Resilience and Adaptation: Assessing the Effects of COVID-19 on Hospital Efficiency and Quality

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Those Were Some Turbulent Times

All industries were affected by the COVID-19 pandemic.

Some were permanently altered...

The Widespread Impact Of COVID-19

Education: School closures and the shift to remote learning were widespread, yet there is evidence suggesting that students may have long-term learning challenges.

Supply Chains: The immediate impact was negative, but investment has led to more resilient systems and the adoption of alternative operating procedures.

Tourism: While stifling tourism, many organizations were forced to think about the long-term viability and sustainability of their experiential offerings.

On The Front Lines

Hospital operations underwent many changes on account of "*flattening the curve.*" Some of these changes had lasting effects.

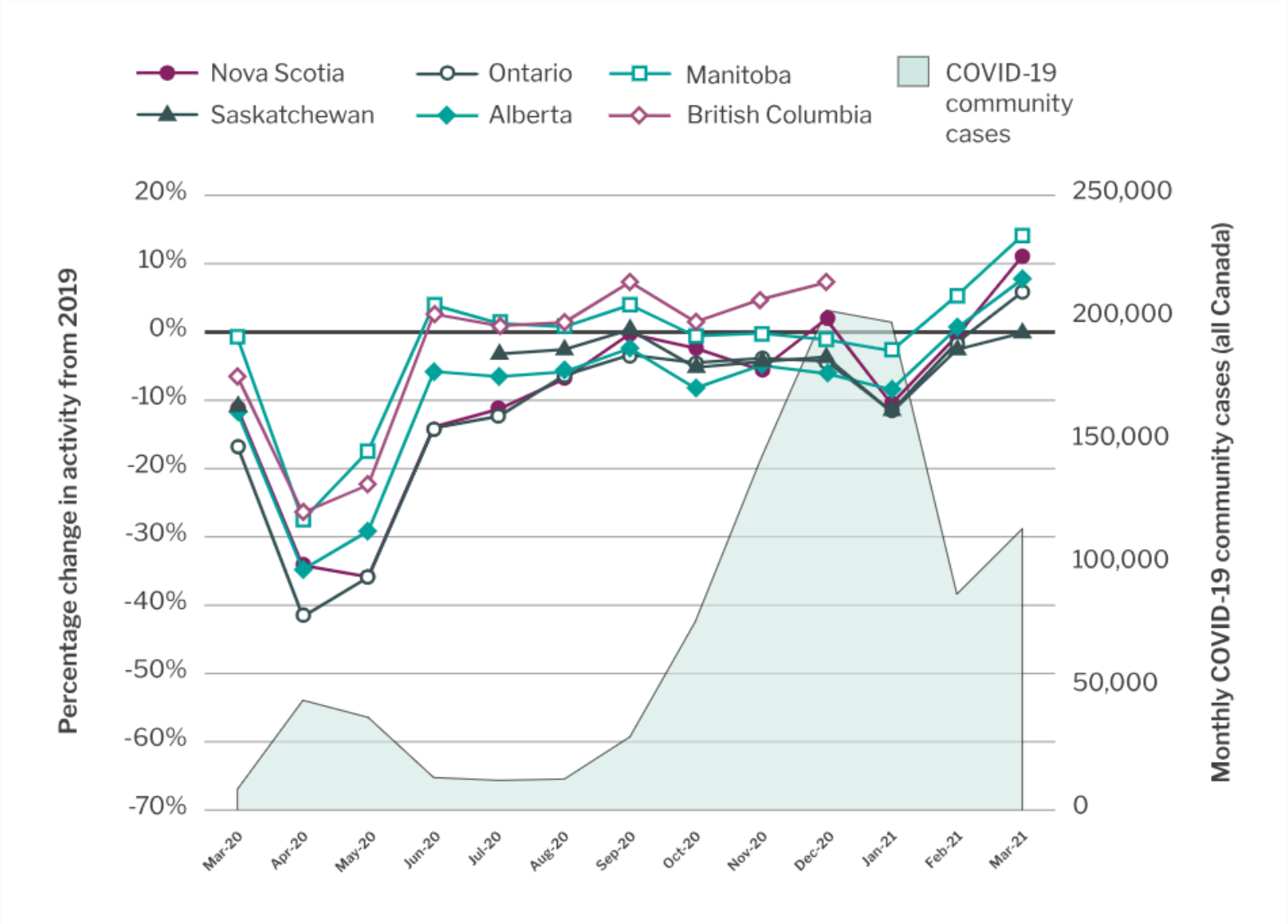
Bearing The Brunt Of The Pandemic

Mental Health: Higher levels of anxiety and loneliness; over 80% of Canadians were negatively impacted.

