Improving Surgical Instrument Reprocessing at the University of Michigan Health System (UMHS)

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Outline

Background
Problem statement
Improving the instrument reprocessing operation
Optimizing how surgical instrument sets are defined
Questions
Background

Reusable surgical instruments must be reprocessed between cases. Instruments are kept in predefined *instrument sets*.
Frequent problems with instruments reprocessing:
- Unavailable Items/sets
- Improperly cleaned items (bioburden and debris)
- Poorly-functioning items

Problems related to instrument sets
- Redundant items (e.g. differing only by vendor or preference)
- Inefficiently defined sets → including items that are not needed for case
Problem Statement

**Goal:** To have all items required for the proper care of the patient available at the time of surgery, properly cleaned and sterilized, and in working condition – while ensuring the efficient use of resources.

Two aspects to this goal:
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1) High quality reprocessing operation
Problem Statement

**Goal:** To have all items required for the proper care of the patient available at the time of surgery, properly cleaned and sterilized, and in working condition – while ensuring the efficient use of resources.

Two aspects to this goal:

1) High quality reprocessing operation
2) Efficiently defined surgical sets
Two-Fold Approach

Partnered with **Neurosurgery** as a pilot department for change.

1) Investigate the current *instrument reprocessing operation*, identify root causes of problems and implement countermeasures.

2) Analyze how the *instrument set definitions* impact the downstream operation and explore ways to improve this decision.
Improving the Reprocessing Operation

Observations and interviews with staff throughout process
- Instrument techs, perioperative techs, OR nurses and Surgeons
- Neurosurgery, OR and CSPD management

General Observations
- Often communication is poor between OR and CSPD
- Typically, staff understand their part of the process well, but not the whole
- OR staff reported that sets seem to “get lost” in the reprocessing operation
- Often the process for responding to problems is hectic or unclear
Improving the Reprocessing Operation

- **Set washed in CSPD**
  - Quality: <100%
  - Maintenance process

- **Set inspected & assembled**
  - Quality: <100%

- **Set sterilized**
  - Quality: <100%
  - Search & expedite

- **Set stored in OR core**
  - Quality: <100%
  - Set stock-out

- **Set opened in OR**
  - Bioburden or debris

- **Surgery performed**
  - Quality: <100%
  - Items missing or broken
  - Hunt for replacement
  - Flash sterilize

- **Items in wrong trays**
- **Used items not soaked**
Improving the Reprocessing Operation

Opportunity: Bioburden Events and “Hard-to-clean” items
- Involved a relatively small number of items
- Often caused by problematic design features (e.g. small channels or grooves)

Countermeasures
1) Identifying items that are prone to bioburden, documenting reason
2) Creating a standard process for mitigating risk of bioburden events
   - Change in cleaning/sterilization procedure?
   - Alternative that is easier to clean?
   - Disposable or recyclable alternative?
Improving the Reprocessing Operation

Opportunity: Managing Item Nomenclature

- Formal vs. common name
- Currently IT system only includes formal name
- Different departments refer to the same item by different common names

Countermeasures

1) Documenting common names
2) Proposing IT changes to include both formal and common names
3) Creating common name reference materials for CSPD staff
Optimizing How Sets are Defined

Two Primary Questions

1) Are all items in the inventory necessary?
2) What is the optimal way to define sets?
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1) Are all items in the inventory necessary?
2) What is the optimal way to define sets?

• ~3,800 distinct items among 340 Neurosurgery sets for 11 surgeons
• “Functionally Equivalent” items?
  • Differing only byVendor, non-clinical preference?
• Requires much input from Surgeons → major obstacle
• Surgeons largely feel that all items in the sets are required
Optimizing How Sets are Defined

Two Primary Questions

1) Are all items in the inventory necessary?
2) What is the optimal way to define sets?

