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From the Patient to the Healthcare Worker: The Transmission Chain of Healthcare-Associated Infections in Cameroon, an Integrated Approach

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Abstract

Background: Healthcare-associated infections (HAIs) arise from a transmission chain involving reservoirs (patients, the environment, medical devices), routes (hand-borne contact, equipment, air, body fluids, percutaneous exposure), and upstream system determinants (water, sanitation and hygiene [WASH], organization, training, safety culture, and access to diagnostics and antibiotics). **Objective:** To propose an integrated interpretation of patient-healthcare worker transmission in Cameroon by identifying dominant links and points where the chain can be interrupted. **Sources and Approach:** A critical narrative review grounded in the international infection prevention and control (IPC) literature and the available evidence from Africa and Cameroon, without a systematic review protocol or pooled quantitative synthesis. **Main Findings:** The literature suggests 1) a measurable burden of HAIs in selected units, 2) heterogeneous implementation of IPC programmes across facilities, and 3) substantial underestimation in the absence of structured surveillance, particularly for surgical site infections (SSIs) after discharge. The most directly actionable determinants lie at the patient-healthcare worker-environment interfaces (hands, devices, high-touch surfaces) as well as in upstream system factors. **Implications:** Prioritizing an integrated package combining IPC governance, a WASH foundation, uninterrupted availability of essential consumables, multimodal strategies, healthcare worker protection, and

alignment between IPC and antibiotic stewardship appears appropriate.

Keywords

Healthcare-Associated Infections, Infection Prevention and Control, Hand Hygiene, Occupational Exposure, WASH, Antimicrobial Resistance, Cameroon

1. Introduction

Framing HAIs "from the patient to the healthcare worker" may suggest a unidirectional transmission pathway. In reality, transmission dynamics are bidirectional: patients can contaminate healthcare workers, healthcare workers can contaminate patients, and the environment can act as an intermediate reservoir. The value of this framing is to place staff protection at the centre of the analysis, as it constitutes an indirect yet meaningful indicator of overall safety within the care system.

These dynamics fit within the classic epidemiologic chain: reservoir, portal of exit, mode of transmission, portal of entry, and susceptible host. A pragmatic integrated approach therefore consists of identifying, within each hospital, the most fragile links in the infection prevention chain (overcrowding, insufficient water points, interruptions in alcohol-based hand rub supply, lack of sharps containers, incomplete cleaning procedures, absent surveillance) so that resources can be prioritized where transmission risk is highest.

2. What the Literature Shows: Burden and Determinants, from Global Evidence to Cameroon

IPC as a lever for safety

World Health Organization (WHO) reports position infection prevention and control (IPC) as a cornerstone of patient safety and health-system resilience, while emphasizing wide variability in implementation across resource settings and facility types [1] [2]. The first WHO global survey of IPC in healthcare facilities highlights heterogeneous implementation levels, marked structural gaps in low-income settings, and a limited proportion of facilities meeting minimum requirements [3]. Within this framework, hand hygiene appears closely linked to overall IPC programme performance, supporting its use as a sentinel indicator [3].

Africa: surveillance and antimicrobial resistance

A systematic review focused on Africa considering healthcare-associated infections through an antimicrobial resistance (AMR) lens highlights the scarcity of continuous surveillance systems and the frequent reporting of pathogens typically associated with HAIs (*Klebsiella* spp., *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas* spp.), with concerning resistance patterns (MRSA, ESBL-producing Enterobacterales) across series [4]. This backdrop is not a separate problem:

IPC quality and resistance dynamics interact and reinforce one another.

Cameroon: available evidence and warning signals

The Cameroonian literature remains fragmented, often single-centre, and focused on a limited set of units or themes (in-hospital HAI surveillance, SSIs, adherence to standard precautions or hand hygiene, IPC maturity assessments). Nevertheless, convergent signals document ongoing transmission and recurrent vulnerabilities.

