THE ROLE OF IMPROVEMENT SCIENCE IN INFECTION CONTROL





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This chapter discusses the application of the science of improvement (also known as delivery science or implementation science) to infection prevention and control, illustrated through a case study from Namibia. It emphasizes processes and systems that can be targeted to yield reliable and effective results for the prevention of health-care-associated infections. This includes the importance of testing changes and monitoring results as a strategy for continuously improving infection control processes. Collaborative improvement and strengthening the capacity of health workers to produce and sustain results is also emphasized.

Quality care is defined as care that is: safe, effective, patient-centred, timely, efficient and equitable *(1)*. With regards to the dimension of safety, the global burden of disease caused by unsafe medical care presents a significant public health issue. Deaths from medical errors are the third leading cause of death in the United States, following heart disease and cancers *(2)*. Of the 421 million annual global hospitalizations, approximately 42.7 million result in adverse events, resulting in the loss of 23 million disability adjusted-life years (DALYs), two-thirds of which occur in low- and middle-income countries (LMICs) *(3)*. LMICs have five-times the population of high-income countries, and experience 50% more adverse events and related injuries: 25.9 million versus 16.8 million annual injuries *(3)*. A study of seven key adverse events experienced in inpatient hospital settings estimated that unsafe health care is the twentieth leading cause of global morbidity and mortality; this figure is likely to be even higher when accounting for adverse events that occur in ambulatory settings or for which there is poor data *(3, 4)*.

Health-care-associated infections and antimicrobial resistance

The WHO Patient Safety Programme has identified 12 key adverse events which contribute most to the global burden of disease for unsafe medical care. These include:

- adverse drug events (ADEs);
- catheter-related urinary tract infections (CR-UTIs);
- catheter-related blood stream infections (BSIs);
- nosocomial pneumonia;
- venous thromboembolisms (VTEs);
- falls;
- pressure ulcers;
- substandard or counterfeit drugs;
- unsafe blood products;
- unsafe injections;
- medical devices; and
- surgical errors *(4)*.

Health-care-associated infections (HAIs) are linked to many of these adverse events, and are a key source of the global disease burden of unsafe medical care. Furthermore, while HAIs are a key issue across country settings, a 2010 systematic review estimates that HAIs are two- to three-times more prevalent in low-income countries than in high-income countries *(5)*.

HAIs prolongs hospital stays, increase mortality rates and raise health-care costs. A study of over 1,000 intensive care

units (ICUs) in 75 countries found that about half of patients were infected, and that infected patients were two-times more likely to die in the ICU than uninfected patients *(6)*. While HAIs may be caused by a variety of pathogens, including viruses and fungi, approximately 80% of HAIs are caused by eight main bacterial pathogens *(7)*. Antibiotic resistant bacterial infections are a global threat, a 2014 global review by WHO revealed that more than 50% of the common pathogens (*E. coli*, *K. pneumoniae* and *S. aureus*) were resistant to commonly used antibacterial drugs *(8)*. Antibiotic-resistant pathogens are more expensive to treat, and result in longer hospital stays. In the United States alone, compared to antibiotic-susceptible pathogens, antibiotic-resistant infections result in an additional US$ 21–34 billion annual cost to the health system and 8 million additional hospital days *(9–11)*. Reducing unnecessary infections reduces potential antibiotic use, thus slowing the spread of antibiotic susceptible and antibiotic resistant organisms. Furthermore, HAIs include occupational experienced by health workers, as well as patients. Health worker safety is a key component of infection control, and has impacts on health worker numbers, morale, retention and a host of other factors. Thus, infection control is critical not only for patient safety, but for provider safety, and should be central to any health systems strengthening effort.

