile, average weight (AP-DRG) grouped by third quartile, level of dependency and PU risk. For each of the variables, we estimated the association between categorical variables with chi square test and calculated the RR with a 95% CI.

To evaluate the interaction variables and/or the possible existence of confounding variables, we also performed a stratified analysis before implementation and after implementation list reminder groups by gender, by the risk of PU (evaluated with modified Norton scale INSALUD) grouped according to patients at risk of PU and patients without risk and by dependency levels grouped into level 1/2 (low dependency) and levels 3/4 (high dependency). As frequencies are low and the odds ratio (OR) is a strong estimator of the RR when the frequencies of cases are low (Szklo & Nieto, 2003), we calculated the OR of the PU for each stratum and their 95% CI. To evaluate any confusion, we estimated the OR adjusted for strata by the Mantel–Haenszel method. The Mantel–Haenszel method produces a single, summary measure of association which provides a weighted average of the odds ratio across the different strata of the confounding factor (Gerstman, 2003; Szklo & Nieto, 2007).

Finally, to evaluate the effect of the reminder list before and after implementation, we used a model of binary logistic regression. In this multivariate model, patient groups were adjusted according to the following variables: gender, age adjusted for the third quartile, average weight (AP-DRG) clustered by the third quartile, PU risk status, level of dependency (low levels 1/2 or high levels 3/4), and by interactions with the patient group that were significant or nearly significant in the stratified analysis. The method used to perform regression was backwards, with manual extraction of factors considering the change in the logarithm of likelihood ratio models when some factor did not fit the model. Since it is a descriptive model, we chose the simplest model with the best fit that was more parsimonious and reasonable. For the validity of the model, we used the Hosmer and Lemeshow test to assess fit.

In all cases, the variable distribution was checked against theoretical models and the assumption of homogeneity of variances was contrasted. As for the ethical and legal aspects, the analyses in this study were performed using data obtained from the basic minimum data set (MDS), the dashboard from the directors and systematized data extractions from clinical records of electronic medical records. These extractions were performed preserving patient anonymity, dissociating personal identification data from the data that were used in this study. The research team had no access to patient medical records, in compliance with article 16.3 of Law 41/2002 of the Government of Spain (Government of Spain Law 41/2002, 2002). This study was approved by the commission of inquiry and the Direction of the University Hospital in Fuenlabrada.

Results

The before implementation reminder list group for this study consisted of 9263 patients discharged in 2009, while an after implementation reminder list group consisted of 9220 patients who were

Table 1
Study population, categorical and quantitative variables.

	Year 2009[(1)]	Year 2010[(2)]	p
Discharges	9263	9220	
Average length of stay (days). Mean (CI 95%)	6.8 (6.7–7.0)	6.8 (6.7–7.0)	0.6567
Average weight (AP-DRG) of the study units. Mean (CI 95%)	1.876 (1.841–1.911)	1.898 (1.855–1.941)	0.473
Average patient age (years) mean (CI 95%)	60.1 (59.7–60.5)	60.4 (60.0–60.8)	0.2852
Gender *n* (%)			0.575
Male	4957 (53.5)	4895 (53.1)	
Female	4306 (46.5)	4325 (46.9)	
DRG Type *n* (%)			0.094
Medical	5948 (64.2)	5810 (63.0)	
Surgical	3315 (35.8	3410 (36.9)	
Levels of dependency *n* (%)			<0.001
Level 1 minimal care	2119 (27.8)	1037 (12.6)	
Level 2 medium care	4289 (50.3)	5041 (61.3)	
Level 3 comprehensive care	912 (12)	1360 (16.5)	
Level 4 very comprehensive care	304 (4.0)	781 (9.5)	
Risk of PU classification*n* (%)			<0.001
No risk	6025 (78.8)	6715 (81.6)	
High risk	809 (10.6)	698 (8.5%	
Very high risk	796 (10.4)	805 (9.8)	
Type of discharge *n* (%)			0.654
1. Cure or improvement	8674 (93.6)	8640 (93.7)	
2. Transfer to hospital	103 (1.1)	93 (1)	
3. Voluntary discharge	22 (0.2)	15 (0.2)	
4. Death	373 (4.0)	378 (4.1)	
5. Transfer to a health center	86 (0.9)	92 (1.0)	
6. Elopement	5 (0.1)	2 (0.0)	

(1) Year 2009—Before implementation of on-screen reminders list.
(2) Year 2010—After implementation of on-screen reminders list.

