Improving Outpatient Chemotherapy Access and Workload Using Optimization Modeling Approach
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BACKGROUND
The chemotherapy infusion unit is the key operational unit of an outpatient hematology/oncology practice. Safe administration of chemotherapy is crucial, and thus optimally managing workflows is a primary concern. National shortages of chemo trained nurses and the need to minimize overhead costs from treatment chairs both drive the need for efficient use of limited resources. A typical pattern of midday (10am – 2pm) peak volumes has led to insufficient staffing and lack of appointment availability. Moreover, the high treatment duration variability and the required medical attentions for each treatment add to the complexity of appointment scheduling. Our team believed that an optimal scheduling template could potentially address these issues.

OBJECTIVE
Although it was important to determine the number of nurses needed, it was foremost critical to allocate nursing resources where patients’ needs were during the infusion when designing a scheduling template. Therefore, the objective was to minimize the nursing resource constraint violations (unmet patient needs) using constraint-based optimization accounting for staffing and space capacity in a finite clinic hour to determine when a patient should be scheduled so that a more evenly-distributed or smoother patient load throughout a clinic day could be achieved.

PLANNING/RESEARCH METHODS
The scheduling template design used optimization approach to achieve smoothed daily workload; see graph. The steps were:
1. Understand scheduling volume and visit type distribution: Appointment data was used to determine the numbers of each patient type should be dedicated in a scheduling template to meet patient preference and medical needs.
2. Define nursing resource constraints: Three constraints were considered: (i) patient to nurse ratio of 2.5:1 at any time in a day; (ii) patient to nurse ratio of 1:1 for the first and the last 15 minutes of treatment; (iii) patient to nurse ratio of 1:1 during treatment in a 15-minute interval defined by medical necessity and experience.
3. Develop the constraint-based optimization model: The objective was to minimize nursing resource constraint violations with constraints of space, nursing staff, hours of operations, patient type mix, and patient volume.
4. Develop the levelling (smoothing) algorithm: The objective was to finalize template by utilizing minimal chair capacity while accommodating patient volume and needs to alleviate high patient volume during the peak hours.

IMPLEMENTATION METHODS
To ensure smooth transition from current practice, the following tasks were executed:
- Create external and internal communications for both patients and medical staffs to understand the changes on what was changing, why the changes were needed, and what else patients and staff should know.
- Develop override policy allowing schedulers to create appointment slots while maintaining as close as possible to the design of the optimal template to increase the appointment scheduling robustness.
- Develop an appointment tracking system providing a visual on how patients were scheduled in a 10-day span to assist schedulers for patient placement and overbooking medical necessity and inevitable preference.

RESULTS
The work is extending to other Mayo infusion centers. The results for Rochester campus (45 chairs and average 150 visits) are:
- Smoothed number of chemo chairs utilized throughout the day for a more predictable, balanced, and safer workload for nurses consistently around 40 patients throughout a day
- Reduced patient time in a chair by 15% allowing for chair utilization to drop from 75% to 60%
- Increased chemotherapy volume by 6.4% (increased patient access to care)
- Increased chemo-related productivity by 6.7% (20% higher than comparable external benchmark)
- Delayed chemotherapy unit facility expansion at least five years

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