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Integrated Key Performance Indicators (Kpis) For Infection Control Compliance: From Medical Laboratories To Family Medicine Clinics

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Abstract
Healthcare-associated infections (HAIs) remain a major threat to patient and healthcare worker safety across all levels of care, from specialized medical laboratories to community-based family medicine clinics. Structured infection prevention and control (IPC) programs, supported by robust monitoring and feedback, are central to reducing preventable infections and antimicrobial resistance (AMR) (World Health Organization [WHO], 2016; Habboush et al., 2024).Key performance indicators (KPIs) provide a quantitative means to assess IPC compliance, identify gaps, and drive continuous quality improvement. However, KPIs are often designed and monitored separately in different sectors of the same health system, leading to fragmented oversight and missed opportunities for integrated improvement.

This paper proposes an integrated framework of IPC KPIs that spans medical laboratories and family medicine clinics, aligned with WHO core components and Centers for Disease Control and Prevention (CDC) core practices (CDC, 2024; WHO, 2016).It categorizes indicators into input, process, outcome, and balancing KPIs, and details core cross-cutting metrics—such as hand hygiene, personal protective equipment (PPE) use, environmental cleaning, staff vaccination coverage, and training completion—alongside setting-specific measures for laboratories (e.g., biosafety cabinet use, sharps injuries, laboratory-acquired infections) and family medicine clinics (e.g., injection safety, instrument reprocessing, triage and respiratory hygiene).

Conceptual tables, figures, and graphs illustrate indicator definitions, calculation formulas, and integrated dashboard layouts for routine monitoring. The paper concludes with practical recommendations for implementation, including governance structures, data feedback loops, and use of run charts and control charts to guide Plan–Do–Study–Act (PDSA) cycles. By adopting integrated KPIs across laboratories and family medicine clinics, health systems can strengthen IPC programs, standardize expectations, and better protect patients, families, and healthcare workers in both hospital and community settings.

1. Introduction

Infection prevention and control is defined as the set of evidence-based practices, policies, and procedures designed to prevent and minimize the spread of infections in healthcare settings (Habboush et al., 2023).Globally, HAIs affect millions of patients each year, increase morbidity and mortality, prolong hospital stay, and contribute substantially to antimicrobial resistance and healthcare costs (WHO, 2016, 2025). While much of the literature focuses on hospitals and intensive care units, IPC risks and responsibilities also extend to medical laboratories and primary care or family medicine facilities, which represent critical nodes in the patient journey.