Improvement science

Health care is provided through processes in which health-care workers provide clinical interventions to patients that need them *(12)*. Delivery of good quality care requires use of the best evidence available and organizing care so that the best evidence is delivered to each patient every time it is needed. This requires meticulous attention to detail and organizing care to the appropriate context, including organizing who does what at each step, and ensuring they have the competencies, equipment, time and resources to do so *(13)*. The process by which this happens utilizes improvement science (also known as quality improvement, implementation science or delivery science), and includes all actions taken to make health care better *(14)*. The basic principle that underlies improvement is that every system is perfectly designed to achieve the result we see *(15)*. We must change the process if we wish to improve. Furthermore, the only way to see if we are improving is by measuring. The two key types of measurements needed to assess the effectiveness of improvement interventions are: 1) process-level measurement in which we are tracking the steps of the care delivery process and ensuring all the patient care actions are aligned with the best knowledge we have, for example tracking handwashing rates and 2) outcome-level, to confirm whether we are meeting the desired objectives, for example tracking HAI rates *(16)*. The extent we are better at process indicators will allow us to see fewer negative outcomes.

Global experience in improving health care has found that working with multiple teams on common objectives has been more effective in the production of systematic, sustained gains *(17)*. The process by which multiple teams work together to improve the same thing and share their learning has become a mainstay in improving health care, and is called collaborative improvement. Collaborative improvement allows for real-world testing of strategies to implement evidence-based interventions. Each team involved in the collaborative applies small-scale tests of changes to improve care processes. These tests are measured regularly using agreed upon indicators, and results and best practices are shared across teams through periodic experiential learning cycles, from which subsequent changes are informed *(18)*. This cyclic processes of testing and learning are known as "Plan, Do, Study, Act" (PDSA) cycles. The collaborative improvement approach allows teams to conduct multiple PDSA cycles in parallel in different locations, and thus accelerates learning and spread of the most effective change concepts, while building energy and ownership over learning *(19, 20)*.

The application of improvement science to reducing HAIs

About half of adverse hospital events may be preventable *(21-23)*. While there is a large body of evidence-based preventive clinical interventions which can reduce HAIs *(24-27)*, there is limited knowledge of how to implement these interventions to address systems failures, which cause communication breakdowns, uncoordinated and inefficient care. However, there is a growing evidence which demonstrates that improvement science strategies can help bridge the "know-do" gap to increase adoption of evidence-based prevention interventions, and reduce HAI rates. A recent systematic review of 30 studies found improved adherence to evidence-based infection control guidelines and reduced infection rates when improvement science strategies like audit and feedback, and provider reminder systems, were added to organization change and provider education *(28)*.

The application of improvement science will be illustrated through a case study of an injection safety and waste management programme in Namibia which was led by the Namibian MOHSS in collaboration with University Research Co., LLC (URC) and the United States Agency for

International Development (USAID) Health Care Improvement (HCI) Project, and the President's Emergency Plan for AIDS Relief (PEPFAR). Together with USAID, URC has led one of the largest improvement science portfolios in low- and middle-income countries.

Case study: Namibia medical injection safety programme

Background

In 2004, the WHO estimated that the global burden of unsafe injection practices is over 9.2 million DALYs lost per year *(29)*. An estimated 16 billion injections were administered annually in LMICs, for an average of 3.4 injections per person per year *(30)*. Up to 96% of those presenting to a primary health-care provider receive an injection, of which 70% are unnecessary or could be given in an oral formulation. While significant global progress has been made in the reduction of injection-related viral infections in the decade since 2000, at the time this case study began, unsafe injections accounted for 5%, 32% and 40% of new HIV, hepatitis B, and hepatitis C infections, respectively, resulting in 260,000, 21 million and 2 million incident cases annually *(29-31)*. The more injections are given, the more people are exposed to the risk of unsafe injection equipment and practices, including blood borne infections and health-care-acquired drug resistant organisms, and the more waste is generated *(32)*.

In 2004, an average of 11.2 injections was prescribed per person per year in Namibia. Most of these injections were for conditions that could be treated with oral medication. A significant proportion (39%) of patients expressed a preference for injections. In some assessed facilities, injections were not prepared in a designated, clean area, and 62% of facilities reported the presence of sharps in their immediate surroundings, posing a risk of needle-stick injury to HCWs and others. Additionally, injection safety boxes were observed in only a handful of facilities and recapping needles was a common practice in most facilities *(33)*.

