Utilisation of Lean Six Sigma Tools to Optimise Patient-Prep, Bed Occupancy, Cost and Throughput in a Busy IR Department


• Our QI project focused on improving patient-preparation (prep) for IR procedures in a tertiary referral inner-city hospital in Dublin, Ireland

• Prep Definition: A prepped patient has no outstanding practical or safety issues that need to be addressed by IR staff prior to commencing the procedure

• July 2019: We carried out a 5-day pilot study and found that 55% (24/44) of patients were not prepped for their procedure on arrival to IR which led to room down-time and cessation of throughput
Lean and Six Sigma are process improvement methodologies that aim to reduce waste and decrease variation in process outcomes and are widely applied in private industry.

There have been several studies that applied Lean-Six Sigma tools to radiology, however, methodological flaws and lack of statistical rigor have prevented robust quantitative assessment of the utility of Lean-Six Sigma in clinical radiology.

- To avoid the reported pitfalls in the Radiology Lean-Six Sigma literature highlighted in the article below, we adapted several recommendations to our study design...
  - We clearly documented our study protocol to reduce the likelihood of selective outcome reporting
  - We measured a diverse set of outcomes
  - We trained staff members in data collection during a pilot study
  - We utilized on-going prospective data collection to assess the sustainability of improvements
  - We used a time-series study design for the throughput analysis. Time-series data sampling is particularly effective at determining whether an intervention has had an effect significantly greater than the underlying trend, providing a greater degree of internal validity compared to an uncontrolled before-and-after study.

Systematic Review of the Application of Lean and Six Sigma Quality Improvement Methodologies in Radiology

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First, we created a process map to examine and dissect our 2019 IR patient-prep pathway.

**IR Patient-Prep Process Map**

**Pre-intervention**

1. The order is discussed, accepted and triaged by IR clinical staff
2. The procedure is scheduled
3. The referring team are verbally informed of patient-prep
4. Inpatients
   - IR staff call the ward the night before the procedure to check patient-prep
5. Outpatient Elective Admissions
   - IR administrative staff phone the patient during scheduling to inform them of procedure date. Patient prep delegated to the referring team
6. The patient arrives to IR on the day of the procedure
7. The procedure is performed
8. The procedure is delayed or cancelled

**Next,**

1. We used a Power-Interest Grid Stakeholder Analysis to help identify influential groups and individuals that were important to project success. Key stakeholders were informed of the project early on and updated as the project progressed.
2. We performed a Critical to Quality Analysis to identify key performance metrics to accurately compare pre and post-intervention process outcomes.
3. We constructed Pareto Charts highlighting common prep issues amongst patients. Pareto Charts are useful tools when identifying areas, teams and individuals to prioritise for intervention.
Interventions commenced January 2020 and are described here on the post-Intervention process map.

**Post-intervention**
(changes highlighted in green)

**Inpatients**
The patient-prep ward round is performed the day prior to the procedure. The ward staff and clinical team are informed of outstanding issues and asked to rectify them prior to procedure.

**Outpatient Elective Admissions**
IR administrative staff informs the patient of the date of procedure AND calls the patient the night before admission to ensure prep using a standardised checklist.

IR clinical staff review the prep status of patients from the ward round and the pre-admission phone call.

Certain non-prepped cases are deferred and slots are given to prepped patients.

The patient arrives to IR on the day of the procedure.
Non-prep and delays are recorded by the radiographer on a standardised data collection template.

IR clinical staff call the ward on the morning of the procedure to ensure that any outstanding prep issues have been dealt with.

The procedure is performed.

The procedure is ready for procedure?

The procedure is delayed or cancelled.
So what effect did these process changes have?

This is a frequency distribution curve illustrating the proportion of non-prepped patients/day on the y-axis vs. month on the x-axis. As you can see, there has been a statistically significant improvement in patient-prep for each month post-intervention.

