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Résumé

Contribution du personnel infirmier et résultats des soins hospitaliers : analyse empirique des hôpitaux de soins de courte durée de l'Ontario

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Les auteurs de cette étude, qui porte sur les hôpitaux de soins de courte durée de l'Ontario (Canada), ont analysé le lien existant entre le degré d'utilisation des soins infirmiers (mesuré en heures de soins par jour-patient), le nombre de jours d'hospitalisation et les résultats pour les patients, dans le but de déterminer si une contribution accrue du personnel infirmier est associée à un raccourcissement des séjours hospitaliers et si, dans le cas de l'affirmative, ce raccourcissement est obtenu sans que cela nuise aux résultats pour la santé. Au terme de leur analyse, qui tient compte de l'effectif infirmier, de la charge de travail, des caractéristiques de la collectivité et du type d'hôpital, les auteurs ont constaté que le nombre d'heures de soins infirmiers avait une incidence négative significative sur la durée des séjours hospitaliers, et ce, sans incidence notable sur la satisfaction des patients ni sur les taux de mortalité à l'hôpital ou de réadmission. Également, les auteurs n'ont observé aucun signe d'une détérioration de la santé des patients pouvant être associée à des séjours hospitaliers plus courts. Ce type d'information est important pour le déploiement d'une palette efficace de ressources en santé ainsi que pour déterminer les besoins à venir en matière de ressources humaines afin de pourvoir à ceux-ci de façon efficace.

Mot clé : résultats pour les patients

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Nursing Inputs and Outcomes of Hospital Care: An Empirical Analysis of Ontario's Acute-Care Hospitals

Gail Tomblin Murphy, Stephen Birch, Linda O'Brien-Pallas, George Kephart, Adrian MacKenzie

The authors analyze the association between intensity of nursing care (as measured by nursing hours per patient day), hospital bed days, and patient outcomes in acute-care hospitals in the province of Ontario, Canada, to determine whether higher levels of nursing inputs are associated with shorter lengths of stay (LOS) and, if so, whether these shorter LOS are achieved at the expense of health outcomes. After controlling for supply of nurses, workload, community characteristics, and hospital type, the authors found that nursing hours per patient day had a significant negative effect on LOS but had no significant effect on patient satisfaction, hospital mortality, or readmission rates. Further, there was no evidence that shorter than expected LOS were associated with poorer patient health. Such information is relevant for efforts to deploy efficient mixes of health-care resources and to identify future human resource requirements to support the efficient provision of health human resources.

Keywords: nursing planning, health human resources planning, patient outcomes, acute care, health-care production

Introduction

In an era when both the costs of funding the health-care system and public expectations regarding the system's performance are continually rising, health-care providers, researchers, and policy-makers alike constantly struggle to ensure that the system is as efficient and effective as possible. Given the relative labour intensity of health services, it is understandable that the attention of health-care decision-makers is often focused on changing the level of human resources. However, decisions affecting health human resources (HHR) are often made without consideration of their relationship to other health-care resources (Vujicic, 2003). Little attention is given to the notion of human resources as inputs in a health-care production function in which input-output relationships (or the rate of productivity of human resources) may be sensitive to the levels of other health-care inputs such as equipment and facilities (Birch, O'Brien-Pallas, Alksnis, Tomblin Murphy, & Thomson, 2003). Decisions about the level and deployment of HHR are often made in response to

short-term financial pressures without any evidence of the effects of changing their use on the production of services and health outcomes.

The aim of this work was to contribute to the evidence base in the field by investigating the relationships between patient length of stay (LOS) in hospital, exposure to nursing care, readmission rates, patient satisfaction levels, and patient health status.