Intervention

Under PEPFAR, and with support from USAID, University Research Co., LLC (URC) supported the Namibian Ministry of Health and Social Services (MOHSS) in a nationwide programme to promote rational use of medication, medical injection safety, and safe disposal of medical waste. The aim of this work was to prevent HAIs, including HIV, by promoting targeted infection control measures. This work began with the Making Medical Injections Safer Project (2004–2009) and continued with the USAID Health Care Improvement Project (HCI) (2007–2014) *(33)*.

The project aimed to reduce per capita injection use to less than one per year by the end of the project in 2009. The project also aimed to achieve significant decrease in needle-stick injuries over the life of the project through improved clinical practices. These two goals were to be achieved through the following:

- (a) develop and support national policy for safe injection practices;
- (b) develop and/or identify cost-effective and sustainable "best practices" to change provider prescription practices and community demand to reduce unsafe and unnecessary injections;
- (c) assist in improving the use of disposable/sterilized syringes;
- (d) improve infection prevention practices at facilities;
- (e) improve disposal practices of sharps and implement standards for safe withdrawal of blood for HIV testing.

A modified version of WHO's Safe Injection Global Network (SIGN) toolkit was used to conduct a rapid baseline assessment in July 2004 to identify existing injection and waste management practices, and opportunities for improvement. A National Injection Safety Group (NISG) was convened with the MOHSS, and national, regional and facility injection safety improvement plans were developed.

A collaborative improvement approach was used to improve injection and waste management practices, and inform national and regional policies. This included training 34 facility-based Safe Injection Teams in improvement methods, these teams then carried out regular Plan, Do, Study, Act (PDSA) cycles. During these PDSA cycles, teams reviewed data on a select number of process and outcome indicators. Ideas across teams were shared in regular learning sessions, and led to the development of a safe injection improvement package, which consisted of the following: effective communication of safe injection guidelines to public and private health-care workers (HCWs); ongoing monitoring of injection equipment use and disposal practices; implementation of strategies to improve awareness among medical injection users (community members) about safe injections; and overall capacity-building at national, regional and facility levels in infection prevention and control. Over the life of the project, URC assisted regional- and facility-level staff in adapting the improvement package in their local settings. The impact of these interventions were monitored closely to track changes in injection safety practices and the participating regions conducted quarterly assessments as part of the PDSA cycle.

Improvement plans were adjusted quarterly, based on the results of the quarterly assessments.

Results

Policy-level advocacy

The project covered all 13 regions in Namibia and 327 facilities. The facilities included a number of large private hospitals as well as independent rural private providers.

Over the course of the project several key national policies were developed by the NISG and adopted by the MOHSS, including: National Infection and Prevention and Control Guidelines, which incorporate TB infection prevention; HIV post-exposure prophylaxis (PEP) guidelines and job aids; National Standard Treatment (STG) guidelines; National Waste Management Policy; Integrated Waste Management Plan and guidelines; Revised Hepatitis B Policy; Quality Assurance (QA) Policy.

URC also established infection prevention and control (IPC) committees at the regional, district and facility levels to develop and implement regional and district IPC plans to promote the availability and use of infection control guidelines. This included training of HCWs, conducting quarterly facility audits, procurement of necessary supplies, prescription review, and support supervision of services.

Capacity building

The project trained over 12,000 HCWs on safe injection practices and waste disposal topics, including: data monitoring and paperwork completion, needle-stick reporting, use of PEP, and management of medical waste. The project also worked closely with the MOHSS to procure over 350,000 safety boxes for sharps disposal, personal protective equipment for waste handlers, and color-coded disposal bin liners. URC worked with the Central Medical Stores (CMS) and MOHSS to develop a long-term procurement plan including the development of a tender for the safety boxes. URC trained procurement officers on forecasting and ordering, promoted the use of stock cards, and collected consumption data submitted to the procurement agency.

