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Predictive Staffing Simulation Model Methodology

Executive Summary

- Many factors contribute to the complexity of planning for and having enough nursing staff; however, antiquated planning strategies are a major issue.
- The purpose of this study was to develop a predictive staffing simulation model.
- The model included integrating staffing needs (actual patient census, care delivery model, and budget) and staffing availability (filled positions, flex staffing, and absences) factors that influence effective and efficient staffing plans using the staffing prediction and simulation analysis tool.
- A predictive staffing simulation model provides the ability for nursing leaders to proactively predict nursing resources in establishing effective and efficient staffing models that support an optimal patient care delivery system.

Inadequate nurse staffing has been a major challenge for the nursing profession, and continues to be the leading dissatisfier in the profession of nursing (Gleim, 2015). Many factors contribute to the complexity of planning for and having enough nursing staff; however, antiquated full-time equivalent (FTE) planning strategies are a major issue. Traditionally, healthcare organizations forecast the number of nursing positions needed in the next fiscal year's staffing plan. The forecast uses two data points: historical patient census and nursing hours per patient day (care delivery model). The data are annualized and presented as a monthly average in totality for staffing planning purposes. The average methodology does not account for the scheduled/unscheduled absences of staff, open positions, fluctuations of low and high census, patient acuity changes, and variation of growth projections among the months of the year (Ponti, Germain, & Moulton, 2010). Typically, revisions of staffing plans do not occur until the next year's budget planning process. Planning for staffing can be described as reactive, as managers and staff nurses continuously address shift-to-shift staffing needs. Solutions to reactionary staffing plans without using the right tools often result in staffing needs being unmet and/or met through staffing models that have higher labor costs. Nursing staff represent 35%-50% of hospital costs (Nguyen, 2006), and can contribute to negative margins with the use of inefficient labor costs. The Medicare Trustees reported that by 2019, 5% more hospitals will experience negative total margins and by 2040, 50% of all hospitals would have a negative margin (Centers for Medicare & Medicaid Services, 2015).

Nurses need to understand the financial impact reactive

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staffing plans place on healthcare organizations and take an active role in reducing inefficient nurse labor costs (high cost of travelers, incentive programs, turnover cost). These high-cost staffing methods also create the potential for overworked and stressed staff, leading to dissatisfaction and potential quality concerns. To achieve significant and sustainable patient outcomes, nurse staffing programs must be grounded in efficiency and effectiveness. The nurse staffing program design must also include the ability to consistently plan for and meet fluctuations in patient census, patient acuity level needs, and factors that influence staff availability.

Healthcare organizations forecast staffing needs, respond to daily staffing needs, and review past staffing practices through separate data analysis without integrating this information to drive the change needed to improve staffing efficiency and effectiveness. For nurse leaders to achieve significant and sustainable staffing outcomes, they must partner with their finance, human resources, and information technology colleagues. This partnership creates an infrastructure to proactively plan staffing operations through the analysis of staffing data, aligning healthcare informatics with staffing and operations.

The purpose of this study was to develop a predictive staffing simulation model as an effective tool for proactively planning staffing needs for nursing. The specific aims were to: (a) establish a predictive staffing simulation model as a methodological framework for analyzing staffing statistics; (b) identify key data staffing measurements needed for use within the staffing model to accommodate variances in patient acuity/census and staff availability; and (c) provide a model using staffing data that executive leaders, along with financial and human resource colleagues, in collaboration with all levels of nursing, can use to proactively predict nurse staffing resources.

Literature Review

Kerfoot (2012) identified staffing as a foundational factor affecting employee satisfaction and patient outcomes. Evidence demonstrates a direct link between inadequate staffing and negative patient outcomes (Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2011), missed nursing care (Kalisch, Landstrom, & Williams, 2009), increased nurse turnover (Jones & Gate, 2007), increased risk in patient mortality (Needleman et al., 2011), and decreased teamwork/nurse satisfaction (Kalisch & Lee, 2011).

