Using Statistical Process Control for Monitoring the Prevalence of Hospital-acquired Pressure Ulcers

Jan Kottner, PhD, RN; and Ruud Halfens, PhD

Abstract
Institutionally acquired pressure ulcers are used as outcome indicators to assess the quality of pressure ulcer prevention programs. Determining whether quality improvement projects that aim to decrease the proportions of institutionally acquired pressure ulcers lead to real changes in clinical practice depends on the measurement method and statistical analysis used. To examine whether nosocomial pressure ulcer prevalence rates in hospitals in the Netherlands changed, a secondary data analysis using different statistical approaches was conducted of annual (1998–2008) nationwide nursing-sensitive health problem prevalence studies in the Netherlands. Institutions that participated regularly in all survey years were identified. Risk-adjusted nosocomial pressure ulcer prevalence rates, grade 2 to 4 (European Pressure Ulcer Advisory Panel system) were calculated per year and hospital. Descriptive statistics, chi-square trend tests, and P charts based on statistical process control (SPC) were applied and compared. Six of the 905 healthcare institutions participated in every survey year and 11,444 patients in these six hospitals were identified as being at risk for pressure ulcers. Prevalence rates per year ranged from 0.05 to 0.22. Chi-square trend tests revealed statistically significant downward trends in four hospitals but based on SPC methods, prevalence rates of five hospitals varied by chance only. Results of chi-square trend tests and SPC methods were not comparable, making it impossible to decide which approach is more appropriate. P charts provide more valuable information than single P values and are more helpful for monitoring institutional performance. Empirical evidence about the decrease of nosocomial pressure ulcer prevalence rates in the Netherlands is contradictory and limited.

Key Words: pressure ulcer, prevalence, quality, statistical process control

Index: Ostomy Wound Management 2010;56(5):54–59

Potential Conflicts of Interest: none disclosed

Measuring clinical practice performance is part of quality improvement and assurance in healthcare.1-3 Hospital-acquired pressure ulcers are used as outcome indicators for measuring the quality of pressure ulcer prevention in various healthcare settings.4,9 Pressure ulcer prevalence rates in European hospitals vary between 8% and 23%.7 In the past years, several national and local quality initiatives have been launched to improve pressure ulcer prevention and management. However, empirical evidence as to whether these initiatives and projects were successful is contradictory. Pressure ulcer prevalence and incidence rates in different settings decreased,8,9 remained stable,10,11 or increased.4 One reason might be that clinical practice improved, did not change, or became worse, subsequently affecting outcomes; assessing changes in clinical practice seems to be a factor of measurement methods and statistical analysis. Two key issues prevail: measurement frequency and trend detection.

Measurement frequency. Numerous improvement projects typically are evaluated by applying before-after measurements9,11,12; subsequent statistical tests are used to detect statistically significant differences. If the null hypothesis is rejected, it is concluded that a “real” change has taken place. This
MONITORING PRESSURE ULCER PREVALENCE

Ostomy Wound Management 2010;56(5):54–59

Key Points

- Many nationwide, regional, and institution-based pressure ulcer (PU) prevalence studies have been conducted to try and ascertain the effect of patient care on PU rates.
- The authors analyzed annual nosocomial grade 2 through 4 PU prevalence data accumulated over 10 years and involving 11,444 at-risk patients.
- According to standard statistical methods, prevalence rates decreased in four hospitals.
- However, when statistical process control (SPC) methods were used, the observed variations appeared to be due to chance.
- Considering the resources involved in prevalence studies and the importance of monitoring outcomes of care, careful consideration of statistical methods used to detect change is warranted.

Methods

Design and measures. An analysis of the LPZ data from 1998 to 2008 was conducted. At the time of the analysis, this data base (owned by the University of Maastricht) contained information about several nursing-sensitive health problems (eg, falls, nutritional status) and about preventive and therapeutic measures implemented among approximately 320,000 individuals in 900 different healthcare institutions across the Netherlands. Confidentiality was ensured by the assignment of identification numbers to participating institutions. For this secondary data analysis, no identifying information (eg, names, addresses) was available.

Hospitals that participated regularly in all survey years were identified and data about pressure ulcer risk and pressure ulcer prevalence were extracted. To adjust for pressure ulcer risk, only patients with restricted mobility were considered for the analysis because immobility is the strongest predictor for pressure ulcer development. The degree of immobility was rated from 1 (completely immobile) to 4 (no limitation) on the 4-point “Mobility” scale included in the Braden scale. Inter-rater reliability of the item scores of the Dutch version were ICC (1,1) 0.86 (95% CI 0.78–0.85) and 0.86 (0.83–0.89). Patients with item scores of 1, 2, or 3 were regarded as being at risk.

Prevalence rates for hospital-acquired pressure ulcers were defined as persons at risk for pressure ulcers with at least one pressure ulcer grade 2, 3 or 4 according to the European Pressure Ulcer Advisory Panel (EPUAP) that developed in the institution divided by all persons in the institution at risk at that point of time. Due to high degrees of measurement error, grade 1 pressure ulcers were excluded from all calculations.

Statistical analysis. Prevalence rates were calculated per year and institution. Chi-square trend tests (Mantel-Haenzel chi-square) testing the significance of linear relationships between increasing years and prevalence were applied for every hospital and assumed that due to improved pressure ulcer prevention over years the prevalence changed. This approach is frequently used to investigate trends of prevalence rates over years. P values <0.05 (two sided) were considered statistically significant.