A number of studies have investigated the relationship between levels of nursing inputs and various patient-care indicators, and a number have found that higher registered nurse (RN) employment is associated with lower costs and better utilization and outcomes (Blegen, Goode, & Reed, 1998; Clarke & Aiken, 2003; Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2002; Sochalski, 2001, 2004. Lichtig, Knauf, and Milholland (1999) found that higher percentages of RNs and more nursing hours per acuity-adjusted patient day were associated with lower rates of pressure ulcers, pneumonia, post-operative infections, and urinary tract infections (UTIs) as well as shorter LOS. Needleman and colleagues (2002) found that, among medical and surgical patients, increased RN inputs were associated with lower rates of UTIs, while Whitman, Kim, Davidson, Wolf, and Wang (2003) found an inverse relationship between nurse staffing and rates of falls, medication errors, and use of restraints. In her review of the literature on nurse staffing and outcomes, Unruh (2008) found that shorter LOS were associated with more RN hours (Brown, Sturman, & Simmering, 2002; Shamian, Hagen, Hu, & Fogarty, 1994), lighter workloads (Behner, Fogg, Fournier, Frankenbach, & Robertson, 1990), and higher nurse-patient ratios (Pronovost, 1999), and that increased RN hours per patient day were associated with reduced risk of pneumonia (Cho, Ketefian, Barkauskas, & Smith, 2003). Unruh also cites two 2002 studies, by Aiken, Clarke, Sloane, Sochalski, and Silber (2002) and Needleman and colleagues (2002), which found that a larger proportion of hours per patient by RNs and a larger number of hours of RN care were associated with shorter LOS; lower rates of UTIs, pneumonia, GI bleeding, shock, and cardiac arrest; and fewer deaths within 30 days of admission.

These studies have generally focused on indicators of quality of care in hospitals and average LOS. However, adverse events might not be confined to the inpatient stay if reductions in LOS were achieved through premature discharge. Put another way, if greater nursing inputs are found to represent a substitution for hospital days, and hence a different mix of hospital inputs, we need to consider whether this substitution is achieved at the cost of reduced quality of care or poorer patient outcomes (measured in a variety of ways). Greater nursing inputs (such as having more nurses deployed in the delivery of care on a day-to-day basis) can be used to increase hospital throughput, but this increased throughput could

involve patients being discharged at an earlier stage of recovery, increasing the risk of readmission, and/or reductions in quality of inpatient care as pressure mounts to "cut corners" to achieve required throughput rates. In this investigation, we consider whether greater use of hospital-based nursing is associated with shorter LOS and whether such reductions have adverse effects on patient outcomes, including readmission rates, mortality, patient satisfaction, and patient self-assessed health status.

Research Questions

The study addressed two research questions: 1. *Are higher levels of nursing inputs (as measured by nursing hours per patient day) associated with shorter LOS?* 2. *Is increased exposure to hospital nursing care (e.g., as in question 1) associated with poorer outcomes as measured by hospital mortality rates, hospital readmission rates, patient satisfaction, and patient health?*

Methods

Conceptual Framework

This work was informed by the conceptual framework adopted by Canada's Federal/Provincial/Territorial Advisory Committee on Health Delivery and Human Resources (2005) (see Figure 1). This framework depicts the dynamic nature of the relationships among the many components of the health-care system. In traditional approaches to planning, these components have been treated, often implicitly, as separate, independent, and in many cases invariant over time. It was the aim of this work to contribute to the base of evidence on the relationships between some of these components.

The framework's outer band indicates that health human resources planning (HHRP) should consider relevant social, political, geographical, technological, and economic factors, including, for example, the capacity of the jurisdiction to support health-care and policy decisions on methods of funding health services. We accounted for as many of these factors as possible in our analysis. Across all sectors of care (system design), HHRP must consider optimal ways of deploying and managing the current practice pool of providers, noting that supply is maintained by the production of new providers and that the flow of services from that supply is influenced by the level of financial resources applied and the management and organization (e.g., models) of service delivery. The flow of services from that supply of human resources will also be influenced by the deployment (e.g., the number of nurse hours made available per patient day) and utilization (e.g., the number of patient days of hospital care used) of these resources. These human resources, when supported by