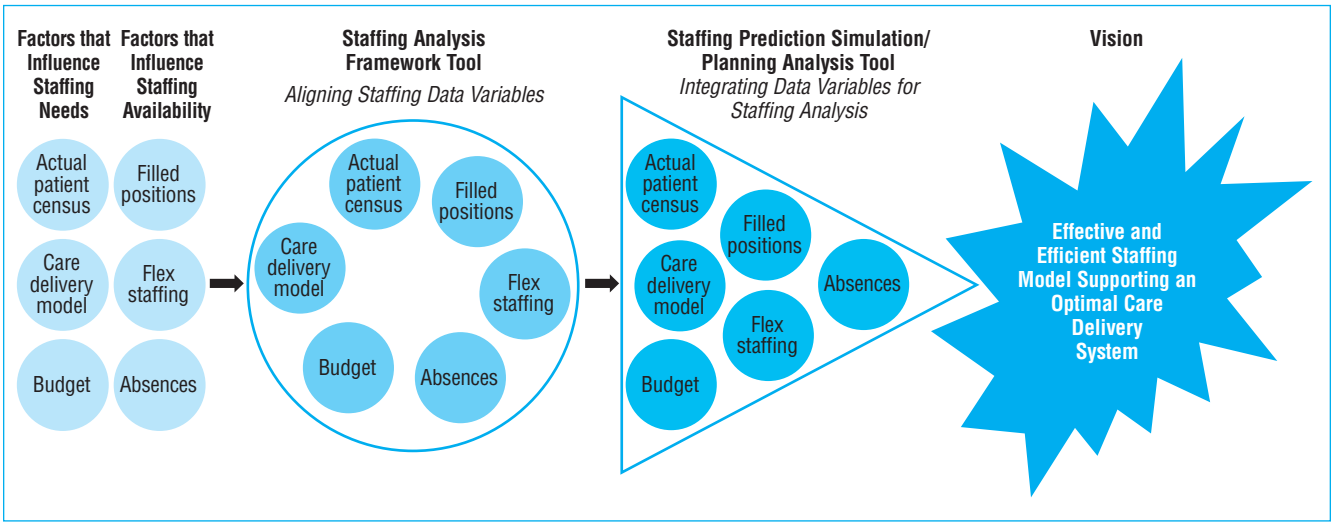
McKenna and co-authors (2011) reported on an implementation of a Nursing Productivity Committee that involved nursing leadership and front-line staff. This committee focused on staffing processes, which resulted in lower nurse-to-patient ratios, better control of labor costs, elimination of agency staff, and greater staff satisfaction. The intensive care unit alone reported their vacancy rate of 33% decreased to 5% with less variability in hours per patient per day fluctuations. Nickitas and Mensik (2015) also recommended a governance structure to analyze staffing data as part of the Data-Driven Model for Evidence and Excellence in Staffing. Formalized structures with the support of technology for data analysis provide the framework for leaders in establishing innovative new models of staffing and care delivery systems.

Professional organizations have addressed the challenges around nurse staffing through both the endorsement of written national standards and formalized recommendations. These standards include *AONE Policy Statement on Mandated Staffing Ratios* (American Organization of Nurse Executives, 2003), *AACN Standards for Establishing and Sustaining Healthy Work Environments* (American Association of Critical-Care Nurses, 2016), and the *ANA Principles of Nurse Staffing* (American Nurses Association, 2012). Formalized staffing recommendations included in the ANA report focused on the need to build an evidence-based staffing framework of which staffing models must be flexible (e.g., staffing plan established at each census level, internal nursing agency) and continuously evaluated (ANA, 2015). There is consensus that staffing challenges are complex and encompass many variables that influence the nurse-staffing model. Adding to the staffing complexity issue is the lack of clarity or consistency in the staffing data analysis process among healthcare organizations from the level of what staffing data should be collected to how the information is used to drive decisions around staffing plans.

The predictive staffing simulation model provides a systematic approach for staffing data analysis. This methodology integrates six key factors for analysis in designing staffing models that are effective and efficient in supporting optimal care delivery systems (see Figure 1).

This conceptual model provides a framework for key factors that affect staffing. The major factors that influence staffing needs (actual patient census, care delivery model, and budget) and staffing availability (filled positions, flex staffing, and absences) compose the framework of the *Staffing Analysis and Staffing Prediction Simulation/Planning Analysis Tools*. The *Staffing Analysis Tool* provides data specific to each of the key six factors for analysis of how each variable independently impacts the staffing plan. The *Staffing Prediction Simulation/Planning Analysis Tool* takes the data analysis process to the next level by integrating the data (identifying the total impact of the six key factors on staffing

Figure 1.
Conceptual Model



plans) for healthcare leaders use in designing staffing plans to best predict staffing needs for optimal patient care.