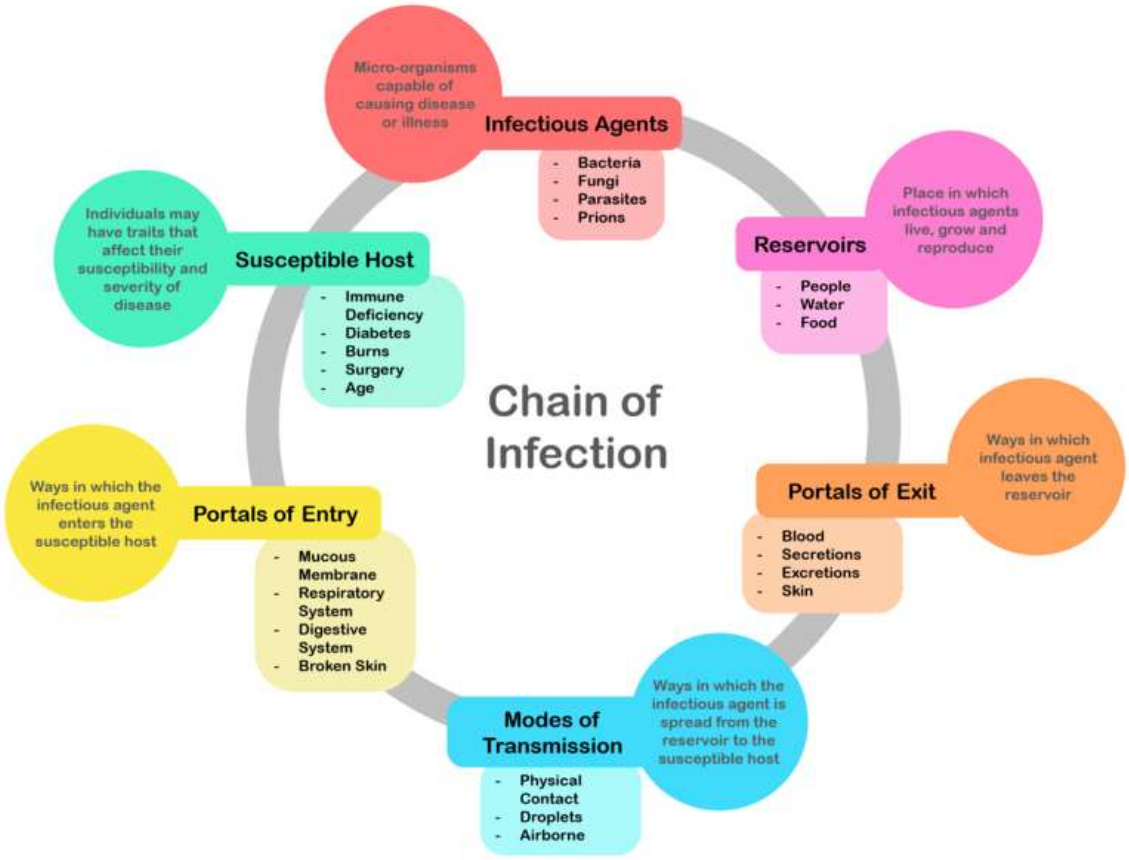

Figure 1: Chain of Infection

Medical laboratories handle potential infectious specimens, operate specialized equipment, and rely on biosafety practices to protect staff and prevent environmental contamination. Failures in laboratory infection control can lead to laboratory-acquired infections, sharps injuries, and unsafe waste management, with downstream effects on staff and the wider community (Ministry of Health, Saudi Arabia, 2021; National Centre for Disease Control, India, 2020).

Family medicine clinics—including general practices, community health centers, and walk-in clinics—are often the first point of contact for patients, including those with respiratory infections, diarrheal illnesses, and emerging diseases (WHO, 2021; European Centre for Disease Prevention and Control [ECDC], 2020). Inadequate hand hygiene, improper instrument reprocessing, poor respiratory hygiene, and crowded waiting rooms can contribute to transmission in these settings.

WHO's guidelines on the core components of IPC emphasize that effective programs must include structured monitoring and audit of IPC practices with regular feedback (core component 6) and surveillance of HAIs and AMR (core component 4) (WHO, 2016).Similarly, the CDC describes a concise set of core IPC practices, applicable across the continuum of care and reinforced through performance monitoring (CDC, 2024).These global frameworks provide a strong rationale for designing KPIs that are:

- **Standardized yet adaptable** for different care levels;
- **Aligned** with evidence-based guidelines (WHO, CDC, national standards);

- **Actionable**, meaning they directly inform quality improvement efforts.

In many health systems, however, laboratories and primary care are monitored using separate tools, dashboards, or audits. For example, laboratory guidelines often focus on biosafety cabinets, specimen handling, and staff exposures (Ministry of Health, Saudi Arabia, 2021), while primary care toolkits emphasize triage, environmental cleaning, and patient flow (Public Health Ontario, 2022; WHO, 2021).This siloed approach can obscure system-wide patterns and make it harder to prioritize cross-cutting interventions such as hand hygiene or vaccination.

Purpose of this paper
This paper aims to:

1. Present a conceptual framework for integrated IPC KPIs applicable across medical laboratories and family medicine clinics.
2. Define key cross-cutting and setting-specific KPIs with clear numerators, denominators, data sources, and suggested targets.
3. Illustrate (through sample tables, figures, and graphs) how these KPIs can be visualized in dashboards and reports to guide local and system-level decision-making.
4. Provide practical recommendations for implementing integrated IPC KPI systems that align with WHO and CDC guidance and support continuous quality improvement.

Table 1. Levels of care and key IPC risk domains relevant to integrated KPIs

Setting	Typical activities	Key IPC risk domains	Examples of relevant KPIs
Medical laboratories	Specimen reception, analysis, storage, waste handling	Biosafety, sharps safety, spills, decontamination	Biosafety cabinet use, sharps injuries, LAIs
Family medicine clinics	Consultations, minor procedures, vaccinations	Hand hygiene, injection safety, reprocessing, crowding	Hand hygiene, safe injections, instrument processing
Shared across both	Staff training, vaccination, environmental cleaning	Basic IPC, PPE, waste management, AMR stewardship	Training completion, PPE compliance, cleaning scores

(Constructed from WHO IPC core components and primary care toolkits, and national laboratory guidance.)