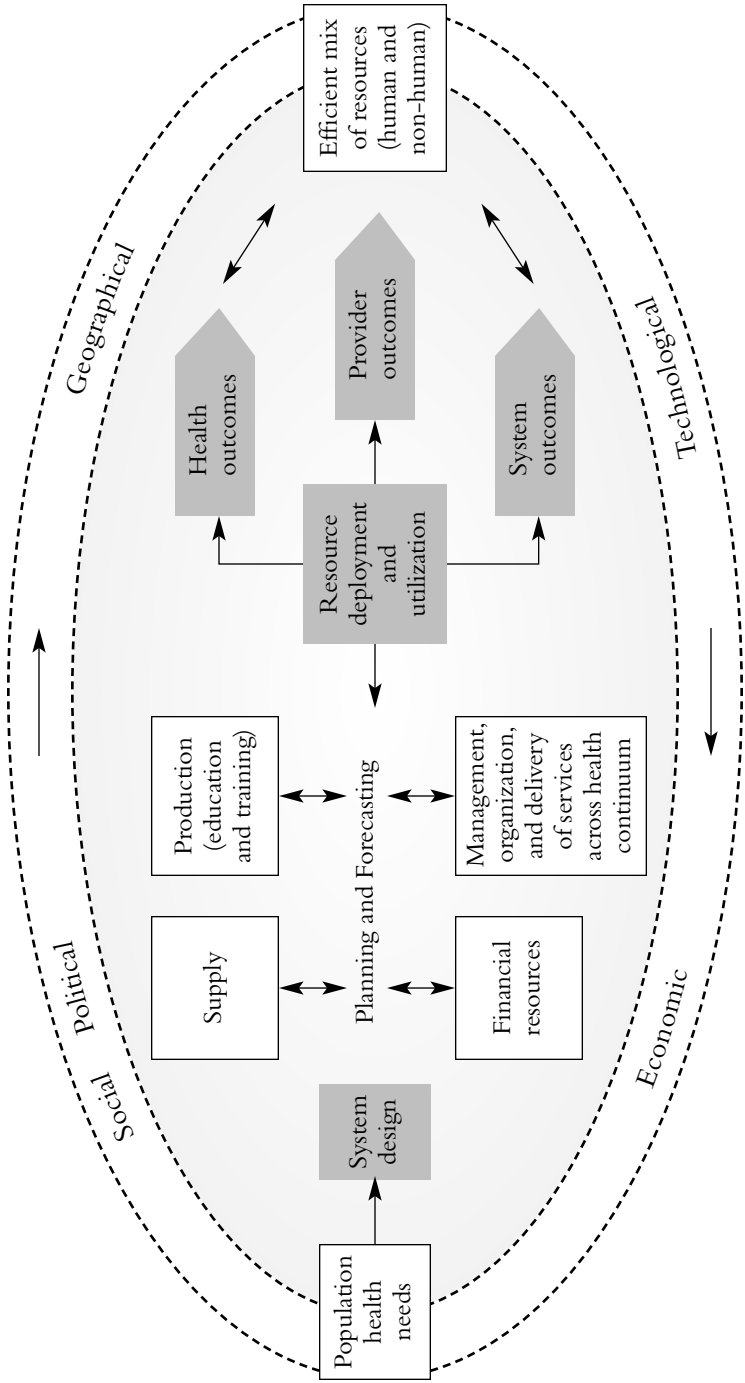

Figure 1 ***Conceptual Framework***

Source: O'Brien-Pallas & Tomblin Murphy (2006)

non-human resources (e.g., facilities and technology), yield patient, provider, and system outcomes that are optimized when the there is an efficient mix of human and non-human resources in the jurisdiction.

We consider the analysis in two parts, one for each of the research questions presented above. In the first part we investigate the association, at the hospital level, between level of nursing inputs (as measured by nursing hours per patient day) and average patient LOS, to determine whether increased "intensity" of hospital care is associated with fewer patient days in hospital; this may indicate a substitution of nursing inputs for hospital days. In the second part of the analysis we determine whether any such substitution (i.e., the resulting shorter LOS) is achieved at the cost of poorer outcomes, as measured by mortality, readmission, patient satisfaction, and patient health.