Methods

Design and setting. The setting for this retrospective comparison design study was an 82-bed neonatal intensive care unit (NICU) in a children's hospital in the western United States. The most critical RN staffing metrics were collected and formatted using the Predictive Staffing Simulation Model. Nursing leaders used the data analysis framework provided by this methodology to develop NICU staffing plans to meet patient needs.

Sample. The NICU's actual RN staffing data (excluding charge nurses and neo-response nurses) was analyzed for four identified quarters of time, FY 2014 (Q3, Q4) and FY 2015 (Q1, Q2) to establish the Predictive Staffing Simulation Model for FY 2015, Q3 and Q4. The data were then compared to the actual data during the same period (FY 2015, Q3 & Q4).

Ethical considerations. Approval for this project was obtained from the senior executive team within the organization. Approval was obtained through the organization's institutional review board in partnership with the regional university.

Procedure. Staffing data for this study were obtained using several of the hospital systems to populate the analysis tools: time keeping, human resources management, scheduling, financial reporting, and electronic medical records. Previously, data from these separate systems were not analyzed concurrently. The data were reviewed for inaccuracies and updated accordingly, with the final authenticity of the data reviewed with the director of business operations. Mathematical formulas associated with the six key factors that influence staffing needs and staffing availability were incorporated into the tools for data automation. The tools than provided the format for the data analysis discussion.

Data analysis. Descriptive data analysis was completed on the staffing needs and staffing availability factors using means and percentages for predicted and actual bedside staffing numbers (excluding charge nurses and neo-response nurses). Analysis of variance (ANOVA) statistical measurement tables were used to determine differences over time between pre-implementation (January-August 2015) and post-implementation (September 2015-April 2016) of the *Staffing Prediction Simulation/Planning Analysis Tool* in examining factors for staffing needs (available RNs vs. target RNs) and staffing availability (hired RN FTEs; terminations/transfer out of unit). This organization also conducted a staff engagement survey in December 2014 and January 2016. Staff responses to "Adequacy of Resources and Staffing" were analyzed pre-implementation and post-implementation of NICU nursing leaders using the *Staffing Prediction Simulation/Planning Analysis Tool* as a data analysis resource in driving decisions of nurse staffing plans.

Measurement and instruments. The Predictive Staffing Simulation Model framework incorporated the use of two tools to analyze staffing needs and determine their value to proactively plan for staffing needs. These two tools were the *Staffing Analysis Framework Tool* and

Staffing Prediction Simulation/ Planning Analysis Tool. Each tool was designed to provide an effective methodology for nurse leaders to evaluate the success of their staffing programs and plan for the future.

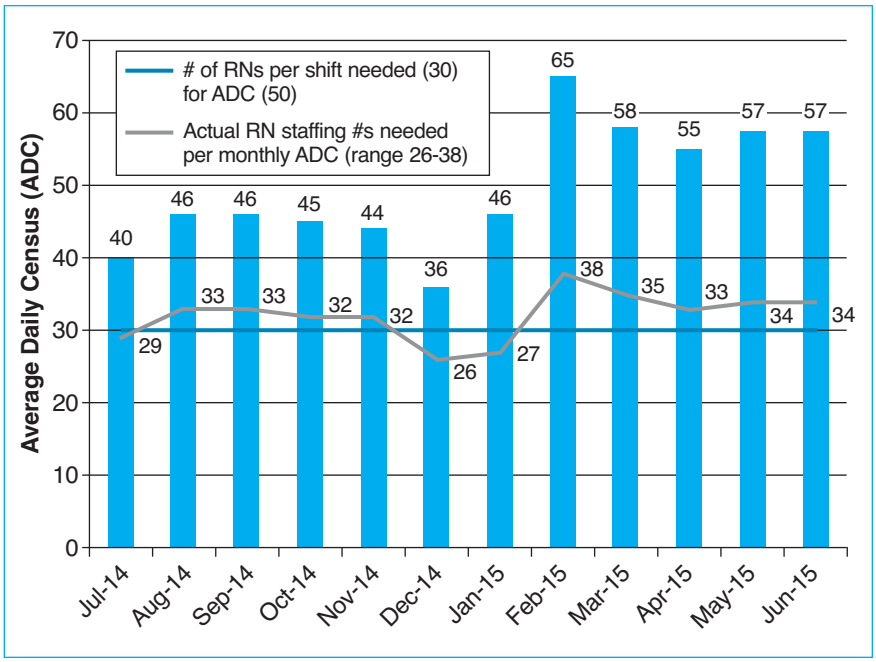
The *Staffing Analysis Framework Tool* comprised key factors that influence the number of RNs available per shift for staffing needs (projected/actual patient census, nursing care delivery model, budgeted FTEs) and staffing availability (filled positions/ terminations, flex staffing programs, scheduled/unscheduled absences). Staffing needs and staffing availability factors were collected over 1 year and used in forecasting the predictive staffing needs for the next 6 months.