2. Body

2.1. Conceptual Framework for IPC KPIs

2.1.1 Types of Indicators
Quality and safety measurement frameworks often classify indicators into input, process, outcome, and balancing measures (Deryabina et al., 2023; WHO, 2016). Applied to infection control in laboratories and clinics:

- **Input KPIs** reflect resources and structures needed for IPC (e.g., availability of alcohol-based hand rub at points of care; proportion of staff vaccinated against influenza).

- **Process KPIs** measure whether recommended practices are being performed (e.g., hand hygiene compliance, correct donning/doffing of PPE, adherence to reprocessing protocols).
- **Outcome KPIs** capture the results of care, such as HAI rates, laboratory-acquired infection incidents, or occupational sharps injuries.
- **Balancing KPIs** ensure that IPC interventions do not create unintended harm, such as severe skin irritation from hand rubs or excessive delays in patient flow due to complex screening processes.

In WHO's core component 6, monitoring and audit are specifically highlighted as a pillar, coupled with feedback to healthcare workers and leadership to drive change (WHO, 2016).Similarly, national IPC guidance in several countries requires health facilities to define measurable indicators and report them to oversight bodies (National Health Service England, 2022; Ministry of Health, Saudi Arabia, 2021).

2.1.2 Domains for Integrated IPC KPIs

An integrated IPC KPI framework for laboratories and family medicine clinics can be organized into the following domains:

1. **Core standard precautions** – hand hygiene, PPE, sharps safety, respiratory hygiene, safe injection.
2. **Environmental and engineering controls** – cleaning, ventilation, zoning, biosafety cabinets.
3. **Occupational health and safety** – staff immunization, exposures, injuries, laboratory-acquired infections.
4. **Decontamination and waste management** – instrument reprocessing, disinfection, waste segregation.
5. **Surveillance and outcomes** – HAI proxies in ambulatory care, positive cultures indicating contamination, AMR trends.
6. **Education, training, and culture** – completion of IPC training, safety climate, IPC audits and feedback.

Table 2. Example of mapping of IPC domains to indicator types

Domain	Input indicator example	Process indicator example	Outcome indicator example
Core standard precautions	% of clinical areas stocked with ABHR*	Hand hygiene compliance rate	HAI incidence (per 1,000 visits or patient-days)
Environmental/engineering	% of lab benches with access to BSC where needed	% of high-risk procedures performed inside BSC	# of contamination events/spills per 1,000 specimens
Occupational health & safety	Staff vaccination coverage (influenza, HBV)	Compliance with sharps disposal protocol	Sharps injuries per 10 FTE per year
Decontamination & waste	Availability of sterilizers and color-coded bins	% reprocessed instruments passing indicator tests	Laboratory-acquired infections, needlestick-transmitted infections

Surveillance & outcomes	Functioning surveillance system in place	Timely reporting of notifiable infections	Trend in AMR rates over time
Education & culture	IPC focal person and committee appointed	% staff completing annual IPC training	Staff IPC knowledge scores, safety climate survey results

*ABHR = alcohol-based hand rub.

2.2. Cross-Cutting IPC KPIs for Laboratories and Family Medicine Clinics

Several KPIs are fundamental to good infection control regardless of care setting. These can be defined once and applied consistently in both laboratories and family medicine clinics, enabling meaningful comparisons and a shared safety culture (WHO, 2016; CDC, 2024).

Figure 2: IPC and WASH-related intervention

2.2.1 Hand Hygiene Compliance

Hand hygiene is widely recognized as the single most important measure to prevent HAIs and cross-transmission (ECDC, 2015; WHO, 2009; CDC, 2002). KPIs typically focus on compliance with the WHO "Five Moments for Hand Hygiene" or setting-appropriate adaptations.

Hand hygiene compliance (%) = (Number of observed correct hand hygiene actions\ Total observed opportunities) x 100

Opportunities in laboratories may include before and after specimen handling, after removing gloves, and after contact with contaminated surfaces; in family medicine clinics, they include before touching a patient, before aseptic procedures, after body fluid exposure, after patient contact, and after contact with patient surroundings (WHO, 2009).

