HealthX Call for Innovation (CFI)

Optimising Surgical Instruments for Safer, More Efficient Surgeries

A. Current State

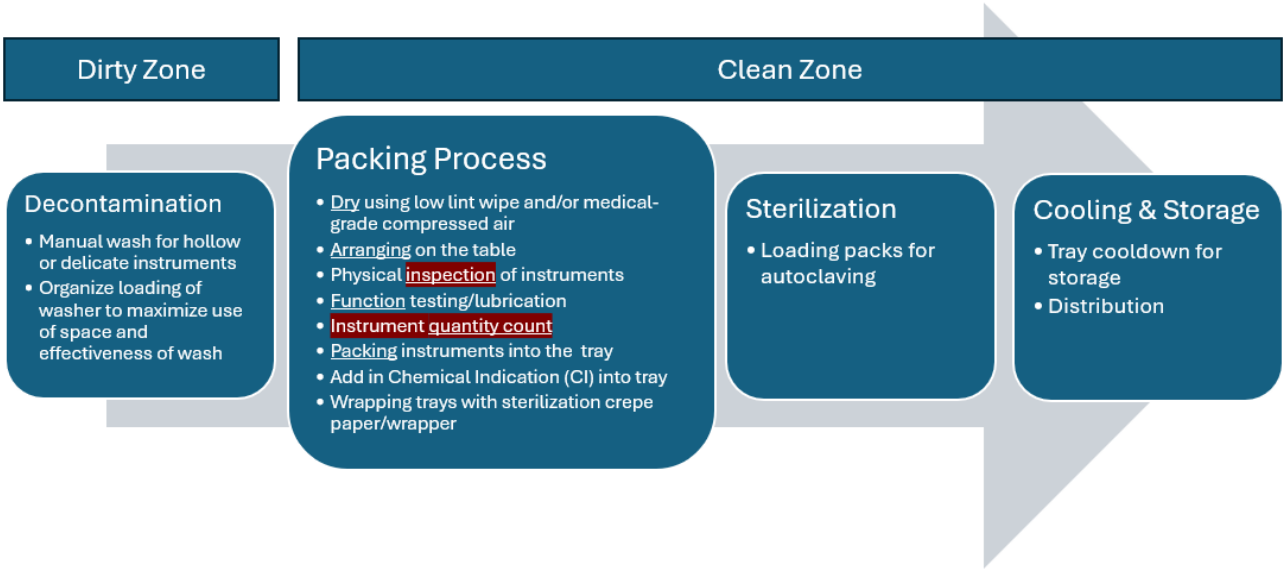
The Central Sterile Supply Department (CSSD) is a critical hospital unit responsible for the reprocessing of reusable surgical instruments. Although surgical instruments undergo automated washing and disinfection cycles, they may appear clean to the naked eye while still harbouring microscopic contaminants that pose a risk to patient safety.

At present, reliance on manual inspection processes – particularly during post-disinfection inspection and final packing stations – introduces significant operational and clinical risks. Relying on human sight to verify hundreds of complex, often similar instruments can result in the following challenges:

a. **Patient Safety Risks:** Undetected instrument damage, contamination, or shortages may compromise patient safety and clinical outcomes.
b. **Operational Inefficiency:** Labour-intensive manual inspection processes prolongs processing times and may contribute to staff fatigue and burnout.
d. **Workflow Disruptions**: Inconsistent instrument readiness can delay surgeries procedures and forces schedule reshuffles.
e. **Limited Data Visibility:** Poor data capture hinders the ability to perform preventative maintenance, hiking inventory and reprocessing costs.
f. **Compliance and Traceability Gaps**: Error-prone manual tracking hinders regulatory auditability, weakens instrument lifecycle traceability and increases compliance risks.

To address these challenges, Woodlands Hospital (WH) is seeking integrated AI-driven solutions that can enhance quality assurance, improve instrument traceability, and increase operational efficiency within the CSSD workflow.

Outlined below is the strict CSSD workflow for the handling of contaminated surgical instruments upon receipt. The two highlighted process steps represent the key focus areas of this Call for Innovation.



Challenge Statement

How might we use AI to track surgical instruments in real time so that hospitals can improve patient safety and operational efficiency?

B. What we are looking for (To-be State)

The proposed solution(s) should deliver **three core capabilities** that collectively enhance accuracy, efficiency, and quality assurance within CSSD operations.