The second instrument, *Staffing Prediction Simulation, Planning, & Analysis Tool*, automates the planning process by utilizing an algorithm that combines all necessary staffing data. This tool has proven effective in guiding hospital leaders through the data analysis process by utilizing a user interface in the format of a "tool" for leaders. The *Staffing Simulation, Planning, & Analysis Tool* was used to illustrate how nursing, finance, and human resources can use the various staffing needs and staffing availability factor data sets to develop staffing budget plans which make allowances for these variable factors. In fact, this tool was a principal factor in streamlining the position management process at this hospital. The automated format and real-time feedback of the *Staffing Simulation, Planning, & Analysis Tool* can be used to strategically drive efficient and effective staffing decisions in proactively planning for staffing needs and availability.

Findings

Staffing Analysis Framework Tool. This tool demonstrated how the care delivery model and census influence budget projections for staffing needs. During 2014 (Q3 & Q4) and 2015 (Q1 & Q2) the patient census had a fluctuation from 36 to 65 patients (average daily census [ADC] 50 patients) (see Figure 2).

Figure 2.
2014 (Q3 & Q4) and 2015 (Q1 & Q2) NICU Monthly Average Daily Census and RN Staffing Needs per Care Delivery Model



During the first 6 months of 2015, the ADC was higher than what was projected (56 vs. 48). The care delivery model however shifted to a lower acuity level need (see Table 1) with 23% of the patients (vs. 44% seen in 2014) at a 1:1 nursing ratio. This resulted in a need for an average of 34 nurses per shift, with the actual staffing availability of 28 nurses per shift, based on the filled RN FTE positions (see Table 1). This demonstrates how filled FTEs, patient census, and patient acuity impact the challenges associated in planning for staffing needs (see Table 2).

There are many factors that influence the RN staffing availability numbers (vacancy, turnover, and scheduled/unscheduled absences) following final approval of the budget. These factors are all important for managers to consider in the development of their staffing plans (see Table 3). Staff resignations accounted for 22.05 FTEs (12.2 FTEs Q3 & Q4 of 2014, 9.85 FTEs Q1 & Q2 of 2015), resulting in availability of two to three less nurses per shift. Unscheduled absences and scheduled absences accounted for a deficit of two to four nurses per shift, with a reported average deficit of three nurses per shift (annual average 13 FTEs). Staff resignations and absences impacted RN staff availability numbers by an average five to six less nurses per shift. The staff availability deficit was offset with travelers, nursing staff overtime, and float nurses (9.1-12.4 FTEs annually), providing an additional two to three nurses per shift. This resulted in average actual filled RN positions of 29 RNs/shift (see Table 3) versus the 31-34 RNs/ shift (see Table 1) needed to pro-

Table 1.

Actual Q3 & Q4 2014

Actual FTE Average Filled	RN/Shift	Average Daily Census	Care Delivery Model			
				RN	Patients	%
120.6	29	43	1 to 1	19	19	44
	Range 26-33	Range 36-46	1 to 2	11	21	49
Range 108-126.5	Range26-30		1 to 3	1	3	7
			Total	31	43	

Actual Q1 & Q2 2015

Actual FTE Average Filled	RN/Shift	Average Daily Census	Care Delivery Model			
				RN	Patients	%
121.35	28	56	1 to 1	13	13	23
	Range 27-38	Range 46-65	1 to 2	20	40	71
Range 121-123.3	Range 28-29		1 to 3	1	3	5
			Total	34	56	

vide coverage for the established patient care delivery model.

