

Supplementary Material

Table S1. Demand and Capacity Assessment (DCA): data collection instrument and variables. PROADI-SUS/Hospital Sírio-Libanês, Brazil, 2018–2023.

Dimension	Variable / indicator	Form of collection
ENTRY - door		
Door	Total of patients treated at the emergency room per year and per day	System / Registration
	Horizontal and vertical patients per day (%)	System / Observation
	Average patient arrival per hour and per day of the week	System
	Care points available and emergency service size	Direct observation
ENTRY - Screening		
Screening	Risk classification system (type and name)	Interview / System
	Distribution of patients by risk level (%)	System
	Average time of care in screening (min)	System / Timing
	Average of nurses in the screening per hour	Direct observation
Passage - Consultation		
Consultation	Door-to-Physician Time (min)	System / Timing
	Average medical care time (min)	System
	Average of doctors in offices per hour	Direct observation
	Daily Patient Visits by Specialty (%)	System
PASSAGE - SADT		
SADT	Average time of examinations: Laboratory, ultrasonography, X-ray and tomography (min)	System / Timing
	Total of patients with each type of examination and corresponding percentage	System
Passage - Overcrowding Indicators (NEDOCS)		
NEDOCS / Indicators	NEDOCS — Measurement at 10:00 a.m. and 04:00 p.m. daily (calculated score)	Direct collection (standardized formula)
	NEDOCS Variables: patients in the emergency department, treatment spaces, admitted patients awaiting an inpatient bed, available operational beds, and patients receiving mechanical ventilation.	Observation / System
	Passing times: LOS without admission, LOS with admission, boarding time (min)	System
Passage - Admission		
Admission	Average Daily Admissions to Ward and ICU Beds Available to the Emergency Department	System
	Average Daily Hospital Admissions to General Inpatient Beds	System
EXIT		

Dimension	Variable / indicator	Form of collection
Exit	Total hospital beds (general, ward and ICU available to the emergency room)	System / Interview
	Average length of stay — ALOS (days): General, ward and ICU	System
	Average of departures per day (discharge, transfer, death) by type of bed	System
	Bed Turnover Rate for Beds Available to the Emergency Department	Calculated
INSTITUTIONAL DATA		
Registration	Registration data: Name, CNPJ, CNES, address, type of hospital, administrative control, clinical reference	Interview / System
	Institutional references: Leaders involved (direction, coordination, NIR)	Interview
	Photographic record of the emergency room facilities	Direct observation

DCA: Demand and Capacity Assessment. HSL: Hospital Sírio-Libanês. LOS: Length of Stay. NEDOCS: National Emergency Department Overcrowding Score. NIR: Internal Regulation Center. SADT: Diagnostic and Therapeutic Support Service. ALOS: Average Length of Stay. ICU: Intensive Care Unit.

Table S2. Standardized implementation roadmap of the Lean in Emergency Departments Project: Activities Conducted During Each Visit Throughout the Intensive Implementation Phase. PROADI-SUS/Hospital S rio-Liban s, Brazil, 2018–2023.