Table 2
Univariate analysis of the study variables.

	Cumulative incidences PU (%)	RR (1)	95% CI (2)	p
Group		0.706	0.506–0.983	0.038
After implementation reminders list (2010)	59/9220 (0.6)			
Before implementation reminders list (2009)	84/9263 (0.9)			
Gender		0.84	0.606–1.165	0.295
Male	70/9852 (0.7)			
Female	73/8631 (0.8)			
Level of dependency*				<0.001
Level 1 minimal care	4/2664 (0.2)	Reference		
Level 2 medium care	32/8625 (0.4)	2.471	0.8747–6.9805	
Level 3 comprehensive care	43/2171 (2)	13.1912	4.7425–36.6908	
Level 4 very comprehensive care	55/1033 (5.3)	35.4598	12.8836–975971	
PU* risk				<0.001
No risk	33/11587 (0.3)	Reference		
High risk	16/1396 (1.1)	3.99	2.2018–7.2306	
Very high risk	84/1508 (5.6)	18.5793	12.4635–27.6961	
Average weight DRG grouped quartile 3		4.312	3.066–6.063	<0.001
<=2.34	53/13211 (0.4)			
>2.34	90/5272 (1.7)			
Age group quartile 3		5.178	3.862–7.283	<0.001
<=76	53/13864 (0.4)			
>76	90/4619 (1.9)			

* Chi square for trend $p < 0.001$.
(1) Relative risk.
(2) 95% confidence interval.

discharged in 2010. The patient characteristics across the 2 years are homogeneous (Table 1), with no demographic or average weight (AP-DRG) patient differences. Dependence level differences and the risk of PU according to the Norton MI scale were statistically significant, although the differences between groups are small.

Fifty-nine new cases of PU originated among the 9220 discharges that took place in 2010, representing a cumulative incidence of 0.64%. In contrast, there were 84 new cases of PU among the 9263 discharges that occurred in 2009, representing a cumulative incidence 0.91%, and a RR of 0.706. These results are statistically significant with an absolute risk reduction of 0.003, a relative RR of 29.4% and an NNT of 333. Thus, including an on-screen reminder system for healthcare professionals suggested an incidence of PU would have been avoided for every 333 medical and surgical patients discharged.

We examined if any of the variables recorded might influence PU occurrence. The incidence of PU is distributed among the variables which could have had an effect on their appearance (Table 2). Here, the cumulative incidence of each variable, RR with corresponding confidence intervals and statistical significance are presented. All variables included in the study are relevant and have a statistically significant effect on the occurrence of PU, except for gender.

We then conducted a stratified analysis to evaluate any interaction and/or confusion of the health professional when faced with the reminder list. This analysis studied the odds ratio of the PU in the group A (before implementation of reminder list) and group B—(after implementation of the reminder list) stratified by each of the variables that were included in the analyses and which could affect the effect of the reminder list (Table 3). We determined that all variables affected the impact of the list, with the p value of chi square Mantel–Haenszel being significant for most variables.

Finally, we conducted a multivariate analysis with a binary logistic regression (Table 4). After adjusting for the variables that were included in the study (risk of ulceration, level of dependency, gender, age, average weight (AP-DRG) and study group interactions) the odds ratio was 0.558. The estimated relative risk reduction of upon implementation of an on-screen reminder list, adjusting for age, gender, average

Table 3
Stratified odds ratio analysis of group B versus group A.

