Project Database quality of nursing (Quali-NURS)

Summary

Introduction.

The literature provides considerable evidence of a correlation between nurse staffing and patient outcomes across hospitals and countries with regard to differently organized and financed health care systems. The majority of these studies use retrospective research through administrative datasets because these data are readily available, inexpensive and cover large populations. The availability of the Hospital Discharge Dataset (HDDS) has made similar research in Belgium possible. What is more, Belgium has a resource to which many other countries aspire — a national Nursing Minimum Data Set (NMDS), which includes data about nursing staff and nursing activities. The purpose of the 'Database Quality of Nursing Care' project is to evaluate how these datasets can be linked to explore the way in which they can be used and improved in nurse staffing and patient outcomes research. The project consists of four phases to achieve this goal: selecting indicators; transforming selected indicators to fit into the context of the Belgian datasets, analysis and development feedback tool.

Phase I: Selecting indicators

Indicator sets have to be developed to make the relationship between nurse staffing and quality of care visible. Relevant variables were selected in two steps.

In the first step, there was a comprehensive search of the relevant scientific literature on staffing and outcomes to develop lists of variables, a summary of findings that connected (or failed to connect) staffing measures with outcomes and a table of evidence to be reviewed by a panel of experts. Three types of variables were of interest in this study: patient outcome variables, nurse staffing variables and background variables. In the first category there were outcome variables involving patients, rather than nurses or their institutions. In this case only variables that were potentially sensitive to nursing care were considered, which means that there is a possible relationship with the impact of the quality of the care that nurses provide. Two types of nurse staffing variables were

identified: the numbers of nursing personnel relative to patient volume and the skill mix of the nursing staff (the composition of the nursing staff in terms of licensure and/or educational status). Background variables included patient, nurse and institutional characteristics, which are potential confounders of relationships between staffing and outcomes. A list of 39 patient outcomes (e.g. pressure ulcers, hospital-acquired pneumonia, patient satisfaction), 14 nurse staffing (e.g. Registered Nursing Hours per Patient Day (RNs), Proportion of RNs with a Bachelor's degree) and 31 background variables (e.g. organizational culture, nurse-physician relationship, hospital size) were identified through a review of the literature.

In the second step, experts examined and rated items on the initial lists of variables to assess the strength of evidence and promise of each of the variables for future research in the area. A purposively selected Delphi panel of researchers (n=24) specializing in nurse staffing and/or quality of health care and nurse administrators (n=8) from 10 different countries agreed to participate. Each participant was e-mailed an up-to-date review of all the evidence relating to the variables and was asked to rate the importance/usefulness of each variable. Summary statistics and earlier responses were e-mailed to each respondent in two subsequent rounds. In Round 2, participants revised their scoring as based on this feedback. Round 3 was intended to overview the group responses. Twenty-nine participants responded to the first round (90.6%), of whom 28 (87.5%) responded to the second round. After the first round of the Delphi review, the panel members added 21 variables (7 patient outcomes, 2 nurse staffing variables and 12 background variables). As result of the second round the pre-defined level of consensus (85%) was reached for 32 patient outcomes, 10 nurse staffing and 29 background variables. The highest consensus levels were found for nurse-perceived care quality, patient satisfaction and pain, and the lowest ratings for renal failure, cardiac failure and central nervous system complications. Nursing Hours per Patient Day was given the highest consensus score with which to measure the number of nursing staff. As a skill mix variable, the proportion of RNs to the total nursing staff achieved the highest consensus level. 100% of the respondents rated both age and co-morbidities as important background variables. There is further study of selected indicators in the second study phase.

Phase II: Selected indicators and the context of Belgian datasets

The indicators selected in Phase I were transformed to fit into the context of Belgian datasets. Internationally available algorithms were used as a starting point to develop the technical specifications of the indicators (algorithms). The research team, with the support of two national panels (B-HDDS experts for the patient outcomes: n=7 and B-NMDS experts for the nurse staffing variables: n=4), made adjustments to these international algorithms to fit the existing Belgian datasets. Out of the 32 selected patient outcomes, 16 could not be calculated due to absence of required data or technical limitations inherent to the B-HDDS. The descriptive statistics illustrated manifest data quality issues for 'Falls', 'Post-operative hip-fracture', 'Aspiration pneumonia' and 'Urinary catheter associated urinary tract infections' for the remaining variables. The following twelve indicators were taken into account for further analysis: 'Pressure Ulcer', 'Deep Venous Thrombosis', 'Shock or Cardiac Arrest', 'Post-operative complications & infections', 'Post-operative Respiratory Failure', 'Urinary Tract Infections', 'Hospital-acquired Pneumonia', 'Ventilator-associated Pneumonia', 'Unplanned extubation or intubation', 'Hospital-acquired sepsis', 'Failure-to-Rescue' and 'In-hospital Mortality'. A measure of the number of nurses may be deducted from the NMDS as 'Registered Nursing Hours per Patient Day' where 'Proportion of RNs with a Bachelor's degree' is a measure of the skill mix. Descriptive statistics demonstrate that the variability in nurse staffing, measured at the hospital level, is limited (P25: 2.46; P50: 2.66; P75: 2.93). This variability increases when nurse staffing is measured at the nursing unit level (P25: 1.96; P50: 2.40; P75: 3.24). It was more difficult to obtain background variables. The B-HDDS contains information about patient-clinical characteristics (age, gender, type of illness, severity of illness, co-morbidities and admission type) and structural characteristics of organizations (institution type, hospital size, technological sophistication). However, nurse characteristics (experience and employment status) and indicators on the organizational process and work environment are not available.