Part 1: Relationship Between Nursing Intensity and Patient LOS

The relationship between nursing intensity and patient LOS is investigated at the hospital level using a logistic regression model, with LOS as the dependent variable. To better understand this relationship, a number of control variables are included in an attempt to separate the influence of the level of health needs of patients at the hospital, the availability of hospital care, the type of hospital, and the mix of patients at the hospital from the effects of nursing intensity. Measures of patient health needs include age (proportion over age 65), sex (proportion of female vs. male), income (proportion in the lowest income quintile), education (proportion who did not complete high school), employment status (proportion not employed), and overall standardized mortality rate. Data for the control variables are available from Statistics Canada at the Public Health Unit (PHU) level.[1] The exceptions are unemployment and standardized mortality rate, which are based on 1991 census data and the 1996 records of the Registrar General's office, respectively. The mean sample size per PHU for the survey was 1,142 respondents.

Because individuals living in a particular PHU may attend hospitals located in areas covered by other PHUs, one cannot simply assume that the demographic characteristics of the patients in a particular hospital (for example, age and sex distributions or income levels) will match those of the PHU in which the hospital is located. We therefore constructed hospital catchment populations to estimate hospital-level variables as weighted averages of the PHU-level variables, weighted according to the proportion of inpatients coming from each PHU.

[1] These variables were derived by Statistics Canada from the 1996 National Population Health Survey (NPHS) and 2001 Canadian Community Health Survey (CCHS).

Table 1 *Variables and Data Sources for LOS — Nursing Intensity Model*

Variable	Type	Source
Average patient LOS	Dependent	StatsCan (NPHS/CCHS)
Nursing hours per patient day	Independent	CIHI MIS
Age (proportion of hospital catchment population over age 65)	Control	StatsCan (NPHS/CCHS)
Sex (proportion of hospital catchment population who were female)	Control	StatsCan (NPHS/CCHS)
Income (proportion of hospital catchment population in the lowest income quartile)	Control	StatsCan (NPHS/CCHS)
Employment status (proportion of hospital catchment population unemployed)	Control	StatsCan (Census)
Education (proportion of hospital catchment population without high school diploma)	Control	StatsCan (NPHS/CCHS)
Population mortality rate (age-standardized mortality rate in hospital catchment population)	Control	Registrar General
Hospital type (small, large, or teaching)	Control	CIHI DAD
Patient mix (hospital's mean RIW[a] for adult patients)	Control	CIHI DAD
Availability of hospital care (number of nurses per 10,000 hospital catchment population)	Control	CIHI MIS

[a] RIW = resource intensity weight

Data on patient mix and LOS were taken from the 2001 Discharge Abstract Database (DAD) of the Canadian Institute of Health Information (CIHI) (2001a). Data on the number of nurses per 10,000 population and nursing hours per patient day were obtained from Management Information System data (CIHI, 2001c). Patient satisfaction information was obtained from the Hospital Report (CIHI, 2001b).[2]

Table 1 summarizes the dependent and independent (including control) variables included in this regression model as well as the data sources from which each was derived.

Part 2: Relationship Between Nursing Care and Outcomes

As in part 1, the relationships between patient exposure to nursing care and, respectively, mortality, readmission, and patient satisfaction are investigated at the hospital level using logistic regression models. The relationship between patient LOS and patient health is investigated at the individual level because it was felt that institution-level changes in patient health would be difficult to measure or detect. In addition, this relationship is investigated using two different measures of patient health (and thus two different models): self-assessed health status, and Health Utility Index (HUI) score. Self-assessed health status was chosen as an indicator of patient health because it has been shown to correlate well with other, more objective, health measures, including physician assessments (Martin, Schoeni, Freedman, & Andreski, 2007; Miilunpalo, Vuori, Oja, Pasanen, & Urponen, 1997; Reijneveld & Stronks, 2001). There is some subjectivity inherent in this measure, however; it was therefore felt that also investigating the relationship between patient health and LOS using one of the more objective measures of patient health such as the HUI would be informative. To facilitate the interpretation of results, the HUI score was dichotomized to simply indicate whether patients were "healthy." An ordinal logit model (Hosmer & Lemeshow, 2000) was used to estimate the equation for self-assessed health status, because this is an ordered, categorical variable. A logistic model (Hosmer & Lemeshow, 1989) was used for regression involving the dichotomized HUI score.