	Odds ratio(After/Before by strata)	95% CI	p	Adjusted* odds ratio	p**
Global (after/before)	0.706	0.506–0.983	0.038		
Gender				0.703	0.039
Male	0.673	0.417–1.088	0.104		
Female	0.733	0.460–1.168	0.19		
PU risk				0.71	0.054
With risk	0.829	0.555–1.240	0.361		
Without risk	0.44	0.213–0.908	0.022		
Levels of dependency				0.445	<0.01
Levels 3/4 high dependency	0.56	0.374–0.838	0.004		
Levels 1/2; low dependency	0.208	0.086–0.499	<0.001		
Age				0.689	0.03
>76 years	0.671	0.439–1.026	0.064		
<76 years	0.721	0.417–1.246	0.239		
Weight DRG grouped quartile 3			0.694	0.032	
<2.34	1.055	0.615–1.810	0.891		
>2.34	0.533	0.345–0.824	0.004		

Group B after implementation of the reminder list.
Group A before implementation of reminder list.
* According to the Mantel–Haenszel method.
** Chi square Mantel–Haenszel.

Table 4
Multivariate analysis: binary logistic regression.

	B [1]	Standard error	Wald	p	Exp (B) [2]	95% CI Exp (B) [3]
Group: Group B (after)/group A (before)	−0.583	0.194	9.075	0.003	0.558	0.382–0.816
Levels of dependency (Levels 3/4 high dependency/levels 1/2 low dependency)	1.508	0.277	29.574	<0.001	4.517	2.623–7.779
PU risk (with risk/without risk)	1.538	0.275	31.361	<0.001	4.655	2.717–7.973

(1) B Beta of the variable in the regression model.
(2) Exp (B) Beta exponent, equivalent to odds ratio.
(3) I.C. 95.0% Exp (B) 95% confidence interval of the beta exponent.

weight (AP-DRG), risk of ulceration measured by the modified Norton scale (INSALUD) and level of dependency was 44.2%. The good fit model was performed with the Hosmer and Lemeshow test, and had a 2.459 chi square, $p = 0.483$.

Discussion

Our results demonstrate a clinical impact of reduced cumulative incidence of AE when a computer-based reminder list was employed. The results are in line with other studies that have reported the success of on-screen reminders when making clinical decisions, are effective and improve clinical process outcomes (Arditi et al., 2012; Bogucki et al., 2004; Dexter et al., 2001; Gandhi et al., 2003; Holt et al., 2010; Kucher et al., 2005; Sebastian-Viana et al., 2012; Shojania et al., 2009). The absolute risk reductions (0.3%) were below those found by different revisions (Arditi et al., 2012; Kahn et al., 2013; Shojania et al., 2009). In their reviews of the effects of reminders on medical practices which was between 4 and 13%. However, our result is very important because it is a patient clinical benefit and not an outcome process or a medical process

The current list of reminders has several limitations. At the beginning of each shift, it provided updated information regarding patient arrival date, latest assessment of PU risk and presence of any PU. It would be interesting to further develop the system to allow updating in real time and further evaluate its clinical impact. These developments would likely result in tool improvements that would affect clinical outcomes and that are pending for development and evaluation. Regardless, it should be noted that despite the current limitations of this system, there were reductions in absolute risk that were of clinical and statistical significance.

The study methodology also represents a limiting factor if attempting to generalize these results. In a before/after quasi-experimental study, there may be unknown factors which cannot be controlled. Such factors are controlled in randomized clinical trials, a methodology that we were unable to employ for this study. Further, more robust studies are needed.

As stated in the main recommendations of care for the prevention of PU (European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel, 2009, Joanna Briggs Institute of Evidence Based Nursing and Midwifery, 2008), identifying at-risk patients can facilitate medical professionals to adopt adequate prevention and monitoring protocols to reduce PU incidence.

The on-screen reminder list used in this study has simplified the ability to identify at-risk patients for development of a PU, and “the opportunity to deliver computer reminders at the point of care represents one of the major incentives to implementing sophisticated clinical information systems” (Shojania et al., 2009).

The list of reminder on screen computer has been a simple system for professionals to obtain benefits of collecting information in the electronic medical record, and it has provided clinical benefits in patients.

In conclusion, our results suggest that including on-screen reminders for medical professionals as an intervention approach is effective for reducing the incidence of PUs that originate in the hospital and can improve the quality of care.

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