1) A measurable inpatient HAI burden with prognostic impact. At the Yaoundé University Teaching Hospital, a prospective longitudinal surveillance study across several units (intensive care, gynaecology, surgery, neonatology) included 307 patients and reported a cumulative incidence of nosocomial infections of 19.21% (95% CI 16.9 - 21.5), with infection-attributable mortality of 28% (95% CI 16.2 - 42.5) among infected patients. Bloodstream infections, skin and soft-tissue infections, and urinary tract infections were among common presentations, and *Klebsiella* spp. was the most frequently isolated organism (27%) [5].

2) Surgical site infections (SSIs) are not rare, and post-discharge follow-up conditions measurement. In a prospective SSI surveillance study at Mbouo Protestant Hospital, 148 patients were included and overall SSI incidence was 7% (11/148); approximately 55% (6/11) of SSIs were detected after discharge, illustrating the substantial risk of underestimation when surveillance ends at hospital discharge [6]. In another setting (Mbingo Baptist Hospital, North-West region), a retrospective study of 304 adults undergoing abdominal surgery reported an SSI prevalence of 12.2% (37/304), with typical risk factors (prolonged operative duration, contaminated/dirty procedures, emergency surgery, etc.) [7].

3) IPC maturity is improving but remains uneven and sensitive to organizational determinants. A multi-regional assessment using the WHO "COVID-19 IPC scorecard" (2020-2023) showed heterogeneous levels, with a minority of facilities reaching an "advanced" level and overall better performance in hospitals and in the private sector, suggesting effects of resources, governance, and organization [8]. These findings align with a national workshop-type evaluation involving key IPC stakeholders, which describes multi-level barriers (structural, organizational, behavioural) and emphasizes implementation levers (governance, training, supervision, availability of supplies) [9].

4) Patient-healthcare worker interface links remain documented friction points. Practice-focused Cameroonian studies show suboptimal compliance that is strongly conditioned by resource availability and supervision. For example, an implementation study in a Cameroonian hospital reported that continuous availability of alcohol-based hand rub at the point of care, supported by training, monitoring, and feedback, increased hand hygiene compliance from approximately one third to more than four fifths of observed opportunities [10]. In parallel, a study in obstetrics-gynaecology in Yaoundé found a high frequency of occupational exposures to body fluids (59% over 12 months) and low hepatitis B vaccine coverage, reinforcing the notion that healthcare worker protection serves as a sen-

tinel indicator of IPC system robustness [11].

Taken together, these findings do not describe "all of Cameroon", but they indicate that a) transmission chains are active and measurable; b) visibility depends heavily on structured surveillance, particularly post-discharge SSI follow-up; c) control capacity varies with IPC maturity and system determinants (WASH, supplies, organization, safety culture); and d) hand-device-surface interfaces and occupational exposure prevention remain high-yield targets for interrupting transmission.

3. The Patient-Healthcare Worker Chain: Where Does Transmission Occur?

Rather than stacking lists of measures, the added value lies in mapping tipping points.

Reservoirs and microbial loads

1) **The patient:** prior colonization, active infection, wounds, drains, diarrhoea, cough, exudates.

2) **Devices:** central and peripheral venous lines, urinary catheters, ventilators, catheters, surgical instruments, infusion sets.

3) **The environment:** high-touch surfaces, linen, water (WASH), waste.

In resource-constrained contexts, WASH and waste-management failures can amplify the environmental reservoir and indirect transmission role (intermittent water supply, inadequate functional toilets, lack of alcohol-based hand rub, glove stock-outs, unsafe waste collection), which WHO reports identify as major safety determinants [1]-[3].

Transmission routes relevant to healthcare workers

In healthcare settings, infectious agent transmission relies on several complementary mechanisms, foremost among them hand-borne contact, with the healthcare worker's hands acting as the central vector between the patient, invasive devices, and environmental surfaces. When key friction points are not effectively controlled, hand hygiene by washing or alcohol-based hand rub, appropriate glove use, and correct glove removal transmission chains remain open. Indirect transmission via frequently shared care equipment (stethoscopes, blood pressure cuffs, thermometers, ultrasound devices, trolleys), often insufficiently disinfected, further contributes. Droplet and airborne transmission mainly occur during respiratory care, suctioning, and intubation procedures, making ventilation quality, patient-flow organization, and triage critical. Finally, percutaneous transmission from needlestick injuries and cuts (needles, blades), needle recapping, or unsafe disposal of sharps constitutes a distinct but preventable risk.

