Using Discrete-Event Simulation to Rightsize Prenatal Care

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Introduction

The United States leads in maternal mortality compared to similarly developed countries despite U.S. prenatal care guidelines recommending the greatest number of prenatal visits of comparable nations. This demonstrates that a larger number of prenatal care visits does not necessarily equate to better pregnancy outcomes. Moreover, the United States prenatal care guidelines have not been updated since the 1930s, creating a significant need to reassess the standard of care and how it affects pregnancy.

Preliminary research suggests the outdated guidelines fail to consider that patients fall under a large spectrum of medical/support risk. This project categorized patients strictly by their medical risk, incrementing points toward a "score" for each medical complication. A simulation model employing historical patient arrival rates was used to compare a cohort of patients in a generic group following current prenatal guidelines to a cohort of patients following tailored care pathways based on their medical risk score.

Objectives

1. To understand if developing a novel patient-centered, "right-sized" model for prenatal care has negative outcomes with regards to clinical operations and patient experience.
2. To utilize simulation methods to evaluate the clinic utilization, overbooking, and patient delays associated with tailored care pathways.

Methods

Simulation is an industrial engineering tool that is used to model systems under uncertainty, allowing researchers to evaluate the outcomes of different scenarios. Partnering with OB/GYN physicians at the University of Michigan, we model the prenatal care system based on the University of Michigan system, and use proposed "right-sized" prenatal care pathways for patients of varying medical risk classifications. We also conduct an analysis of a year's worth of patient data to determine accurate patient arrival rates.

We run a discrete-event simulation in C++, with several hundred replications. Using the simulation, we calculate the desired metrics: weekly unused clinic capacity, total yearly delayed appointments, and total number of over-booked appointments.

Results and Discussion

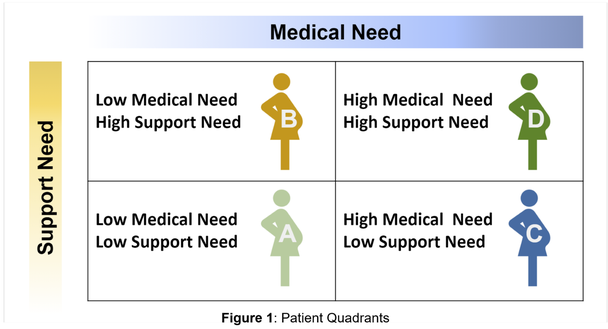

Figure 1: Patient Quadrants

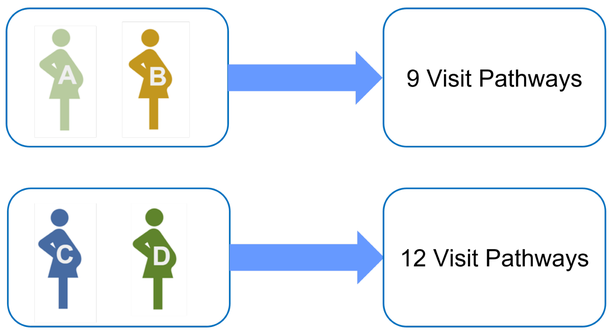

Figure 2: Proposed Prenatal Care Pathways

Table 1: Results for Care Utilization

	Median Yearly Care Utilization by Location and Modality								
	Clinic Location								
Scenario	**Care Modality**	**Canton Health Center**	**VVWH**	**Briarwood**	**East_AA**	**West_AA**	**Brighton**	**Northville**	**Ypsilanti**
Non-Catered Pathways	In person	69%	80%	75%	75%	82%	83%	76%	97%
	Virtual	84%	83%	81%	72%	82%	72%	85%	n/a
Catered Pathways	In Person	66%	78%	73%	72%	81%	81%	74%	97%
	Virtual	81%	80%	78%	69%	78%	68%	83%	n/a

Table 2: Results for Overbooked Appointments

	Median Number of Overbooked Appointments by Patient Type and Modality per Week							
	Patient Type							
Scenario	**Care Modality**	**A - Hybrid**	**B - Hybrid**	**C - Hybrid**	**D - Hybrid**	**A - In Person**	**B - In Person**	**C - In Person**	**D - In Person**
Non-Catered Pathways	In person	31	82	31	82	48	120	48	136
	Virtual	21	55	21	55	0	0	0	0
Catered Pathways	In Person	21	56	29	78	33	83	45	128
	Virtual	15	40	21	55	0	0	0	0

Table 3: Results for Weeks Delayed

	Median Number of Weeks Delayed per Patient Type							
	Patient Type							
Scenario	**A – Hybrid**	**B - Hybrid**	**C - Hybrid**	**D - Hybrid**	**A - In Person**	**B - In Person**	**C - In Person**	**D - In Person**
Non – Catered Pathways	5.95	6.01	6.01	6.04	5.25	5.26	5.25	5.27
Catered Pathways	4.00	4.03	5.55	5.57	3.28	3.28	4.63	4.63

Conclusions

Overall, our simulation shows that catered prenatal care pathways yield similar system performance outcomes as the current standard care model. A common criticism of tailoring pathways to meet patients' needs is that clinic capacity will be underutilized, and patients will experience more delayed appointments in their desired care. Our results show that implementing this tailored model of prenatal care does not have these negative impacts on clinical operations and patient satisfaction.

In the future, we plan to include:

- Dynamically changing patient types
- Prioritization of patient types
- Assessment of pregnancy outcomes
- Patient no-shows or cancellations

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