Visit	Day 1	Day 2
	Activities — 1st day	Activities — 2nd day
Visit 1 (Initial DCA)	• Institutional Presentation • Initial DCA Presentation • Gemba — visit at the emergency room • Presentation 5S + Action Plan + Dynamics (Gemba)	• Presentation - indicators • NEDOCS simulation • Board meeting — Stakeholders discussion • Gemba — visits the main hospital premises
	Activities — 1st day	Activities — 2nd day
Visit 2	• Report indicators • Presentation 5S (TIME) • Lean Tool Package: SIPOC, Brainstorming, Ishikawa Diagram, 5 Whys, 5W2H, and the Effort–Impact Matrix, including the associated workshop exercise. • VSM Presentation • Dynamic VSM Vertical + Gemba VSM	• Dynamic VSM vertical and horizontal • Gemba PS • Plan of Action
	Activities — 1st day	Activities — 2nd day
Visit 3	• Report indicators • Report Action Plan • Dynamic Huddle + presentation • Gemba PS • Presentation Flow strategy • Spaghetti diagram — drawing "As is" (vertical and horizontal) • Spaghetti Action Plan	• 1st Huddle with the team • Presentation Management of beds + 4PS from discharge • Kanban bed management + dynamic • Plan of Action
	Activities — 1st day	Activities — 2nd day
Visit 4	• Report indicators • Report Action Plan • Huddle with the team • Discharge Process Mapping and Bed Turnover • Presentation of the Full Capacity Protocol (FCP) and development of triggers, cards, and the communication plan	• Team huddle and Emergency Department gemba walk • Continuation of the development of triggers, cards, and the communication plan
	Activities — 1st day	Activities — 2nd day
Visit 5	• Report indicators • Report Action Plan • Huddle with the team • Continuation of the development of triggers, cards, and the communication plan • Gemba	• Team huddle and Emergency Department gemba walk • NIR Presentation + NIR Evaluation Checklist • Gemba NIR • Plan of Action
Visit 6	Activities — 1st day	Activities — 2nd day

Visit	Day 1	Day 2
	• Report indicators • Report Action Plan • Huddle with the team • Validation of PCP cards • Table Top Presentation + Dynamic • Presentation of the simulation spreadsheet	• Huddle with the team + 1^a PCP activation • Start of PCP actions + Follow-up with the team • Debriefing with the team • Action Plan + PCP adjustments
	Activities — 1st day	Activities — 2nd day
Visit 7	• Report indicators • Report Action Plan • Huddle with the team • Detailed monitoring of high impact/low effort actions • Dynamics of validation of actions (what worked? What didn't work? What could have worked out?) • Gemba PS	• Huddle with the team • Gemba other units • Application and monitoring of the tools already learned • Plan of Action
	Activities — 1st day	Activities — 2nd day
Visit 8	• Report indicators • Report Action Plan • Huddle with the team • Detailed monitoring of high impact/low effort actions • Gemba PS	• Huddle with the team • Demonstration of the template for final presentation • Gemba other units • Application and monitoring of the tools already learned • Plan of Action
	Activities — 1st day	Activities — 2nd day
Visit 9	• Report indicators • Report Action Plan • Huddle with the team • VSM Vertical and Horizontal Patient "TO BE" • Design vertical and horizontal patient spaghetti "TO BE"	• Huddle with the team • Presentation Next steps • Support in the assembly and structuring of the presentation of results
	Activities — 1st day	Activities — 2nd day
Visit 10 (Final DCA)	• Report indicators • Report Action Plan • Validation of the final presentation of results	• Presentation of the final DCA • Presentation Next steps • Closure of the project • Celebration with the team

DCA: Demand and Capacity Assessment. GEMBA: Direct observation in the workplace (from Japanese 'the real place'). NIR: Internal Regulation Center. FCP: Full capacity plan. ER: Emergency room. SIPOC: Suppliers, Inputs, Process, Outputs, Customers. VSM: Value Stream Mapping. 5W2H: What, Why, Where, When, Who, how much. Each visit corresponded to two consecutive days of face-to-face work, lasting approximately 16 hours in total.

Table S3. Operational indicators monitored during the Lean in Emergency Departments Project: Classification, description, metric and reporting frequency. PROADI-SUS/Hospital S rio-Liban s, Brazil, 2018–2023.