The regressions run at the hospital level (patient LOS regressed against, in turn, hospital mortality, readmission, and patient satisfaction) include the same control variables used to investigate the relationship between LOS and nursing intensity in part 1 of the analysis, described above. The regressions run at the individual level (patient LOS against self-assessed health status and against HUI score) also include many similar control variables, although these are measured at the individual

[2] While the other hospital data sources included 122 acute-care facilities in Ontario, the Hospital Report included data on 65 of these hospitals.

Table 2 *Variables and Data Sources for Nurse Intensity–Hospital Mortality, Nurse Intensity–Patient Satisfaction, and Nurse Intensity–Readmission Models*[a]

Dependent Variable	Source	Independent Variable	Source
Hospital mortality rate (% of adult patients who died while in hospital)	CIHI DAD	Nurse intensity (nursing hours per patient day)	CIHI MIS
Patient satisfaction (% of adult patients reporting satisfaction with unit-based care [nursing care])	CIHI Hospital Report		
Readmission (% of adult patients readmitted within 30 days of discharge for same diagnosis — dichotomized as less than 1% or 1% and higher)	CIHI DAD		

[a] Each of these models used the same control variables listed in Table 1; these variables are omitted here for the sake of brevity.

Table 3 ***Variables for Increased LOS/Patient Health Models***

Variable	Type	Source
Self-assessed health status (excellent, very good, good, fair/poor) OR HUI score (less than 0.8; 0.8 and higher)	Dependent	StatsCan (NPHS/CCHS)
Difference between actual and expected number of hospital days	Independent	StatsCan (NPHS/CCHS)[a]
Age (5-year groups for those over 20; ages 75 and up grouped together)	Control	StatsCan (NPHS/CCHS)
Sex	Control	StatsCan (NPHS/CCHS)
Income (by quintile)	Control	StatsCan (NPHS/CCHS)
Employment status (employed; unemployed or out of labour force)	Control	StatsCan (NPHS/CCHS)
Education (no high school diploma, high school diploma, community college or trade school diploma, university degree)	Control	StatsCan (NPHS/CCHS)
Residential location (metropolitan urban, non-metropolitan urban, rural)	Control	StatsCan (NPHS/CCHS)

[a] Estimated using double-hurdle model based on NPHS/CCHS data as described above.

level — patient age, sex, income status, education level, and employment status. They also include the type of location of the patient — rural, non-metropolitan area urban, or metropolitan area urban — as a measure of the patient's urban/rural residency. Each of these variables was obtained from the Canadian Community Health Survey (CCHS).

Because hospital LOS is determined in part by individual health status, with sicker people being more likely to have been admitted to hospital, estimation of a simple equation to explain variations in health status between individuals would be subject to endogeneity bias (i.e., differences in health are expected to be associated with differences in number of hospital days). To account for this endogenous relationship in our analysis, we first estimated an equation for the *expected* number of hospital days, based on an individual's characteristics, and then compared this value to the reported number of hospital days to derive a variable for excess number of hospital days. In other words, we examined whether the individual received more or less hospital care than the average respondent with the same characteristics associated with "need." By entering this into the equation for health status, we were able to examine whether variations in the excess number of days of care received explained variations in health status. Data from the 1996 National Population Health Survey (NPHS) (Statistics Canada, 1997) were used to derive the equations for expected use, with data from the 2001 CCHS (Statistics Canada, 2001) entered into the equations to generate the expected use in 2001, conditional on the individual's characteristics in 2001.

The difference between observed and expected hospital days for 2001 was incorporated as the independent variable in the equation for explaining variations in individual health status alongside the control variables described above. The variables and data sources used in the regression models for part 2 of the analysis are shown in Tables 2 and 3.