The basic assumption of SPC is that repeated measurements from a process will exhibit variation. If the process is stable, its variation is predictable within some limits and can be described by a statistical distribution. Natural random variation within a process over time is called common cause variation. Based on the statistical distribution, common cause variation is stable and predictable within upper and lower control limits. Special cause variation refers to unnatural variation due to events, changes, or circumstances (eg,
quality improvement projects) not typical or inherent to the regular process.2,31,32

P charts were created for every hospital. Prevalence rates were plotted over the years in chronological order including the center line (mean) and upper and lower control limits. Subsequently, every P chart was screened for special cause variation. Special cause variation was assumed when 1) a single data point exceeded the upper or lower control limit, 2) eight consecutive data points were on the same side of the center line, or 3) a trend (six data points constantly increasing or decreasing) was exhibited.2,31 Finally, results of the descriptive statistics, chi-square tests for trends, were compared with the presence of special cause variations detected by SPC methods.

Results

In total, 905 different healthcare institutions throughout the Netherlands participated in at least one survey between 1998 and 2008. Some institutions participated only once, some participated regularly. Six hospitals (labeled A to F) participated in all years (see Table 1). A total of 11,444 patients across these six hospitals and 10 years were considered at risk for developing pressure ulcers. Prevalence rates per year ranged from 0.05 (hospitals B, E, F) to a maximum of 0.22 (hospital D). Mean prevalence rates between all six hospitals were comparable, ranging from 0.10 to 0.12. Results of chi-square trend tests suggest the prevalence rates changed significantly over time with increasing years in hospitals A, B, C and E (see Table 1).

P charts are shown in Figures 1 through 6. Based on the predetermined rules, there was one case of special cause variation in hospital D (see Figure 4); one data point was above the upper control limit in 2001. Prevalence rates of the remaining hospitals exhibited common cause variation.

Discussion

Six hospitals participated annually in the national prevalence studies in the Netherlands between 1998 and 2008. Based on calculated proportions, the prevalence rates in the first half of the study period appear to be higher than in the second half. However, considerable variation between these point estimates was observed. Chi-square trend tests revealed statistically significant changes for four hospitals. When SPC methods were applied, no decrease in hospital-acquired pressure ulcers grade 2, 3 or 4 from 1998 to 2008 could be
detected. Changes in prevalence rates of five hospitals were considered as common cause variation, indicating that a real change or shift in the process had not taken place. Assuming a stable process, the only significant increase of hospital-acquired pressure ulcers was observed in 2001 in one hospital.

Results of the chi-square trend tests and SPC methods were not comparable. In four cases, \( P \) values indicated downward trends; whereas, \( P \) charts showed common cause variation only. It is impossible to decide which approach is more appropriate or “correct,” but \( P \) charts display much more relevant information. Single \( P \) values are unable to characterize the ups and downs of prevalence rates per year.

Hospital B provides a valuable example: According to the chi-square trend test, pressure ulcer prevalence was reduced significantly over the study period but the corresponding \( P \) chart reveals a rather cyclic behavior within predictable limits. Hospital D provides another example. Based on the \( P \) value of 0.078, one must accept the null hypothesis and conclude no trend occurred over the years. However, the corresponding \( P \) chart (see Figure 4) reveals that in 2001 the prevalence rate was significantly higher statistically as could be expected by chance.

The examples provided indicate that \( P \) charts are more helpful for institutions monitoring their own performance. First, based on data from the past, future performance can be predicted assuming no fundamental change is instituted and the process remains stable. Second, \( P \) charts help evaluate the success of quality improvement projects because they indicate when and whether significant changes have taken place. After the change, \( P \) charts can be used as a monitoring aid to ensure improvements are sustained over time.

SPC methods have been applied in various fields of quality improvement in healthcare such as infection control, blood sugar management in diabetes, medication errors, or mortality after certain procedures.\(^{2,33}\) The current results support the idea that control charts are also suitable and useful for monitoring clinical performance.\(^{32-35}\) However this approach has limitations. Even if processes are under statistical control, the values of the measured indicators are not automatically clinically acceptable or desired.\(^{33}\) This is especially true for this topic, considering the long-enduring debate whether all pressure ulcers are preventable.\(^{36}\) Measurement alone is not appropriate for improving care but the authors believe that application of SPC provides a valuable tool for measuring and evaluating processes in pressure ulcer management.
Limitations
Based on the results, the answer to the research question regarding whether nosocomial pressure ulcer prevalence rates in hospitals in the Netherlands changed is tempered by the fact that only a few institutions with annual participation in such efforts were identified. Therefore, a selection bias is most likely and findings are not generalizable to other hospitals in the Netherlands. Furthermore, more frequent point estimates (e.g., more frequent incidence or prevalence studies) would have helped in detecting trends.

Conclusion
Evidence regarding a decrease of pressure ulcer prevalence in Dutch hospitals examined is contradictory. Based on SPC methods, no decrease in hospital-acquired pressure ulcer prevalence in at risk patients occurred from 1998 to 2008. SPC methods provide valuable tools to measure and monitor care processes and outcomes in pressure ulcer and wound care. Control charts help managers and practitioners distinguish between natural and special variation and to decide whether “real” changes have taken place over time.

Acknowledgements
The authors thank the nurses and patients who participated in the annual pressure ulcer prevalence surveys.

References