Classification	Indicator	Description	Metric	Report
Primary	NEDOCS	International score of hospital overcrowding measurement.	Measurement and record of the absolute value of the score obtained in round at the emergency room at 10h and 16h of the same day.	Daily
Primary	LOS without admission	Time spent by a patient in the Emergency Department (ED) without an indication for hospital admission.	Sum of the time, in minutes, from the patient's arrival at the ED until discharge during a one-month period, divided by the number of patients discharged without an indication for hospital admission during the same period. Start: Patient arrival at the ED. End: Discharge from the ED without a medical indication for hospital admission.	Monthly
Primary	LOS with admission	Time spent by a patient in the Emergency Department (ED) with an indication for hospital admission. Patients with a medical indication for hospital admission for whom an Authorization for Hospital Admission (AIH) was issued.	Sum of the time, in minutes, from the patient's arrival at the ED until actual departure during a one-month period, divided by the number of patients admitted during the same period. Start: Patient arrival at the ED. End: Departure from the ED due to discharge, death, or transfer to a definitive inpatient bed.	Monthly
Secondary	Average Length of Stay (ALOS)	Average time a patient remains hospitalized in the hospital. Represents the efficiency of hospital discharge management, directly influencing the availability of inpatient beds.	Total number of patient-days in the hospital during a one-month period divided by the total number of discharges, external transfers, and deaths during the same period.	Monthly
Secondary	Mortality Rate Within 24 Hours	Number of deaths occurring within the first 24 hours among patients admitted through the Emergency Department (ED), relative to the total number of presentations to the emergency service.	Number of deaths occurring within the first 24 hours ÷ Total number of presentations to the emergency service.	Monthly
Secondary	Days of Full Capacity Protocol Activation	Number of days on which the Full Capacity Protocol (FCP) was activated, regardless of the activation level.	Total number of days during the month on which the Full Capacity Protocol was activated, at any activation level.	Monthly
Secondary	Total Emergency Department Presentations	Total number of patients registered in the Emergency Department (ED) during the reporting period, regardless of outcome.	Total number of patients with a recorded presentation to the Emergency Department during a one-month period.	Monthly
Secondary	Hospital Bed Utilization Factor	Percentage of overutilization or underutilization of operational hospital beds.	Total number of operational beds (Number of hospital admissions	Half-yearly

Classification	Indicator	Description	Metric	Report
			during one month)×(Average Length of Stay (ALOS) during one month)	
Secondary	Left Without Being Seen (LWBS) Rate	Percentage of patients who left the Emergency Department (ED) after registration but before being evaluated by a physician.	(Total number of Emergency Department presentations during the same six-month period)/(Number of patients who left after registration and before physician evaluation during a six-month) period ×100%	Half-yearly

AIH: Authorization of hospital admission. LOS: Length of Stay. NEDOCS: National Emergency Department Overcrowding Score. ED: Emergency Department ALOS: Average Length of Stay The primary indicators (NEDOCS, LOS without admission, and LOS with admission) and Average Length of Stay (ALOS) were the indicators analyzed in this study, as they were collected in a standardized manner and were available across all implementation cycles. The remaining indicators were monitored throughout the project but were not included in the comparative analysis because of limitations in data standardization or availability.