Phase III: Analyzing the relationship between nurse staffing and patient outcomes

One of the first issues in this research area is the influence of the differences across patients with regard to the likelihood of an adverse event. Researchers, therefore, typically account for the impact of patients' clinical characteristics on the risk of poor outcomes. If not, spurious relationships could occur. Better staffed units/hospitals may appear to have poorer outcomes, when, in fact, the better staffing is a consequence of a more ill, high-risk patient group. Secondly, it is also necessary to adjust for differences in the intensity of nursing care because staffing needs vary, not only in the number of patients being cared for, but also in the type of care provided for each of those patients. As nursing care intensity increases, the number of nursing staff required to care for patients will increase. However, it is not common to integrate data about workload or patient acuity into the nurse staffing and patient safety research as this requires hospitals to use workload measurement systems. Belgium can deliver a unique contribution to this research area by introducing the B-NMDS in the nurse staffing and patient outcomes research. In 1992 Sermeus showed how to deduct a measure of the intensity of nursing care from the B-NMDS.

In the first analysis there was an investigation into whether this measure of intensity of nursing care still holds good for the B-NMDS by using 2003 data. Similar work was done in 1992, where the validity of the B-NMDS was tested against the San Joaquin patient classification system, which was designed to measure the intensity of nursing care. All factors that were needed to classify patients in one of the 4 categories of the San Joaquin instrument (ranging from self-care to intensive care) are included in the B-NMDS. The 23 nursing activities measured in the B-NMDS were synthesized into one new latent variable by PRINQUAL analysis. This variable, named the main NMDS-factor, was evaluated as a measure of nursing care intensity by using key characteristics of the San Joaquin Patient Classification System. A retrospective analysis was done of the B-NMDS data from all Belgian acute hospitals (n=115) for the year 2003. The sample included 690,258 in-patient days for 298,691 patients that were recorded on 1,637 acute-care nursing units. The main NMDS factor from the PRINQUAL analysis accounted for 26.8% of the variance. The distribution of inpatient days over all four San Joaquin categories was as follows: 11.1% (self-care); 40.4% (average care); 30.8% (above-average care); 17.7% (intensive care). The average main NMDS-factor scores were

confirmed against the ordinality in the San Joaquin classification system in 97.5% of the nursing units. What is more, the San Joaquin categories alone explained more variability—70.2% in the main NMDS factor – than did other determinants, such as department type, age, diagnosis-related groups (DRGs), severity of illness, hospital type and hospital size together. As such, the main NMDS-factor complies with the main characteristics of the San Joaquin Patient Classification system. It can be concluded that the B-NMDS, uniformly measured in all Belgian hospitals, can be used to obtain a measure of the intensity of nursing care.

In the second analysis a linear mixed modeling approach was used to develop a nursing workload measure. The model calculated the expected number of nursing staff (expressed as Nursing Hours per Patient Day or NHPPD) as based on several factors, such as nursing intensity, type of service (intensive or general), type of day (week or weekend) and type of hospital (academic or general). A random effects model was fitted to account for some unexplained variability emanating from the nursing units within hospitals and the hospitals themselves, besides the variability attributed to the covariates. The analyses showed that much of the variability in the random part of the model was attributed to the nursing units (82%) as compared to the hospital level (18%). The result of this model is a workload measure labeled as “acuity-adjusted NHPPD”. It is calculated as follows:

$$\text{Acuity Adjusted NHPPD}_{ij} = \frac{\text{Observed NHPPD}_{ij}}{\text{Expected NHPPD}_{ij}} \times \text{Crude NHPPD}_{ij}$$

If the Observed NHPPD is greater than the Expected NHPPD, then the nursing unit has more nursing staff assigned, giving the covariates, and a lower workload can then be assumed. The acuity-adjusted NHPPD measure will be entered in future research steps to measure the relationship between nurse staffing levels and patient outcomes.