• Can’t store and process all ~3,800 item types individually → Define sets
• Can’t deliver all 3,800 item types to every surgery
• Trade-off: generalizing sets vs. customizing sets
Optimizing How Sets are Defined

Benefits of generalizing?
• Simplifies inventory management
• Increases consistency (e.g. more easily locating sets or items within sets)
• Saves storage space
• Reduces time OR nurses spend opening sets before cases

Benefits of customizing?
• Avoids needlessly contaminating items → unnecessary workload
• Saves space in the OR
• Reduces time OR nurses spend counting
Optimizing How Sets are Defined

Competing Objectives
- OR administration $\rightarrow$ Minimize cost
- Neurosurgery $\rightarrow$ Minimize delays / Inconveniences
- CSPD $\rightarrow$ Minimize reprocessing workload

Dependencies
- ↓ reprocessing workload $\rightarrow$ ↑ process outcomes and/or ↓ cost
Optimizing How Sets are Defined

Heuristic approaches
- **Basic sets**: items required for a majority of cases
- **Specialty/Supplement sets**: items required less for specific type of cases
- **Provider Specific sets**: items requested by specific surgeons
- **Implant or Vendor sets**: sets created by outside vendor for implant cases

Integer programming approaches
- Clear decision variables and parameters
- Many competing objectives, many difficult to quantify
- No single decision maker
Simple Problem: Decide how to consolidate all items from S current set definitions into T new set definitions, to minimize excess items. (T<\textless S)

\[
\text{Min } \sum_{i\in I} \sum_{s\in S} \sum_{t\in T} c_{is} e_{is} y_{st}
\]

s.t.

(1) \( \sum_{t\in T} y_{st} = 1 \ \forall \ s \in S \)

(2) \( d_{is} y_{st} + e_{is} = x_{it} \ \forall \ i \in I, s \in S, t \in T \)

(3) \( x_{it}, e_{is} \in \mathbb{Z}^+, y_{st} \in (0,1) \)
Optimizing How Sets are Defined

Possible Extensions
- Consider alternative objectives (i.e. min cost, min probability of stock out)
- Incorporate inventory decisions
- Items in current sets vs. items currently used

Limitations
- Item use information difficult to collect
- Problem potentially intractable → consider focusing on 1-2 physicians
- Multiple decision makers with competing interests
- Effect of poor quality in reprocessing operation
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CHEPS and the HEPS Master’s Program

• **CHEPS**: The Center for Healthcare Engineering and Patient Safety

• **HEPS**: Industrial and Operations Engineering (IOE) Master’s Concentration in Healthcare Engineering and Patient Safety offered by CHEPS

• CHEPS and HEPS offer unique multidisciplinary teams from engineering, medicine, public health, nursing, and more collaborating with healthcare professionals to better provide and care for patients

• For more information, contact Amy Cohn at amycohn@umich.edu or visit the CHEPS website at: [https://www.cheps.engin.umich.edu](https://www.cheps.engin.umich.edu)
Questions?
Model Formulation

Consider the problem of how to consolidate $S$ current set definitions into $T$ new set definitions, to minimize excess items. ($T < S$)

Assumptions

- Each current sets must be contained in some new set that replaces it
- There is some cost associated with excess instruments

Sets

$I$: set of all instrument types
$S$: set of all current set definitions
$T$: set of all new set definitions
Model Formulation

Decision Variables

\( x_i t \): the number of items of type \( i \) in new set \( t \) \( \forall \ i \in I, t \in T \)

\( y_s t \): 1 if set \( s \) is “replaced” by new set \( t \), 0 otherwise \( \forall \ s \in S, t \in T \)

\( e_i s t \): excess of item type \( i \) in the set replacing current set \( S \) \( \forall \ s \in S, t \in T \)

\( a_i s t \): an artificial variable (used in constraints) \( \forall \ s \in S, t \in T \)

Parameters

\( d_i s \): the number of items of type \( i \) in current set \( s \) \( \forall \ i \in I, s \in S \)

\( c_i s \): unit cost of excess of item \( i \) relative to set \( s \) \( \forall \ i \in I, s \in S \)

\( M \): sufficiently large number (used in constraints)
Min $\sum_{i \in I} \sum_{s \in S} c_{is} e_{is}$

s.t.

1) $\sum_{t \in T} y_{st} = 1 \ \forall \ s \in S$

2) $d_{is} y_{st} + e_{is} + a_{ist} = x_{it} \ \forall \ i \in I, s \in S, t \in T$

3) $M(1 - y_{st}) \geq a_{ist} \ \forall \ i \in I, s \in S, t \in T$

4) $x_{it}, e_{is}, a_{ist} \in \mathbb{Z}^*$

5) $y_{st} \in (0,1)$