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Research

*Corresponding author
Bruno Piedboeuf, MD
Centre de recherche du CHU de Québec - Université Laval
Centre Mère Enfant du CHU de Québec, 2705 Boulevard Laurier
Québec, QC, Canada, G1V 4G2
Tel. (418) 656-2131
Fax: (418) 656-3442
E-mail: bruno.piedboeuf@fmed.ulaval.ca

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Factors and Costs Associated With the Use of Registered Nurse Overtime in the Neonatal Intensive Care Unit

Marc Beltempo, MD[1]; Guy Lacroix, PhD[2]; Michele Cabot, BSc, RN[3]; Bruno Piedboeuf, MD[3*]

[1]Department of Pediatrics, McGill University Health Centre, Montreal, QC, Canada
[2]Department of Economics, Université Laval, Québec, QC, Canada
[3]Department of Pediatrics, CHU de Québec and Université Laval, Québec, QC, Canada

ABSTRACT

Background: Planning the number of registered nurses (RN) per shift in the neonatal intensive care unit (NICU) is a constant stressor and overtime is often used to assure adequate nurse to patient ratios at high costs.
Aim: To identify the factors associated with shift-to-shift variations in the use of RN overtime in the NICU and assess the economic impacts of reducing overtime.
Methods: We developed a two-year retrospective study in a NICU (CHU de Québec, Level 3 unit, capacity of 51 beds). Detailed administrative data for each shift of the day (night, day, evening) was collected. Non-modifiable organizational factors included patient volume, patient acuity, number of admissions, season, days of the week and work shift. The modifiable factors included the paid hours not at the bedside and the implementation of a bundle to reduce RN overtime (increase in full-time nurse positions and conversion of 10% of RN to regular 12-hour shifts). Multivariate linear regression models were used to assess the association between organizational factors and RN overtime per shift.
Results: A total of 2184 shifts were included. Mean RN overtime per shift was 9.5±10.4 h corresponding to 4.7±5.2% of total hours worked per shift. RN overtime use was influenced by non-modifiable factors including unit occupancy, season and the number of acute patients. Paid hours not at the bedside were associated with overtime. Also, the implementation of a bundle to reduce RN overtime brought the mean RN overtime from 11.7±11.2 h to 6.5±8.5 h (p<0.001). This was associated with a reduction in nursing costs per patient day [386±10 $ *vs.* 381±7 $ (p<0.001)]. That corresponded to a yearly 102,948$ cost reduction.
Conclusion: Reducing RN overtime in the NICU is associated with cost reduction.

KEYWORDS: Nursing overtime; Cost; Reducing overtime; NICU.

ABBREVIATIONS: CI: Confidence Interval; NICU: Neonatal Intensive Care Unit; RN: Registered Nurse; ANOVA: Analyses of variance with Scheffé post hoc test.

INTRODUCTION

In Canada, the regionalization of perinatal care has led to the development of large neonatal intensive care units (NICUs) (>50 beds) that face constant fluctuations in unit occupancy.[1] Consequently, registered nurse (RN) overtime is used to adjust the on service work force to meet patient-to-nurse ratios and face understaffing.[2] RN overtime is defined as hours worked beyond the regular work schedule[3] and has become as significant public health issue across all (NICUs) in Canada and other developed countries.[1,4,5] This is because it has undesirable effects on workers such as increased fatigue, work injuries and burnout.[6-8] It is also associated with adverse patient events like increased nosocomial infections and medication errors.[9-11] Also, RN overtime hours represent a significant cost for the Canadian health care system, estimated between $252.30 million and $430.78 million[12] per year. A better understanding of factors

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that influence RN overtime in the NICU from shift-to-shift is required to address this issue.

Previous studies have focused on factors associated with between hospital and unit variation of RN overtime in adult hospitals. The following organization characteristics have been described as influencing the amount of overtime: level of occupancy, unit size, and financial pressure, whether RN are unionized, RN average wage, RN average work week, and patient acuity.[2,13,14] However, those factors are not under the direct control of the manager. Factors associated with overtime and under the control of management include the total number of RN employed by the unit and absent nurses. The absent nurses due to vacation, maternity, training and prolonged sick leaves can to some extent be planned. For example, summer vacations can be reorganized to try to avoid peak periods in personnel shortages and temporary positions can be created to compensate foreseeable long-term absences. Also the using a mix of RN on regular 8 and 12 h shifts can help offer better coverage by maintaining a more regular work-schedule.[5] To the authors' knowledge, no study has addressed these factors on a shift-to-shift basis in the NICU. The objective of this study was to identify the factors (non-modifiable and modifiable) associated with variations in the use of registered nurse (RN) overtime within the neonatal intensive care unit (NICU) from shift-to-shift to shift and assess the impact of a bundle of interventions to reduce RN overtime. Second, we aimed to assess if the implantation of the bundle resulted in cost reductions in patient care.

