Beth Israel Lahey Health
Beth Israel Deaconess Medical Center

CLOSED: Closing Loops by Operationalizing Systems Engineering and Design

Talya Salant[1], James Benneyan[2], Nicole Nehls[2], Mark Aronson[3], Scot Sternberg[3], Gordon Schiff[4,5], Russell Phillips[3,5], Maria Rivera, DeeDee O'Brian, Meghan Dreilak
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[4]Center for Patient Safety, Brigham and Women's Hospital, [5]Center for Primary Care, Harvard Medical School

Motivation

- **Diagnostic errors** in primary care are **costly** and often are due to failures to follow up ("close the loop") on diagnostic tests, referrals, and symptoms
  (1) Diagnostic tests and referrals often are not completed
  (2) Tests and referral results often are not communicated to patients and PCPs
  (3) PCPs frequently are not informed when symptoms evolve, altering diagnosis
- Methodical systems approach to closing loops on diagnostic processes will measurably **improve timely completion from approximately 70% to 90%**

Objective

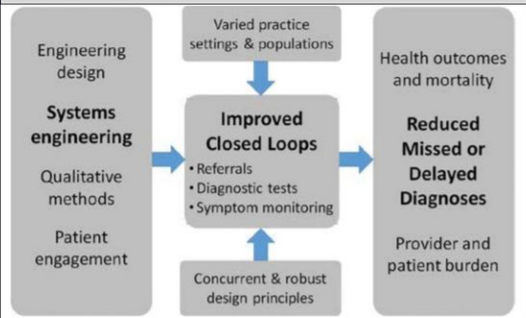
Aim to **reduce diagnostic errors using systems engineering methods** to 1) redesign diagnostic processes (diagnostic testing, specialist referrals, and symptom monitoring) in primary care and 2) develop **highly reliable and generalizable, "closed loop" systems**

2020	2021	2022	2023	2024
Problem Understanding	Solution Design & Testing	Solution Implementation	Impact Evaluation	

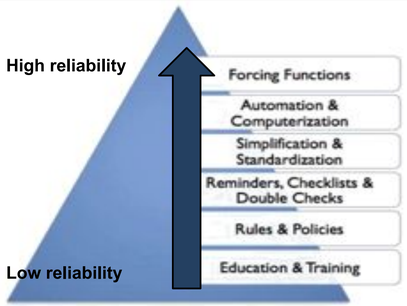
Methods

Problem Understanding	Solution Design & Testing
• Data analysis of loop closure rates, timeliness, and disparities • Statistical process control charts to evaluate stability of process performance • Process mapping using Lean, human factors, and reliability concepts • Failure Modes Effect Analysis (FMEA) and Fault Tree Analysis (FTA) • Chart reviews and patient interviews • Simulation modeling of "loop of loops"	• Structural Analysis Design Technique for design and ideation • Participatory patient-centered design • Quality improvement and health services research approaches • Process improvement and redesign • Pilot testing and prototyping using reliability design science concepts • Simulation modeling to evaluate interventions and impact

Conceptual Framework of Project



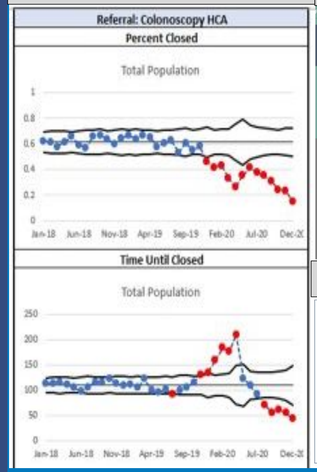
Reliability Science Design Pyramid



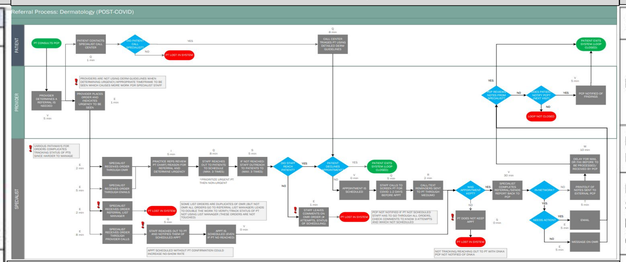
Results

- Loop closure rates and timeliness of loop closure varies significantly based on the department and test site
- Process maps highlighted areas most susceptible to failures and in most need of intervention and extra support
- Failure analyses emphasized the severity and frequency of the failures identified in the process mapping stage
- Structural analysis design technique diagrams and reliability design science concepts helped facilitate process redesign brainstorming and new thinking which resulted informed potential solutions and pilot tests