1. **Instrument Identification & Counting**

   The solution should accurately identify and count surgical instruments across different shapes, sizes, and manufacturers, with a target accuracy of at least 95%.

   i) **Scaling Differences:** The solution must intelligently account for variations in dimensions and design by focusing on proportional characteristics rather than fixed measurements. Examples:
      (1) A "medium" haemostat from different vendors may range from 125-135mm in length.
      (2) Surgical scissors labelled as "5-inch" may actually measure between 4.8-5.2 inches.
      (3) Forceps designated as "standard" may have jaw widths varying by 2-3mm.

   ii) **Multi-Vendor Compatibility:** The solution should support multi-vendor compatibility through adaptive learning, enabling seamless onboarding of new instrument types. Examples:
      (1) Clamps: Ratchet mechanisms may have different tooth patterns, jaw shapes, or locking mechanisms while maintaining the same clinical purpose.
      (2) Forceps: Vendor A may produce forceps with straight tips, while Vendor B's equivalent has slightly curved tips, yet both serve the same surgical function.

   iii) **Discrepancy & Lifecycle Alerts:** Real-time discrepancy detection and lifecycle tracking should also be incorporated to flag incomplete sets, detect abnormalities, and support predictive maintenance insights. Examples:
      (1) Maintenance History: Some instruments may have been refurbished, re-sharpened, or had components replaced.
      (2) Usage-Related Changes: Frequently used instruments may have worn markings, smoothed textures, or slightly altered profiles.

2. **Post-Disinfection Quality Check**

   i) **Advanced Contamination Detection:** The solution should enable advanced contamination detection using multi-spectral imaging to identify microscopic residues (e.g. blood, protein, residual organic matter) that are not visible to the human eye. This includes detecting contamination in complex instrument structures such as joints and lumens. Examples:
      (1) Infrared Imaging: Detects organic protein residues.
      (2) UV Fluorescence: Spots hidden blood components.
      (3) High-Resolution Visible Light: Identifies physical scratches and surface flaws.
      (4) Polarised Light: Catches oily film and chemical residues.

   ii) **Surface Discolouration Indicators**: The solution should scan for visual flaws that reveal hidden damage, including:
      (1) Corrosion: Early rust or oxidation spots that weaken the tool.
      (2) Chemical Stains: Disinfectant marks that can hurt tool performance.
      (3) Heat Damage: Burn marks or colour changes from high steriliser heat.
      (4) Water Spots: Mineral deposits from hard water that can trap bacteria.

   iii) **Mechanical & Structural Defects**: The solution should identify physical damage that compromises tool safety, such as:
      (1) Chipped Edges: Damage on cutting or grasping parts (like scissors or forceps).
      (2) Cracks: Hairline fractures in tool bodies, joints, or handles.
      (3) Misalignment: Bent components or hinges that cause improper closure.
      (4) Blunt Edges: Worn-out or dull cutting surfaces that affect precision.
      (5) Loose Joints: Unstable or degraded joints and ratchet mechanisms.

(6) Surface Pitting: Tiny holes or worn material that weaken the tool's strength.

iv) **Functional Degradation Indicators**: The solution should detect signs of wear from repeated use, including:

(1) Deformation: Tools bent out of shape from mechanical stress or bad handling.
(2) Excessive Wear: General degradation that goes beyond acceptable limits.

v) **Automated Quality Assurance:** The solution should standardise pass/fail decisions across all shifts to eliminate subjective human variability. Items that fail predefined quality thresholds should be automatically flagged and rerouted for reprocessing as appropriate.

vi) **Audit Readiness:** The solution should generate automated compliance documentation on cleaning effectiveness, while using predictive analytics to identify instruments requiring preventive maintenance.

3. Final Packing Quality Check

i) **Pre-Sterilisation Verification:** The solution should perform image-based verification against reference databases to ensure instrument set completeness and identify any remaining structural defects before sterilisation. This includes verification of Chemical Indicators (CI) at packing.

ii) **Infrastructure Integration:** The solution should integrate seamlessly with existing CSSD systems (e.g. SSETs, T-Doc) to enable real-time workflow visibility and tracking.

iii) **Traceability & Compliance:** The solution should maintain end-to-end digital traceability to support regulatory compliance, enable precise batch tracking, and efficient recall management when required.