METHODOLOGY

The analysis is based upon a retrospective database at the CHU de Québec (QC, Canada), Level 3 NICU (51 beds) from April 1st 2011 to March 31st 2013. The local ethics comity approved this study. The CHU de Quebec NICU is a tertiary/quaternary 51-bed referral centre with surgical and medical consultants available on site. During the study period, there were 29 Level 3 beds and 22 Level 2 beds in the unit. Admissions were mainly composed of inborn patients admitted directly to the NICU (75%), intra-hospital transfers from another unit (9%) and out born patients transferred from another hospital (16%). At night, an in-house resident and a consulting neonatologist attended every delivery of at-risk newborns.

Nurse staffing was reassessed before each shift or whenever there was a change in the nurse-to-patient ratios or patient acuity. Planned nurse staffing was based on patient acuity, unit occupancy and planned elective activities for the shift (surgical procedures, elective admissions, etc). Provincial guidelines included four categories of patients with corresponding nurse-to-patient ratio requirements.[15] Patients were categorized as unstable (1 to 1.5 nurses), intensive care (0.7 nurse), intermediate care (0.3 nurse) or continuing care (0.25 nurse). When nurses were deemed in shortage, management initially turned to available off-duty nurses (no overtime involved). Next, a pool of floating trained NICU nurses were relied upon. Finally, it resorted to voluntary and mandatory overtime to meet the required staffing needs. External nursing agencies were never relied upon to fill staffing requirements.

The total number of RNs employed in the NICU is determined by the combination of financial resources and estimated patient needs. First, funding is allocated by global budget based on historic budgets (The most common healthcare funding method in Canada).[16] Second, nursing needs for the coming year are estimated based on the previous year's occupancy rates and total nursing worked hours.[17] However, these methods do not include the paid hours not at the bedside, the variation in acuity and the organization of the workforce. In 2011 there were 150 registered nurses employed part-time or full-time in the NICU, of whom 79% worked on 8-hour shifts (n=118) and 21% work done 12-hour shifts (n=32). In June 2012, a bundle of interventions was implemented to reduce RN overtime, which included the creation of 15 new full-time positions and converting 10% of nurses to 12-hour shifts.

Variable Definitions

Shifts were defined as follows: Night shifts (0:00-7:59); day shifts (8:00-15:59) and evening shifts (16:00-23:59). In line with collective agreements, nursing overtime was defined as hours worked beyond the scheduled work shifts.[3] In most cases this represented a nurse who either started her shift (8 or 12-hour shift) earlier or finished it later than scheduled and which amounted to a maximum of 16 consecutive hours. Overtime also occurred if a nurse worked above 37.5 hours per week. This definition is similar to the one used in the rest of Canada and the United States.[1,2]

Based on empirical and logical considerations, we chose to assess the association between non-modifiable (shift, day of the week, month, unit occupancy, admissions, patient acuity) and modifiable factors (paid hours not at the bedside, impact of changes implements in June 2012) on the one hand, and RN overtime, on the other hand.

Paid hours not at the bed side included sick leave, maternity leave, vacation, disability leave, paid training and preventive withdrawal from work. This represents the absent workforce and based on previous work, approximately 75% of these hours can be anticipated.[4,12] Also, the periods before and after the implementation of the bundle to reduce RN overtime (June 1st 2012) were compared.

Since, there may be differences in required RN due to higher activity during the days of the week, we compared RN overtime for each shift and for the day of the week (Monday to Friday compared to Saturday-Sunday).[5] Summer months (June, July and August) may have more overtime due the combination of summer vacations and higher turnover in personnel. Indeed, nurses tend to retire in the summer and be replaced in September when the new RN graduates are fully trained making this period a potential confounder. All organizational variables for each shift were collected using the hospital scheduling database

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The daily number of admissions was collected. All new born arrivals in the NICU were counted as admissions, including admissions directly from the delivery room, intra-hospital transfers and inter-hospital transfers to the NICU. Unit occupancy was based on the total number of patients at the beginning of each shift. Since patients are categorized by acuity at the beginning of each shift as per the provincial guidelines described before, we included the number of acute infants for each shift (categorized as unstable or intensive care). This data was collected using the unit clinical database.