Another key action that facilities undertook was to appoint an on-site point person to advocate for and supervise safe injection and waste management practices. This point person was responsible for conducting quarterly facility audits, training staff in the guidelines established, and working with the regional, district and facility-level IPC committees to review progress. Facility audits had previously been done by facility supervisors, however, the point person chosen was usually a nurse. Appointing nurses to perform facility audits, and to manage information system data tools, was seen as a more effective alternative, as nurses could notice shortcomings better and work to improve safe practices during trainings of HCWs.

Behaviour change

URC targeted community and provider perceptions in order to reduce the demand for and prescription of unnecessary and potentially unsafe injections. In particular, there was a perception among some community members and provides that injections were more effective than oral medicines. Furthermore, patients who were not offered an injection would simply go to a different clinic to find one.

URC worked with the MOHSS and its Information, Education and Communications (IEC) Office to develop a communication strategy and materials to change the behaviour of clients regarding the demand for injections and of providers on safe injection practices and prescription practices according to national standards. This included the development of communication materials in local languages to improve knowledge about safe injections and reduce the demand for and prescription of unnecessary injections.

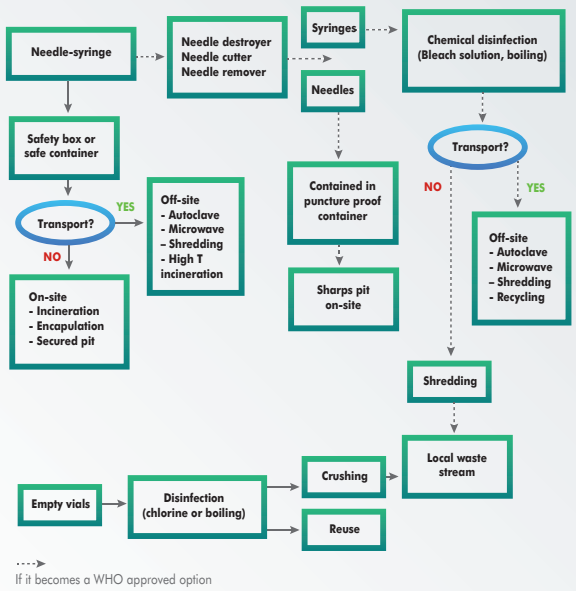
URC also enabled community educators to raise public awareness on the rational use of medication. The objective was to reduce demand for unnecessary injections and ensure proper disposal of infectious waste generated in the community, such as by insulin-dependent diabetics.

To influence provider prescription and injection administration practices, the educators worked with HCWs to communicate injection safety and waste management messages, for example through posters and wall charts along with job aids for HCWs. This included flowcharts on safe disposal of used needles and syringes for a broad arrange of scenarios, including facilities in: urban, peri-urban and rural areas with and without access to modern waste treatment facilities, as well as for primary health centre- and community-based immunization outreach activities (Fig. 1). These flow charts encouraged compliance with approved guidelines, including use of the safety boxes for correct disposal of sharps.

Another key change included training in the use of color-coded bags for correct waste segregation, as well as the development and dissemination of job aid posters (Fig. 2). Additional posters developed included posters on: 1) first do no harm; 2) hand hygiene; 3) prevention of cross-infection; 4) PEP flowcharts, 5) responsibilities of HCWs when injured on duty; g) nature of the workforce.

Additionally, the project conducted regular chart audits as well as observed provider practices in a sample of facilities.

Figure 1: Senario 5: Needle syringes waste management – immunization at PHC



Citation: Namibia Integrated Health Care Waste Management Plan (2011)

Figure 2: Namibia Medical Injection Safety Project and USAID Health Care Improvement Project (2011)

Citation: Namibia Medical Injection Safety Project and USAID Health Care Improvement Project (2011)

The results from audits and observations were shared during the quarterly Plan-Do-Study-Act (PDSA) cycle meetings so that teams could take action based on the data.