2.2.2 PPE Compliance

Correct use of PPE (e.g., gloves, gowns, masks/respirators, eye protection) reduces exposure to blood, body fluids, and respiratory pathogens. CDC's core practices emphasize risk-based PPE selection, appropriate donning and doffing, and consistent adherence (CDC, 2024).
PPE compliance (%) = (Number of observed procedures with correct PPE use/ Number of procedures observed where PPE was indicated) x100

This KPI is particularly relevant for:

- Laboratory staff handling high-risk specimens or performing aerosol-generating procedures.
- Clinic staff performing procedures (e.g., injections, wound care), or caring for patients with suspected respiratory infections.

2.2.3 Environmental Cleaning and Disinfection

High-touch surfaces in laboratories (benches, centrifuge controls) and clinics (exam couches, door handles, waiting room chairs) can serve as vectors for pathogens. WHO and several national guidelines recommend standardized cleaning protocols, use of appropriate disinfectants, and routine auditing (WHO, 2016; Ministry of Health, Saudi Arabia, 2021).

Example process KPI:

- Environmental cleaning audit score (%) = number of items/areas passing a standardized checklist divided by the total number evaluated, multiplied by 100.

Table 3. Sample environmental cleaning audit checklist items

Area	Item	Standard (pass criteria)
Laboratory bench	Surface decontamination	Cleaned between specimens and after spills with approved agent
Centrifuge	Internal bowl cleaning	Wiped daily and after spills according to SOP
Clinic exam room	Couch surface and pillow	Disinfected between patients; cover changed if soiled
Waiting area	Armrests and door handles	Disinfected at least twice per shift

(Audit tools adapted from WHO IPC resources and national auditing guides.)

2.2.4 Staff Vaccination Coverage

Occupational immunization (e.g., hepatitis B, influenza, COVID-19) is a key component of IPC and worker safety. WHO and various national guidelines recommend risk-based vaccination strategies for healthcare workers (WHO, 2016; National Health Service England, 2022).
Vaccination coverage (%) = (Number of staff with documented complete vaccination/ Total Number of staff eligible) x 100

Vaccination KPIs can be stratified by staff category (e.g., laboratory technicians, family physicians, nurses, cleaning staff) and by vaccine type.

2.2.5 Education, Training, and Competency

Sustained IPC compliance requires regular training and competency assessment. WHO and StatPearls emphasize education as a central pillar of IPC programs (Habboush et al., 2023; WHO, 2016).

Process KPIs include:

- Percentage of staff who have completed IPC training in the last 12 months.
- Percentage of relevant staff who passed competency assessments for high-risk tasks (e.g., endoscope reprocessing, biosafety cabinet use).

2.3. Laboratory-Specific IPC KPIs

Medical laboratories have distinctive risks related to specimen handling, biosafety, and specialized equipment. National and international laboratory IPC guidelines highlight the need for practices such as risk assessment, biosafety cabinet use, appropriate PPE, and waste management (Ministry of Health, Saudi Arabia, 2021; National Centre for Disease Control, 2020).

2.3.1 Biosafety and Specimen Handling

Example KPIs:

1. **Biosafety cabinet (BSC) use compliance**
   - Definition:

     BSC use compliance (\%) = (Number of aerosol-generating procedures performed inside BSC/ Total Number of aerosol-generating procedures observed) x 100
   - Scope: Culture manipulation, specimen vortexing, pipetting potentially infectious materials.
2. **Specimen packaging and labeling compliance**
   - Percentage of outbound specimens packaged and labeled according to national or international transport regulations.
3. **Specimen rejection rate due to improper collection or labeling**
   - Although primarily a quality indicator, high rates can indicate poor adherence to safe collection practices in clinics feeding the lab.

2.3.2 Laboratory-Acquired Infections (LAIs) and Exposures

LAIs, though relatively rare, have serious consequences. Laboratory guidelines emphasize prompt reporting and investigation of incidents such as spills, leaks, sharps injuries, and exposure to aerosols (Ministry of Health, Saudi Arabia, 2021; National Centre for Disease Control, 2020).

Outcome KPIs include:

- Number of laboratory-acquired infections per 10,000 specimens processed per year.
- Number of reported exposure incidents (e.g., spills, splashes, non-intact PPE) per 10 full-time equivalent (FTE) staff per year.
- Sharps injuries rate per 10 FTE staff per year.

These should be analyzed with root cause analysis and corrective action plans.

2.3.3 Decontamination and Waste Management

Safe decontamination of surfaces, instruments, and equipment, and appropriate segregation and disposal of hazardous waste, are critical (WHO, 2016; National Centre for Disease Control, 2020).