In the third analysis a risk-adjustment model for each patient outcome was developed. To identify model variables, we drew heavily on what has been published. The variables included age, sex, surgery type and dummy variables indicating the presence of chronic pre-existing health conditions (co-morbidities) reflected in the ICD-9 codes of the B-HDDS. For Failure-to-Rescue and Mortality the co-morbidities defined by Silber (1997) were used. For the other outcomes the co-morbidities defined by Elixhauser

(1998) were applied. We obtained data on all Belgian acute in-patient hospitalizations from all 115 Belgian acute hospitals for the year 2003. Using the APR-DRG, we selected a sample of general, orthopedic and vascular surgery patients analogue to international published work on nurse staffing and patient outcomes (Aiken et al., 2002, 2003). The final sample included 260,293 patients. A statistical reduction of all possible covariates was performed for each patient outcome. The full dataset was split into two mutually exclusive random samples: a learning and a validation set. Starting from the learning dataset, significant variables were selected. A logistic regression was used on the learning dataset to measure the stability of the models to predict various patient outcomes. A similar procedure was followed on the validation dataset. The two hospital ranks on predicted patient outcomes were compared by using the Spearman rank correlation coefficient. The Spearman rank correlation coefficients for all patient outcomes ranged from 0.98 to 0.99. These values support the stability of the used models. The c-statistics (area under the receiver operating curve) ranged from 0.801 to 0.924. The risk-adjusted model allows one to compare patient outcome rates across hospitals. In Belgian hospitals risk-adjusted outcomes vary considerably across hospitals for a selection of surgical procedures. This substantial variation in patient outcomes reveals a potential quality gain that would encourage further action.

In the fourth analysis the relationship between nurse staffing and patient outcomes was investigated. The independent variables (acuity-adjusted NHPPD and percentage of Bachelor-prepared RNs) and the organization characteristics (size, type and technological specification of hospital) were measured at the hospital level. The dependent variables (patient outcomes), together with the risk-adjustment variables, were measured at the patient level. Logistic regression analyses were used to investigate the association. All logistic regression models were estimated by using a Generalized Estimation Equation Model (GEE) to adjust standard errors of the parameter estimates, which were the result of the clustering for patients within hospitals. Analyses were repeated using a two-level structure multi-level model including the hospital and patient level. No significant relationship was found between the acuity-adjusted NHPPD, Proportion of Bachelor-prepared RNs and the selected patient outcomes. Only for urinary tract infections was a significant counter-intuitive result found with acuity-adjusted NHPPD.

Phase IV: Feedback tool

A feedback tool will be installed at the portal website of the Federal Ministry of Public Health (www.health.fgov.be). It will have two separate components: feedback about nurse staffing (number and educational level) and feedback about patient outcomes. Hospitals will be able to log in via a secured website where they will be able to compare data about their hospital with a benchmark (all hospitals, a selection of hospitals with a similar size or type). For both staffing and patient outcomes uncorrected as well as corrected (risk adjustment for patient outcomes and acuity adjustment for nurse staffing) data will be provided.

Discussion

The international literature reports (across a variety of study designs and clinical populations) that low levels of staffing among nurses are typically associated with increased rates of poor patient outcomes in inpatient care. The "Database Quality of Nursing Care" project investigated this relationship in the Belgian setting. Despite the methodological rigorousness of this study this association could not be confirmed for Belgian acute hospitals. Several reasons may attributed to this: data quality issues; analytic issues; aspects specific to the Belgian Healthcare organization, etc.

First of all, there is a possibility that the quality of the data is flawed. The B-NMDS were not collected, and neither were the B-HDDS, primarily for the purpose of this study. Consequently, many shortcomings arose. For example, the B-HDDS from which we derived our measures for quality did not distinguish whether a complication was present on admission. Furthermore, the use of these databases for the hospital financing contains the risk of registration creep. Hospitals are more inclined to register only those secondary diagnoses which have an impact on the hospital budget. The patient outcomes that can be deducted from the B-HDDS are only a subset of the outcomes suggested by the international expert panel. It is possible that these outcomes are less sensitive to nursing parameters. Data quality concerns about the use of the B-NMDS to measure nurse staffing per nursing unit also exist. In particular, the concatenation of data over a 24-hour

period to one registration record hinders an accurate link between performed nurse staffing hours and number of inpatients. In addition, the nursing practice environment could not be studied because no data about this subject were available in the existing datasets. However, it was illustrated in international studies that this measure has a significant impact on care quality.