C. Use Cases

To enhance both safety and operational efficiency, the solution should be deployed at two critical points: immediately after the cleaning process and just before final packaging. Serving as a digital quality assurance layer, the solution helps identify defects, contamination, or process deviations that may not be readily detectable through manual inspection alone. The following use cases outline how the solution should respond to various scenarios encountered during routine operations:

Post-Disinfection Quality Check Use Cases

1) **Use Case 1: Bloodstain Detection.** After the automated washing cycle, a haemostat from a trauma surgery appears clean to the naked eye but retains microscopic blood residue in the ratchet mechanism. The solution should detect this discolouration and flags the instrument for re-cleaning, preventing a potentially contaminated instrument from reaching the sterile field.
2) **Use Case 2: Corrosion Identification.** During post-disinfection inspection, a surgical instrument (e.g. a pair of scissors) exhibits early signs of corrosion that may compromise sterility or performance. The solution should identify these subtle surface defects and flag the instrument for maintenance assessment, preventing damaged instruments from proceeding to sterilisation and clinical use.

Final Packing Quality Check Use Cases

3) **Use Case 3: Instrument Verification Against Database.** During final packing of a "Medium Set" for orthopaedic surgery, the solution should verify each instrument against the reference image database to ensure the correct bone rongeur model and all required instruments is included and meets the required specifications for the scheduled procedure. Any incorrect, missing, or additional instrument within the set is identified and flagged as well.

4) **Use Case 4: Damage Detection Before Sterilisation.** A surgical instrument (e.g. retractor) developed a hairline crack in its handle during use. The solution should identify this defect before the instrument is sterilised and packaged, enabling timely intervention by preventing potential unsafe instruments from being used during surgery.
5) **Use Case 5: Multiple Instrument Detection Before Sterilisation.** The solution should be able to handle accurate detection across the multiple instruments placed within each of the following sets:
    a. Small Sets
    b. Medium Sets
    c. Large Sets
    d. Complex Sets

These use cases demonstrate how the solution addresses the core problems of manual inspection errors, workflow disruptions, and safety risks while providing the real-time visibility and traceability needed for modern surgical operations.

Applicants submitting a proposal for this challenge should demonstrate a solution that meets all, or the majority, of the requirements outlined in the use cases above. Where certain requirements are not currently supported, applicants should be willing and open to exploring the development and enhancement of their solution to address the requirements specified in the use case descriptions.

D. Expected Outcomes and Benefits

1. **Patient Safety Enhancement:**
    - Elimination of contaminated or damaged instruments reaching patients
    - Improved infection control through consistent quality standards
    - Dramatic reduction in surgical delays due to instrument issues
    - Enhanced surgical outcomes through reliable instrument availability
2. **Operational Efficiency Gains:**
    - Reduction in manual inspection time
    - Faster instrument turnaround between surgeries
    - Reduced staff overtime and burnout
    - Optimised inventory levels through predictive analytics
3. **Financial Impact:**
    - Reduced instrument replacement costs through better maintenance
    - Decreased surgical cancellations and delays
    - Lower staff costs through automation
    - Improved asset utilisation and planning
4. **Data-Driven Decision Making:**
    - Analytics on instrument usage patterns and lifecycle
    - Predictive maintenance scheduling
    - Evidence-based procurement decisions
    - Performance benchmarking across hospital departments

This comprehensive "To-be State" transforms surgical instrument management from a reactive, manual process into a proactive, intelligent solution that enhances patient safety, operational efficiency, and staff satisfaction while providing the data insights needed for continuous improvement.

E. Key Considerations

1. **Technical Feasibility** - Demonstrate ability to identify, count, and inspect surgical instruments.
2. **Healthcare Relevance** - Prior experience or proven use cases in healthcare settings, especially surgical or CSSD workflows.
3. **Scalability & Integration** - Seamlessly integrate with existing hospital systems and CSSD workflows, enabling real-time data exchange, compatibility with current hardware and software infrastructure, and scalable deployment across multi-site healthcare networks.
4. **User Experience Design** - Deliver an intuitive, mobile-accessible and role-based user experience with customisable dashboards, real-time updates, and automated reporting to minimise training needs and support management and compliance requirements.
5. **Data Privacy & Security** - Measures to ensure compliance with healthcare privacy standards, especially in sensitive areas.
6. **Cost Effectiveness** - Value for money and sustainability of solution beyond POC.