Example KPIs:

- Percentage of lab waste correctly segregated into color-coded containers during spot audits.
- Percentage of autoclave loads that pass biological indicator tests (where applicable).
- Turnaround time from generation of infectious waste to final decontamination or removal.

Table 4. Sample laboratory IPC KPI set

KPI	Type	Numerator	Denominator	Suggested frequency
BSC use compliance (%)	Process	# aerosol-generating procedures in BSC	# aerosol-generating procedures	Monthly
Laboratory-acquired infections per 10,000 tests	Outcome	# confirmed LAIs	# tests performed/10,000	Annual
Sharps injuries per 10 FTE	Outcome	# sharps injuries among lab staff	# FTE lab staff/10	Quarterly
Correct waste segregation (%)	Process	# waste containers correctly segregated	# containers inspected	Monthly
Autoclave cycle pass rate (%)	Process	# cycles meeting parameters and indicators	# cycles performed	Monthly

2.4. Family Medicine Clinic–Specific IPC KPIs

Family medicine and primary care clinics are central to early detection and management of infectious diseases in the community. WHO's primary care IPC toolkit, ECDC guidance, and national checklists emphasize triage, patient flow, environmental cleaning, and safe procedures (WHO, 2021; ECDC, 2020; Public Health Ontario, 2022).

2.4.1 Triage, Respiratory Hygiene, and Patient Flow

During outbreaks (e.g., COVID-19, influenza), rapid identification and separation of patients with respiratory symptoms is essential to prevent transmission in crowded waiting rooms (WHO, 2020; ECDC, 2020).

Example KPIs:

- Percentage of patients with respiratory symptoms who are masked and seated in designated areas within a defined time (e.g., 10 minutes) of arrival.
- Percentage of clinics with visible signage promoting respiratory hygiene and cough etiquette.
- Average waiting time in common areas for symptomatic patients.

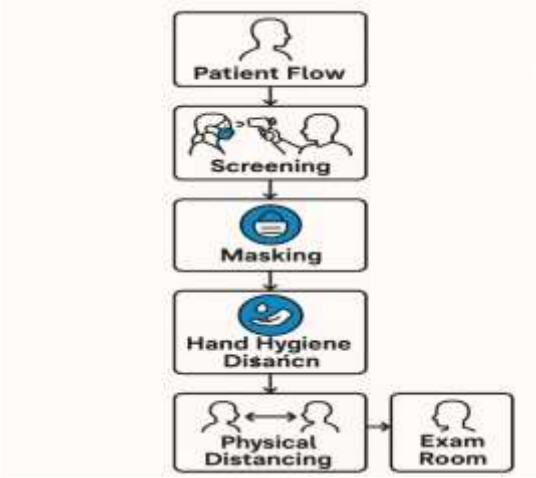

Figure 3: Process map diagram of patient flow in a family medicine clinic

2.4.2 Safe Injection and Minor Procedure Practices

Primary care and family medicine clinics often perform intramuscular or subcutaneous injections, vaccinations, and minor procedures. WHO and national guidelines emphasize single-use syringes, proper needle disposal, and aseptic technique (Public Health Ontario, 2022; National Centre for Disease Control, 2020).

Example KPIs:

- Percentage of observed injections using single-use sterile needles and syringes with no reuse.
- Percentage of sharps disposed into approved containers immediately after use.
- Percentage of invasive procedures performed with appropriate skin antisepsis and sterile equipment.

2.4.3 Instrument Reprocessing and Environmental Hygiene

Clinics that perform examinations involving reusable instruments (e.g., otoscopes, speculums, minor surgical sets) require effective reprocessing and/or the use of high-level disinfection or sterilization (WHO, 2016; WHO, 2021).

KPIs:

- Percentage of reprocessed instruments that pass chemical/biological indicators or visual inspection before reuse.
- Percentage of clinic rooms where high-touch surfaces are cleaned between patients.
- Compliance with reprocessing SOPs during direct observations.