Hierarchy of controls: why "more PPE" is not enough

In fragile health systems, a common reflex response to IPC failures is to "compensate" by increasing reliance on personal protective equipment (PPE). However, the hierarchy of controls prioritizing elimination or isolation of hazards at the source, engineering controls, then organizational controls before PPE reminds

us that PPE is the last line of defence. When PPE becomes the primary prevention strategy, it typically reflects insufficient stabilization of upstream system levels. The Cameroonian study using the "COVID-19 Infection Prevention and Control scorecard" explicitly fits within this framework, proposing a relevant tool to prioritize prevention actions and guide operational priorities [8].

4. Critical Discussion

Confusing "rules" with "systems"

Many IPC programmes fail because they are reduced to individual injunctions (train, remind, post posters) without securing the system: availability of consumables, standardized procedures, audits, feedback, and managerial accountability. The WHO IPCAF survey shows that "training" and "workload/occupancy" components are recurrent weaknesses, even when guidelines exist [3]. In practice, during an IPC audit, the central question is not whether staff know the recommendations, but whether the care system makes the appropriate behaviour easy, rapid, feasible, and socially expected.

Underestimating "post-discharge" and long chains

SSIs and some device-related infections often occur after discharge. When post-discharge follow-up is absent, facilities may incorrectly conclude that SSIs are "not a problem". Mbouo surveillance data illustrate this bias, as more than half of identified SSIs occurred after discharge [6]. Practically, integrating a simple, standardized post-discharge follow-up through day 30 is needed; beyond increasing detection rates, it helps identify weak links along the care pathway particularly antibiotic prophylaxis, skin preparation, sterilization, implant management, and dressing quality.

Separating IPC and antimicrobial resistance: a strategic error

HAIs increase antibiotic consumption, while antimicrobial resistance makes these infections more complex to treat, reflecting a tightly coupled system. This relationship is not merely theoretical in Cameroon; it is reflected in local microbiological patterns. In the Yaoundé surveillance study, nosocomial infections were dominated by Enterobacterales, particularly *Klebsiella* spp. (27% of isolates), along with *E. coli* and *S. aureus* pathogens central to hospital AMR challenges [5]. Circulation of these organisms in care units concretely illustrates the link between prevention failures and antibiotic selection pressure: inadequate control of hand-borne transmission, prolonged use of invasive devices, and avoidable infections increase empiric use of broad-spectrum antibiotics, fostering emergence and spread of resistant strains. Conversely, resistant bacteria complicate HAI management, prolong hospital stays, and increase system burden.

WHO reports on IPC and AMR surveillance underscore the value of joint actions linking IPC and antibiotic stewardship to reduce both transmission and selection pressure [1]-[3] [12]. In Cameroon, where *Klebsiella* spp., *E. coli*, and *S. aureus* are among the main documented HAI pathogens, separating IPC from AMR ignores a core determinant of local dynamics. In practice, each IPC pro-

gramme should be systematically coupled with a minimal antibiotic stewardship programme, including appropriate antibiotic prophylaxis procedures, de-escalation rules, recommended treatment durations, prescription audits, and where feasible targeted microbiological monitoring focused on the most frequently isolated pathogens.

5. Operational Priorities for Cameroon: An Integrated, Measurable Package

To make these priorities directly actionable, objectives are explicitly differentiated by level of responsibility, distinguishing levers under national decision-makers, facility managers, and unit-level leaders.

Non-negotiable foundation (0 - 6 months) for national decision-makers and facility managers

1) Securing WASH and healthcare waste management primarily falls under national health authorities and hospital leadership, who must ensure investment, maintenance, and continuity of water, sanitation, and waste-management infrastructure prerequisites for any IPC policy.

2) Uninterrupted availability of essential consumables is a governance responsibility of facilities, requiring procurement planning, secured supply chains, and dedicated budgeting to ensure continuous access to alcohol-based hand rub, soap, gloves, risk-appropriate masks, sharps containers, and surface disinfectants.