Pre-intervention patient-prep data sample: August 2019 (132 patients)

Post-intervention patient-prep data sample: Jan-Aug 2020 (1113 patients)
Similarly, this graph illustrates IR room downtime due to non-prep vs. month. Again, there has been a significant decrease in room downtime for each month post-intervention.

Of note, improvements in prep-rates and room downtime were sustained in July and August 2020 during the yearly junior physician changeover as new interns begin work in hospitals. This is an important observation as it provides a like for like comparison with August 2019 baseline data, removing the confounding variable of increasing junior physician experience as the academic year progresses.

**Mann-Whitney Test**
- Aug 2019 vs Jan 2020 p<0.0063**
- Aug 2019 vs Feb 2020 p<0.00453*
- Aug 2019 vs Mar 2020 p<0.0146*
- Aug 2019 vs Apr 2020 p<0.0002***
- Aug 2019 vs May 2020 p<0.0003***
- Aug 2019 vs June 2020 p<0.0017***
- Aug 2019 vs July 2020 p<0.0003***
- Aug 2019 vs Aug 2020 p<0.0005***

Pre-intervention patient-prep data sample: August 2019 (132 patients)

Post-intervention patient-prep data sample: Jan-Aug 2020 (1113 patients)
These improvements have coincided with a significant increase in Peripherally Inserted Central Venous Catheter (PICC) throughput in 2020 relative to data samples from the past 5-years.

Median PICC Throughput:
2015-2019: 113 (2/day) vs 2020: 157 (3/day)
P = 0.0058**
Mann-Whitney test

Pre-intervention data were taken from the 1st 10 weeks for each of the past 5-years (2015-2019) and compared to post-intervention throughput data from the 1st 10 weeks of 2020.

The analysis was limited to 10-weeks as COVID-19 began restricting IR throughput after this period.
Mean total IR throughput has increased significantly by 10% relative to data samples from the past 5 years.

Average Procedure Throughput:
2015-2019 (360/10 weeks) vs 2020 (400/10 weeks)

Mean Procedure Throughput:
2015-2019 (7.2/day) vs 2020 (8/day)
p = 0.0143* 95% CI -1.44,-0.16
Unpaired t-test

Pre-intervention data were taken from the 1st 10 weeks for each of the past 5-years (2015-2019) and compared to post-intervention throughput data from the 1st 10 weeks of 2020.

The analysis was limited to 10-weeks as COVID-19 began restricting IR throughput after this period.
We also identified several protracted hospital stays for elective IR admissions due to non-prep. There were 19.1 days of such bed occupancy in August 2019 which came to a cost of €18,111.

Thankfully, such instances have not occurred to date post-intervention.
Use of Lean Six Sigma methodology in our clinical radiology process was associated with significant waste reduction, decreased variance and a consistent improvement in patient-prep, IR room downtime and inappropriate bed occupancy sustained up to 8-months post-intervention.

Comparison of pre-intervention time-series data samples from the preceding 5 years (2015-2019) to 2020 revealed a 10% increase in IR throughput post-intervention despite consistent staffing levels and capacity.

Data collection is ongoing to assess the long-term sustainability of improvements.

Finally, an IR Process Improvement Committee was established in Jan 2020 to monitor and sustain improvements.

To date the committee has...

- Drafted and distributed an IR patient-prep manual for junior physicians
- Developed and implemented a standardised IR interhospital patient transfer policy
- Completed SOPs for Tech-led prep ward rounds and PICC insertions

In Summary...

- Use of Lean Six Sigma methodology in our clinical radiology process was associated with significant waste reduction, decreased variance and a consistent improvement in patient-prep, IR room downtime and inappropriate bed occupancy sustained up to 8-months post-intervention.
- Comparison of pre-intervention time-series data samples from the preceding 5 years (2015-2019) to 2020 revealed a 10% increase in IR throughput post-intervention despite consistent staffing levels and capacity.
- Data collection is ongoing to assess the long-term sustainability of improvements.