Backlog of Services: Cataract surgery, MRI, knee and hip replacement, heart bypass, diagnostic exams.

Staffing Shortages: Nurses, doctors, home care and long-term care workers, administrators, managers.

My Extra Mile



Change in physician activity from March 2020 to June 2021.

Some Issues May Be Chronic

Family doctors are working more now then before the pandemic. However, on average, they are seeing fewer patients.

Increased Costs: Ontario spent over $19 billion on COVID-related measures, many of this supported the health system.

The Effect On Hospital Operations

How has the pandemic altered our ability to efficiently and effectively provide care to patients in Ontario Hospitals?

1. What aspects of health care delivery have been affected?
2. Are these changes consistent or are they idiosyncratic?
3. What factor(s) are driving the observed changes?

Challenges:

- There are multiple dimensions of efficiency and effectiveness.
- We wish to evaluate short- and long-term effects.
- Our results should provide a *causal* explanation.

Our Contribution

- To assess different aspects of hospital operations, we use Data Envelope Analysis (DEA) to operationalize performance:

  Technical Efficiency: Throughput (e.g., surgeries).

  Clinical Efficiency: Health outcomes (e.g., mortality rate)

  Patient Experience: Patient quality (e.g., wait times).

- We use two empirical specifications that allow us to causally analyze immediate effects and long-term trends:
  1. Heterogeneous difference-in-differences (DiD).
  2. Interrupted time series (ITS).

Overall Findings

Technical Efficiency

There were no statistically significant changes due to COVID-19.

Clinical Efficiency

There was a statistically significant decrease immediately after the onset of COVID-19, and this decrease has been sustained.

Patient Experience

There were no statistically significant changes due to COVID-19.

Our findings are robust to different empirical models and alternative specifications of the DEA scores.

Talk Overview

Data Set: What Data Was Collected And How Was It Processed?

Data Envelope Analysis: Operationalizing Performance

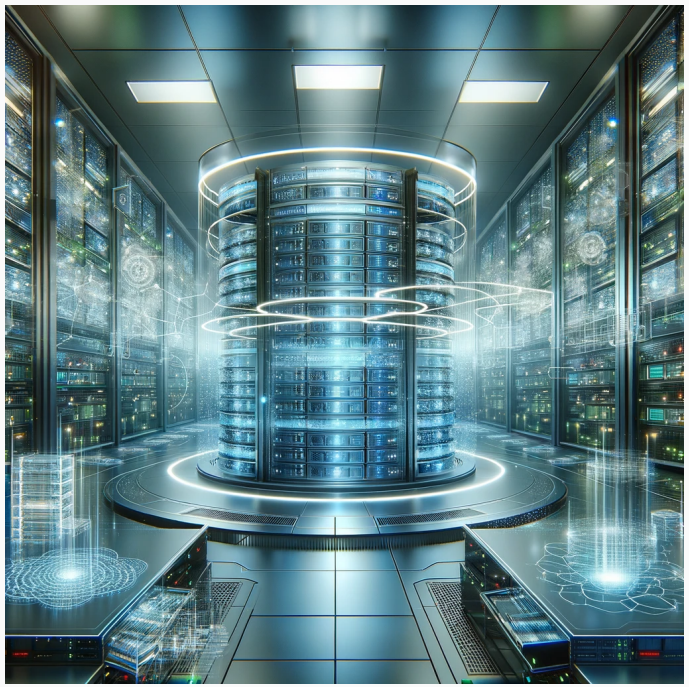
Empirical Analysis: Short- and Long-Term Trends

Underlying Mechanism: Why Do We Think This Is Happening?

Data Set: What Data Was Collected And How Was It Processed?

GEMINI Medicine Database

- GEMINI: Collects, validates, and standardizes administrative and clinical data from Ontario hospitals.
- Fourteen hospitals: 4 teaching and 10 non-teaching.
- We analyzed 288,581 admissions involving 202,308 unique patients between January 1, 2019, and August 31, 2021.