As the NPHS and the CCHS have a complex multi-stage stratified sampling design (Béland, 2002; Tambay & Catlin, 1995), the regressions were weighted using survey sample weights to adjust for unequal probabilities of inclusion in the sample. Standard errors for the regression coefficients were estimated as the standard deviation of the parameter estimates produced from the regressions being run for each of the survey's 500 sets of bootstrap weights.

Results

Means and standard deviations for the variables used in the hospital-level analyses are presented in Table 4. Recall that these variables are measured at the hospital level. The estimated coefficients for the equations for LOS, readmission, mortality, and patient satisfaction[3] are presented in Table 5.

[3]As noted above, the patient satisfaction analysis was based on a subset of these data.

Table 4 *Descriptive Statistics for Mortality, LOS, and Readmission Models*

Variable Name	*Mean*	*SD*	*Range*
Nurses/10,000 population	43.019	34.092	13.51–282.43
Patient mix (mean RIW[a] for adult patients)	1.315	0.272	0.90–2.96
Lowest income quartile	2.664	0.726	1.41–4.77
Age (over 65 years)	17.758	2.551	11.23–23.46
Sex (female)	50.322	1.580	35.82–52.17
Less than high school	12.841	2.975	5.55–19.55
Unemployment rate	6.829	2.155	3.69–11.40
Mortality rate	1.087	0.096	0.81–1.26
Worked hours/patient day	6.685	1.446	2.99–10.63
Hospital-level mortality	4.310	1.545	0–10.27
LOS	6.766	1.415	4.34–14.36
	Frequencies		
Hospital type: small	52		
Hospital type: large	63		
Hospital type: teaching	7		
Readmission: proportion over 1%	77.9%		

[a] RIW = resource intensity weight

Table 5 *Regression Results for Mortality, LOS, Patient Satisfaction, and Readmission*

Variable	LOS β (SE)	Readmission Rate β (SE)	Mortality Rate β (SE)	Patient Satisfaction β (SE)
Nurses/10,000 population	0.003 (0.003)	-0.013 (0.008)	0.008 (0.004)	-0.009 (0.011)
Patient mix (mean RIW for adult patients)	5.635** (0.697)	1.329 (1.794)	4.064** (1.013)	-2.684 (1.849)
Lowest income quartile	-0.268 (0.159)	0.197 (0.476)	0.039 (0.231)	0.326 (0.175)
Age (over 65 years)	-0.018 (0.037)	-0.015 (0.122)	0.063 (0.054)	0.125** (0.043)
Sex (female)	-0.037 (0.061)	0.011 (0.187)	-0.052 (0.088)	-0.184 (0.117)
Less than high school	-0.002 (0.047)	-0.324* (0.160)	-0.025 (0.068)	0.022 (0.052)
Unemployment rate	0.049 (0.070)	-0.357 (0.230)	-0.361** (0.102)	-0.156 (0.096)
Mortality rate	1.785 (1.794)	11.422 (7.15)	3.619 (2.610)	0.280 (1.743)

Hospital type: large	0.493 (1.245)	1.067 (3.92)	2.220 (1.811)	-3.347 (2.487)
Hospital type: teaching	9.743** (1.675)	1.645 (5.166)	-0.863 2.437	-3.132 (2.506)
Interaction teaching* RIW	-5.570** (0.993)	-1.021 (2.811)	-1.721 (1.445)	2.248 (1.936)
Interaction large* RIW	-0.724 (0.971)	-0.050 (3.00)	-2.417 (1.412)	2.156 (2.032)
Worked hours/patient day	-0.177** (0.065)	-0.287 (0.183)	0.173 (0.095)	-0.003 (0.100)
Adjusted R^2	0.595	0.173[b]	0.280	0.234
N	122	122	122	65

[a] RIW = resource intensity weight
[b] Cox & Snell R^2
* $p < 0.05$; ** $p < 0.01$