Table 5. Sample family medicine clinic IPC KPI set

KPI	Type	Numerator	Denominator	Frequency

Respiratory triage compliance (%)	Process	# symptomatic patients triaged and masked within 10 min	# symptomatic patients observed	Monthly
Safe injection practice compliance (%)	Process	# injections meeting all criteria	# injections observed	Monthly
Proper sharps disposal (%)	Process	# sharps disposed immediately into approved containers	# sharps use opportunities observed	Monthly
Reprocessed instrument quality pass rate (%)	Process	# instruments passing quality checks	# instruments inspected	Monthly
Waiting room occupancy within IPC standards (%)	Balancing	# observation periods meeting occupancy/distancing norms	# observation periods monitored	Monthly

2.5. Integrated IPC KPI Dashboard Across Laboratories and Clinics

An integrated dashboard brings together KPIs from the laboratory and family medicine clinics into a unified view for the facility IPC committee and leadership. WHO and CDC emphasize coordinated, system-level IPC programs that include governance, surveillance, and feedback structures spanning all services (WHO, 2016; CDC, 2024).

2.5.1 Data Structure and Governance

Key design principles for an integrated IPC KPI system include:

1. **Common definitions and data standards** – A central IPC policy manual defines each KPI (numerator, denominator, inclusion/exclusion criteria), ensuring comparability across departments.
2. **Regular data collection cycles** – Monthly or quarterly audits and automated data feeds (e.g., from incident reporting systems) ensure timely information.
3. **Clear accountability** – Each KPI has an assigned owner (e.g., lab manager, clinic head nurse) responsible for data accuracy and action plans.
4. **Stratification and drill-down** – Indicators can be stratified by unit (lab vs clinic), staff category, or time period to identify specific areas needing improvement.

2.5.2 Example Integrated KPI Dashboard Layout

Table 6. Illustrative integrated IPC dashboard (monthly summary)

Domain	**KPI**	**Facility target**	**Laboratory result**	**FM clinics result**	**Status (R/Y/G)**
Standard precautions	Hand hygiene compliance (%)	≥ 85%	78%	82%	Y
PPE	Correct PPE use (%)	≥ 90%	92%	88%	Y
Environmental hygiene	Cleaning audit score (%)	≥ 90%	95%	87%	Y
Occupational health	Staff vaccinated against influenza (%)	≥ 80%	90%	75%	Y

Lab-specific safety	Sharps injuries per 10 FTE	≤ 1	1.5	N/A	R
Clinic-specific procedures	Safe injection compliance (%)	≥ 95%	N/A	97%	G

(R = red, Y = yellow, G = green.)

2.5.3 Use of Statistical Process Control

To distinguish real improvement from random variation, facilities can use run charts and statistical process control (SPC) charts. These tools are widely used in quality improvement to assess whether interventions, such as a new training package or environmental redesign, have led to significant and sustained changes in performance (Selmi et al., 2021).

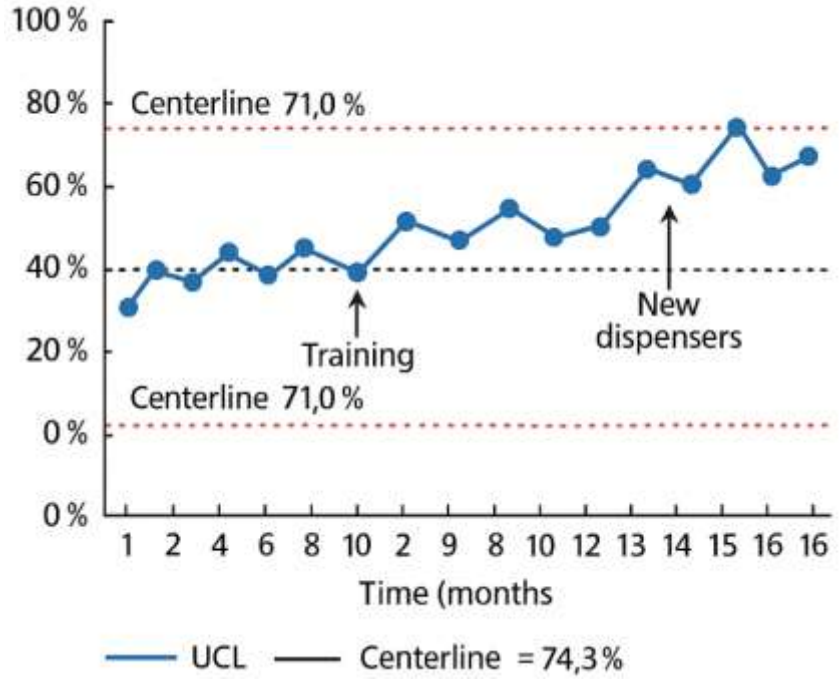

Figure 4. SPC chart for hand hygiene compliance in the laboratory

2.6. Implementation, Challenges, and Continuous Improvement

2.6.1 Implementation Steps

Drawing on WHO and national IPC implementation guides, an integrated KPI program can be developed in stages (WHO, 2016; PAHO, 2016).