Staffing Prediction Simulation/Planning Analysis Tool. This tool provided a methodology to analyze how integrating the six key staffing factors with the potential decisions leaders would make on FTE RN allocation impacts future staffing plans. Using 2014 (Q3 & Q4) and 2015 (Q1 & Q2) data, the tool was utilized to forecast hiring and staffing plans for 2015 (Q3 & Q4). Based on the care delivery model, projected census, and historical influence of factors on available staff for the NICU, the automation provided by the tool simulated a need for 126 full-time/part-time core RN FTEs and 20 RN FTEs in a Flex Model Staffing Program for a total of 146 RN FTEs. The 20 RN FTEs allocat-

Table 2.
Impact of Census/Activity on RN Staffing

			RN/Shift Needed
Actual	2015 High Census (56)	2015 Low Acuity (ratio 1:1, 23%)	34
What If…	2015 High Census (56)	2014 High Acuity (ratio 1:1, 44%)	39
	2015 had 2014 Low Census (43)	2015 Low Acuity (ratio 1:1, 23%)	26
	2015 had 2014 Low Census (43)	2014 High Acuity (ratio 1:1, 44%)	31
		Average	33

Table 3.
Staffing Availability Factors

Staffing Availability Factors	Actual July-December 2014	# RNs/Shift 2014	# RNs/Shift 2015	Actual January-June 2015
Filled Positions	121 FTEs	29	30	126 FTEs
Staffing **Flexibility** Plan (Overtime/Travelers/Floats)	1.0 FTE 4.0 FTEs 4.1 FTEs Total 9.1 FTEs	2	3	1.1 FTE 7.2 FTEs 4.1 FTEs Total 12.4 FTEs
Total	130.1 FTEs	31	33	138.4
Unscheduled/Scheduled **Absences**	11.51 FTEs	2-3	3-4	14.45 FTEs
Total		28-29	29-30	
Impact on Filled Positions				
Terminations/Transfers	12.2 Range 0-4.4/month Avg 2.0 FTE/month (3 RNs fewer/shift)			9.85 FTEs Range 0-3.3/month Ave 1.64 FTEs per month (2 RNs fewer/shift)

Figure 3.
Staffing Prediction (Simulated Census): 146 FTEs (20 Flex)
Quarters 3 & 4 2015

Staffing Simulation, Planning, & Analysis Tool

Assessment Report

Unit: NICU **Current Month:** July **Orientation Average:** 3 Months
Current RN FTEs: 146 **Current RN FTEs which are Flex:** 20

Year	Month	Hiring Plan (RN FTEs)	Traveler Plan	Planned RN FTEs	Required RN FTEs	FTE Difference	FTE Difference Adjusting for Flex RNs	Estimated Labor Cost	Labor Opportunity Cost
2015	July	10	0	146	140.1	5.9	0.0	$1,172,504	0
2015	August	0	0	144.7	138.9	5.8	0.0	$1,242,086	0
2015	September	0	0	141.9	142.2	(0.3)	(0.3)	$1,183,694	$1,000
2015	October	0	0	151.1	137.7	13.4	0.0	$1,293,399	0
2015	November	0	0	149.2	141.5	7.7	0.0	$1,159,432	0
2015	December	0	0	147.1	142.2	4.9	0.0	$1,181,092	0
						Annualized Costs:		*$7,232,207*	*$1,000*

ed for a flex staffing model included planning for hiring 9.0 FTE nurses (10 nurses) in July, based on historical turnover rate to proactively plan for staff turnover the last half of 2015 (Hire Ahead Flex Program) and up to 11 FTEs (range 4-13 FTEs) to accommodate for the flexibility needed for staff availability (see Figure 3, FTE Difference column). A staffing plan with a flex and hire ahead program predicted eliminating the need for travelers and incentive staffing programs (see Figure 4, Traveler Plan and Labor Opportunity Cost and Cost of Over/Under Hire columns). The 2015 (Q3 & Q4) NICU FTE staffing prediction plan, once finalized for what decisions leaders would have made based on the information from the *Staffing Prediction Simulation/Planning Analysis Tool,* was then compared with actual staffing plans and patient census retrospectively for the same period. The prediction plan matched with what occurred for the ADC and care delivery model for 2015 Q3 and Q4.