Data Analysis

Descriptive statistics using mean and standard deviation for continuous variables were used to determine variations in organizational factors for each shift. We then used t-tests and analyses of variance with Scheffé post hoc test (ANOVA) to examine relationships between RN overtime and categorical variables. Bivariate linear regressions were used to assess the association of continuous variables with RN overtime. We used multivariate fixed-effect linear regression analysis to assess the associations between RN overtime per shift and the previously mentioned organizational variables. Models were fit using least square estimations. Possible multi-collinearity between covariates in the models was assessed with values of the variance inflation factor (VIF) >2.5.[18] Overall model significance was tested with the F-test and individual covariates' statistical significance were tested with t-tests. Lastly, we generated a histogram with a normal probability plot to ensure that our residuals were normally distributed. R version 3.2.2 (R Foundation for Statistical Computing, Vienna, Austria) was used to make the statistical analyses with statistical significance evaluated using two-sided *p*-values at the 5% testing level.

Cost Analysis

To compare the economic impact of the bundle to reduce overtime we first calculated the average of RN overtime as a percentage of total hours worked for each day. We then estimated standard cost of overtime for each patient day using 11.8 h/patient as reference (the mean hours worked per patient over the study period). The cost for each patient day was based on the ratio of RN regular and overtime hours for that day. One hour of regular RN work was 31.70 $ and one hour of RN overtime was 47.48$.[1] This was conservative since overtime can be paid 1.5 to 2x the regular wage. The yearly cost was estimated using 51 bed occupancy (mean for the study period).

RESULTS

Unit Characteristics

A total 728 days were included in the analyses, corresponding to 2184 shifts. There was no missing data. During the study period, the average occupancy per shift was 51.4±3.2 patients (Table 1). The unit was functioning at >100% capacity on more than half of total shifts. This is representative of what many large NICUs report in Canada.[19] The mean number of RN per shift was 27.0±2.6 and were working a total 202.6±19.7 hours per shift (regular hours+overtime hours). There was significant variation in the use of RN overtime per shift. This represented 4.7±5.2% of total hours worked per shift, again a similar variation to what is reported in other NICUs in Canada.[4] Paid hours not at the bedside represented on average 31.6±8.9% of total RN hours paid for each shift, similar to the national average.[4] The average ratio of actual RN for each shift compared to recommendations (based on patient acuity scores) was 100.2±9.5%.

Overtime

Table 2 presents the results of the bivariate analyses. There was significantly less RN overtime after the implementation of the overtime reduction bundle in June 2012. The mean RN overtime per shift decreased from 11.7±11.2 h to 6.5±8.5 h ($p<0.001$). Summer months (June, July, August) were associated with higher RN overtime. Day shifts had less RN overtime compared to the night and evening shifts. Other variables associated with higher RN overtime in the bivariate analyses included week days, unit occupancy, paid hours not at the bedside, number of unstable and intensive care patients and number of admissions.

Table 3 shows the results of the multivariate fixed-effect

Characteristics	Mean	SD
Unit occupancy, n	51.4	3.2
Total number of RN hours worked, h	202.6	19.7
Number of RN, n	27.0	2.6
RN overtime, h	9.5	10.4
RN overtime as percentage of total hoursworked, %	4.7	5.2
Number of admissions, n	1.4	0.7
Paid hours not at bedside, h	98.5	40.4
Number of unstable patients, n	3.0	1.4
Number of intensive care patients, n	13.8	5.1
Ratio of actual staffing/recommended nurses, %	100.2	9.5

RN=Registered nurses, SD=Standard deviation.

Table 1: Organizational characteristics of each shift included in the analyses (n=2184).

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Variable	Mean	SD	*p*-value[a]
Time period			
Before June 2012	11.7	11.9	<0.001
After June 2012	6.5	8.5	
Season			
Summer (June, July, Aug)	10.8	12.3	0.003
Rest of year	9.1	9.7	
Shift			
Night	10.8	10.6	<0.001
Day	6.4	8.4	
Evening	11.4	11.4	
Day of week			
Week day	10.0	10.6	0.002
Weekend	8.5	10.0	
	Coefficient	**95% CI**	***p*-value[b]**
Unit occupancy	0.51	0.37, 0.64	<0.001
Paid hours not at bedside	0.03	0.02, 0.04	<0.0001
Number of highly acute patients	0.82	0.51, 1.12	<0.001
Number of intensive care patients	-0.14	-0.23, -0.06	<0.001
Admissions	0.55	0.36, 0.75	<0.001

[a]based on t-tests for period, season, day of week and ANOVA for shift, [b]based on bivariate linear model, RN=Registered nurse, CI=Confidence interval

Table 2: Bivariate analyses of factors associated with nursing overtime.