Outcomes

Over the life of the project, significant improvements in provider practices were made. The project made PEP kits widely available across facilities, as well as guidelines and job aids. Knowledge of PEP and injury reporting was increase among all staff, including morgue workers, students, laundry workers and waste handlers. For example, knowledge on use of PEP within 72 hours post exposure increased from 47% in 2004 to 100% in 2009. There were also significant reductions in sharps related injuries as well as increases in the use of post-exposure prophylaxis (PEP) among HCWs experiencing needle-stick injuries. For example, no cases of occupationally-acquired HIV infection was reported in Namibia in 2010. Furthermore, the average number of injections administered per patient per quarter declined from 11.2 in the first quarter of 2005 to fewer than 2 in facilities reporting by the last quarter of 2011 (Fig. 3).

The programme also monitored the injection process in supported facilities and adherence to safe practices, like the use of safety boxes. Safety boxes were only seen in 2% of 32 hospitals at baseline, however by the end of June 2011, they were present in 98% of 190 facilities reporting. Additional improvement included a reduction in the practice of leaving needles in multi-dose vials after injection, and proper disposal of needles without recapping, in order to reduce needle-stick injuries. The project also introduced the use of single dose vials to minimize cross-infections that can occur when using multi-dose vials without proper needle sterilization techniques.

Additionally, waste management practices were monitored, including: replacing containers once they were three-quarters full to prevent overfilling, which can cause needles to pierce the sides; ensuring containers meet safety standards; and ensuring facilities had access to a functional incinerator (Fig. 4). In addition to repairing old incinerators, the project procured and installed 17 new incinerators, and included proper use of incinerators in regional waste policies and guidelines. Access to functional incinerators increased from 60% at the beginning of 2009 to 98% among 198 facilities reporting in September 2011. Use of effective waste management strategies was also associated with a reduction in the presence of used needles and sharps on health facility grounds, which decreased from presence at 62% of facilities in 2004 to less than 1% in 2011.

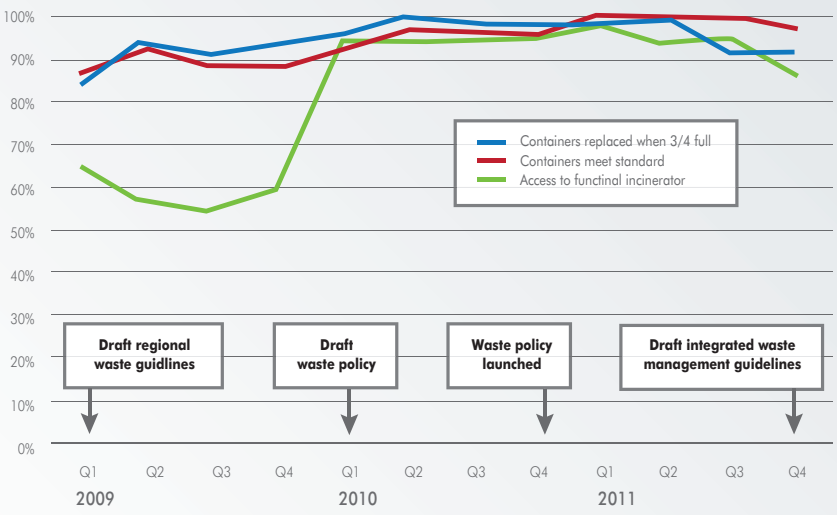
Discussion

There are many established best practices that are known to reduce if not eliminate HAIs. However, as important as the discipline-specific knowledge is for reducing HAIs, it is

Figure 3: Average number of doses administered per patient in Namibia, 2005–2011

Citation: Namibia Medical Injection Safety Project and USAID Health Care Improvement Project (2011)

Figure 4: Improvement in waste management practices in Namibia, 2009–2011



Citation: Namibia Medical Injection Safety Project and USAID Health Care Improvement Project (2011)

invariably on its own insufficient to just "know." What we need to do is address the "know-do" gap *(18)*. To a large extent, we know what needs to be done to reduce HAIs: hand hygiene, safe sharps disposal and rational use of injections. However like this case study in Namibia showed, this knowledge is not consistently implemented in practice. When health-care workers in Namibia learned improvement science and applied its methods, they were able to implement this knowledge and bring down the rate of injections and improve health worker safety. Thus, improvement science became a powerful tool for change.