Table 6 ***Ordinal Logit Regression Results for Self-Assessed Health***

Variable	Coefficient	Standard Error	95% Confidence Interval		Odds Ratio	
Actual nights in hospital/ expected nights in hospital	-0.020	0.004	-0.028	-0.013	0.980	**
Unemployed	-0.067	0.108	-0.279	0.145	0.935	
Not in labour force	-0.828	0.056	-0.937	-0.719	0.437	**
Non-metropolitan urban	0.211	0.042	0.128	0.294	1.235	**
Rural	0.062	0.035	-0.007	0.131	1.064	
Low-middle income	-0.130	0.130	-0.384	0.124	0.878	
Middle income	0.225	0.109	0.012	0.439	1.252	*
High-middle income	0.493	0.107	0.284	0.703	1.638	**
High income	0.749	0.106	0.540	0.957	2.114	**
High school diploma	0.496	0.052	0.395	0.598	1.643	**
Community college or trade school diploma	0.594	0.051	0.495	0.693	1.811	**
University degree	0.942	0.062	0.822	1.063	2.566	**
Pseudo-R-squared					0.0641	
N					25923	

* Significant at $\alpha = 0.10$
** Significant at $\alpha = 0.05$
Note: Values adjusted for age, sex, and age-sex interaction.

In the LOS model (Table 5, column 1), the coefficient for worked nursing hours per patient day is negative and statistically significant ($p < 0.05$), indicating that hospitals with greater intensity of nursing have shorter LOS, other things being equal. These estimates suggest that higher levels of nursing inputs support reductions in other inputs, in this case hospital bed days.

For hospital readmission (Table 5, column 2), the variable for worked nursing hours per patient day is negatively associated with the probability of readmission rates being greater than 1% of all adult admissions, although this is not significant. Consequently there is no evidence that higher levels of nursing intensity, and hence shorter average LOS, is associated with higher rates of readmission.

Similarly, there is no evidence that responses to increasing nursing inputs, such as reduced LOS, have any impact on hospital mortality (Table 5, column 3) — although the coefficient on hospital mortality is positive, it is not significantly different from zero. Finally, there is no significant association between nursing hours per inpatient day and patient satisfaction (Table 5, column 4). Although the coefficient is positive, implying greater satisfaction associated with greater inputs of nursing care, the association is not significant.

These results suggest that hospitals with higher levels of nursing input per patient day tend to have shorter average LOS after controlling for variations in population and patient characteristics. However, there is no evidence that this is associated with poorer patient outcomes as measured by readmission, hospital mortality, or patient satisfaction.

Turning to the individual-level analysis, Tables 6 and 7 report the estimated coefficients for the equations for self-assessed health status (using an ordinal logit procedure) and probability of HUI > 0.8 (using a logit procedure), respectively.

Goodness of fit is much lower in these equations than in the hospital-based analysis, as would be expected for an individual-level analysis. In terms of self-assessed health status, there is a small but statistically significant negative correlation between the reported-expected hospital days variable and better health. This implies that individuals who have more hospital days than one would expect, given their characteristics, are observed to be significantly less healthy in terms of self-assessed health. However, the size of the coefficient is very small, which raises questions about the practical significance of this finding (the associated odds ratio indicates that for every "extra" hospital day experienced, the patient's odds of having poorer health status increase by only 2%). Moreover, because we cannot be sure that we have fully quantified the need for nursing services in the estimated equation for individual-level hospital days (i.e., there may be residual need variations not captured in our

Table 7 *Logistic Regression Results for HUI Score > 0.8*

Variable	Coefficient	Standard Error	95% Confidence Interval		Odds Ratio	
Actual nights in hospital/ expected nights in hospital	-0.014	0.004	0.980	0.995	0.987	**
Unemployed	-0.374	0.150	0.393	0.982	0.687	*
Not in labour force	-1.138	0.063	0.202	0.451	0.327	**
Non-metropolitan urban	0.199	0.068	1.111	1.376	1.244	**
Rural	0.072	0.047	0.999	1.184	1.091	
Low-middle income	0.290	0.147	0.977	1.555	1.266	
Middle income	0.555	0.123	1.355	1.837	1.596	**
High-middle income	0.808	0.120	1.912	2.382	2.147	**
High income	1.029	0.127	2.414	2.913	2.664	**
High school diploma	0.358	0.065	1.317	1.571	1.444	**
Community college or trade school diploma	0.440	0.066	1.423	1.683	1.553	**
University degree	0.733	0.080	1.939	2.252	2.096	**
Pseudo-R-squared					0.1068	
N					25968	