Variable	Coefficient	95% CI	*p*-value
After June 2012 (Ref: before)	-9.21	-10.29, -8.13	<0.001
Summer months (Ref: other months)	4.67	3.71, 5.64	<0.001
Night shift (Ref: day shift)	3.94	2.93, 4.94	<0.001
Evening (Ref: day shift)	5.20	4.18, 6.22	<0.001
Weekend (Ref: week days)	0.30	-0.79, 1.41	0.58
Unit occupancy	0.97	0.82, 1.12	<0.001
Paid hours not at bedside	0.02	0.01, 0.03	0.006
Number of unstable patients	0.78	0.50, 1.06	<0.001
Number of intensive care patients	0.18	0.08, 0.28	0.005
Admissions	0.10	-0.10, 0.29	0.31

Number of observation=2181, F statistic: 55.7 on 11 and 2172 degrees of freedom, *p*-value for model <0.001, R=0.46, R^2=0.22
CI=Confidence interval, RN=Registered nurses

Table 3: Fixed-effect regression of the association of selected variables with RN overtime.

regression to assess factors associated with RN overtime variation from shift-to-shift. After adjusting for all other covariates, the implementation of the bundle to reduce RN overtime in June 2012 was associated with a 9.2 h reduction of RN overtime per shift (95% CI=8.1, 10.3, $p<0.001$). Summer months compared to the rest of the year had more RN overtime. Evening shifts and night shifts had more overtime than day shifts. Unit occupancy, number of unstable and intensive patients, paid hours not at bedside and RN straight hours per acute day were associated with higher RN overtime. The number of admissions per shift and the day of the week (relative to the weekend) were not associated with RN overtime. VIF values were all <1.9 indicating no multicollinearity. The proportion of RN overtime use per shift explained by this model was 22% ($p<0.001$). The bundle to reduce RN overtime was associated with a reduction in the mean cost of nursing per patient day [386±10 $ =. 381±7 $ ($p<0.001$)] (Table 4). This was associated with a cost reduction of 102,948$ (95% CI=88,977-116,619).

DISCUSSION

In this detailed analysis of factors associated with shift-to-shift variation in RN overtime in the NICU, we found that RN overtime was associated with non-modifiable factors (unit occupancy, patient acuity, timing of the shift and RN consecutive hours per patient day) and modifiable factors (bundles to reduce overtime and paid hours not at the bedside). The bundle was also associated with a reduction in nursing costs per patient day.

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	Before Bundle	After Bundle	*p*-value
RN overtime as % of total hours worked, % (SD)	6.0 (5.6)	3.0 (3.9)	<0.001
Ratio of actual staffing/recommended nurses, %, mean (SD)	102 (10)	100 (9)	<0.001
Standardized RN regular hours worked per patient day,[a] h, mean (SD)	11.1 (0.7)	11.5 (0.5)	<0.001
Cost per patient day in regular hours,[b] $, mean (SD)	346 (38)	373 (34)	<0.001
Standardized RN overtime hours worked per patient day[a], h, mean (SD)	0.7 (0.7)	0.4 (0.5)	<0.001
Cost in OT hours per patient day, $, mean (SD)	33 (32)	17 (22)	<0.001
Standardized estimated cost of RN per patient day,[a] $, mean (SD)	386 (10)	381 (7)	<0.001
Estimated yearly cost[d], $, mean (SD)	7,195,353 (197,605)	7,092,405 (135,292)	<0.001

[a]Based on a mean 11.8 h per patient day (the mean total hours/patient day over the study period)
[b]Cost of 1 RN hours worked=31.70$
[c]Cost of 1 RN overtime hours=47.48$
[d]Based on a mean 11.8 h worked per patient day and 51 bed occupancy (the observed means in the unit during the study period)
RN=Registered nurse, SD=Standard deviation.

Table 4: Estimated economic impact of the implementation of RN overtime reduction bundle.