1. **Baseline assessment**
   - Use existing IPC assessment frameworks and checklists to understand current practices in laboratories and clinics (WHO, 2018; Public Health Ontario, 2022).
   - Map existing audits and reporting systems.
2. **Stakeholder engagement**
   - Establish or strengthen an IPC committee including laboratory leadership, family medicine representatives, nursing, occupational health, and facility management.
   - Co-design the KPI set with frontline staff to enhance relevance and buy-in.
3. **Selection and definition of KPIs**

- Prioritize a limited but meaningful set of indicators in each domain (e.g., 10–15 core KPIs), ensuring alignment with guidelines and regulatory requirements.
- Develop a KPI dictionary with clear definitions and calculation methods.

4. **Data collection and IT support**
   - Use standardized audit tools, online forms, or electronic medical record data where available.
   - Ensure data security, confidentiality, and role-based access.
5. **Feedback and action**
   - Present dashboard results at regular IPC meetings and share key messages with staff (posters, newsletters, huddles).
   - Encourage local unit-level PDSA cycles targeting specific issues (e.g., sharps injuries in the lab, hand hygiene in clinics).

2.6.2 Common Challenges

Data quality and workload
Staff may be concerned about added documentation burdens. Streamlining data collection, integrating IPC audits into existing rounds, and sampling strategically can reduce workload while maintaining reliability (Deryabina et al., 2023).

Fear of blame
KPIs can be perceived as punitive. WHO and StatPearls stress that IPC programs should foster a just culture, focusing on system improvements rather than individual blame (Habboush et al., 2023; WHO, 2016).

Fragmentation of responsibility
If laboratories and clinics are overseen by different departments, alignment may be difficult. Formalizing IPC governance (e.g., hospital- or district-wide IPC committees) and embedding KPI reporting into management structures helps overcome this barrier (WHO, 2025; NHS England, 2022).

2.6.3 Linking KPIs to Improvement Interventions

The value of KPIs lies in how they are used. For example:

- Low hand hygiene compliance in both settings may prompt a multimodal improvement strategy—access to ABHR, reminders, training, role modeling, and feedback—consistent with WHO's approach (WHO, 2016, 2021).
- Elevated sharps injuries in laboratories can lead to targeted interventions such as safer sharp devices, revised SOPs, and refresher training; subsequent KPI trends can confirm impact.
- Poor safe injection compliance in clinics may trigger process redesign (e.g., pre-prepared trays, designated sharps disposal points) and observing improved KPIs provides positive reinforcement.

3. Conclusion

Integrated IPC KPIs offer a powerful mechanism to unify infection control efforts across medical laboratories and family medicine clinics. Grounded in WHO core components and CDC core practices, the indicators described in this paper span standard precautions, environmental controls, occupational health, decontamination, surveillance, and education.

By using common definitions of hand hygiene, PPE compliance, environmental cleaning, staff vaccination, and training completion, health systems can monitor and compare performance across settings while preserving flexibility for local adaptation. Laboratory-specific KPIs (e.g., biosafety

cabinet use, LAIs, sharps injuries) and family medicine clinic KPIs (e.g., respiratory triage, safe injections, instrument reprocessing) complement these cross-cutting measures and address context-specific risks.

Graphical dashboards—featuring run charts, SPC charts, and comparative bar graphs—make KPI data understandable and actionable for clinicians, managers, and policymakers. When embedded in a culture of learning and supported by robust governance and data systems, KPIs help guide practical improvement actions, rather than serving as mere reporting obligations.

Recommendations:

1. **Standardize and integrate** a core set of IPC KPIs across laboratories and family medicine clinics, aligned with national and international guidelines.
2. **Invest in data systems and training** to support reliable measurement, analysis, and feedback, minimizing additional workload.
3. **Use visual dashboards and SPC methods** to track trends over time and evaluate the impact of interventions.
4. **Foster a just safety culture** that uses KPIs to learn and improve rather than to blame.
5. **Periodically review and update KPIs** as evidence, guidelines, and local priorities evolve, ensuring alignment with emerging threats such as new pathogens or AMR patterns.

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