Risk Adjustment And Controls

Unit of analysis: Hospital performance in a given month.

Hospitals Serve Different Patient Populations

We risk-adjusted several dependent variables using patient-level data (e.g., sex, Charlson comorbidity index score, admission category, LAPS score, transfer details, COVID-19 indicator) according to Ontario Health: OurPractice (General Medicine Background and Indicator Details report).

Hospitals Exist In Different Regions

We added controls to the regression models using census-level information (e.g., median income, proportion of post-secondary education, unemployment rate, proportion of visible minorities, proportion of Canadian citizens, proportion of children).

Data Envelope Analysis: Operationalizing Performance

Estimating Hospital Performance Using DEA

Defines a performance frontier based on the best performing hospital, creating a benchmark against which others are evaluated.

- Considers multiple input and output variables.
- Weights of each input and output are endogenous.
- Method is non-parametric and data-driven.

Hospitals on this frontier are assigned a score of 1, signifying optimal performance. Those falling below receive scores ranging between 0 and 1, indicating sub-optimality relative to the frontier.

- DEA scores are obtained by solving a linear program.

Operationaling Different Measures Of Performance

Input Variables: Number of physicians per bed, occupancy levels.

Technical Efficiency

Number of outpatient visits, surgeries, discharges.

Clinical Efficiency

30d-readmission rate, mortality rate, and length-of-hospital-stay.

Patient Experience

Wait times in the ER and for radiography/echocardiograms.

Empirical Analysis: Short- and Long-Term Trends

Short-Term Analysis: DiD Model

We estimate:

$$Y_t = \alpha + \beta_1 \cdot t + \beta_2 \cdot D + \beta_3 \cdot (t \times D) + \boldsymbol{\beta_4} \cdot \boldsymbol{Z} + \beta_5 \cdot R + \epsilon_t$$

where

- t is time (months) and Y_t is a performance metric
- D is a binary indicator that signifies whether a hospital is currently treating COVID-19 patients or not
- $t \times D$ is the interaction term captures the differential effect of the treatment over time
- $\boldsymbol{Z}$ is a vector of census-level controls
- R is a binary indicator that signifies whether a hospital is a teaching or non-teaching institution

Short-Term Analysis: Results

There was no statistically significant effect for technical efficiency or patient experience. However, for clinical efficiency, we get:

Coefficient	Estimate	Std. Error	p-value
Intercept	0.793643	0.028867	$\leq$ 2e-16***
COVID indicator	0.217055	0.056351	0.000134 ***
Month	0.007107	0.003391	0.036645 *
Hospital Type (Teaching)	-0.020421	0.019361	0.292097
COVID indicator:Month	-0.012706	0.003935	0.001332 **

- There was a 1.2% decrease in clinical efficiency post-COVID.
- The effect is not isolated to a specific hospital type.

Long-Term Analysis: ITS Model

We estimate:

$$Y_t = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot D + \beta_3 \cdot \tau + \boldsymbol{\beta_4} \cdot \boldsymbol{Z} + \beta_4 \cdot R + \epsilon_t$$

where

- t is time (months) and Y_t is a performance metric
- D is a binary indicator that signifies whether a hospital is currently treating COVID-19 patients or not
- τ is the time since the first COVID-19 case was treated
- $\boldsymbol{Z}$ is a vector of census-level controls
- R is a binary indicator that signifies whether a hospital is a teaching or non-teaching institution