Non-Modifiable Factors Associated with Overtime

In this study, RN overtime in the NICU was associated with non-modifiable factors like unit occupancy and patient acuity since managers and clinicians have little control on these variables. This makes NICU particularly more dependent upon overtime than other units.[14] Managers must find strategies to have flexibility in the number of available nurses for each shift while avoiding overstaffing. The use of specially trained float nurses that can be reassigned to specialized units (co-trained in paediatric and neonatal intensive care) has been suggested to help mitigate these circumstances.[20,21]

Although, seasonal variation in RN overtime is a non-modifiable factor, it's recurrent pattern makes it predictable. Indeed, there was higher RN overtime in the summer months compared to the rest of the year. This occurred because more nurses are on vacation during these months, retirements occur more frequently during this period and there is a delay before graduating nurses become available for work. Indeed, in Canada, nurses graduate at the end of May and must take an extra month of training before integrating a NICU. Consequently, newly employed RN are available in August at the earliest, thus explaining the summer spike in overtime. A recent Canadian epidemiological study found an increase in healthcare-associated infections in NICUs over the course of summer.[22] RN overtime could be a contributing factor to these infections rates and should be further investigated.

We also found that night and evening shifts had more RN overtime. It this unit, newer nurses tend to be assigned evening and night shifts and tend to take more paid hours not at the bedside for maternity leave.[23] This is reflected by the higher number of paid hours not at the bedside on nights and evenings. However, the absent nurses were not the only factor contributing to higher RN overtime on night and evenings since we adjusted for the timing of the shift and paid hours not at the bedside in the final model, and neither factor was collinear. This means other factors related to staffing and scheduling contribute to higher overtime at night and evenings. The higher RN overtime at night could contribute to patient outcomes like the higher mortality observed in infants admitted at night.[24]

Modifiable Factors Associated with RN Overtime

Paid hours not at the bedside are inversely proportional to the available workforce on a given day. Consequently, more paid hours not at the bedside have a positive association between nurse shortage and overtime.[25] They are partly predictable as they include vacations, maternity leave, and extended sick leaves. These should be accounted for when the work schedules are drawn up and could help reduce overtime.

This study also emphasizes that administrative strategies to reduce overtime can be efficient. The implementation of the bundle to reduce RN overtime in June 2012 (increase of 10% of RN working 12 h shifts and increase in full-time positions) was associated with a significant decrease in RN overtime. This is similar to other studies in workforce management that showed that 12 h shifts and increase hiring can help reduce overtime.[26,27] These measures were cost-effective since the increase in total regular hours led to a significant decrease in costs per patient day. Further, increase in full time nurses was not associated with overstaffing (a concern for administrators when hiring more full time personnel). Indeed, the ratio of actual staffing to recommended nurses actually decreased from 102% to 100% suggesting less overstaffing. This suggests that current methods to estimate the total number of employed nurses based on historic budget, occupancy and total hours of patient care are imprecise. Detailed planning should integrate the economic benefits associated with reducing overtime by increasing the number of employees.

Strengths and Limitations

The results of the current study are limited by the fact that data stem from a single unit. On the other hand, focusing on a single unit allowed us to have detailed daily administrative data for every shift and to develop an appropriate regression model to explain overtime. Further, the variations in RN was similar to what has been reported elsewhere in Canada. This illustrates the importance of having individual department quality data when

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making administrative decisions on personnel management.

Another limitation of the study is the fact that we did not collect daily information on the number of nurses working 12 h *versus* 8 h shifts. Also, information on the number of nurses scheduled for each shift would have helped develop a better model. However, those data are unavailable. Indeed, the nursing work schedule is constantly modified due to variations in sick days, shift exchanges and the three times daily reassessments of the required number of nurses. Other studies on overtime have found that there is under reporting of overtime hours by nurses in certain non-unionized and private hospitals.[28] This is unlikely in this study since this was a public-funded unionized hospital where the head nurse documents all hours worked and is verified by the unit secretary and an electronic system reports hours worked.

In this project, we did not collect data on patient outcomes. Assessing the impact of RN overtime on patient outcomes in the NICU is an important research question but was not the objective of this paper. Indeed, a better understanding of the variation in overtime and its economic impact was required before it is linked to patient data. This is what makes this paper's contribution important.

CONCLUSION

RN overtime is associated with adverse patient outcomes and higher hospital costs.[11] This study has found that overtime is a significant issue in the NICU, and that it does not only depend on non-modifiable factors. Overtime is also dependent upon the available workforce which itself depends upon paid hours not at the bedside. Increased hires and a more efficient workforce scheduling are efficient measures to reduce overtime and reduce costs. Larger multi-centre comparative studies are required to determine other strategies to reduce RN overtime in the NCIU and their potential association with neonatal outcomes.

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CONFLICTS OF INTEREST STATEMENT

The Research Ethics Board of the Centre University Hospital de Québec (CHU de Quebec) has approved the research that has been conducted for this study. Authors also declare having neither competing interest nor conflicts of interest either financial or of any other nature.

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