Secondly, many major problems arise concerning the complex analysis. It is acknowledged that the used risk adjustment methods have some limitations. The nurse staffing data were corrected for the intensity of nursing care. This correction was based on "actual staffing and nursing activities information" and did not include a required or evidence-based staffing component. Furthermore, we also acknowledge that the APR-DRG and co-morbidities adjustment cannot be a complete control for all levels of risk leading to the development of adverse outcomes, nor are the studies available, or likely to tell us which risk adjustor is best.

An additional analytic issue is the level of analysis. In this study, as in most studies on this topic, the hospital was used as the level of analysis. This caused problems in the Belgian setting, not only because of the fact that hospitals having multiple sites is ignored. It has also been shown that the variation in staffing between hospitals is smaller than among nursing units within hospitals. Thus, taking the hospital as the unit of analysis can lead to two types of errors, called the Simpson's paradox and ecological fallacy. Simpson's paradox includes drawing erroneous conclusions from grouped data, drawn from heterogeneous populations. Ecological fallacy means that a correlation at group level is interpreted as it was on individual level.

Thirdly, the Belgian Healthcare system and its hospital financing mechanism differs from the most pre-dominantly Anglo-Saxon settings where, so far, most of these staffing studies have been performed. A first mechanism is the inclusion of minimum nurse staffing ratios at baseline (e.g. 12 FTE per 30 surgical beds) in the hospital financing system. A second mechanism consists of the allocation of a part (6.5%) of the budget, based on the performed nursing activities and using the B-NMDS for medical, surgical and pediatric units and ZIP/ZAP (Zones with Intensive care Profiles and Zones with Other [ander] Profiles) for intensive care. As such, an instrument does exist to provide hospitals with an extra budget if the intensity of nursing care is more elevated as

compared to the national benchmark. This hospital financing system results in less variation in staffing when data are aggregated at the “hospital level”. Furthermore, when variation exists it is most likely to be attributed to differences in intensity of nursing care, and thus justified.

Conclusion

This study incorporated two necessary corrections in the analysis of the relationship between nurse staffing and patient outcomes. The correction for the risk of patient outcomes, typically done by researchers, resulted in risk-adjusted patient outcome rates, which illustrates substantial differences between Belgian hospitals, possibly due to differences in care quality. A second correction included the adjustment of nurse staffing for the intensity of nursing care. The latter makes this study a unique contribution to the international body of knowledge. Despite these methodological improvements, our findings do not indicate a consistent association between nurse staffing and the selected patient outcomes at the hospital level. The data quality issues and analytic issues that are attributed to this lack of association are leading to recommendations for database improvements and further research.

It is recommended that some changes be made to the Belgian datasets to facilitate this type of research in the future. Secondary diagnoses present on admission should be considered as co-morbidities, and not as complications. Efforts to include “time stamps” for diagnoses in a next version of the B-HDDS are encouraged. Furthermore, by introducing an additional application (quality screening) to this database, we believe that hospitals will in the future also register “secondary diagnoses” relevant to this application (e.g. falls, decubitus, etc.). At least, this awareness should be stimulated by the Belgian Ministry of Public Health (e.g. feedback reports, auditing for specific codes used in the quality screens, etc.). Additionally, outcome indicators that are more directly linked to the nursing care process and can currently not be registered, such as “functional status” and “Nurse-perceived care quality” should be considered for inclusion in future revisions of the existing databases. Next, a more stringent recording of nursing staff and nursing activities per nursing unit is recommended by starting a new registration every time the

patient moves to another nursing unit. This will result in a more accurate nursing staff measure per nursing unit.

It is also recommended that investment be made in research, where the impact of the "nursing practice environment" on patient outcomes is investigated. Next, the external criteria of nursing intensity developed by Sermeus et al. (2007) for the revised B-NMDS can be introduced in the nursing workload measure in the future.

To gain a better insight into the relationship between nurse staffing and patient outcomes in Belgium it is recommended that only selected homogenous pathology groups such as cardiac surgery or orthopedic surgery study this association. Furthermore, the hierarchical structure of the data should be included in the analyses: hospitals (size, technological sophistication, type), nursing units (staffing variables, variables about nursing practice environment) and patients (patient characteristics and patient outcomes). This will require an analysis structure using complex hierarchical modeling. For example, a patient changes nursing units during his or her stay. This can be addressed by using a multiple membership model where all the nursing units attended by the patient are given some weights.

Finally, the feedback tool that results from this study is the first in its kind in Belgian Health care. It will support hospital administrators to gain insight into the staffing policy and care quality of their hospital compared to different benchmarks.