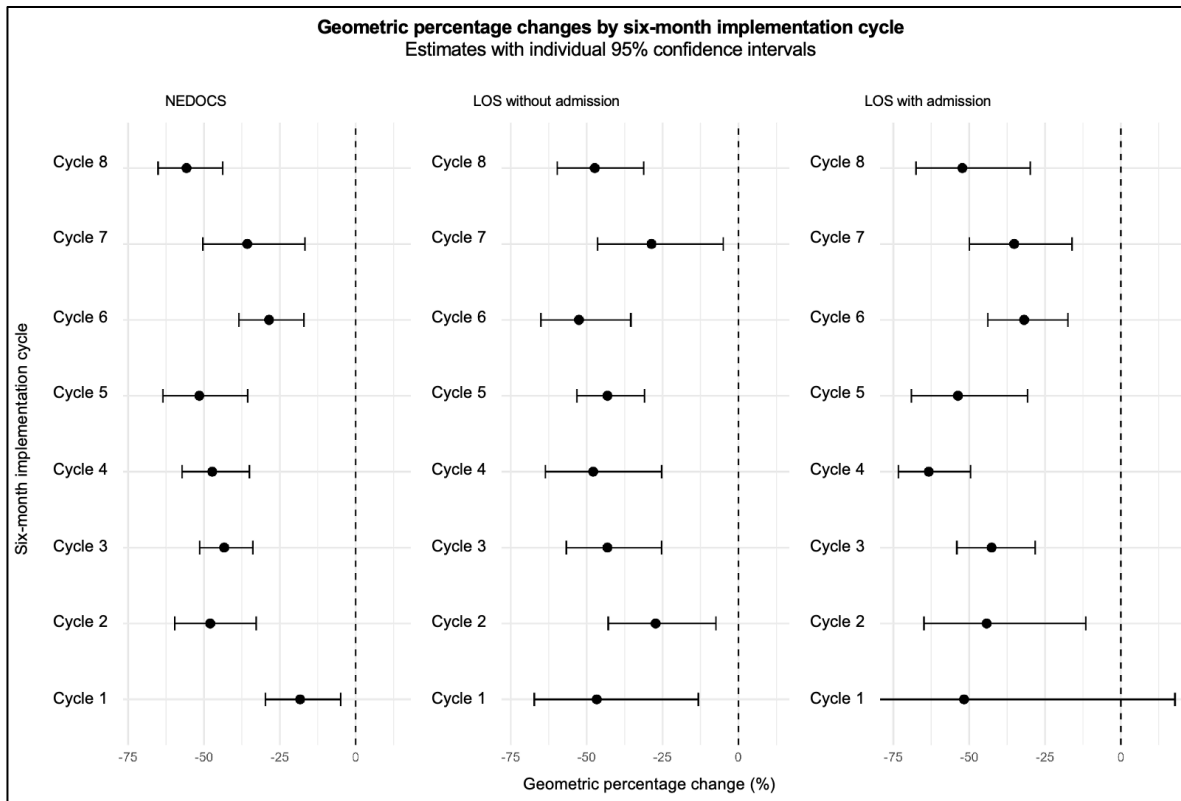
Table S4. Bootstrap sensitivity analysis. Lean in Emergency Departments Project, PROADI-SUS/Hospital Sírío-Libanês, Brazil, 2018–2023.

Indicator	Parametric		Bootstrap		Difference (p.p.)	
	Δ geom% (%)	95%CI (%)	Δ geom% (%)	95%CI (%)	Lower Limit	Upper limit
NEDOCS	-44.1	-48.4 to -39.4	-44.1	-48.4 to -39.5	-0.02	-0.11
LOS without admission	-43.1	-49.1 to -36.5	-43.2	-49.2 to -36.8	-0.05	-0.33
LOS with admission	-49.5	-55.3 to -42.9	-49.5	-55.4 to -43.2	-0.06	-0.32

A bootstrap sensitivity analysis ($B = 10,000$ resamples with replacement) was performed to assess the stability of the confidence intervals for the geometric percentage changes. The close agreement between the parametric and bootstrap confidence intervals, with differences of less than 0.4 percentage points for all indicators, indicates that the interpretation of the primary estimates is not strongly dependent on the parametric approximation.

Geometric % change (Δ geom%): geometric percentage change estimated from the final-to-baseline log ratio. 95% CI: 95% confidence interval. LOS: Length of Stay. NEDOCS: National Emergency Department Overcrowding Score. p.p.: percentage points. The difference between limits was calculated as bootstrap value minus parametric value. Bootstrap performed with $B = 10,000$ resampling with replacement of hospitals ($n = 142$).

Figure S1. Geometric percentage changes by implementation cycle. Lean in Emergency Departments Project, PROADI-SUS/Hospital S rio-Liban s, Brazil, 2018–2023.



95% CI: 95% confidence interval. LOS: Length of Stay. NEDOCS: National Emergency Department Overcrowding Score. The 95% confidence intervals presented are cycle-specific and do not represent adjusted pairwise comparisons between implementation cycles. The global one-way ANOVA identified a statistically significant difference in the magnitude of the reduction across implementation cycles for NEDOCS ($F = 2.43$; $p = 0.022$), with no significant difference for LOS without admission ($F = 0.86$; $p = 0.537$) and LOS with admission ($F = 1.79$; $p = 0.095$).