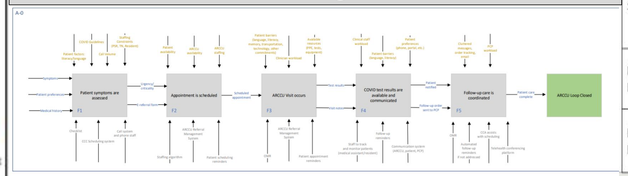
SPC Charts



Process map



SADT Diagram



Rapid cycle pilot testing

Source	Pilot Test	Type	Reliability Level		
Process map	Revised OMR Order Form	Automation/Computerization	High (>4 sigma)	PCP Office	Ordering Process
		Forcing Function	High (>4 sigma)		
		Education/Awareness	Low (1 sigma)		Educating Patient
FMEA FTA	Patient Understanding	Education/Awareness	Low (1 sigma)		
FMEA SADT Modeling Chart review	Real-time Scheduling	Forcing Function	High (>4 sigma)		Scheduling Process
		Opt-out	Moderate (2-3 sigma)		
SADT	Remind and intervene unscheduled	Automation/Computerization	High (>4 sigma)	Specialist Office	
		Time-based Trigger	High (>4 sigma)		
		Reminder	Low (1 sigma)		
Process map FMEA	Rescheduling DNKAs	Double Checks	High (>4 sigma)		Completing Referral
		Checklist	Low (1 sigma)		
FTA RBD	Improve follow-up/recall processes	Automation/Computerization	High (>4 sigma)		Follow-up Process
		Double Checks	High (>4 sigma)		

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Lessons Learned

General	Solution Design & Testing
• Systems engineering approaches have proven to be useful to study complex problems in healthcare and improve and redesign care processes and outcomes • Improvement of loop closure rates in clinical domains that were heavily impacted by COVID will have direct clinical and cost benefits • Incorporated equity as a key dimension of quality within our systems engineering will optimize the generalizability and universality of our proposed systems redesign • Our model of collaboration, which integrates the perspectives of patient advisors, staff, and experts from disciplinary fields both within and outside clinical care prompts us to be more innovative and pragmatic • Our multidisciplinary approach to patient safety and quality may serve as a model for future work in systems redesign	• Need to consider patient diagnostic and care journey through the loop of loops • Need to find right balance of effort vs reward: Is the juice worth the squeeze? • Higher reward with focusing efforts on upstream processes (efficient, timely scheduling and patient education) rather than further downstream (rescheduling after DNKAs) • Important to have primary processes that prevent failures for majority (~80%) of patients and secondary processes to detect failures • Need reliable mechanisms and processes to detect and mitigate for patients with loops not closed • Processes and solutions should put emphasis on patients that providers are actually concerned about (to reduce staff burden and information overload) • Need to generate more "out of the box" ideas that are still practical given constraints and priorities of system • Need to operationalize and align sense of urgency between providers and patients

Publications

Benneyan J, White T, Nehls N, Yap T, Aronson M, Sternberg S, Anderson T, Goyal K, Lindenberg K, Kim H, Cohen M, Phillips R, Schiff G (2020). Systems analysis of a dedicated ambulatory respiratory unit for seeing and ensuring follow-up of patients with COVID-19 symptoms, Journal of Ambulatory Care Management, in publication. ID: NIHMS1714749

Nehls N, Yap T, Salant T, Aronson M, Schiff G, Olbricht S, Reddy S, Sternberg S, Anderson T, Phillips R, Benneyan J (2021), Systems Engineering Analysis of Diagnostic Referral Closed Loop Processes, under review

•Radiology paper under review

What is Systems Engineering?

- Systems engineering is a structured approach and set of methods to methodically analyze, design, and optimize effective processes that perform robustly and with high reliability
- Different and complementary to traditional quality improvement and strongly advocated by the Institute of Medicine, NIH, and others.
- Includes human factors, process and failure analysis, design concept generation, rapid prototyping, process design, reliability engineering, computer modeling, and systems integration methods.
- AHRQ's Patient Safety Learning Labs grants are funded to integrate systems engineering in patient safety initiatives.
- For more information or assistance with systems engineering: www.hsye.org

For more information, contact:

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