Improving Radiology Productivity by Optimizing Planned Staffing Levels and Supporting Real-Time Adjustments

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Baptist Memorial Health Corporation

Baptist Memorial Healthcare Corporation (BMHCC) is a non-profit network of over 176 healthcare facilities that serve the Mid-South Region. They are headquartered in Memphis, Tennessee. We are working with the Women's Hospital's radiology department in Memphis, TN. The radiology department at Women's performs four different types of procedures, or modalities, and has a dedicated technician type for each one. The four modalities are MRI, CT, Ultrasound, and X-Ray.

Productivity in the Radiology Department

The radiology department is not meeting the productivity goals set by BMHCC. Meeting productivity goals is important since productivity is used to budget for the department. BMHCC calculates productivity by adding fixed and variable labor hours and dividing those by the number of billable procedures the department performs. With this calculation, the department will need to come in under the set productivity targets for each two-week pay period. To help the radiology department improve productivity we have determined to focus on the improvement of their staffing as that was a major area of concern in the department.
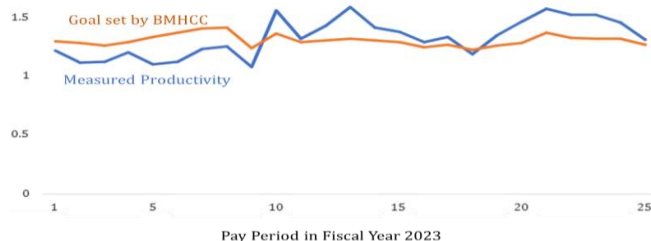

Current Process for Staffing the Radiology Department

The current staffing process for the department is done manually by the managers. They use a baseline staff level that was created long ago from the manager's experience in the department. Due to unknown demand throughout the day from emergency procedures ordered, managers review the staffing levels every four hours throughout the day. This allows them to adjust from the baseline levels to not only better prepare for demand but also to impact the productivity of the department. However, they currently struggle in this area as they are not able to see the current productivity of the department.

Optimizing the Planned Staff Level

To improve productivity, we first wanted to look into the baseline staff level for each type of technician in the department. Our main goal was to see how we could improve this staffing plan to better meet the average demand they saw in 2023.
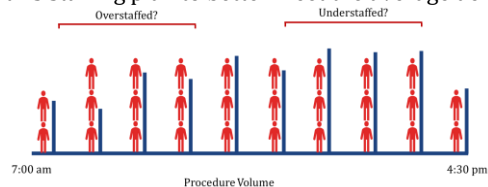
We have created an optimization model to minimize the number of labor hours needed to cover demand and the minimum requirements for a specific type of technician. There are four models total to get the optimal baseline staff level, shift start times, and shift lengths for the technicians. Each model resulted in a new baseline staff level. As a result, we saw a significant increase in the total number of labor hours for the staff plan. We then performed further analysis on the current baseline staff level to find that the current staff plan cannot meet the demand of the department.

Decision Variables:
W_j Number of 8-hour staff starting at shift time j
X_j Number of 9-hour staff starting at shift time j
Y_j Number of 10-hour staff starting at shift time j
Z_j Number of 12-hour staff starting at shift time j

Parameters:
P_i Demand of procedures during 15-min block i
A_{ij} 8-hour Shift Binary Matrix
B_{ij} 9-hour Shift Binary Matrix
C_{ij} 10-hour Shift Binary Matrix
D_{ij} 12-hour Shift Binary Matrix
M_i Minimum labor required during 15-min block i

Objective:
Minimize Labor Hours
$$\sum_{j=0}^{671} 8 * W_j + 9 * X_j + 10 * Y_j + 12 * Z_j$$

Constraints:
Satisfy demand during 15-min block i
$$\sum_{j=0}^{671} W_j * A_{ij} + X_j * B_{ij} + Y_j * C_{ij} + Z_j * D_{ij} \geq P_i \ \forall i$$

Meet minimum labor requirements for 15-min block i
$$\sum_{j=0}^{671} W_j * A_{ij} + X_j * B_{ij} + Y_j * C_{ij} + Z_j * D_{ij} \geq M_i \ \forall i$$

Our new optimal baseline staff level will better equip the department to handle demand compared to their current staff level. This piece of the project will have a positive impact on the radiology department as it will lead to a better staff plan and a lower chance of calling in technicians in overtime pay, managers can see patterns in the number of procedures and times of procedures, and it will reduce workload on managers by better matching to the average demand handled by the department.
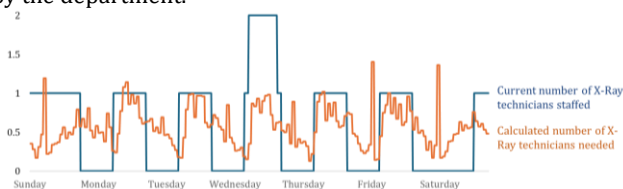
Supporting Staff Level Adjustments

We have created a decision support tool to aid managers in deciding if real-time adjustments to the staff level are needed to meet productivity goals. To do this, we used an alternative definition of productivity to allow for the estimation of productivity (as measured by BMHCC) over the next four hours.
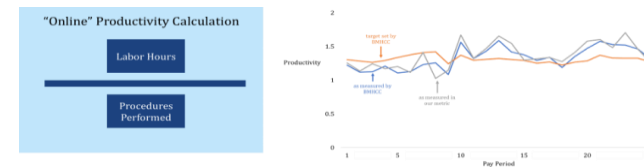
In addition to estimating the productivity of the department, the tool also provides recommended staff changes for each type of technician if the estimated productivity is not meeting the targets set by BMHCC. This gives managers an insight view on how staffing will affect productivity and how they can make proactive changes to staffing to keep their department on track.

	Estimated Productivity	7AM-11AM Recommended Staff Change	Adjusted Productivity
CT	1.317	No Change	1.317
MRI	2.663	-1	1.331
Ultrasound	0.528	No Change	0.528
X-Ray	0.338	No Change	0.338
Comments			

The tool will also create a graph of the estimated productivity for each modality to allow managers to review throughout the day. This graph plots the estimated productivity and the estimated productivity after the recommended staff level changes from the tool are made.

Example Graph for CT