The work of the Namibian MOHSS, supported by the USAID Health Care Improvement Project demonstrated that a combination of policy-level changes as well as facility-based improvement allowed for significant, sustained implementation of interventions that have a direct link with reductions HAIs and spread of antimicrobial resistance. These changes involved building the capacity of health workers through trainings, and through the use of nurse champions, and involvement in collaborative improvement efforts. The collaborative improvement approach strengthened HCWs ability to collect and use relevant data for decision-making, and to inform an improvement package which was scaled up nationally.

Due to space constraints, we have described only one example, but there are others examples from developing countries in the use of improvement science to improve infection control. In 2012, The USAID Health Care Improvement Project collaborated with Bridge Consultants, Karachi, to improve injection safety and waste management in Karachi, Pakistan. In this project 25 health-care providers worked together to improve compliance with 11 key infection prevention practices (availability of soap and water, hand hygiene, use of sharps boxes, etc.) from 18% at baseline (February 2012) to 54% at endline (December 2012) *(34)*. The USAID Applying Science to Strengthen and Improve Systems (ASSIST) Project is currently implementing similar interventions in 60 sites in Swaziland.

There are more examples in developed country contexts, including many led by the Institute for Healthcare Improvement (IHI). These include studies which led to the development of How-to Guides and change packages to prevent catheter-associated urinary tract infections, surgical site infections and central line-associated bloodstream infections *(35, 36)*. One key example includes the use of improvement science methods to implement evidence-based interventions to reduce ventilator-

associated pneumonias (VAP) under the Scottish Patient Safety Programme, led by Scotland's National Health Service and using IHI methods. PDSA cycles were used to identify an implementation method which maximized compliance, including the use of nurse and medical champions, teaching materials and posters, education sessions, and 24-hour observation charts. Overall, bundle compliance was 70%, and there were significant reductions in VAPs, from 32 cases per 1,000 ventilator days to 12 cases per 1,000 ventilator days ($p<0.001$) *(37)*. In addition to reduced VAP acquisition, patients also had significantly reduced antibiotic use and decreased rates of methicillin-resistant Staphylococcus aureus acquisition *(37)*. These findings have significant implications, as VAPs are the third most common HAI, accounting for approximately 15% of all HAIs (38).

Additionally, a recent systematic review of 30 HAI reduction studies primarily from U.S. hospitals found evidence that use of improvement science strategies provided added benefits over provider-education only interventions, including improved adherence to evidence-based infection control guidelines and reduced HAI rates. *(28)* The improvement strategies included audits and feedback, as well as provider reminder systems. Further studies are needed in resource-limited settings which use strong quasi-experimental designs appropriate to examining the effects of interventions in real-world settings.

Conclusion

Compared to pure content interventions, the use of improvement strategies combined with content-based approaches allows the best results in improving adherence to guidelines, as well as reduced incidence of HAIs. A focus on improving patient safety requires a patient-centred approach, a focus on systems and processes, teamwork, and improved use of data for decision-making to continuously improve processes to deliver reliably safe, high quality care. Patient safety is one dimension of quality care, and improvement involves a focus on structural factors, care processes and care outcomes *(4)*. The use of improvement approaches can serve as a key tool to reduce HAIs, and thus avoiding unnecessary harm to patients and providers, limiting the unnecessary use of antibiotics and limiting the development of antimicrobial resistance. •

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