3) Formalizing a minimal IPC organization is a joint responsibility of facility leadership and supervising authorities, including official designation of an IPC focal point, functional reporting pathways, and regular IPC steering meetings integrated into hospital governance.

"High-yield" strategies (6 - 18 months) for facility managers and unit leaders

4) Deploying a multimodal hand hygiene strategy is incumbent upon hospital leadership and unit heads, combining staff training, point-of-care access to alcohol-based hand rub, visual reminders, regular audits and feedback, supported by standardized self-assessment and monitoring tools.

5) Implementing prevention bundles for invasive devices primarily rests with clinical unit leaders, with organizational support, including systematic insertion and maintenance checklists, indication documentation, and promotion of early removal whenever possible.

6) Standardizing SSI prevention targets operating room teams and surgical and anaesthesia leadership, with managerial support, to harmonize antibiotic prophylaxis, skin preparation, sterilization, operating room discipline, and proportionate surveillance including post-discharge follow-up.

Protecting the healthcare worker (cross-cutting) for unit leaders and facility leadership

7) Securing high-risk procedures is a direct responsibility of front-line supervisors, who must prohibit needle recapping, ensure immediate availability of sharps

containers, and secure disposal pathways for sharps and cutting waste.

8) Effective implementation of post-exposure prophylaxis and staff vaccination is the responsibility of hospital leadership, in coordination with health authorities, to ensure real access to HIV post-exposure prophylaxis, hepatitis B vaccination, and dissemination of exposure procedures that are known, available, and regularly tested.

9) Promoting a just culture is a cross-cutting managerial objective aimed at ensuring that reporting an occupational exposure or an HAI is recognized as a system signal requiring analysis and improvement, rather than an individual fault.

Measuring what matters for facility managers and unit leaders

Teams, under the impetus of leadership, should track process indicators such as hand hygiene compliance, availability of alcohol-based hand rub, and adherence to prevention bundles; outcome indicators including SSI incidence, catheter-associated bloodstream infections, and catheter-associated urinary tract infections when surveillance capacity allows; and structural indicators such as the formal existence of an IPC programme, allocation of a dedicated budget, annual training delivery, and regular audit implementation.

Practical implications: graded recommendations

These recommendations draw on the coherence of international evidence (WHO, IPCAF, African literature) and the signals available in Cameroon (surveillance studies, IPC assessments). They are intended to support operational decision-making and do not replace national guidelines.

1) Establishing or strengthening a functional IPC programme (focal point, plan, audits) is strongly recommended, given the high expected benefit and its conditioning role for other measures [1]-[3] [8].

2) Ensuring the WASH foundation and essential consumables (alcohol-based hand rub, gloves, sharps containers) is strongly recommended as a prerequisite for prevention [1]-[3].

3) Deploying and monitoring a multimodal hand hygiene strategy is strongly recommended as a high-yield measure and a sentinel indicator of IPC level [2] [3].

4) Organizing proportionate surveillance of priority HAIs (SSIs and selected device bundles) is moderately recommended, as it enables governance but requires minimal resources [3] [5] [6].

5) Linking IPC and AMR through a minimal stewardship programme is moderately recommended, as systemic effects on transmission and antibiotic use are expected [1]-[3] [12].

6. Limitations

This synthesis is narrative and does not have the strength of a systematic review. Internationally indexed Cameroonian literature remains limited, exposing a visibility bias because publishing facilities may not be representative. Finally, "national" results derived from assessment tools may be influenced by facility selec-

tion and by the temporal dynamics of evaluations [8].

7. Conclusion

In Cameroon, the HAI transmission chain "from the patient to the healthcare worker" is less a knowledge problem than a system problem. Available data suggest 1) a real burden of hospital HAIs, 2) an IPC implementation that is improving but remains uneven, and 3) the importance of active surveillance particularly post-discharge to adequately measure events such as SSIs. An integrated approach should break the chain at dominant points (hands, devices, environment, percutaneous exposures) while addressing upstream determinants (WASH, organization, workload, audits, culture). The goal is not perfection, but a measurable, continuous, and sustainable improvement.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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