If this staffing plan as designed through predicting staffing options had been implemented, 22 FTEs would have been needed (vs. 20 FTEs predicted) of the 146 FTEs in the flex program. In planning for expected turnover, one more FTE was reported than what was projected (9.9 FTEs vs. 9.0 FTEs) through the Hire Ahead Flex Program and would have needed up to 12.5 FTEs in flex staffing (see Figure 4, FTE Difference column). This predicted simulated staffing plan closely matched the actual RN FTE need, and would have reduced the need for high-cost RN travelers (8 FTEs) and incentive programs that were required for staffing needs. In using the *Staffing Prediction Simulation/Planning Analysis Tool,* if the prediction plan had been operationalized, the NICU would have demonstrated (a) decreased need for travelers and incentive programs (estimated 6-month savings of over $400,000 in labor cost), and (b) decreased difference between RN need and available RN FTEs (actual RN FTE need *SD* 12.2 RNs; planned RN FTE need *SD* 10.4 RNs).

The NICU incorporated the *Staffing Prediction Simulation/Planning Analysis Tool* and methodology in discussions for staffing plans in September 2015. This unit's results were analyzed for statistical significance comparing the pre and post-implementation periods. ANOVA analysis reported a statistically significant difference ($p<0.05$) between pre-implementation (January-August 2015) and post-implementation (September 2015-April 2016) when comparing the number of RN FTEs hired in the NICU. Statistical significance was also found when comparing the variance between RNs available with target RNs required. There was no statistical significance in turnover between pre and post-implementation, although the rate decreased from 1.4% to 1.2% (see Tables 4a-c). There was also a reported statistical difference (from the employee engagement questionnaire vendor) between pre and post-implementation in the *nurse engagement* responses to the item "Adequacy of Resources and Staffing" (pre 3.69; post 3.78; SS>0.06). Also, while the national benchmark average on this item decreased during this period (December 2014 – 3.52; January 2016 – 3.48), this unit's score increased.

Tables 4a-c.
Pre/Post Staffing Prediction Simulation/Planning Analysis
Tool Implementation Statistical Results
(Pre-Implementation Period – Jan-Aug 2015; Post-Implementation Period – Sept 2015-Apr 2016)

Table 4a.

Groups	Count	Sum	Average	Variance
Pre FTE	8	1,025	128.125	5.553571
Post FTE	8	1,025	154.375	235.4679

ANOVA

Source of Variation	SS	df	MS	F	*p*-Value	F crit
Between Groups	2756.25	1	2756.25	22.87141	0.000292	4.60011
Within Groups	1687.15	14	120.5107			
Total	4443.4	15				

SUMMARY: Comparing the number of RN FTEs in the NICU; Statistically significant difference ($p<0.05$)

Table 4b.

Groups	Count	Sum	Average	Variance
Pre FTE Variance	8	-138.1	-17.2625	178.1798
Post FTE Variance	8	51.9	6.4875	61.03554

ANOVA

Source of Variation	SS	df	MS	F	*p*-Value	F crit
Between Groups	2256.25	1	2256.25	18.86376	0.000675	4.60011
Within Groups	1674.508	14	119.6077			
Total	3930.758	15				

SUMMARY: Comparing variances of RNs available and target RNs post implementation; Statistically significant between pre and post ($p<0.05$)

Table 4c.

Groups	Count	Sum	Average	Variance
Pre-Churn Rate	8	0.113383	0.014173	0.000113
Post-Churn Rate	7	0.086498	0.012357	4.43E-05

ANOVA

Source of Variation	SS	df	MS	F	*p*-Value	F crit
Between Groups	1.23E-05	1	1.23E-05	0.151179	0.703705	4.667193
Within Groups	0.001059	13	8.14E-05			
Total	0.001071	14				

SUMMARY: Comparing churn rate pre- and post-implementation of the methodology: Not statistically significant; however, churn rate is lower than pre-implementation rate (1.4% pre; 1.2% post).