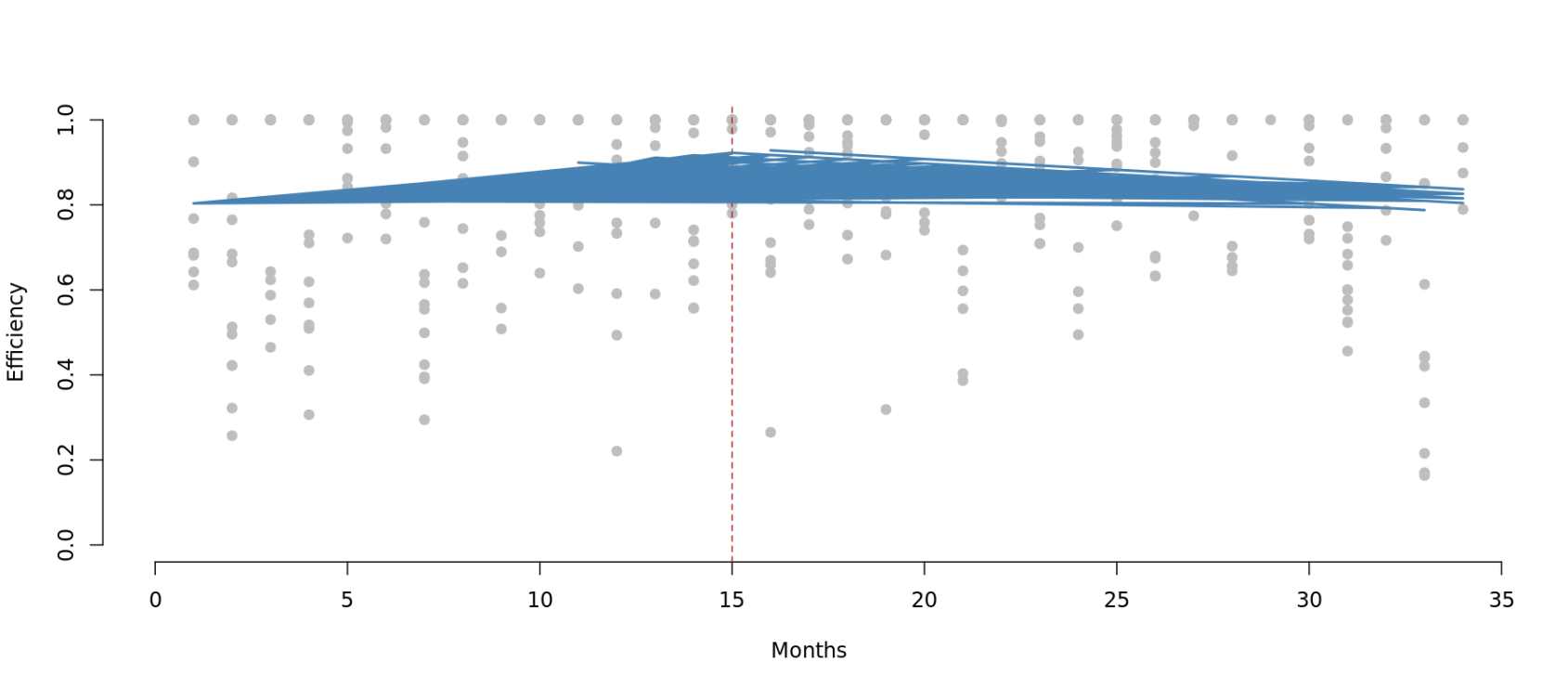
Long-Term Analysis: Results

There was no statistically significant effect for technical efficiency or patient experience. However, for clinical efficiency, we get:

Coefficient	Estimate	Std. Error	p-value
Intercept	0.7964515	0.02837636	$\leq$ 2e-16***
COVID indicator	.0466304	0.03407878	0.1719
Month	0.0066617	0.00329612	0.0439 *
Hospital Type (Teaching)	-0.0187760	0.01937146	0.3329
Post COVID Month	-0.0122292	0.00382398	0.0015 **

- There was a 1.2% decrease in clinical efficiency post-COVID.
- The effect is not isolated to a specific hospital type.

Clinical Efficiency



All hospitals were treating patients with COVID-19 after Month 15.

Robustness Checks

- Used alternative input and output variables for DEA.
- Experimented with different empirical specifications for short- and long-term analysis (Robust DiD, segmented regression).
- Estimated the DiD model using weekly data.
- Calculated output variables by *not* adjusting for case-mix.
- Analyzed different time points for the initiation of treatment (e.g., lagged or delayed response, random times).
- Used a two-stage model to control for endogeneity in the ITS (i.e., certain hospitals may be more prepared for COVID).

Underlying Mechanism: Why Do We Think This Is Happening?

Sicker Patients

- Preliminary work suggests that worse clinical efficiency scores are due to admissions with higher LAPS and Charlson scores.
- It's not yet clear whether medical interventions at the hospital are attenuating or amplifying this effect.