* Significant at $\alpha = 0.10$
** Significant at $\alpha = 0.05$
Note: Values adjusted for age, sex, and age-sex interaction.

double-hurdle procedure), this small reduction in health status may well be a result of unmeasured need rather than exposure to "extra" hospital care. Most of the other coefficients carry the expected sign and are statistically significant.

The above results are generally replicated when the HUI score is used as the indicator of health status. As with self-assessed health status, individuals reporting more hospital days than expected are less likely to have a HUI score of 0.8 or higher, although, as above, the practical significance of this finding is called into question by the very small coefficient. Although fewer of the other variables are statistically significant, the signs are, in most cases, in the expected direction.

In summary, the findings for the individual-level analysis suggest that, far from being associated with lower levels of health, patients who have a smaller number of hospital days than expected tend to have higher levels of health status, other things being equal. In other words, the "null hypothesis" that there is no association between hospital days and self-assessed health status cannot be rejected. Given the limitations presented by the endogenous relationship between patient health status and time in hospital, as well as the relatively small size of the estimated coefficients on "excess days," we would not want to put too much emphasis on this finding. However, the individual-level analysis is consistent with the hospital-level analysis presented above, in that there is no evidence that shorter LOS are associated with poorer health, other things being equal.

Limitations

While the methods used to develop catchment areas and map data between hospitals and PHUs may serve as an important methodological contribution, they are not perfect and patient-level data would be preferable for this sort of analysis. Also, despite the strategies employed to deal with endogeneity, the probability of residual endogeneity remains, for two reasons. First, the models used to estimate the need for hospital days are not perfect in that they do not completely capture the "need" that individuals have for hospital services. Considerable unexplained variation remains, some of which might be due to unmeasured variation in need. Second, the effects of need variables are estimated using 1996 NPHS data, but the model is then applied to 2001 data on individual characteristics; longitudinal data rather than repeated cross-sectional data would have better suited our purposes, but were not available within project timelines. If residual endogeneity exists, any bias in the estimated effect of hospital days is expected to be negative because any unmeasured need is likely to increase the number of hospital days. Thus, if we had found that observed minus expected hospital days was associated with better

health status, a finding of a positive association would be robust. However, finding a null or negative effect, as we did, we are not able to determine whether this is due to endogeneity bias or the existence of a negative relationship between "extra" hospital care and patient health. Finally, the dichotomizing of the HUI score as below 0.8 or 0.8 and higher, as opposed to a different value, was somewhat arbitrary; a sensitivity analysis would have been informative for this article but was not possible given the data and time constraints of the study.

Discussion and Conclusions

The findings suggest that differences in the deployment of nursing resources are associated with differences in other inputs. In particular, greater intensity of nursing inputs (as measured by nursing hours per patient day) is associated with shorter LOS after controlling for other factors. However, there was no evidence that this resulted in poorer patient outcomes as measured by higher rates of readmission, lower levels of patient satisfaction, or lower levels of self-assessed health. This information is of clear relevance for those considering the planning and deployment of HHR.

Greater attention needs to be paid to how changes in input levels affect levels of service delivery and patient outcomes. This cannot be determined in isolation from the available level of other inputs. The service levels and patient outcomes that can be delivered through the deployment of more beds, theatres, MRIs, or physicians will be determined by the number of nurses with which these inputs can be combined to generate service outputs and health outcomes. The results of this study highlight the infrastructural and organizational barriers that need to be addressed if HHRP is to be conducted in ways that meet the needs of populations.

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