Figure 4.
Predicted Staffing Simulation Compared to Actual Staffing/Census
Quarters 3 & 4 2015

Staffing Simulation, Planning, & Analysis Tool

Assessment Report

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Discussion

A predictive staffing simulation methodology is an effective strategy as a means of providing a comprehensive integrated analysis of staffing situations that can assist healthcare leaders in designing staffing plans that proactively predict nursing staffing resources. This model provides the department leaders, finance staff, and human resources staff a systematic structure for collaboration in strategically developing and approving staffing plans. This methodology could be used organization wide in developing staffing plans for all departments, not just nursing. Currently, a comprehensive predictive staffing model and automated tool, as seen in this study, has not been reported in the literature. Models that exist include a narrow framework of factors including hours per patient day and acuity (Fenton, 2015).

The *Staffing Analysis Framework Tool* provided leaders an understanding of how key staffing needs (census, budget, care delivery model) and availability factors (filled positions, turnover, absences, flex staffing) affect the number of RNs per shift available for staffing needs. The automated *Staffing Prediction Simulation/ Planning Analysis Tool* integrates key factors for staffing analysis through simulation technology, providing healthcare leaders a means to drive evidence-based staffing planning decisions efficiently and effectively. The tool gives leaders the ability to populate different assumptions around the key staffing needs and availability factors to understand the impact each of the options analyzed would have on staffing coverage and financial impact.

The *Staffing Analysis Framework Tool* demonstrated the importance that nursing leaders understand how the RN FTE budgeted numbers translate into actual RN staffing numbers per shift (see Figure 5). Leaders must validate the budgeted RN FTEs support the staffing numbers needed according to projected care delivery model and projected census, working with the finance department to establish the baseline RN FTEs needed. Additionally, the process for planning RN FTEs needs to consider the impact staffing availability factors have on the total number of RNs available per shift. The *Staffing Prediction Simulation/ Planning Analysis Tool* demonstrates the importance of a strong partnership between nursing and human resources in establishing strategic timely hiring plans, which incorporate the right mix of full-time, part-time, and flex staff.

Effective and efficient staffing models are dependent on the successful integration with the patient care delivery model, staffing plan, and flexible workforce plan. Once the patient care delivery model has been established, healthcare leaders utilizing staffing analysis tools can develop staffing models that provide consistent staffing coverage that supports the patient care delivery model. To ensure the ultimate effectiveness of the staffing plan, nurse leaders need to establish a flexible workforce-scheduling plan that provides the foundational support for both the patient care delivery model and staffing plan. A governance structure must be in place to ensure nursing at all levels, as well as finance and human resource departments, proactively plan for the effectiveness of the patient care delivery model, staffing plan, and flexible work-

Figure 5.
Formula for Translating FTEs to Available Staff

Step 1
Number of RN FTEs ÷ 0.9 FTE (1 person) = estimated number of RN staff provided by FTEs *Example:* 121 FTE/0.9 = 134 nurses
Step 2
Estimated number of RN staff x 3 (scheduled shifts per week per 0.9 FTEs = 3 shifts per week) = Total shifts covered per week given number of RN FTEs *Example:* 121 FTE/0.9 = 134 nurses x 3 shifts per week = 403 shifts per week
Step 3
Total shifts covered per week ÷ 14 (7 days/week, at 2 shifts/day = 14 shifts/week) = Number of nurses available per shift given number of RN FTEs *Example:* 121 FTE/0.9 = 134 nurses x 3 shifts/week = 403 shifts/week ÷ 14 shifts = 28-29 nurses/shift)

force plan in meeting patient care needs. This governance structure proves most effective when staffing plans are evaluated and revised continuously. The complexity around nurse staffing does not have to influence the level of quality, effectiveness, or efficiency of patient care that is provided within a healthcare organization. Staffing challenges do not have to continue to plague the nursing profession. Though complex, utilizing strategies as seen through this study, and in collaboration with financial and human resource colleagues, effective and efficient staffing models for nursing can be put into place that support an optimal care delivery system for patients. **$**

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